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# EFFECT OF SUPPLEMENTAL LINSEED AND ANTIOXIDANT IN RABBIT DIET ON FATTY ACID PROFILE AND SUSCEPTIBILITY OF MEAT LIPIDS TO OXIDATION*

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Key words: rabbits, feeding, linseed oil, meat quality.

A b s t r a c t

The aim of the study was to determine the effect of a 4% linseed oil supplement with and without antioxidant ($\alpha$-tocopherol) added to rabbit diets on the composition of the meat lipid fraction, cholesterol content and susceptibility of meat fat to oxidation after different storage periods.

Supplementing linseed oil to rabbit feeds had a beneficial effect on the composition of the meat lipid fraction. In the lipids of rabbit leg muscles there was a significant increase in the level of polyunsaturated fatty acids (PUFA), especially *n-3* PUFA, thanks to which the ratio of *n-6* to *n-3* PUFA decreased. Adding antioxidant (vitamin E) to the feed prevented lipid oxidation in the stored meat. The dietary factor used had no effect on rearing performance of the rabbits.

## WPŁYW DODATKU OLEJU LNIANEGO ORAZ PRZECIWUTLENIACZA W PASZY DLA KRÓLIKÓW NA PROFIL KWASÓW TŁUSZCZOWYCH I PODATNOŚĆ NA UTLENIANIE LIPIDÓW MIĘSA

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Słowa kluczowe: króliki, żywienie, olej lniany, jakość mięsa.

A b s t r a k t

Celem prowadzonych badań było określenie wpływu 4% dodatku oleju lnianego oraz przeciwutleniacza naturalnego ($\alpha$-tokoferol), dodanych do paszy dla królików, na skład frakcji lipidowej mięsa, zawartość cholesterolu oraz podatność na utlenianie tłuszczu mięsa po różnym okresie przechowywania.

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Badania przeprowadzono na 30 samicach stada podstawowego i całości uzyskanego od nich potomstwa. Króliki grupy kontrolnej żywiono pełnodawkową mieszanką standardową. W grupach doświadczalnych zwierzętom wprowadzono do receptury mieszanki 4% dodatek oleju lnianego i zwiększono o 100% dodatek witaminy E. Przeprowadzono analizę podstawową pełnodawkowych mieszanek paszowych. W okresie trwania doświadczenia kontrolowano liczebność i masę miotu po urodzeniu, w 21., 35. i 90. dniu życia oraz śmiertelność i przyrosty zwierząt. W 90. dniu życia przeprowadzono uboje kontrolne i ocenę poubojową królików zgodnie z obowiązującą metodyką. W próbkach mięsa, pobranych z mięśni tylnych nóg zwierząt, oznaczono profil wyższych kwasów tłuszczowych, poziomu cholesterolu całkowitego, witaminy E oraz TBA w mięsie mrożonym po 2 tyg. i 3 mies. przechowywania.

W przeprowadzonych badaniach w grupach doświadczalnych stwierdzono spadek zawartości nasyconych kwasów tłuszczowych w mięśniach nóg króliczych o ok. 28% w stosunku do grupy kontrolnej. Najwyższe potwierdzone różnice dotyczyły kwasu palmitynowego i stearynowego. Na szczególną uwagę zasługuje wysoko istotny wzrost zawartości kwasów tłuszczowych PUFA w grupach doświadczalnych, w tym kwasów z rodziny *n*-3, dzięki czemu nastąpiło zawężenie proporcji kwasów PUFA *n*-6 do PUFA *n*-3 w kierunku wzrostu tych ostatnich. Jest to pożądane dla diety współczesnego człowieka, gdyż taka proporcja ma istotne znaczenie w profilaktyce miażdżycy i schorzeń powstających na jej podłożu.

Dodatek witaminy E w paszy bardzo wyraźne zwiększył odkładanie się jej w mięsie. Zastosowany w badaniach przeciwutleniacz korzystnie wpłynął na zmniejszenie podatności lipidów mięśni na utlenianie. W grupach doświadczalnych obserwowano tendencję do obniżania się poziomu cholesterolu całkowitego.

## Introduction

Enriching milk, meat or eggs with components having a potentially beneficial effect on the human body has for many years been used to improve the dietetic value of animal products. This has been the reason for production of function (health-promoting) food, which is supplemented with long-chain PUFA, mainly *n*-3 long-chain PUFA in addition to trace elements and vitamins. These acids take part in cholesterol transport and synthesis and are found in cell membrane phospholipids, which enables them to influence all cell functions. In Poland, like in the majority of European countries, the typical diet is deficient in these acids and their consumption is several times too low (Kolanowski, Świderski 1997, Ziemlański 1997).

From the dietary point of view, the most suitable oil for supplementing animal feeds is linseed oil, half of which is formed by *n*-3 fatty acids and only 9.8% by saturated acids.

Xiccato and Trocino (2003) showed a positive effect of feeding plant fats on the cholesterol content of rabbit meat and found that the amount of cholesterol is affected not so much by the presence of unsaturated fatty acids (UFA) as by the relationships between them. The mutual relationships in feed between *n*-6 and *n*-3 PUFA affect the composition of fatty acids of cell membrane phospholipids, which in turn determines the permeability of these membranes. This effect may help HDL lipoproteins to bind on the surface of muscle cells and to take excess cholesterol away (Barowicz, Brzóska 2001). However, the high UFA content of feeds makes them susceptible to oxidative processes. Fat rancidity results in the formation of free radicals, lipid pe-

roxides of aldehydes and further oxidation products, which have a negative effect on the dietetic value of fat. The oxidation of acids may also take place in meat during storage and be detrimental to its quality by having a negative effect on meat stability, aroma, taste and nutritive value, reducing the PUFA content and increasing the number of fat oxidation products and cholesterol. It is therefore necessary to protect fat from oxidation.

The aim of the present study was to determine the effect of a 4% linseed oil supplemented with and without antioxidant ($\alpha$-tocopherol) to the feed of rabbits on the composition of the meat lipid fraction, cholesterol content and susceptibility of meat fat to oxidation after different storage periods.

## Material and Methods

A total of 30 New Zealand White does of the foundation herd and all of their offspring were investigated in three feeding groups (10 animals per group). Does of the foundation herd were fed experimental diets from first mating. The experimental results concern the third litter of does.

Group I – fed a standard basal diet in pellet form,

Group II – fed a pelleted diet with 4% linseed oil,

Group III – fed a pelleted diet with 4% linseed oil and vitamin E content increased by 100% (100 mg/kg diet).

The complete standard diet given to rabbits contained dried meadow grass, soybean meal, wheat bran, ground maize, milk replacer, NaCl, Di calcium phosphate, and a mineral-vitamin supplement with a coccidiostat. In the experiment, animals from groups II and III received a 4% linseed oil supplement and a lower proportion of soybean meal, dried meadow grass and ground maize.

Rearing performance of rabbits, i.e. body weight and litter size 24 h after birth and at 21, 35 and 90 days of age, and daily gains from 35 to 90 days of age were studied. During the experiment, blood was taken from animals to determine selected biochemical parameters of blood serum (glucose, total cholesterol, HDL cholesterol, triglycerides).

At the end of the experiment, the animals were slaughtered (6 animals per group). Control slaughters and postslaughter analysis were performed in accordance with standard methods. Muscling and fatness traits of rabbit carcasses were analysed

After dissection, the samples of rear leg muscles were analysed for the profile of higher fatty acids using gas chromatography (determination of free fatty acids), total cholesterol (using the colourimetric method) and vitamin E (HPLC method). The degree of fat oxidation in meat was measured using TBA, which was determined in a reaction of secondary oxidation products with thiobarbituric acid (after 14 and 90 days of meat storage).

The results were analysed statistically using analysis of variance and Duncan's D-test in the Statgraphics Plus 4.0 packet.

## Results and Discussion

Table 1 shows the results of basic analysis of the complete pelleted diets used in the experiment.

Adding the linseed oil supplement increased the amount of crude fat from 2.42% to 5.05–5.17%. FRAGA et al. (1989) reported that a 3–5% dietary plant or animal fat supplement produces good practical results as it increases the energy level without reducing fibre or excessively increasing the starch content of the diet.

Table 1

Results of basic analysis of complete pelleted diets

| Group | Dry matter (%) | Crude ash (%) | Organic matter (%) | Crude protein (%) | Crude fat (%) | Crude fibre (%) | N-free extract-ives (%) |
|---|---|---|---|---|---|---|---|
| I | 89.40 | 5.83 | 83.57 | 16.74 | 2.42 | 9.21 | 55.20 |
| II | 87.74 | 5.30 | 82.44 | 16.34 | 5.05 | 9.44 | 51.61 |
| III | 87.84 | 5.47 | 82.37 | 16.36 | 5.17 | 9.28 | 51.56 |

Analysis of the results of the production experiment (Table 2) showed no significant differences in the size and weight of litter or rate of animal growth. The postslaughter analysis of carcasses showed that the dietary factor had a highly significant effect on carcass fat content (group III vs. groups I and II). There was a tendency towards better muscling in animals from group II.

Table 2

Rearing performance and results of carcass quality evaluation (g, %)

| Trait | Group | | | |
|---|---|---|---|---|
| | I | II | III | SEM |
| Litter weight after birth (g) | 444.5 | 478.0 | 422.1 | 32.551 |
| Litter size after birth (head) | 7.0 | 7.1 | 6.7 | 2.112 |
| Litter weight at 21 days of age (g) | 2110.0 | 2028.0 | 1977.0 | 27.345 |
| Litter size at 21 days of age (head) | 6.5 | 6.4 | 6.3 | 1.003 |
| Litter weight at 35 days of age (g) | 4961.2 | 4771.2.0 | 4791.5.0 | 43.211 |
| Litter size at 35 days of age (head) | 6.2 | 6.0 | 6.13 | 1.200 |
| Daily gain at 35-90 days of age (g) | 31.6 | 32.4 | 3.2 | 0.902 |
| Preslaughter weight (g) | 2475.00 | 2415.00 | 2385.83 | 32.002 |
| Hot carcass weight with head (g) | 1375.00 | 1416.66 | 1332.50 | 38.002 |
| Cold carcass weight without head (g) | 1178.33 | 1245.83 | 1141.67 | 36.236 |
| Weight of muscles in carcass (g) | 890.00*a* | 954.16*b* | 878.33*a* | 32.634 |
| Proportion of muscles in carcass (%) | 75.62 | 76.60 | 76.66 | 0.512 |
| Weight of bones in carcass (g) | 230.83 | 226.67 | 233.33 | 5.464 |
| Proportion of bones in carcass (%) | 19.55 | 18.21 | 20.67 | 0.662 |
| Weight of fat in carcass (g) | 57.50*A* | 65.00*A* | 30.00*B* | 4.103 |
| Proportion of fat in carcass (%) | 4.83 | 5.19 | 2.67 | 0.276 |
| Dressing percentage (%)* | 55.55 | 58.66 | 55.85 | 2.668 |

* dressing percentage was calculated as the ratio of hot carcass weight (with head) to preslaughter animal weight after 24-h feed withdrawal

The blood serum of rabbits of all the groups (Table 3) showed no deviations from the standards given for this species of animals in the reference values of basic laboratory tests in veterinary sciences (WINNICKA 1997).

Table 3

Selected biochemical parameters of blood serum and rear leg muscle

| Item | Group | | | SEM |
|---|---|---|---|---|
| | I | II | III | |
| Blood serum: | | | | |
| Total cholesterol (mg/dl) | 48.44 | 45.44 | 51.27 | 1.200 |
| HDL (mg/dl) | 28.42 | 28.02 | 27.08 | 0.960 |
| Triglycerides (mg/dl) | 94.48 | 104.86 | 89.78 | 1.430 |
| Glucose (mg/dl) | 110.98 | 102.14 | 123.50 | 3.960 |
| Rear muscle of leg: | | | | |
| Total cholesterol (mg 100 $g^{-1}$) | 69.15*a* | 60.55*b* | 60.86*b* | 1.420 |
| Vitamin E (mcg $g^{-1}$) | 1.81*A* | 2.12 | 3.18*B* | 0.233 |
| TBA after 14 days of storage (mg $kg^{-1}$) | 0.426 | 0.350 | 0.346 | 0.014 |
| TBA after 90 days of storage (mg $kg^{-1}$) | 0.535 | 0.512 | 0.487 | 0.011 |

*a*, *b* – means with different letters differ significantly at $P<0.05$, *A*, *B* – at $P<0.01$

A highly significant increase in the vitamin E content of rabbit leg muscles was observed in group III. The dietary vitamin E supplement (100 mg $kg^{-1}$ diet) protected leg muscle lipids from the oxidation processes during 3-month storage. The total cholesterol content in groups II and III was significantly ($P<0.05$) lower than in the control group.

The addition of 4% linseed oil supplement caused a highly significant increase in *n-3* PUFA (Table 4). The highest differences concerned linolenic acid (C18-3). The *n-6* to *n-3* PUFA ratio was observed to decrease from 10.08:1 in the control group to 3.89:1 and 2.08:1 in the meat lipids of rabbits from groups II and III, respectively, and this process was enhanced by the antioxidant supplement.

Table 4

Results of determinations of the profile of higher fatty acids in the muscle tissue of rear leg (% of total acids)

| Item | Group | | | SEM |
|---|---|---|---|---|
| | I | II | III | |
| 1 | 2 | 3 | 4 | 5 |
| C14 | 2.830*a* | 1.576*b* | 1.546*b* | 0.335 |
| C16 | 30.131*A* | 15.061*B* | 15.102*B* | 0.650 |
| C18 | 6.427 | 4.737 | 5.084 | 1.200 |
| C18:1 | 26.821*A* | 20.572 | 18.209*B* | 1.066 |
| C18:2 | 23.826*A* | 42.766*B* | 36.904*B* | 1.191 |
| C18:3 | 2.404*A* | 11.033*B* | 18.695*B* | 1.200 |

cont. Table 4

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| EPA | 0.071 | 0.123 | 0.240 | 0.199 |
| DHA | 0.087 | 0.181 | 0.288 | 0.769 |
| SFA | 39.496*A* | 21.965*B* | 22.152*B* | 1.066 |
| UFA | 60.503*A* | 78.035*B* | 77.848*B* | 0.786 |
| MUFA | 31.947*a* | 22.088*b* | 20.228*b* | 0.598 |
| PUFA | 28.555*A* | 55.947*B* | 57.620*B* | 1.177 |
| PUFA-6 | 25.857*A* | 44.107*B* | 38.048*B* | 1.346 |
| PUFA-3 | 2.563*A* | 11.338*Ba* | 18.222*Bb* | 1.020 |
| DFA | 66.930*A* | 82.773*B* | 82.932*B* | 0.785 |
| OFA | 33.069*A* | 17.227*B* | 17.067*B* | 0.995 |
| UFA/SFA | 1.544*A* | 3.572*B* | 3.537*B* | 0.148 |
| DFA/OFA | 2.046*A* | 4.842*B* | 4.911*B* | 0.238 |
| MUFA/SFA | 0.812*A* | 1.010*B* | 0.913 | 0.332 |
| PUFA/SFA | 0.732*A* | 2.562*B* | 2.624*B* | 0.236 |
| PUFA (*n*-6)/(*n*-3) | 10.088*A* | 3.89*B* | 2.08B | 1.342 |

*a*, *b* – means with different letters differ significantly at $P<0.05$, *A*, *B* – at $P<0.01$

## Conclusions

It is concluded that the dietary linseed oil supplement had a beneficial effect on the composition of the rabbit meat lipid fraction. In the lipids of rabbit leg muscles there was a significant increase in the level of PUFA, especially *n-3* PUFA, thanks to which the ratio of *n-6* to *n-3* PUFA decreased. Adding antioxidant (vitamin E) to the feed prevented lipid oxidation in the stored meat. The dietary factor used had no effect on rearing performance of the rabbits.

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# ACTIVITY OF $\Delta^9$-DESATURASE IN INTRAMUSCULAR FAT OF LAMBS ACCORDING TO SLAUGHTER STANDARD

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K e y  w o r d s: lamb meat, fatty acids, activity of $\Delta^9$-desaturase.

A b s t r a c t

The aim of the study was to determine the activity of the enzyme $\Delta^9$-desaturase in the meat of lambs representing extreme age and weight standards: light (70 days of age, 19 kg body weight) and heavy (35–40 kg). The fatty acid composition of intramuscular fat was analysed in 42 lambs. The age and weight standard resulted in significant differences in the level of some fatty acid substrates (C14:0, C17:0 and C18:1T) and all acids produced by $\Delta^9$-desaturase (C14:1, C15:1, C16:1, C17:1, C18:1 and CLA). Greater activity of $\Delta^9$-desaturase was found in the intramuscular fat of lambs fattened to high weight standards: a higher C16:1/C16:0 and C18:1/C18:0 ratio, a lower C15:1/C15:0 ratio, and a higher index of $\Delta^9$-desaturase activity (0.541 and 0.487, respectively).

## AKTYWNOŚĆ $\Delta^9$-DESATURAZY W TŁUSZCZU ŚRÓDMIĘŚNIOWYM JAGNIĄT W ZALEŻNOŚCI OD STANDARDU RZEŹNEGO

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S ł o w a  k l u c z o w e: mięso jagnięce, kwasy tłuszczowe, aktywność $\Delta^9$-desaturazy.

A b s t r a k t

Celem badań było określenie aktywności enzymu $\Delta^9$-desaturaza w mięsie jagniąt ze skrajnych standardów wiekowo-wagowych – lekkich (wiek 70 dni, masa ciała 19 kg) i ciężkich (35–40 kg). Badano skład kwasów tłuszczowych tłuszczu śródmięśniowego 42 jagniąt. Standard wiekowo-wagowy zwierząt różnicował istotnie zawartość części kwasów tłuszczowych substratów (C14:0, C17:0 i C18:1T) oraz wszystkich kwasów produktów $\Delta^9$-desaturazy: C14:1, C15:1, C16:1, C17:1, C18:1 i SKL. Większą aktywność $\Delta^9$-desaturazy stwierdzono w tłuszczu śródmięśniowym jagniąt tuczonych do wysokich standardów wagowych; wyższy stosunek C16:1/C16:0 i C18:1/C18:0, a niższy C15:1/C15:0 i w sumie wyższy indeks aktywności $\Delta^9$-desaturazy (odpowiednio 0,541 oraz 0,487).

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## Introduction

One of the characteristics of animal food product (meat and milk) health quality is the level of unsaturated fatty acids (UFA). The enzyme $\Delta^9$-desaturase has been shown to play a significant role in the endogenous synthesis of UFA, including CLA (Dobrzyń 2006, Jelińska 2005, Malinowska 1999, Smith et al. 2002). This enzyme catalyzes the incorporation of a double bond at position cis between carbon atoms 9 and 10 in saturated fatty acids with chain lengths of 10–18 carbon atoms.

The aim of the study was to determine the activity of the enzyme $\Delta^9$-desaturase in the meat of slaughter lambs representing extreme age and weight standards.

## Material and Methods

The study was carried out in two replications (I in 2001 and II in 2002) using intramuscular fat of 42 ram-lambs, the three-breed crosses of Merino sheep with the prolific (Finn, Romanov, Booroola) and East Friesian dairy breeds. Fat from light-type lambs (L) slaughtered directly after weaning (70 days of age and 19 kg body weight on average) was compared with fat from lambs fattened semi-intensively to 35–40 kg body weight (H). Intramuscular fat was extracted using the Soxhlet method from the *m. semitendinosus*. Fat

Table 1

Fatty acids content in lamb's intramuscular fat; g 100 g$^{-1}$

| Fatty acid | Weight standard | | Repetition | | SEM |
|---|---|---|---|---|---|
| | L | H | I | II | |
| No of lambs | 22 | 20 | 20 | 22 | |
| C 14:0** | 4.15*A* | 2.37*A* | 3.23 | 3.37 | 0.180 |
| C 14:1 | 0.25*A* | 0.16*A* | 0.22 | 0.19 | 0.012 |
| C 15:0** | 0.47 | 0.51 | 0.38*A* | 0.59*A* | 0.035 |
| C 15:1 | 0.19*A* | 0.12*A* | 0.16 | 0.16 | 0.008 |
| C 16:0 | 21.06 | 21.32 | 21.75*a* | 20.67*a* | 0.245 |
| C 16:1 | 2.29*A* | 2.58*A* | 2.26*A* | 2.58*A* | 0.055 |
| C 17:0 | 1.47*A* | 1.81*A* | 1.71*a* | 1.55*a* | 0.040 |
| C 17:1 | 1.15*A* | 1.47*A* | 0.77*A* | 1.79*A* | 0.090 |
| C 18:0 | 12.79 | 12.76 | 13.27*a* | 12.33*a* | 0.193 |
| C 18:1** | 32.15*A* | 39.60*A* | 37.15*A* | 34.38*A* | 0.761 |
| C 18:1T** | 2.50 | 2.03 | 1.79*A* | 2.72*A* | 0.158 |
| CLA** | 0.37 | 0.32 | 0.31*a* | 0.39*a* | 0.019 |
| SFA | 40.77*a* | 39.16*a* | 40.93*a* | 39.16*a* | 0.404 |
| MUFA | 38.73*A* | 46.10*A* | 42.49 | 42.01 | 0.714 |

L – light (19 kg); H – heavy (35–40 kg)
SFA (saturated fatty acids): Σ C10:0; C12:0; C14:0; C15:0; C16:0; C17:0; C18:0; C20:0
MUFA (monounsaturated fatty acids): Σ C14:1; C15:1; C16:1; C17:1; C18:1; C20:1
SEM – standard error mean, *AA* – $P \leq 0.01$; *aa* – $P \leq 0.05$
Interaction weight standard x repetition: ** $P \leq 0.01$; * $P \leq 0.05$

extraction was performed according to standard procedures given by FOLCH et al. (1957). The composition of fatty acids was determined using the procedures reported by KRAMER et al. (1997) with modifications used at the Meat and Fat Research Institute in Warsaw (BORYS et al. 1999). A Hewlett Packard model 6890 gas chromatograph with a flame-ionization detector and an Rtx-2330 column (105 m x 0.25 mm x 20 μm) were used.

The activity of $\Delta^9$-desaturase was measured by the ratio of fatty acids that are substrates and products of this enzyme (from C10:1/C10:0 to C18:1/C18:0 and CLA/C18:1T). The desaturase index (DI), estimated using the MUFA SFA + MUFA ratio, was also calculated (CORL et al. 2001). The fatty acids analysed are given in notes to Table 1.

## Results and Discussion

The age and weight standard of lambs differentiated the level of some fatty acid substrates (C14:0 and C18:1T) to a significantly greater extent in L than in H lambs by 75.1 and 23.2%, with a reverse pattern for C17:0, by 23.1% (Table 1). The intramuscular fat of L and H lambs differed in the level of all fatty acids being the products of $\Delta^9$-desaturase. The fat of L lambs contained significantly more C14:1 and C15:1 (by 56.2 and 58.3%, respectively), and less C16:1, C17:1 and C18:1 (by 11.2, 21.8 and 18.8%, respectively). The fat of L lambs contained 15.6% more CLA compared to the fat of H lambs (NS). Overall, the weight standard of lambs resulted in significant differences in both SFA and MUFA content of intramuscular fat. The differences between L and H lambs were + 4.1% ($P \leq 0.05$) and 16.0% ($P \leq 0.01$), respectively.

A higher activity of $\Delta^9$-desaturase was found in the intramuscular fat of H lambs fattened to high weight standards (Table 2). Compared to L lambs, H lambs had higher C16:1/C16:0 and C18:1/C18:0 ratios (by 11.9 and 28.7%, $P \leq 0.01$) and showed a non-significant tendency towards higher C14:1/C14:0 and CLA/C18:1T (NS), with a significantly lower C15:1/C15:0 ratio (by 61.9%;

Table 2

The parameters of the $\Delta^9$-desaturase activity

| Fatty acid | Weight standard | | Repetition | | SEM |
|---|---|---|---|---|---|
| | L | H | I | II | |
| C14:1/C14:0 | 0.060 | 0.068 | 0.071*a* | 0.058*a* | 0.003 |
| C15:1/C15:0** | 0.654*A* | 0.249*A* | 0.664*A* | 0.276*A* | 0.061 |
| C16:1/C16:0 | 0.109*A* | 0.122*A* | 0.104*A* | 0.125*A* | 0.003 |
| C17:1/C17:0* | 0.828 | 0.825 | 0.442*A* | 1.177*A* | 0.065 |
| C18:1/C18:0 | 2.530*A* | 3.144*A* | 2.835 | 2.811 | 0.079 |
| CLA/C18:1T | 0.164 | 0.171 | 0.177 | 0.158 | 0.008 |
| DI** | 0.487*A* | 0.541*A* | 0.509*a* | 0.516*a* | 0.005 |

The explanation of shortcuts and statistical significances as to Table 1.
DI – index of the $\Delta^9$-desaturase activity (DI = MUFA/SFA + MUFA).

$P \leq 0.01$). Overall, the intramuscular fat of H lambs showed a significantly higher (by 11.1%) $\Delta^9$-desaturase index than in L lambs ($P \leq 0.01$).

The replication significantly although not very characteristically differentiated the level of most fatty acids analysed (Table 1). For the ratio of acid products to substrates, not very characteristic differences were found between the replications. Significantly higher C14:1/C14:0 and C15:1/C15:0 ratios were found in replication I than in replication II, with a reverse trend for C16:1/C16:0 and C17:1/C17:0 ratios. Overall, the values of the $\Delta^9$-desaturase index were similar (1.4% greater in fattening replication II than in replication I; $P \leq 0.05$).

The differences found in $\Delta^9$-desaturase activity in meat according to the age and weight standard of the lambs are confirmed by Sikora et al. (2007) for the meat of kids according to age at slaughter, and by Impemba et al. (2005) for goat's milk according to feeding system and stage of lactation.

## Conclusion

The analysed ratios of fatty acids and the derived DI index, which characterize $\Delta^9$-desaturase activity in the meat of lambs show that it was significantly higher in heavier than in lighter slaughter lambs, with not very characteristic differences according to replication.

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# MOLECULAR INSIGHT IN THE PH-DEPENDENT RADICAL-SCAVENGING ACTIVITY OF BETANIDIN

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Key words: betalains, betanin, betanidin, radical scavenging activity, TEAC value, DFT calculations.

Abstract

In the present study, the pH-dependent radical-scavenging activity of betanidin in the TEAC (Trolox equivalent antioxidant capacity) assay was determined and compared to that of betanin (betanidin 5-*O*-*β*-glucoside). It was observed that at pH range 2–4 betanidin is more active than betanin. The observed higher antiradical activity of betanidin at acid pH, in comparison with betanin, is discussed in terms of their calculated phenolic OH homolytic bond dissociation energies (BDE) and ionization potentials (IP). The theoretical results obtained reveal that a relatively high antiradical activity of cationic and mono-deprotonated forms of betanidin, which are present at acid pH, can be related to the presence of catechol moiety in betanidin molecule.

## WPŁYW PH NA AKTYWNOŚĆ PRZECIWRODNIKOWĄ BETANIDYNY – BADANIA DOŚWIADCZALNE I TEORETYCZNE

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Słowa kluczowe: betalainy, betanina, betanidyna, aktywność przeciwrodnikowa, wartość TEAC, metoda funkcjonałów gęstości (DFT).

Abstrakt

W teście TEAC (trolox equivalent antioxidant capacity) zmierzono aktywność przeciwrodnikową betanidyny w zależności od pH środowiska i porównano ją z aktywnością betaniny (5-*O*-*β*-glucozyd betanidyny). Stwierdzono, że w pH o wartości od 2 do 4 betanidyna wykazuje wyższą aktywność przeciwrodnikową niż betanina. Zaobserwowane różnice były analizowane w odniesieniu do obliczonych dla cząsteczek tych związków wartości energii dysocjacji grupy OH (BDE) i potencjałów jonizacji (IP). Uzyskane wyniki obliczeń teoretycznych wskazują, że względnie wysoka aktywność przeciwrodnikowa kationowej i monodeprotonowanej formy betanidyny, obserwowana już w kwaśnym pH, może wynikać z obecności ugrupowania katecholowego w cząsteczce betanidyny.

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## Introduction

Betalains are natural water soluble colorants present in e.g. red beet (*Beta vulgaris*) and prickly pear (*Opuntia ficus indica*). Two main groups of red beet betalains are the red-violet betacyanins (e.g. betanin and isobetanin) and the yellow betaxanthins. The most important betacyanin in red beet is betanin (75–95% of the total coloring matter found in the beet), which is a betanidin 5-*O*-$\beta$-glucoside (Figure 1). It is used, as food additive E162, in a variety of processed foods, especially in ice creams and frozen desserts because it colours without changing the flavour profile. Recently, it was reported that radical-scavenging activity of betanin, measured in the TEAC (trolox equivalent antioxidant capacity) assay, is pH-dependent and exceptionally high at pH higher than 4 (Gliszczyńska-Świgło et al. 2006). The increase in the radical-scavenging activity of betanin was attributed to the increasing of its H-donation and electron-donation ability when going from cationic to mono-, di- and tri-deprotonated states with increasing pH values (Gliszczyńska-Świgło et al. 2006).

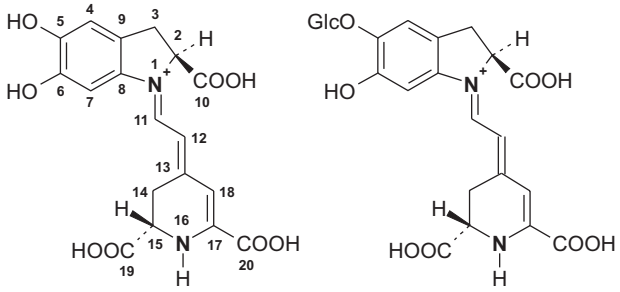


Fig. 1. Chemical structures and atom numbering system of betanidin and betanidin 5-*O*-$\beta$-glucoside (betanin)

One of the betanin decomposition products is betanidin (Figure 1). Degradation of betanin to betanidin is catalyzed by e.g. a $\beta$-glucosidase (Zakharova, Petrova 2000). In the present study, the pH-dependent radical-scavenging activity of betanidin in the TEAC assay was determined and compared to the pH-dependent TEAC profile of betanin. The difference between the TEAC profiles of betanidin and betanin, especially at acid pH, is discussed in terms of their calculated phenolic OH homolytic bond dissociation energies (BDE), representing H-atom donation, and ionization potentials (IP), representing electron donation.

## Materials and Methods

### Chemicals

2,2′-Azinobis(3-ethylbenzothiazoline-6-sulphonic acid) diammonium salt (ABTS), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), microperoxidase-8 (MP-8) and $\alpha$-amylase from *Aspergillus oryzae* (crude) were purchased from Sigma-Aldrich (Steinheim, Germany). Hydrogen peroxide (30%) was purchased from Merck (Darmstadt, Germany).

### Preparation of betanin and betanidin

Juice from beetroot was obtained as described previously (Gliszczyńska-Świgło et al. 2006). Betacyanins and betaxanthins were separated by gel filtration on a Sephadex G-25 column (40 x 2.2 cm) according to the method of Kanner et al. (2001) as described previously (Gliszczyńska-Świgło et al. 2006). Betanidin was obtained from isolated betanin (final concentration 0.2 mM) by enzyme hydrolysis with $\alpha$-amylase (final concentration 0.1 mg $cm^{-1}$). Hydrolysis was carried out in 50 mM phosphate buffer pH 3.5 for 6 hours at 25°C. HPLC purity of betanidin measured at 270 and 536 nm was about 97%.

### TEAC assay

The TEAC assay is based on the ability of the antioxidant to scavenge the blue-green colored $ABTS^+$ radical cation relative to the $ABTS^+$ scavenging ability of the water-soluble vitamin E analogue, Trolox (Rice-Evans et al. 1996). The radical-scavenging activity of betanidin was measured by the modified TEAC assay performed essentially as described previously (Rice-Evans et al. 1996) with some modifications concerning usage of microperoxidase-8 (MP-8) instead of metmyoglobin to generate the $ABTS^+$ radical cation (Tyrakowska et al. 1999). The major advantage of the modified TEAC assay is that it permits studies of radical scavenging activity over a wide pH range (2–9). The generation of $ABTS^+$ radical cation and preparation of its solutions of different pH was described previously (Gliszczyńska-Świgło et al. 2006).

### Quantum mechanical calculations

In the first step, geometry optimization of molecule studied was performed using B3LYP functional with 6-31G** basis set. In order to obtain some thermochemical parameters, such as deprotonation energy (DE), phenolic OH bond dissociation energy (BDE) and ionization potential (IP)

values, the betanidin was studied in various protonation/deprotonation states as well as in one-electron oxidized state. All thermochemical data given in this work were computed in the next, "single-point" step with more extended 6-311+G(d,p) basis set using optimized structures. Due to the limited computing capacity, solvation effects were not considered and all calculations were performed in so-called "gas-phase". More details on calculation procedure can be found in our previous paper (Borkowski et al. 2005). All calculations were performed using Gaussian 98 computational package (Gaussian Inc., Pittsburg, PA, USA).

## Results and Discussion

Degradation of betanin by e.g. a $\beta$-glucosidase leads to the betanidin molecule (Zakharova, Petrova 2000) therefore it was interesting to compare the radical-scavenging activity of betanin and its aglycone. In the present study, the pH-dependent radical-scavenging activity of betanidin in the TEAC assay was determined and compared with the pH-dependent TEAC profile of betanin (Gliszczyńska-Świgło et al. 2006) – Figure 2. For both compounds, radical-scavenging activity is increasing with an increase of pH value. These results are in agreement with the results of Escribaño et al. (1998) who found that the radical-scavenging activity of betanin at basic pH is much higher than that at acid pH. From Figure 2 it also follows that radical-scavenging activity of betanidin in the pH range 2–4 is about 5.4 to 1.4-fold higher than the radical-scavenging activity of betanin. Similar difference between the TEAC values of glucoside and aglycone at acid pH was observed for other natural colorants anthocyanins e.g. cyanidin and cyanidin 3-*O*-$\beta$-glucoside, which at pH 1–3 exist mainly as flavylium cation (Borkowski et al. 2005).

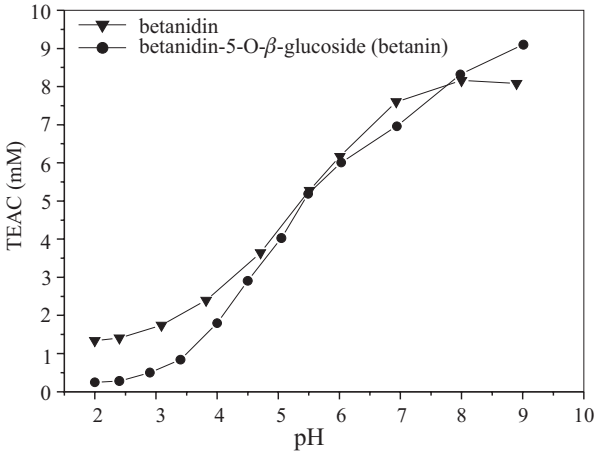


Fig. 2. Comparison of pH-dependent radical-scavenging activity of betanin and betanidin observed in the TEAC assay

Relatively high antiradical activity of betanidin in acid environment and its increase with pH value may be of biological relevance taking into account that the pH range of different human body fluids is known to vary widely from pH 1 in the stomach, pH 5.3 in the small intestine, pH 6.8 in mouth saliva, pH 7.4 in blood and tissue fluid, pH 8 in the large intestine to pH 7–8.7 in the pancreas and pH 8.3–9.3 in the duodenum (GRZYMISŁAWSKI 2000). In a strongly acid environment, the betanin and betanidin molecules may exist in a cationic form with an excessive positive charge localized in the proximity of N-1 atom. Because betanidin contains three carboxyl groups and potentially ionizable H-N16, C5-OH and C6-OH protons, in mild acidic solution it can appear in the form of various deprotonated states. In the case of betanin it was suggested that at pH<2 mainly a cationic form appears, at pH = 2 zwitterion form appears, at 2<pH<3.5 a monoanion with deprotonated C2-COOH and C15-COOH groups appears, at 3.5<pH<7 a dianion with deprotonated C2-COOH, C15-COOH and C17-COOH groups appears, and at 7<pH<9.5 a trianion with deprotonated all carboxyl groups and additionally phenolic C6-OH group appears (FRANK et al. 2005). The pKa value for betanin related to its phenolic OH group was measured to be 8.5 (NILSSON 1970). The pKa of two carboxyl groups was suggested to be approximately 3.4. The third carboxyl group in the C2 position was suggested to have a lower pKa, as the isoelectric point of betanin was found in the pH range 1.5–2.0 (NILSSON 1970). As far as we know no such estimations were published for aglycone of betanin. The presence of two OH groups in betanidin molecule, C5-OH and C6-OH, forming the catechol moiety, may significantly influence its acid/basic equilibria. To establish the order of the most easy deprotonating groups, the gas-phase deprotonation energies (DE) were calculated. In Table 1 and 2, theoretically calculated relative stabilities ($\Delta$DE) of various deprotonated forms of betanidin and betanin are presented. It is striking that phenolic C5-OH and C6-OH groups in betanidin are predicted to be more acidic than all carboxyl groups. This can be explained by the fact that C5-OH group is placed in para-position to positively charged, strongly electron withdrawing, heterocyclic N1 atom. It is of importance to stress that the gas-phase calculations do not take into account solvation effects therefore they only approximate a very complex phenomena having place in the real solutions.

In our previous paper (GLISZCZYŃSKA-ŚWIGŁO et al. 2006) we have suggested that the exceptionally high antioxidant activity of betanin is associated with an increasing of its H-donation and/or electron-donation ability when going from cationic state to mono-, di- and tri-deprotonated states present at different pH of environment. Since the marked difference in antiradical activity of betanin and betanidin was observed in the range of pH values 2–4, further comparison between these compounds are focused on the region of acid pH where we can expect mainly the cationic, mono-deprotonated and di-deprotonated states of both compounds. Tri-deprotonated forms that may be expected at neutral and basic pH values are not shown and discussed. Table 1

Table 1

Thermochemical parameters calculated for betanidin in cationic, mono- and di-deprotonated states: relative stability (ΔDE, kcal $mol^{-1}$) in relation to the most stable structure assumed as "0.0" (shown in a decreasing order, in kcal $mol^{-1}$), and corresponding bond dissociation energy (BDE, kcal $mol^{-1}$) and ionization potential (IP, kcal $mol^{-1}$) values

| Pattern of betanidin deprotonation | Relative stability ΔDE | BDE | IP |
|---|---|---|---|
| Cation | | 82.6 (C5-OH)<br>84.4 (C6-OH) | 227.9 |
| Mono-deprotonated (neutral) forms | | | |
| N16$^-$ | "0.0" | 74.7 (C5-OH)<br>77.4 (C6-OH) | 159.3 |
| C5-O$^-$ | 4.1 | 79.5 (C6-OH) | 137.9 |
| C6-O$^-$ | 9.2 | 74.4 (C5-OH) | 134.7 |
| C17-COO$^-$ | 10.4 | 75.3 (C5-OH)<br>77.9 (C6-OH) | – |
| C2-COO$^-$ | 11.2 | 77.8 (C5-OH)<br>79.4 (C6-OH) | 167.1 |
| C15-COO$^-$ | 13.0 | 76.2 (C5-OH)<br>79.2 (C6-OH) | – |
| Di-deprotonated forms (monoanions) | | | |
| N16$^-$, C5-O$^-$ | "0.0" | 79.7 (C6-OH) | 68.7 |
| N16$^-$, C6-O$^-$ | 1.5 | 78.2 (C5-OH) | 69.9 |
| C2-COO$^-$, N16$^-$ | 4.1 | 67.8 (C5-OH)<br>71.1 (C6-OH) | – |
| C2-COO$^-$, C5-O$^-$ | 5.0 | 77.0 (C6-OH) | 77.9 |
| C17-COO$^-$, C5-O$^-$ | 5.2 | 80.0 (C6-OH) | 74.5 |
| C17-COO$^-$, C6-O$^-$ | 6.7 | 78.5 (C5-OH) | 75.4 |
| C15-COO$^-$, C5-O$^-$ | 7.0 | 79.9 (C6-OH) | 76.3 |
| C2-COO$^-$, C6-O$^-$ | 9.6 | 72.5 (C5-OH) | 75.0 |
| C2-COO$^-$, C15-COO$^-$ | 9.9 | 71.2 (C5-OH)<br>74.5 (C6-OH) | – |
| C15-COO$^-$, C6-O$^-$ | 10.1 | 76.8 (C5-OH) | 76.1 |
| C2-COO$^-$, C17-COO$^-$ | 11.4 | 68.8 (C5-OH)<br>71.5 (C6-OH) | – |
| C15-COO$^-$, C17-COO$^-$ | 11.6 | 70.5 (C5-OH)<br>74.5 (C6-OH) | – |
| C15-COO$^-$, N16$^-$ | 15.9 | 67.7 (C5-OH)<br>72.6 (C6-OH) | – |
| C17-COO$^-$, N16$^-$ | 16.7 | 66.6 (C5-OH)<br>70.6 (C6-OH) | – |

Forms with the calculated relative energies higher than 20 kcal $mol^{-1}$, in relation to the most stable structure, were not considered

Table 2

Thermochemical parameters calculated for betanin in cationic, mono- and di-deprotonated states: relative stability (ΔDE, kcal $mol^{-1}$) in relation to the most stable structure assumed as "0.0" (in a decreasing order, in kcal $mol^{-1}$) and corresponding bond dissociation energy (BDE, kcal $mol^{-1}$) and ionization potential (IP, kcal $mol^{-1}$) values

| Pattern of betanidin deprotonation | Relative stability ΔDE | BDE | IP |
|---|---|---|---|
| Cation | | 97.9 (C6-OH) | 219.3 |
| Mono-deprotonated (neutral) forms | | | |
| $16N^-$ | "0.0" | 88.4 (C6-OH) | 158.3 |
| $C17\text{-}COO^-$ | 10.1 | 89.2 (C6-OH) | – |
| $C15\text{-}COO^-$ | 13.6 | 89.8 (C6-OH) | – |
| $C2\text{-}COO^-$ | 14.1 | 87.6 (C6-OH) | – |
| $C6\text{-}O^-$ | 15.4 | – | 141.1 |
| Di-deprotonated forms (monoanions) | | | |
| $16N^-$, $C6\text{-}O^-$ | "0.0" | – | 83.9 |
| $C17\text{-}COO^-$, $C6O^-$ | 5.7 | – | 89.1 |
| $C2\text{-}COO^-$, $16N^-$ | 7.6 | 76.2 (C6-OH) | – |
| $C15\text{-}COO^-$, $C6O^-$ | 10.5 | – | 88.3 |
| $C2\text{-}COO^-$, $C17\text{-}COO^-$ | 11.8 | 78.2 (C6-OH) | – |
| $C2\text{-}COO^-$, $C6\text{-}O^-$ | 13.2 | – | 83.9 |
| $C15\text{-}COO^-$, $C17\text{-}COO^-$ | 14.9 | 79.6 (C6-OH) | – |
| $C2\text{-}COO^-$, $C15\text{-}COO^-$ | 16.2 | 79.3 (C6-OH) | – |
| $C15\text{-}COO^-$, $16N^-$ | 18.6 | 74.9 (C6-OH) | – |
| $C17\text{-}COO^-$, $16N^-$ | 18.8 | 75.3 (C6-OH) | – |

and 2 show the calculated thermochemical data starting from cationic forms of betanidin and betanin through the various mono- and di-deprotonated states. The observed much higher antiradical activity of betanidin at acid pH is reflected in calculated BDE values, for both cationic and mono--deprotonated forms. For example, the BDE value for C6-OH group in betanin cation was calculated to be about 98 kcal $mol^{-1}$, while in betanidin molecule the corresponding BDE value drops to about 83 and 84 kcal $mol^{-1}$ for C5-OH and C6-OH, respectively. The values of ionization potentials (IP) calculated for cationic forms seem to be too high to consider electron donation as the mechanism of antiradical activity. Taking into account the most stable mono-deprotonated (neutral) form of both compounds (indicated as 0.0 in Table 1 and 2), it can be seen that the BDE values calculated for phenolic groups are again significantly lower for betanidin than for betanin: about 88 kcal $mol^{-1}$ for C6-OH in betanin and about 77 and 75 kcal $mol^{-1}$ for C6-OH and C5-OH, respectively, in betanidin molecule. Detailed analysis of BDE values calculated for less stable mono-deprotonated forms of betanin and betanidin leads to final conclusion that betanidin is much better H-atom

donor than its glucoside form – betanin. For betanin, the calculated BDE values for all mono-deprotonated forms are higher than 87 kcal $mol^{-1}$ and for betanidin the corresponding values are lower than 80 kcal $mol^{-1}$. For di--deprotonated forms, the differences between the calculated BDE values for betanin and betanidin tend to diminish what is observed experimentally as nearly the same antiradical activity at pH>4. In the more basic solution, the antiradical mechanism may change to electron donation mechanism. The results of theoretical calculations of ionization potentials (Table 1 and 2) show that in highly deprotonated states both molecules studied exhibit high electron donation capacity, what is in good agreement with experimental data shown in Figure 2.

Altogether, the results obtained lead to the conclusion that a relatively high antiradical activity of betanidin, at physiologically relevant acid pH, in which cationic and mono-deprotonated forms dominate, can be related to the presence of catechol moiety in betanidin molecule.

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# THE EFFECT OF THERMAL PROCESSING OF BARLEY GROATS WITH VARIED PROCESSING RATES ON DIETARY FIBER CONTENT

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K e y  w o r d s: barley groats, dietary fiber, ground rate, thermal processing.

A b s t r a c t

The content of dietary fiber and its fraction composition were determined in barley groats with varied ground rates, i.e. coarse (*C*), medium (*M*) and finely ground (*F*), not subjected to thermal processing and in fluffy groats cooked traditional style (*C-BT*, *M-BT* and *F-BT*) and groats boiled in perforated plastic bags (*C-BB*, *M-BB* and *F-BB*). It was shown that dietary fiber content depended on the ground rate of groats and the method of thermal processing. Analyzed groats showed a high variation in terms of their dietary fiber content and its fraction composition. Groats *C-BB* showed significantly lower contents of dietary fiber and its fractions in comparison to fluffy groats.

## WPŁYW OBRÓBKI TERMICZNEJ KASZY JĘCZMIENNEJ O RÓŻNYM STOPNIU PRZETWORZENIA NA ZAWARTOŚĆ BŁONNIKA POKARMOWEGO

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S ł o w a  k l u c z o w e: kasza jęczmienna, błonnik pokarmowy, stopień rozdrobnienia, obróbka termiczna.

A b s t r a k t

Oznaczono zawartość błonnika pokarmowego oraz jego skład frakcyjny w kaszach jęczmiennych o różnym stopniu rozdrobnienia, tj. grubej (*C*), średniej (*M*) i drobnej (*F*) nie poddanych obróbce cieplnej oraz w kaszach gotowanych na sypko metodą tradycyjną (*C-BT*, *M-BT* i *F-BT*) i w woreczkach perforowanych (*C-BB*, *M-BB* i *F-BB*). Wykazano, że zawartość błonnika pokarmowego zależała od stopnia rozdrobnienia kasz oraz sposobu

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obróbki cieplnej. Badane kasze charakteryzowały się dużym zróżnicowaniem pod względem zawartości błonnika pokarmowego i jego składu frakcyjnego. Kasza *C-BB* cechowała się istotnie niższą zawartością błonnika pokarmowego oraz jego frakcji w porównaniu z kaszą gotowaną na sypko.

## Introduction

In Poland rich sources of dietary fiber are groats, produced mainly from barley, oat, buckwheat and wheat. In cereal products the content of dietary fiber varies considerably and depends on the share of individual parts of kernels, as well as the comminution rate and the applied thermal processing method. During grain processing to produce groats the fruit and seed coats, germs and – depending on the processing rate – also a part of the aleurone layer are removed. Groats packaged into portion plastic bags are very popular among consumers due to their convenience. Barley groats are widely used in the Polish diet. Barley, due to the advantageous chemical composition of its grain, is considered to be a cereal raw material preventing health problems and as such should be incorporated in the daily diet (Gąsiorowski 1997, Kahlon, Chow 1997, Kalra, Jood 2000, Wołoch, Pisulewski 2002, Kawka 2004).

The aim of the study was to determine the effect of the applied thermal processing method used for barley groats (cooking fluffy groats traditional style and boiling in perforated plastic bags) and the comminution rate of groats (coarse, medium and finely ground groats) on the content and fraction composition of dietary fiber.

## Material and Methods

Experimental material consisted of groats with different ground rates, i.e. coarse (*C*), medium (*M*) and finely (*F*) ground groats from a grain milling plant in Oborniki Wielkopolskie. Groats were boiled in water, at a product: water ratio of 1:2.0 (v/v), cooking time of 35 min, while groats in perforated plastic bags was boiled for 20 min, in the amount of water covering the groats. After cooking groats were lyophilized and next comminuted in a Cyclotec grinder by Tecator.

The contents of neutral dietary fiber (NDF), acid detergent dietary fiber (ADF), lignin (LIG) and cellulose (CEL) were determined using the detergent method according to Van Soest (Van Soest 1963, 1967). Thermostable symbol $\alpha$-amylase was used to digest starch (McQueen, Nicholson 1979). Contents of hemicelluloses (HEM) may be calculated as a difference between NDF and ADF. Contents of total dietary fiber (TDF), soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) were determined according to Asp (Asp et al. 1983). Assays were performed using a Fibertec apparatus by Tecator.

Results of the study were verified statistically using the analysis of variance with the Fisher test at significance level $p<0.05$ and expressed in g $100^{-1}$ g groats.

## Results and Discussion

Analyzed groats exhibited a varied dietary fiber content expressed in terms of NDF (Table 1). Among groats with a varied grinding rate not subjected to thermal processing a higher NDF content was found for groats *C* (8.55%) in comparison to groats *M* (7.26%) and *F* (7.06%). The dominant fractions in groats *C* and *M* were the hemicellulose and cellulose fractions,

Table 1

Content of dietary fiber (NDF) and its fraction composition in the barley groats (g $100^{-1}$ g of product)

| Size grain | NDF | ADF | Hemicelluloses | Lignin | Cellulose |
|---|---|---|---|---|---|
| *C* | 8.55±0.17$^{d}$ | 4.40±0.30$^{f}$ | 4.15±0.18$^{f}$ | 0.32±0.08$^{b}$ | 4.35±0.18$^{g}$ |
| *C-BT* | 4.57±0.14$^{b}$ | 0.43±0,04$^{b}$ | 4.14±0.15$^{f}$ | 0.17±0.03$^{a}$ | 0.27±0.01$^{b}$ |
| *C-BB* | 4.09±0.19$^{a}$ | 0.34±0.04$^{a}$ | 3.74±0.2$^{e}$ | 0.14±0.02$^{a}$ | 0.21±0.02$^{a}$ |
| *M* | 7.26±0.18$^{c}$ | 3.99±0,09$^{e}$ | 3.20±0.08$^{b,c}$ | 0.31±0.09$^{b}$ | 3.71±0.08$^{f}$ |
| *M-BT* | 4.69±0.17$^{b}$ | 0.58±0.18$^{b,c}$ | 4.10±0.2$^{f}$ | 0.15±0.02$^{a}$ | 0.44±0.06$^{c}$ |
| *M-BB* | 4.73±0.19$^{b}$ | 0.68±0.08$^{c}$ | 4.05±0.16$^{f}$ | 0.13±0.02$^{a}$ | 0.55±0.08$^{c,d}$ |
| *F* | 7.06±0.07$^{c}$ | 4.21±0.19$^{e,f}$ | 2.84±0.13$^{a}$ | 0.22±0.08$^{b}$ | 4.0±0.18$^{g}$ |
| *F-BT* | 4.22±0.18$^{a}$ | 0.90±0.08$^{d}$ | 3.31±0.07$^{c}$ | 0.12±0.02$^{a}$ | 0.78±0.08$^{e}$ |
| *F-BB* | 4.31±0.12$^{a}$ | 0.70±0.1$^{c}$ | 3.60±0.15$^{d,e}$ | 0.13±0.03$^{a}$ | 0.56±0.04$^{d}$ |

*C* – coarse ground groats; *C-BT* – coarse ground groats cooked the traditional method; *C-BB* – coarse ground groats cooked in perforated plastic bag; *M* – medium ground groats; *M-BT* – medium ground groats cooked the traditional method; *M-BB* – medium ground groats boiled in perforated plastic bag; *F* – finely ground groats; *F-BT* – finely ground groats cooked the traditional method; *F-BB* – finely ground groats cooked in perforated plastic bag; *NDF* – Neutral Detergent Fibre; *ADF* – Acid Detergent Fibre; *a*, *b*, *c*, *d*, *e*, *f*, *g* – values ($x$ ± SD) within a column with different letters differ significantly at $p<0.05$.

which in groats *C* amounted to 4.15% and 4.35%, respectively, while in groats *M* they accounted for 3.20% and 3.71%, respectively. In groats *F* the cellulose fraction was dominant (4.0%). Analyzed groats contained the lowest amounts of the lignin fraction, whereas groats *F* contained a lower amount of this fraction in comparison to groats *C* and *M*. The percentages of individual fractions in dietary fiber of raw groats are presented in Figure 1. The coarse barley groats showed a similar share of fractions HEM and CEL in dietary fiber, i.e. 48.5% and 50.9%, respectively, while in groats *M* and *F* fraction CEL predominated, accounting for 51.2% and 56.7%, respectively. The chemical characteristics of dietary fiber in cereals have been the subject

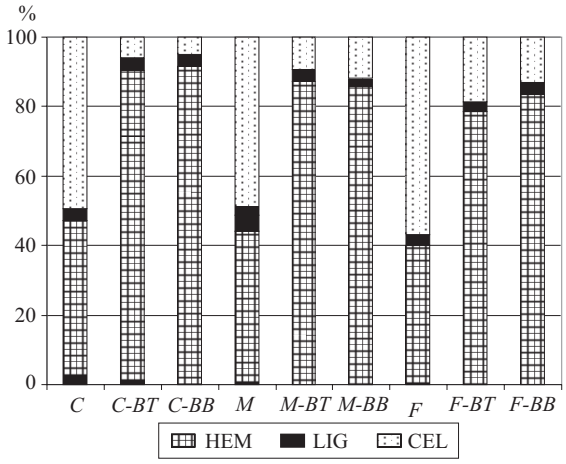


Fig. 1. Percentages of individual fractions in dietary fiber of barley groats with varied ground rates

HEM – hemicelluloses; LIG – lignin; CEL – cellulose; C – coarse ground groats; *C-BT* – coarse ground groats cooked the traditional method; *C-BB* – coarse ground groats cooked in perforated plastic bags; *M* – medium ground groats; *M-BT* – medium ground groats cooked the traditional method; *M-BB* – medium ground groats cooked in perforated plastic bags; *F* – finely ground groats; *F-BT* – finely ground groats cooked the traditional method; *F-BB* – finely ground groats cooked in perforated plastic bags

of numerous studies (Siljestrom et al. 1986, Åman, Graham 1987, Newman, Newman 1991, Kawka 2004). In the opinion of many authors the main components of dietary fiber in cereals are hemicelluloses, accounting for 65% total neutral dietary fiber (NDF), while cellulose amounted to less than 25%, while lignin had the smallest share in dietary fiber of analyzed cereals (Newman, Newman 1991, Kawka et al. 1999). A significant effect of the applied thermal processing method was found on contents of dietary fiber and its fractions (Table 1). In *C-BT* groats dietary fiber content was reduced by 46.5%, while in groats *C-BB* it was by 52.2%. No significant effect of the thermal processing method was found on contents of dietary fiber in finely and medium ground groats. These groats showed a lower NDF content, by approx. 35% and 39%, respectively. In coarse groats the level of fraction CEL decreased by approx. 94%, while in medium and finely ground groats by approx. 86% and 83%. At the same time an increase was found in the content of fraction HEM in groats *M-BT* and *M-BB* by 28% and 35%, respectively, while in groats F-BT and F-BB it was by 16.5% and 26.8%, respectively.

Contents of total dietary fiber (TDF), the soluble fraction (SDF) and the insoluble dietary fiber (IDF) are presented in Table 2. Groats not subjected to thermal processing showed varied TDF levels, ranging from 10.83 (*F*) to 13.21% (*C*). Insoluble dietary fiber (IDF) constituted the dominant fraction in all types of groats. In groats *C* the IDF fraction content was 8.65%, while

Table 2

Contents of total dietary fibre (TDF) and its fraction composition in groats (g $100^{-1}$ g of product)

| Size grain | TDF | IDF | SDF |
|---|---|---|---|
| *C* | $13.21\pm0.29^{g}$ | $8.65\pm0.20^{f}$ | $4.56\pm0.09^{f}$ |
| *C-BT* | $7.99\pm0.18^{d}$ | $5.19\pm0.17^{d}$ | $2.80\pm0.13^{c,d}$ |
| *C-BB* | $7.11\pm0.10^{b}$ | $4.31\pm0.10^{a,b}$ | $2.80\pm0.12^{c,d}$ |
| *M* | $11.78\pm0.25^{f}$ | $7.37\pm0.27^{e}$ | $4.41\pm0.28^{f}$ |
| *M-BT* | $7.46\pm0.24^{c}$ | $4.52\pm0.08^{c}$ | $2.94\pm0.16^{d}$ |
| *M-BB* | $7.38\pm0.22^{b,c}$ | $4.47\pm0.16^{b,c}$ | $2.91\pm0.10^{d}$ |
| *F* | $10.83\pm0.25^{e}$ | $7.09\pm0.25^{e}$ | $3.74\pm0.15^{e}$ |
| *F-BT* | $6.94\pm0.07^{a,b}$ | $4.22\pm0.07^{a}$ | $2.72\pm0.01^{b,c}$ |
| *F-BB* | $6.87\pm0.11^{a}$ | $4.23\pm0.09^{a,b}$ | $2.64\pm0.04^{a}$ |

*C* – coarse ground groats; *C-BT* – coarse ground groats cooked the traditional method; *C-BB* – coarse ground groats cooked in perforated plastic bag; *M* – medium ground groats; *M-BT* – medium ground groats cooked the traditional method; *M-BB* – medium ground groats boiled in perforated plastic bag; *F* – finely ground groats; *F-BT* – finely ground groats cooked the traditional method; *F-BB* – finely ground groats cooked in perforated plastic bag; *TDF* – Total Dietary Fibre; *SDF* – Soluble Dietary Fibre; *IDF* – Insoluble Dietary Fibre; *a*, *b*, *c*, *d*, *e*, *f* – values ($x$±SD) in a column with different letters are significantly different at $p \leq 0.05$

in groats *M* and *F*, it was 7.37% and 7.09%, respectively. According to Åman, Graham (1987) barley grain exhibits a rather considerable and diverse content of $\beta$-glucans, ranging from 3% to 11%. However, most frequently its level was between 4 and 7%.

Thermal processing significantly decreased contents of TDF, and SDF and IDF fractions. In case of coarse groats cooked the traditional style (*C-BT*) the TDF content decreased by 39.5%, while for coarse groats boiled in plastic bags (*C-BB*) it was by 46.2%. The content of total dietary fiber (TDF) in medium and finely ground groats decreased to a lesser degree (on average by approx. 36.6%, irrespective of the type of groats and the applied thermal processing method). The level of the SDF fraction in coarse groats decreased by 39%, while in medium and finely ground groats by approx. 33% and 28%, respectively, irrespective of the applied thermal processing method. The content of the IDF fraction was reduced to a bigger degree. In groats *C-BT* the level of this fraction decreased by 40%, while in groats *C-BB* by 50% in comparison to raw groats. In case of medium and finely ground groats the level of this fraction deceased by 39% and 40%, respectively, irrespective of the thermal processing method. Thermal processing modifies the structure of both cell walls and storage polysaccharides, probably by its effect on the damaged tissue and the destruction of the protein-saccharide system, thus reducing the solubility of dietary fiber (Siljestrom et al. 1986).

## Conclusions

1. Analyzed barley groats exhibit considerable variation in terms of their contents of dietary fiber and its fraction composition.

2. Among analyzed groats the biggest amount of dietary fiber was recorded in coarse barley groats. The fractions of dietary fiber found in analyzed groats in biggest amounts were the hemicellulose and cellulose fractions.

3. Thermal processing of groats caused a varied, significant decrease in the contents of dietary fiber and its fractions. The coarse barley groats cooked in plastic bags was characterized by a significantly lower content of dietary fiber and its fractions in comparison to fluffy groats cooked the traditional style.

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# BIOACTIVE COMPONENTS IN THE CHERRY TOMATOES (*LYCOPERSICON ESCULENTUM* VAR. *CERASIFORME*) CULTIVATED ON ROCKWOOL AND COCOFIBRE

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Key words: cherry tomato, fruit bioactive components, rockwool, cocofibre.

Abstract

Two cultivars of cherry tomato (Conchita, Favorita) and one standard tomato cultivar Cunero were grown in the greenhouse on rockwool and cocofibre – Cocovita, in the autumn cycle in the years 2000 and 2001. In the vegetation period, plants were supplied with a nutrient solution of the fixed mineral content. In the ripe fruits concentration of the following parameters were determined: dry matter, vitamin C, beta-carotene, lycopene and flavonols counted for quercetin. The obtained results showed that fruits coming from plants cultivated on cocofibre were richer in lycopene. Moreover they contained more witamin C, beta-carotene, dry matter and flavonoids. Cherry tomato fruits had higher nutritional value compared to standard cultivar Cunero.

## SKŁADNIKI BIOAKTYWNE POMIDORÓW CHERRY (*LYCOPERSICON ESCULENTUM* VAR. *CERASIFORME*) W UPRAWIE NA WEŁNIE MINERALNEJ I PODŁOŻU KOKOSOWYM

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Słowa kluczowe: pomidor cherry, składniki bioaktywne owoców, wełna mineralna, podłoże kokosowe.

Abstrakt

Dwie odmiany pomidora cherry (Conchita, Favorita) oraz odmianę standardową Cunero uprawiano w szklarni na wełnie mineralnej i włóknie kokosowym Cocovita w cyklu jesiennym w latach 2000 i 2001. W okresie wegetacji roślinom podawano pożywkę o ustalonym składzie mineralnym. W dojrzałych owocach określono zawartość suchej masy, witaminy C, beta-karotenu, likopenu oraz flawonoli w przeliczeniu na kwercetynę. Zgromadzone wyniki wskazały, że owoce pozyskane z roślin uprawianych na

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matach kokosowych były bogatsze w likopen. Ponadto zawierały więcej witaminy C, beta-karotenu, suchej masy oraz flawonoidow. Pomidory cherry charakteryzowały się istotnie wyższą wartością odżywczą owoców w stosunku do odmiany standardowej Cunero.

## Introduction

In the soil-less technology of cultivation one of the important factors determining crops of good quality is the type of substrate. Currently the most popular substrate in such cultivations is rockwool, which compared to other materials allows for significant increase of yields (MARTYN 1996). However, new, competing with rockwool types of substrates are being introduced (BARTKOWSKI 1998). Utilization of old substrate after growing season is a serious problem (KURPASKA 1996, BENOIT et al. 1998). In the nineteen-nineties the organic substrate which can be biodegraded after growing season appeared. This was the cocofibre, which has good physical properties. However it hasn't replaced rockwool so far, even though study results of SHINOHARA et al (1997) and PIRÓG (1999) showed that it is useful for tomato cultivation under greenhouse. The yield from plants cultivated on cocofibre was similar to that obtained from cultivation on rockwool, whereas the quality of fruits was not investigated.

Cherry tomato (Lycopersicon esculentum var. cerasiforme), called also cocktail or small-fruited tomato, is still novelty on the Polish market. The fruit yield of cherry tomato is nearly half lower in comparison to yield of large-fruited tomato (GURP 1995). On the other hand, the characteristic property for cherry tomato is the much higher fruit biological value than that of standard tomato fruit (HOBSON 1989, HALLMANN 2003).

The aim of this study was to determine the quality of cherry tomato fruits, cultivated on rockwool and cocofibre in comparison to standard tomato cultivar Cunero.

## Materials and Methods

Two cultivars of cherry tomato (Conchita, Favorita) and standard tomato cultivar Cunero were grown in the greenhouse on rockwool and cocofibre – Cocovita slabs, in the autumn cycle in the years 2000 and 2001. In the vegetation period, plants were supplied with a nutrient solution of the following contents of ingredients per 1 $dm^3$: N – 140 mg, P – 70 mg, K – 400 mg, Mg – 60 mg, Ca – 190 mg, Fe – 2.0 mg, Mn – 0.6 mg, Cu – 0.2 mg, Zn – 0.3 mg, B – 0.3 mg, Mo – 0.2 mg. The concentration of nutrient solution was EC – 2.4 and pH – 5.6. The following parameters were determined in fully ripe fruits: dry matter by the scale method (PN-90/A-75101/03), vitamin C by the Tillman's method (PN-90 A-75101/11), beta-carotene and lycopene content by the column chromatography method (SANIAWSKI et al. 1983) and

flavonols content by the Christ – Müller's methods (STRZELECKA et al. 1978) counted for quercetin. The results concerning qualitative properties of fruits were statistically calculated by Statgraphics 4.1 programme using Tukey's test at the significance level $\alpha = 0.05$.

## Results and Discussion

The obtained results show that in autumn cycle all the investigated cultivars grown on the cocofibre and rockwool contained more dry matter (Figure 1). Moreover cherry tomato had 48.6% on cocofibre and 34.5% on rockwool higher levels of dry matter compared to standard cultivar Cunero.

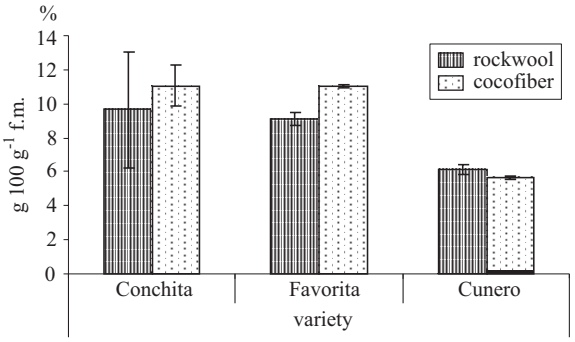


Fig. 1. The dry matter content of tomatoes grown on mineral rockwool and cocofiber slabs

These findings confirm the results obtained by KOŁOTA et al. (1999) who concluded that cherry tomato in comparison to large-fruited tomato contained much more dry matter, vitamin C and nearly three times more total sugars. Fruits of cultivars grown on cocofibre characterize higher levels of vitamin C (Figure 2), and it was 28.16 mg 100 $g^{-1}$ f.m. on cocofibre and 27.21 mg 100 $g^{-1}$ f.m. on rockwool respectively. SHINOHARA et al. (1997) stress that substrate may be the factor which modifies content of components,

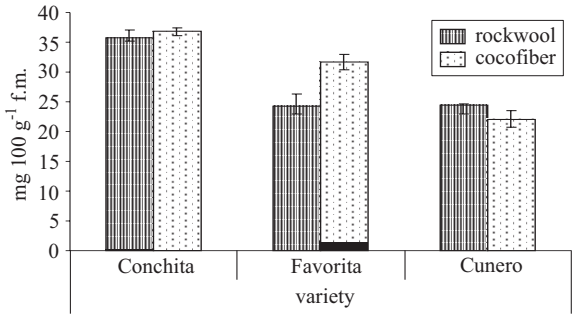


Fig. 2. The vitamin C content of tomatoes grown on mineral rockwool and cocofiber slabs

especially in case of l-ascorbic acid. Cherry tomato had significantly higher levels of vitamin C compared to standard cultivar Cunero. The type of substrate had significant impact on lycopene accumulation in tomato fruits (Figure 3). On average fruits grown on cocofibre produced 46.8% more

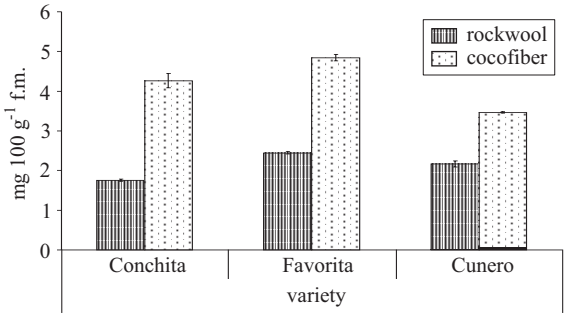


Fig. 3. The lycopene content of tomatoes grown on mineral rockwool and cocofiber slabs

pigment than those grown on rockwool. Cherry tomato showed significantly higher content of lycopene – 3.33 mg 100 $g^{-1}$ f.m. in comparison to Cunero cultivar – 2.81 mg 100 $g^{-1}$ f.m. There is a hypothesis that cherry tomatoes as being closer related to wild tomato, may contain more beta-carotene than lycopene (POTACZEK, MICHALAK 1994). The type of substrate had no significant impact on beta-carotene and flavonol concentration in tomato fruits (Figure 4, 5).

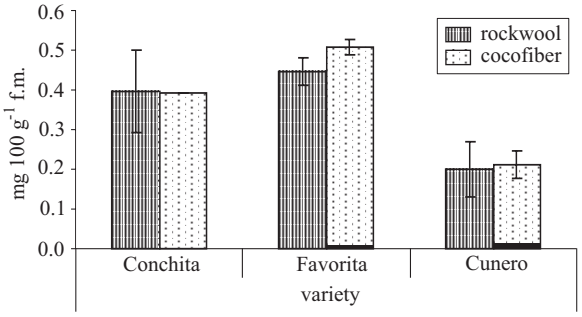


Fig. 4. The beta-carotene content of tomatoes grown on mineral rockwool and cocofiber slabs

However small-fruited tomatoes had nearly two-fold higher levels of beta--carotene (0.44 mg 100 $g^{-1}$ f.m.) in comparison to standard cultivar Cunero (0.21 mg 100 $g^{-1}$ f.m.). Flavonol content in tomato fruits were mainly determined by the type of cultivar. Cherry tomatoes contained even 63% more flavonols compared to Cunero cultivar (Figure 5). The similar findings were reported by CROIZER et al. (1997), who obtained flavonol content in Favorita cultivar on the level of 4.1 mg 100 $g^{-1}$ f.m., whereas for the second cultivar Paloma (cherry tomato) it was as much as 17.9–20.3 mg 100 $g^{-1}$ f.m.

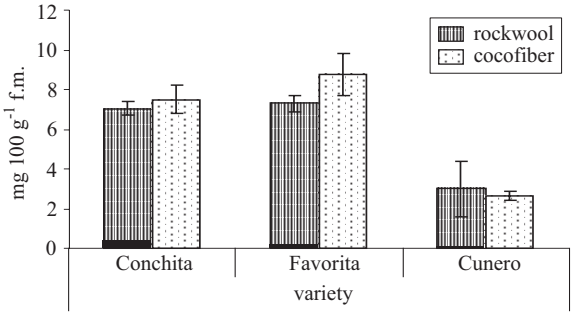


Fig. 5. The total flavonoids (quercetin) content of tomatoes grown on mineral rockwool and cocofiber slabs

## Conclusions

1. The type of substrate and cultivar had statistically significant impact on vitamin C, lycopene content in tomato fruits.

2. Tomatoes grown on cocofibre contained more carotenoids, vitamin C, dry matter and total flavonoids.

3. Cherry tomatoes (Favorita, Conchita) contained significantly more dry master, vitamin C, lycopene, beta-carotene than standard cultivar Cunero.

4. The highest levels of beta-carotene, lycopene and quercetin was found in the fruits of Favorita cultivar, whereas the highest levels of vitamin C and dry matter was noted in fruits of Conchita cultivar.

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# INFLUENCE OF THERMAL PROCESSING ON BIOACTIVE COMPOUNDS CONTENT IN APPLE PUREE PREPARED FROM ORGANIC FRUITS OF OLD AND NEW APPLE CULTIVARS

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Key words: apple purée, bioactive compounds, old cultivars, new cultivars, pasteurization.

Abstract

Apples are the fruits rich in many compounds with antioxidant properties. Apple juice, jam or pulp is also the source of several valuable bioactive compounds. Since fruits of old cultivars contain a lot of bioactive compounds, the hypothesis was formed that apple purée (pulp) has also better nutritional value in comparison to the product made from fruits of new cultivars. The study was conducted on apple purée prepared from three cultivars Książe Albrecht Pruski, Złota Reneta and Cesarz Wilhelm, belonging to old cultivars group, and three organic cultivars Idared, Lobo and Jonagold, as well as the same three conventional cultivars. The following bioactive compounds were determined in the fresh prepared pulp and after pasteurization: vitamin C, phenolic acids, flavonols and dry matter. Results showed that before pasteurization the highest levels of dry matter, phenolic acids and vitamin C were found in the purée prepared from old cultivars, whereas pulp made from organic apples contained the highest levels of flavonols. Pasteurization caused drop in all the studied parameters contained in apple purée. After pasteurization the highest levels of dry matter and flavonols were noted in purée made from organic apple cultivars, whereas the highest levels of phenolic acids and vitamin C were found in samples prepared from old apple cultivars.

## WPŁYW OBRÓBKI TERMICZNEJ NA ZAWARTOŚĆ ZWIĄZKÓW BIOAKTYWNYCH W PRZECIERACH JABŁKOWYCH WYKONANYCH Z OWOCÓW JABŁONI ODMIAN EKOLOGICZNYCH I NOWYCH

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A b s t r a k t

Jabłka są owocami bogatymi w liczne związki o charakterze antyoksydacyjnym. Soki, dżemy czy musy jabłkowe są również źródłem wielu cennych związków bioaktywnych. Ponieważ owoce starych odmian zawierają liczne związki aktywne, to istnieje hipoteza, że przecier jabłkowy (mus) będzie również wyróżniał się wyższą jakością żywieniową w porównaniu z produktem wykonanym z owoców odmian nowych. Do doświadczenia wybrano mus zrobiony z trzech odmian jabłoni: starych (Książę Albrecht Pruski, Złota Reneta oraz Cesarz Wilehlm), ekologicznych (Idared, Lobo, Jonagold) i trzech takich samym odmian nowych. W przygotowanym kremogenie na świeżo i po pasteryzacji oznaczono następujące składniki bioaktywne: witaminę C, kwasy fenolowe, flawonole oraz zawartość suchej masy. Wyniki wskazują, że przed pasteryzacją najwięcej tych związków zawierał przecier z owoców odmian starych, a największą ilość flawonoli stwierdzono w musach z jabłek odmian ekologicznych. Pasteryzacja przyczyniła się do obniżenia zawartości wszystkich badanych parametrów w przecierach jabłkowych. Po zakończeniu tego procesu najwięcej suchej masy oraz flawonoli stwierdzono w przecierach z jabłek ekologicznych, a kwasów fenolowych i witaminy C – w produktach wykonanych z owoców starych odmian.

## Introduction

In the end of 20th century very intense development of modern fruit-growing methods was observed, which led to the increase of fruit-growing land area (Pieniążek 1995). Very often well-known and popular apple cultivars that could have recently been found in home orchards have been replaced with different, more fertile or those with outstanding taste values. Consumers still keep in mind old apple cultivars and look for them on the fruit market. According to Rembiałkowska et al. (2006) old fruit cultivars had significantly more flavonoids, vitamin C and anthocyanins. Old apple cultivars from home orchards are grown without pesticide and fertilizer inputs, thus old fruit cultivars can be classified as the pro-organic crops. A great number of studies confirmed the theory that crops and food products from organic farming contain more health-promoting bioactive compounds. The second type of cultivation which produces apples that promote human health is the certified organic cultivation. Apples from such farming system contained more vitamin C, flavonoids or anthocyanins (Rembiałkowska et al. 2003). Organic crops and foods have higher levels of health beneficial bioactive compounds and macro and microelements. Organic fruit preserves can play import role in composing varied diet. Apple purée is a rich source of numerous compounds with antioxidant properties, like: polyphenols including phenolic acids, especially chlorogenic acid, quercetin, vitamin C, as well as fibre and pectins (Lu et al. 1996, Figuerola et al. 2005). Juice and purée from organic apple cultivar Jonagold had significantly higher content of total phenols and antioxidant activity compared to samples from conventional apples (Rembiałkowska et al. 2005). Pasteurization process can lead to change in the content of antioxidant compounds in the fruit preserves. Apple juice

contained even 2 – 30 times less of phenolic compounds, especially chlorogenic acid, in comparison to fresh apples. On the other hand according to the study conducted by SLUIS et al. (2002) apple purée contained significantly more quercetin derivatives and therefore it has shown higher antioxidant activity than the fresh apples. The aim of the study was to determine the impact of the pasteurization process on bioactive compound content in preserves prepared from organic fruits, fruits of old cultivars and conventional (new) cultivars.

## Materials and Methods

The experiment was conducted in 2005 at Warsaw Agricultural University in the Organic Foodstuffs Division. The study was carried out on apple purée prepared from three cultivars Książę Albrecht Pruski, Złota Reneta and Cesarz Wilhelm, belonging to old cultivars group, and three organic cultivars Idared, Lobo and Jonagold, as well as the same three new, conventional cultivars. The fruits chosen to processing were carefully washed, crashed and scalded together with the skin. Prepared product was then passed through a sieve and put to a glass jar and then pasteurized for 20 minutes at 70°C. The following parameters were determined in the apple pulp: bioactive compounds: flavonols by the Christ – Müller's methods (STRZELECKA et al. 1978), total phenolic acids (FIGUEROLA et al. 2005), vitamin C by the Tillman's method (*Oznaczanie zawartości...* PN-90 A-75101/11), and dry matter by the scale method (*Oznaczanie zawartości...* PN-90 A-75101/03). All the chemical analyses were done in two ways: on the fresh prepared apple purée and after pasteurization process. Obtained results were statistically analyzed using Tukey's test at the significance level $\alpha = 0.05$.

## Results and Discussion

The obtained results show that apple purée prepared from old cultivars contained significantly more dry matter (Table 1), but after pasteurization pulp from organic cultivars had higher content of dry matter, and it was 12.78 g 100 $g^{-1}$ f.m. and 12.09 g 100 $g^{-1}$ f.m respectively. Organic apple preserves contained significantly more total flavonols, both before and after pasteurization (Table 1), but in the case of organic apple purée thermal processing caused drop in flavonols, with losses around 36.4% of prepasteurization levels. The lowest level of flavonols was found in the pulp prepared from new, conventional apple cultivars, both before and after pasteurization. These results are in accordance with those presented by REMBIAŁKOWSKA et al. (2005), who concluded that apple purée prepared from organic cultivars contained significantly more flavonols (48.0%) compared to pulp made from

Table 1

The antioxidant compounds in apple puree prepared from old, organic and conventional apple cultivars before and after pasteurization process

| Before pasteurization | | | | | |
|---|---|---|---|---|---|
| | | dry matter (%) | flavonols (mg %) | phenolic acids (mg %) | vitamin C (mg %) |
| Old cultivars | Książę Albreht Pruski | 12.66 | 96.25 | 938.70 | 234.56 |
| | Złota Reneta | 13.88 | 16.94 | 1005.14 | 116.46 |
| | Cesarz Wilhelm | 11.79 | 66.31 | 869.72 | 171.63 |
| Average | | 12.78 | 59.83 | 937.85 | 174.22 |
| Organic | Lobo | 13.75 | 59.49 | 342.78 | 83.60 |
| | Jonagold | 12.03 | 115.35 | 491.10 | 113.45 |
| | Idared | 10.54 | 50.57 | 636.84 | 86.11 |
| Average | | 12.11 | 75.13 | 490.24 | 94.39 |
| Conventional | Lobo | 11.18 | 27.92 | 313.86 | 78.28 |
| | Jonagold | 12.15 | 53.22 | 468.53 | 81.76 |
| | Idared | 9.72 | 41.34 | 699.46 | 90.09 |
| Average | | 11.02 | 40.83 | 493.95 | 83.38 |
| NIR /0.05/ | | 2.83 | 17.46 | 248.64 | 34.54 |
| After pasteurization | | | | | |
| | | dry matter (%) | flavonols (mg %) | phenolic acids (mg %) | vitamin C (mg %) |
| Old cultivars | Książę Albreht Pruski | 11.56 | 41.30 | 921.2 | 74.47 |
| | Złota Reneta | 12.21 | 5.56 | 464.5 | 67.32 |
| | Cesarz Wilhelm | 11.06 | 19.19 | 849.3 | 54.56 |
| Average | | 11.61 | 22.02 | 745.00 | 65.45 |
| Organic | Lobo | 13.73 | 55.56 | 337.29 | 26.32 |
| | Jonagold | 12.00 | 65.64 | 351.44 | 30.11 |
| | Idared | 10.54 | 22.22 | 294.38 | 28.57 |
| Average | | 12.09 | 47.80 | 327.70 | 28.33 |
| Conventional | Lobo | 11.15 | 23.29 | 272.97 | 26.99 |
| | Jonagold | 11.70 | 8.96 | 345.61 | 28.32 |
| | Idared | 9.58 | 12.61 | 270.33 | 28.46 |
| Average | | 10.81 | 14.96 | 296.30 | 27.92 |
| NIR /0.05/ | | 3.72 | 17.95 | 248.6 | 34.54 |

conventional apples. Old apple cultivars showed high concentration of phenolic compounds, in the calculation of gallic acid. In the conducted research it was found that apple purée prepared from old cultivars had the highest levels of phenolic acids in comparison to organic cultivars and new – conventional ones (Table 1). Similar results were obtained by KAHLE et al. (2005), who have examined phenolic compounds content in juice prepared from German old cultivars and new, commercial cultivars, present on the market. It was proven that juice from old cultivars (Boskoop, Bittenfelder, Brettacher, Winterrambur, Kaiser Wilhelm, Kaiser Alexander or Bohnapfel) contained on average 72.7% more total polyphenols, including 84.4% higher concentration in case of flavonols compared to new cultivars (Granny Smith, Gulden Delicious o Fuji). Apple purée prepared from old cultivars contained also the highest levels of vitamin C, both before and after pasteurization, and it was 174.22 mg 100 $g^{-1}$ d.m. and 64.45 mg 100 $g^{-1}$ d.m. respectively. The second concentration had the apple purée made from organic fruits and the lowest levels were found in new, conventional cultivars (Table 1). In their research Planchon et al. (2004) have shown that old apple cultivars grown in Belgium (Grenadier$^{RGF}$, Bramley Seedlings, Reinette de Blenheim$^{RGF}$, Court--Pendu Gris, Reinette de Waleffe, Reinette Hernaut$^{RGF}$) contained more vitamin C in comparison to the new, market cultivar (Jonagold Decosta), and it was on average 16.3 mg 100 $g^{-1}$ f.m for the old cultivars and 10.33 mg 100 $g^{-1}$ f.m for the new cultivar.

## Conclusions

1. Apple purée made from fruits of old cultivars showed significantly higher levels of dry matter, phenolic acids and vitamin C.

2. Apple purée from organic production contained more flavonols, both before and after pasteurization process.

3. The lowest levels of bioactive compounds were observed in apple purée prepared from fruits of new, conventional cultivars.

4. The pasteurization caused the decrease of bioactive compounds in apple purée. The biggest drop in flavonols and phenolic acids was noted in conventional apple purée, vitamin C in organic foods and the dry matter in the puree from old apple cultivars.

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# A COMPARISON OF ANTIOXIDANT ACTIVITY IN FROZEN AND CANNED *BOLETUS EDULIS* MUSHROOMS

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Key words: antioxidant activity, frozen mushrooms, canned mushrooms, ABTS, DPPH.

Abstract

The present study compares the antioxidant activity in frozen and canned *Boletus edulis* mushrooms undergoing different kinds of preliminary treatment. The products were assessed after 12 months of storage. The activity of methanolic extracts was determined against the stable DPPH$^{\bullet}$ (1.1-diphenyl-2-picrylhydrazyl) free radical and the ABTS (2.2′-azino-bis-(3-ethylbenzthiazoline-6-sulfonic acid)) cation radical. Results revealed that frozen products showed stronger antioxidant activity, expressed in terms of fresh mass, than canned products by about 23–41% (DPPH$^{\bullet}$) and 2–9% (ABTS), the differences being significant only in the case of DPPH$^{\bullet}$ radicals. Against DPPH$^{\bullet}$, frozen and canned products exhibited one-half to one-fifth the antioxidant capacity that was measured against ABTS.

## PORÓWNANIE AKTYWNOŚCI PRZECIWUTLENIAJĄCEJ MROŻONEK I KONSERW STERYLIZOWANYCH Z BOROWIKA SZLACHETNEGO

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Słowa kluczowe: aktywność przeciwutleniająca, mrożone grzyby, sterylizowane grzyby, ABTS, DPPH$^{\bullet}$.

Abstrakt

W badaniach porównano aktywność przeciwutleniającą mrożonek i konserw sterylizowanych z owocników borowika szlachetnego (*Boletus edulis*), poddanych przed konserwowaniem zróżnicowanej obróbce wstępnej. Produkty oceniano po 12 miesiącach składowania. Pomiar aktywności ekstraktów metanolowych przeprowadzono wobec trwałego wolnego rodnika DPPH$^{\bullet}$ i kationorodnika ABTS. Wykazano, że mrożonki w porównaniu

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z konserwami sterylizowanymi charakteryzowały się (w przeliczeniu na świeżą masę) wyższą aktywnością antyoksydacyjną o 23–41% (DPPH•) i o 2–9% (ABTS), przy czym zanotowane różnice były istotne tylko w przypadku rodnika DPPH•. Zbliżone tendencje wykazano w odniesieniu do suchej masy. Pojemność przeciwutleniająca mrożonek i konserw sterylizowanych wobec DPPH• była 2–5-krotnie mniejsza niż wobec ABTS.

## Introduction

Natural substances with antioxidant capacity have attracted increasing interest in recent years due to their free radical scavenging activity, which protects cells against undesirable changes caused by reactive oxygen forms (Donaldson 2004). Edible mushrooms constitute a raw material with antioxidant activity whose ability to reduce free radicals depends to a large degree on the species of mushroom (Murcia et al. 2002). According to Elmastat et al. (2007), among popular edible mushrooms a higher antioxidant capacity against the DPPH• radical is found in *Pleurotus ostreatus* than in *Agaricus bisporus or Boletus badius*.

Since fresh mushrooms are highly perishable and, in the case of Boletus edulis, for example, subject to seasonal availability, their processing is recommended (Czapski 2000). With one or two exceptions, the literature contains virtually no studies on the antioxidant activity of mushroom products or changes in their antioxidant capacity resulting from processing. Murcia et al. (2002) showed that freezing resulted in only slightly lower antioxidant capacity in Lentinus edodes and Cantharellus lutescens mushrooms than sterlisation. Choi at al. (2006) observed that the antioxidant activity of mushrooms doubled when treated at 100°C and 121°C.

The aim of the present work was to compare the antioxidant capacity in frozen and canned products of *Boletus edulis* (Bull. Fr.) mushrooms undergoing different preliminary treatment.

## Materials and Methods

Frozen and canned products of *Boletus edulis* (Bull. Fr.) mushrooms stored for 12 months provided the experimental material. Samples were obtained from mushrooms which had undergone the following stages of preliminary treatment: picking and sorting; cleaning; separating the pileus from the stipes; washing; draining on sieves; cutting (in the case of pilei above 5 cm diameter); soaking (if necessary); blanching; cooling; draining on sieves; and cutting.

Blanching was carried out in 5 different solutions: water (BW); sodium metabisulfite (0.2%) and citric acid (0.5%) water solution (BSM); citric acid (0.5%) and L-ascorbic acid (0.1%) water solution (BCA); lactic acid (1.0%) and L-ascorbic acid (0.1%) water solution (BLA); and finally citric acid (0.5%),

L-ascorbic acid (0.1%) and low methoxyl pectin (0.5%) water solution (BPE). In addition, 3 methods of soaking and blanching were applied for the same solution: in citric acid (0.5%) and L-ascorbic acid (0.1%) water solution (SBCA); in lactic acid (1.0%) and L-ascorbic acid (0.1%) water solution (SBLA); and in citric acid (0.5%), L-ascorbic acid (0.1%) and low methoxyl pectin (0.5%) water solution (SBPE). The mushrooms were soaked for 1 hour. Blanching was carried out at 96-98°C for 3 min. (caps) and 1.5 min. (stipes). The mushrooms were then cut into 5 mm thick strips, placed in unit packages and frozen at –35°C. Freezing was carried out for 120 minutes until the thermal centre of the samples reached –25°C, at which temperature they were stored until analysis.

The antioxidant activity of methanolic extracts (40 mg of the sample/1 ml of extract) was evaluated by means of the spectrophotometric method against the DPPH$^{\bullet}$ (1.1-diphenyl-2-picrylhydrazyl) stable radical (Pekkarinen et al. 1999) and the ABTS (2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) cation radical (RE et al. 1999). The results were expressed as the Trolox equivalent in µmols of Trolox (6-Hydroxy-2,5,7,8-tetramethylchroman--2-carboxylic acid – water-soluble analogue of $\alpha$-tocopherol)$\cdot$1 g$^{-1}$ of fresh matter and dry matter. Absorbance was measured over 10 minutes using a Shimadzu UV-160A Spectrophotometer, at 516 nm for the DPPH free radical and at 734 nm for the ABTS cation radical wavelength. Antioxidant activity was calculated from four replicates. Finally, the results were statistically evaluated using the F-Snedecor and *t*-Student tests. The least significant difference was calculated for $\alpha = 0.01$. The linear correlation coefficient between the antioxidant activity determined against the DPPH$^{\bullet}$ radical and that stated for the ABTS cation radical was also established.

## Results and Discussion

There are two radicals commonly used for determining antioxidant activity in various kinds of biological material. These are the DPPH$^{\bullet}$ radical and the ABTS cation radical (Lee et al. 2006, Re et al. 1999). Figure 1 and Table 1 indicate that antioxidant activity in frozen *Boletus edulis* mushrooms differed from that in canned mushrooms.

After 12 months of storage, antioxidant activity measured against DPPH$^{\bullet}$ was noticeably higher (by 23-41%) for the frozen as opposed to the canned product. Differences recorded between the two were probably caused by the salt brine which was added to the canned product, which could have resulted in the dilution of water-soluble constituents in the product. A similar correlation was observed in *Lentinus edodes* by Murcia et al. (2002). In the present work the antioxidant capacity of mushroom products depended on the preliminary treatment applied before preservation. The highest level of radical-scavenging activity, expressed as µmols of Trolox 1 g$^{-1}$ of fresh

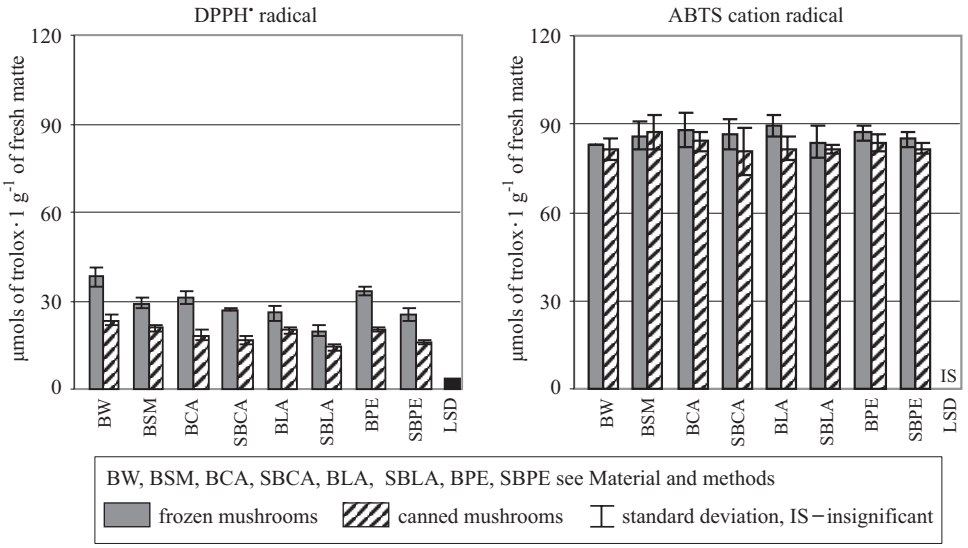


Fig. 1. Antioxidant activity in frozen and canned B. edulis, after 12 months of storage (av. values from four replicates and standard deviation)

matter, was found in products blanched in water, being 38.0 for the frozen and 23.4 for the canned product. The lowest values were found in mushrooms soaked and blanched in lactic acid solution, being 19.7 and 14.1 respectively. The results also revealed that, regardless of the solution applied in preliminary treatment, blanched products exhibited stronger antioxidant capacity than those which had been soaked as well as blanched. For the frozen product the respective mean values were 29.9 and 24.1 µmols of Trolox 1 $g^{-1}$ of fresh matter and 313.4 and 276.0 µmols of Trolox 1 $g^{-1}$ of dry matter. For the canned product these values were 19.6 and 15.5 (fresh matter) and 209.6 and 179.5 (dry matter) respectively (Figure 1, Table 1).

It was found that evaluation against the ABTS cation radical resulted in a considerably smaller (in fact, statistically insignificant) difference in antioxidant activity between the frozen and canned products than evaluation against the DPPH• radical (Figure 1, Table 1). For frozen mushrooms the levels of antioxidant capacity per 1 g of fresh and dry matter were 86.1 and 932.5 µmols of Trolox, while for canned products they were 82.8 and 915.7 µmols of Trolox respectively.

In the products analysed, the type of radical used determined their capacity for free radical elimination. Compared with the antioxidant values obtained using the ABTS method, those established by the DPPH• method were 2 to 4 times lower in frozen and 3 to 5 times lower in canned products. Moreover, SUN et al. (2003) reported 90% higher antioxidant activity against the ABTS radical than the DPPH• radical in asparagus juice. In contrast to the results for fresh matter, those given for dry matter showed a strong

Table 1

Antioxidant activity in frozen and canned *B. edulis*, after 12 months of storage in μmols of Trolox 1 $g^{-1}$ of dry matter (av. values from four replicates ± standard deviation)

| Kind of preliminary treatment | Kind of radical | | | |
|---|---|---|---|---|
| | DPPH• | | ABTS | |
| | frozen mushrooms | canned mushrooms | frozen mushrooms | canned mushrooms |
| BW | 396.4±27.99 | 250.0±16.93 | 866.0±10.48 | 871.6±30.00 |
| BSM | 302.6±27.31 | 229.8±9.90 | 897.8±46.93 | 964.9±51.81 |
| BCA | 322.9±19.94 | 196.4±16.04 | 918.6±52.90 | 900.7±34.18 |
| SBCA | 308.4±4.65 | 189.9±15.19 | 987.9±50.29 | 930.2±79.71 |
| BLA | 272.4±24.97 | 212.3±7.28 | 940.1±28.87 | 866.3±35.70 |
| SBLA | 226.6±19.15 | 163.7±10.78 | 965.8±58.94 | 942.4±19.82 |
| BPE | 345.0±16.27 | 220.1±6.97 | 909.1±13.66 | 901.1±22.52 |
| SBPE | 292.9±18.48 | 185.0±6.83 | 975.0±22.37 | 948.6±9.33 |
| LSD, $\alpha$ = 0.01 | 37.48 | | insignificant | |

Kind of preliminary treatment – see Material and Methods

correlation ($r$ = –0.70) between antioxidant activity and the type of radical used in the case of frozen *Boletus edulis*, while for canned products a medium correlation ($r$ = –0.46) was established (Figure 2). The differences observed in the antioxidant activity of the products examined were probably due to the fact that the DPPH• and ABTS cation radicals react differently with antioxidants; flavonoids, for example, deactivate the ABTS cation radical to a significantly higher degree than the DPPH• radical (Lee et al. 2006). Furthermore, Szwajger et al. (2005) report that of the cinnamon and benzoic acid derivatives, the highest ABTS radical-scavenging activity was shown by vanilic and synapic acids, while the highest DPPH• radical-scavenging activity was demonstrated by methyl ferulate and methyl syriginate.

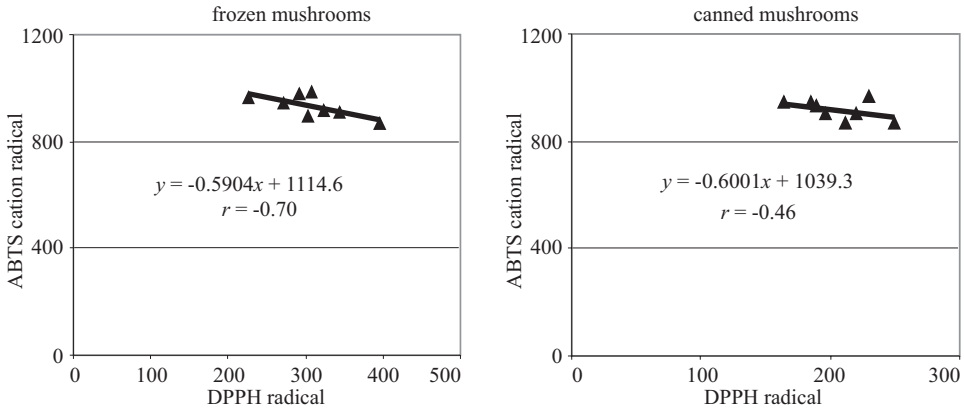


Fig. 2. Dependence between antioxidant activity in B. edulis products (μmols of Troloxu 1 $g^{-1}$ dry matter) determined in the presence of DPPH• radical and ABTS cation radical

## Conclusions

The results obtained lead to the conclusion that frozen *Boletus edulis* mushrooms showed higher antioxidant activity than the canned product and that significant differences between these products were observed only in measurements using the $DPPH^{\bullet}$ radical. Soaking and blanching mushrooms during preliminary processing resulted in lower antioxidant capacity than blanching alone.

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# THE EFFECT OF TIME OF ACID HYDROLYSIS ON THE MODIFICATION OF ANTIOXIDANT PROPERTIES OF RAPESEED PROTEIN HYDROLYSATES

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Key words: rapeseed meal, acid hydrolysis, protein hydrolysates, antioxidant activity.

Abstract

Protein hydrolysates obtained from rapeseed exhibited good antioxidant properties in case of the applied methods. Extension of the applied time of hydrolysis, in the presented tests modified differently antioxidant properties of protein hydrolysates by causing changes in the quantitative and qualitative composition of products. This was connected with partly different mechanisms of antioxidant action exhibited by peptides and amino acids, polyphenols and products of the Maillard reaction (PRM), which were determined indirectly by colour measurements. A positive correlation was found between the protection coefficient in rape oil in the Oxidograph test and protein content ($r = 0.96$, $p<0.05$), the $DPPH^{\bullet}$ radical scavenging capacity and the colour of hydrolysates ($r = 0.92$, $p<0.05$), and between the reducing power and the colour of hydrolysates ($r = 0.87$, $p<0.05$), and their total content of polyphenols ($r = 0.98$, $p<0.05$).

## WPŁYW CZASU HYDROLIZY NA KSZTAŁTOWANIE WŁAŚCIWOŚCI PRZECIWUTLENIAJĄCYCH HYDROLIZATÓW BIAŁKOWYCH ŚRUTY RZEPAKOWEJ

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Słowa kluczowe: śruta rzepakowa, hydroliza kwasowa, hydrolizaty białkowe, właściwości przeciwutleniające.

Abstrakt

Hydrolizaty białkowe śruty rzepakowej wykazały dobre właściwości przeciwutleniające w każdej z zastosowanych metod badawczych. Wydłużanie czasu hydrolizy, powodujące zmiany w ilościowym i jakościowym składzie produktu, miało zróżnicowany wpływ na

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kształtowanie właściwości przeciwutleniających hydrolizatów. Było to związane z częściowo innym mechanizmem działania przeciwutleniacego, wykazywanym przez peptydy i aminokwasy, polifenole oraz produkty reakcji Maillarda, które oznaczono pośrednio, kolorymetrycznie. Wykazano dodatnią korelację między współczynnikiem ochronnym dla oleju rzepakowego w teście Oxidograph a zawartością białka w hydrolizatach ($r = 0.96$, $p<0.05$), zdolnością zmiatania rodnika DPPH$^{\bullet}$ a barwą hydrolizatów ($r = 0.92$, $p<0.05$), a także między siłą redukującą a barwą hydrolizatów ($r = 0.87$, $p<0.05$) oraz całkowitą zawartością polifenoli ($r = 0.98$, $p<0.05$).

## Introduction

Antioxidant action of protein hydrolysates is connected with their content of polyphenolic compounds, free amino acids and peptides, as well as products of the Maillard reaction. Variable hydrolysis conditions, including its duration, determine the rate of decomposition of proteins to peptides and amino acids, the formation of products of the Maillard reaction and contents of polyphenols, which may be partly released from bonds with proteins, as well as degraded. The total antioxidative effect of such a mixture depends on the quantitative and qualitative composition of formed as a result of fragmentation of protein material, the amount and type of polyphenols and secondary reactions, occurring during hydrolysis in the acid medium (Korczak et al. 1998, Moon et al. 2002).

Excessive extension of the hydrolysis process causes on the one hand e.g. increased degradation of proteins and polyphenols, on the other hand it contributes to the formation of products of the Maillard reaction. Thus it seems advisable to estimate antioxidant properties of protein hydrolysates depending on the time of hydrolysis, as well as the application of various tests for this purpose, investigating different types of antioxidant activity of protein hydrolysates and their action in different media.

## Material and Methods

Analyses in this study were conducted on a dark-seeded rape cultivar Kana (2001/2002), coming from a plant breeding company Hodowla Roślin "Strzelce", branch in Borowo. Ground rape seeds were hydrolysed by heating with an addition of 6M hydrochloric acid under a reflux condenser at 105°C for 4, 6, 12 and 24 h (Pazoła 1970). Hydrolysates were characterized in terms of contents of total nitrogen, $\alpha$-amino nitrogen, salt, ash, dry matter and colour. Total polyphenol contents were determined colorimetrically at a wavelength of 750 nm using the Folin-Ciocalteu method (Horwitz 1970). Monosaccharides were determined using high performance liquid chromatography (HPLC) in a MERCK-HITACHI liquid chromatographer (a set with a MERCK-HITACHI L-7250 automatic sample injector, and a pump (MERCK-

-HITACHI L-7100) with an RI detector (MERCK-HITACHI L-7490). An Aminex HPX-87H 300x7.8 mm column (BIO-RAD) was used for assays. The applied eluent was 0.005M $H_2SO_4$, at a flow rate of 0.6 ml/min. Assays were performed at 30°C. Samples of 30 µl were injected onto the column. Qualitative and quantitative identifications were performed using an external standard with peak areas (measurement and computer integration with Chromatography Data Station Software, MERCK-HITACHI). Volatile products, mainly short-chain acids coming from the degradation of hydroperoxides, were determined in a Rancimat apparatus using conductometry (JEBE et al. 1993). Direct measurements of the amounts of oxygen absorbed by a fat sample incubated at 110°C were taken using an Oxidograph (LARSEN 1989). Spectrophotometry consisted in the determination ($\lambda$ = 234 nm) of the increment in the contents of conjugated dienes in an emulsion of linolic acid at a concentration of 10mM and pH of 7.2 (LINGNERT et al. 1979). Free radical scavenging capacity was estimated on the basis of colorimetrically ($\lambda$ = 517 nm) determined changes in the stable $DPPH^{\bullet}$ radical in relation to the blank test (SANCHEZ-MORENO et al. 1998). Chelating activity was determined on the basis of colorimetric ($\lambda$ = 562 nm) measurements of discoloration rate of iron(II) chloride complexes with ferrosin by solutions of protein hydrolysates (TANG et al. 2002). The reduction power of protein hydrolysate solutions was determined by colorimetric measurements ($\lambda$ = 700 nm) of discoloration rates of iron(III) solutions (OYAIZU 1986). Results are presented in terms of sinapic acid per gram of sample. These values were read from the analytical curve, prepared for sinapic acid (as modified by the authors).

## Results and Discussion

The chemical composition of rapeseed protein hydrolysates, obtained using different hydrolysis times, is presented in Table 1.

Values of protection coefficients of rapeseed protein hydrolysates, in rape oil, lard and linoleic acid emulsion, are presented in Table 2. Under the conditions of accelerated tests (Rancimat and Oxidograph) in rape oil all hydrolysates exhibited higher coefficients than those obtained using a 0.02% BHT addition. These coefficients increased with the extension of hydrolysis time. Statistical analysis of results showed a positive correlation between the protection coefficient for rape oil in the Rancimat test ($r$ = 0.99, $p$<0.005) and Oxidograph test ($r$ = 0.96, $p$<0.05) and protein content in the material. An opposite trend was found under the conditions of both tests in lard – the highest values of protection coefficients were observed at a 4 h hydrolysis time. Values of protection coefficients of oxidative stability of lard in both types of tests were higher than those obtained for rape oil. This results from the higher content of saturated fatty acids, characteristic for animal fats, in which antioxidants usually exhibit higher activity (KORCZAK 1998).

Table 1

The chemical composition of protein hydrolysates obtained from rapeseed meal

| Hydrolysis time (h) | 4 | 6 | 12 | 24 |
|---|---|---|---|---|
| Total nitrogen (g 100 $g^{-1}$) | $0.90\pm0.022^{b}$ | $0.83\pm0.027^{a}$ | $0.88\pm0.009^{b}$ | $0.89\pm0.013^{b}$ |
| Amino nitrogen (g 100 $g^{-1}$) | $0.68\pm0.014^{ab}$ | $0.65\pm0.025^{a}$ | $0.68\pm0.014^{ab}$ | $0.69\pm0.001^{b}$ |
| Degree of hydrolysis (%) | 75.55 | 78.31 | 77.27 | 77.53 |
| Sodium chloride (g 100 $g^{-1}$) | $21.33\pm0.082^{a}$ | $22.86\pm0.489^{b}$ | $23.05\pm0.737^{b}$ | $22.95\pm0.074^{b}$ |
| Ash (g 100 $g^{-1}$) | $20.07\pm0.294^{a}$ | $23.57\pm0.278^{b}$ | $23.95\pm0.042^{b}$ | $25.42\pm2.993^{b}$ |
| Dry matter (g 100 $g^{-1}$) | $28.46\pm0.045^{a}$ | $31.26\pm0.698^{b}$ | $31.83\pm0.087^{b}$ | $31.81\pm0.034^{b}$ |
| Polyphenols (g 100 $g^{-1}$) | $0.506\pm0.0448^{b}$ | $1.031\pm0.1104^{d}$ | $0.383\pm0.0318^{a}$ | $0.625\pm0.0385^{c}$ |
| Colour (E420) | $0.258\pm0.0065^{aa}$ | $0.505\pm0.0020^{b}$ | $0.208\pm0.0053^{a}$ | $0.489\pm0.1493^{b}$ |
| Glucose (g/l) | $1.39\pm0.286^{a}$ | $5.84\pm0.337^{c}$ | $2.05\pm0.101^{b}$ | $6.47\pm0.059^{d}$ |
| Arabinose (g/l) | $0.64\pm0.091^{a}$ | $1.24\pm0.171^{b}$ | $0.64\pm0.081^{a}$ | $1.63\pm0.017^{c}$ |
| Xylose, galactose, mannose (g/l) | $1.64\pm0.345^{ab}$ | $1.24\pm0.193^{a}$ | $1.08\pm0.095^{a}$ | $3.10\pm0.085^{b}$ |

Data presents mean value from four replicates and standard deviation; data marked by different letter within the same line are significantly different at $p<0.05$

Table 2

Protection coefficients of 2% concentration of rapeseed protein hydrolysates in rape oil and lard in accelerated tests and in linoleic acid emulsion

| Hydrolysis time (h) | Rancimat | | Oxidograph | | Linoleic acid emulsion |
|---|---|---|---|---|---|
| | Rapeseed oil | Lard | Rapeseed oil | Lard | |
| 4 | $1.30\pm0.026^{b}$ | $2.42\pm0.027^{d}$ | $2.22\pm0.062^{b}$ | $4.06\pm0.094^{c}$ | $0.69\pm0.069^{b}$ |
| 6 | $1.75\pm0.045^{c}$ | $1.98\pm0.014^{b}$ | $3.08\pm0.092^{c}$ | $2.83\pm0.074^{a}$ | $0.58\pm0.098^{a}$ |
| 12 | $1.70\pm0.045^{c}$ | $2.17\pm0.086^{c}$ | $3.36\pm0.149^{d}$ | $2.91\pm0.050^{a}$ | $0.67\pm0.069^{a}$ |
| 24 | $2.08\pm0.056^{d}$ | $2.13\pm0.053^{c}$ | $3.52\pm0.116^{d}$ | $2.86\pm0.074^{a}$ | $0.59\pm0.036^{a}$ |
| BHT 0.02% | $1.16\pm0.047^{a}$ | $1.53\pm0.069^{a}$ | $1.51\pm0.094^{a}$ | $3.74\pm0.037^{b}$ | $0.95\pm0.052^{c}$ |

Data presents mean value from four replicates and standard deviation; data marked by different letter within the same column are significantly different at $p<0.05$

No dependence was found between hydrolysis time and the value of the protection coefficient in linoleic acid emulsion. Probably the applied initial hydrolysis time of 4 h, applied in this study, was sufficiently long to obtain in this test maximum antioxidant properties by ground rape hydrolysates. Extension of hydrolysis time and the resulting decrease of values of protection coefficients may be explained by the lower antioxidant activity of free amino acids rather than peptides (Yamaguchi et al. 1975) and products of the Maillard reaction, formed by them (Lingnert and Eriksson 1980b). A similar effect was also observed for hydrolysates of casein (Korczak 1998).

The effect of hydrolysis time on antioxidant activity of protein hydrolysates, expressed in the DPPH$^{\bullet}$ radical scavenging capacity, chelating activity and reducing power is presented in Table 3. No clear dependence was found between hydrolysis time and values obtained in these tests. The highest

Table 3

The antioxidant activity of protein hydrolysates obtained from rapeseed meal (2% concentration of hydrolysate for DPPH• and chelating activity and 1% for reducing power)

| Hydrolysis time (h) | DPPH• (%) | Chelating activity (%) | Reducing power | |
|---|---|---|---|---|
| | | | (mEq sinapic acid $g^{-1}$ of hydrolysate) | Absorption E700 |
| 4 | 27.6±1.76$^a$ | 78.2±8.65$^b$ | 5.6±0.81$^a$ | 0.316 |
| 6 | 47.9±4.42$^c$ | 37.1±2.74$^a$ | 17.9±1.72$^c$ | 0.456* |
| 12 | 27.1±2.89$^a$ | 90.6±3.78$^c$ | 3.9±0.71$^a$ | 0.228 |
| 24 | 51.7±1.50$^c$ | 37.4±0.77$^a$ | 27.2±1.69$^d$ | 0.369** |
| BHT 0.02% | 41.6±1.85$^b$ | no activity | 10.9±0.49$^b$ | 0.551 |

Data presents mean value from four replicates and standard deviation; data marked by different letter within the same column are significantly different at $p<0.05$
* concentration of hydrolysate 0.5%
** concentration of hydrolysate 0.25%

activity in scavenging DPPH• free radicals was shown by hydrolysate obtained within the period of 24 h. When analyzing dependencies between the DPPH• radical scavenging capacity and the chemical composition of raw materials a negative correlation was found with protein content ($r = –0.98$, $p<0.05$). This could have been caused by the blocking of amino acids by polyphenols or by the insufficient concentration of amino acids (Decker 1998). A positive correlation was found between antioxidant activity, measured using this test and the colour of hydrolysates ($r = 0.92$, $p<0.001$). This shows that PRM contributed considerably to the scavenging of free radicals (Moon et al. 2002). Chelating activity of two hydrolysates was very high, within the range of 78.2–93.9%. The other hydrolysates, obtained as a result of 6 and 24 h hydrolysis, exhibited a lower chelating capacity. At the same time they were characterized by dark colour and high glucose content. These results are rather difficult to interpret unequivocally. The antioxidant effect of non-enzymatic browning products is affected by the type of saccharides and amino acids participating in the Maillard reaction. PRM formed under certain conditions may exhibit low antioxidant activity. Such a situation was reported by Davidek et al. (1990). Products of interaction of glucose and amino acids obtained and analyzed by those researchers exhibited low antioxidant activity.

Obtained values of reducing power were highest for hydrolysates obtained after 6 and 24 h of the process. Statistical analysis of results showed a positive correlation of reducing power with the colour of hydrolysates ($r = 0.87$, $p<0.05$) as well as total contents of polyphenols ($r = 0.9842$, $p<0.05$). The observed strong positive correlation with the amount of polyphenols ($r = 0.92$, $p<0.001$) would rather suggest a much bigger role of polyphenols in the modification of reducing power of hydrolysates.

## Conclusions

1. All ground rape protein hydrolysates exhibited good antioxidant properties irrespective of hydrolysis time.

2. The rich composition of protein hydrolysates, changing during the process, did not make it possible to find a clear trend in the modification of antioxidant activity by hydrolysis time in all tests.

3. The effect of hydrolysis time on the antioxidant activity of rapeseed protein hydrolysates depended on the type of the applied test.

4. Extension of hydrolysis time resulted in an increase of protection coefficients under the conditions found in the Rancimat test and their decrease in the Oxidograph test.

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# EFFECTS OF GREEN TEA EXTRACT ON GASTROINTESTINAL TRACT METABOLISM, SERUM PARAMETERS AND ANTIOXIDANT STATUS IN RATS FED A HIGH-FRUCTOSE DIET

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K e y  w o r d s: fructose, green tea, antioxidant status, triacylglycerol, caecum.

A b s t r a c t

The aim of this study was to estimate the influence of an extract from green tea leaf on some gastrointestinal tract and blood parameters of rats fed a high-fructose diet. The experiment was conducted on 24 male Wistar rats fed with model diets: control (*C*), high-fructose (*F*) and the *F* diet with 0.2% addition of the green tea extract (*FT*). In the *F* group triacylgliceroly level was increased, and parameters of antioxidant status were generally decreased. The extract decreased triacylglycerol and glucose levels (in *FT* group), as well as elevated total antioxidant status. The highest mucosal disaccharidases activity in the small intestine was in *F* group, whereas extract slightly decreased the activity. Both experimental treatments caused an enlargement of liver and kidneys relative mass, and decreased the caecal concentration of short-chain fatty acids (SCFA). The concentration of branched-SCFA was significantly decreased in *FT* group. Our results indicates that the green tea extract displayed a beneficial influence on blood parameters, and antioxidative properties therein, however, there was no essential effects on gastrointestinal tract parameters disturbed by a high-fructose diet.

## WPŁYW EKSTRAKTU Z ZIELONEJ HERBATY NA METABOLIZM PRZEWODU POKARMOWEGO, PARAMETRY SUROWICY I STATUS ANTYOKSYDACYJNY U SZCZURÓW ŻYWIONYCH DIETĄ WYSOKOFRUKTOZOWĄ

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S ł o w a  k l u c z o w e: fruktoza, zielona herbata, status antyoksydacyjny, triacyloglicerol, jelito ślepe.

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A b s t r a k t

Celem pracy było zbadanie wpływu dodatku ekstraktu z liści zielonej herbaty na wybrane parametry przewodu pokarmowego i krwi u szczurów żywionych dietą wysokofruktozową. Doświadczenie przeprowadzono na 24 samcach szczepu Wistar, żywionych modelowymi dietami: kontrolną (grupa *C*), wysokofruktozową (grupa *F*) oraz dietą *F* z 0,2% dodatkiem ekstraktu z liści zielonej herbaty (*FT*). W grupie *F* zaobserwowano podwyższony poziom triacylogliceroli i obniżony parametrów statusu antyoksydacyjnego. Zastosowany ekstrakt obniżył poziom triacylogliceroli w grupie *FT*, a także podniósł całkowity status antyoksydacyjny. Najwyższą aktywność disacharydaz w śluzówce jelita cienkiego zaobserwowano w grupie *F*, a podany ekstrakt nieznacznie ją obniżył. W obu grupach eksperymentalnych zaobserwowano relatywny wzrost masy narządów wewnętrznych oraz spadek zawartości krótkołańcuchowych kwasów tłuszczowych (SCFA) w jelicie ślepym. Zawartość SCFA o rozgałęzionej strukturze była najniższa w grupie *FT*. Wyniki badań wskazują, że dodatek ekstraktu z zielonej herbaty korzystnie wpłynął na parametry biochemiczne krwi, w tym status antyoksydacyjny, natomiast nie miał istotnego wpływu na parametry przewodu pokarmowego zakłócone przez dietę wysokofruktozową.

## Introduction

A substantial increase in the intake of dietary fructose (from sucrose and high fructose syrups) and a low intake of polysaccharides have been recognized as the major reasons of many metabolic disorders *e.g.* adverse changes in glucose metabolism and dyslipidemia (Suter 2005). In addition, this type of diet may unfavourably influence the distal part of the gastrointestinal tract (GIT) (Skoog, Bharucha 2004). At present, green tea and its polyphenols are widely the subject of in vivo studies, in which authors are trying to demonstrate theirs antioxidative properties as well as hypolipidemic and antidiabetic actions (Li et al. 2006). On the other hand, it is known that polyphenols have also local effects on the gut (Hollman 2001). However the GIT response to the green tea polyphenols remains still scarce, especially in an organism with the disturbed metabolism.

The aim of this study was to estimate the influence of an extract from green tea leaf on some biochemical parameters of blood, including indicators of antioxidant status, and also physiological parameters of the GIT, including disaccharidases activity in the small intestine and fermentation processes in the caecum of rats fed a high-fructose diet.

## Materials and Methods

The experiment was conducted on 24 grown up male Wistar rats fed for 4 weeks with three model diets: control diet (*C*), high-fructose diet (*F*) and *F* diet with 0.2% addition of the green tea extract (*FT*). The detailed composition of the diets and green tea extract is presented in Table 1.

Table 1

Composition of the diets (%)

| Component | Diet | | |
|---|---|---|---|
| | *C* | *F* | *GT* |
| Casein | 20 | 20 | 20 |
| Cellulose | 5 | 5 | 5 |
| DL-methionine | 0.3 | 0.3 | 0.3 |
| Soybean oil | 5 | 5 | 5 |
| Mineral mix[1] | 3.5 | 3.5 | 3.5 |
| Vitamin mix[1] | 1 | 1 | 1 |
| Fructose | – | 65 | 65 |
| Green tea extract[2] | – | – | 0.2 |
| Maize starch | 65.2 | 0.2 | – |

*C* – control diet; *F* – high-fructose diet; *FT* – high-fructose diet with 0.2% content of green tea extract.

[1] AIN-93G mineral and vitamin mix

[2] The total content of polyphenols in the lyophilized extract was 611 mg $g^{-1}$, and it consisted mainly of (–)epicatechin (262.5 mg $g^{-1}$) and epigallocatechin gallate (276.8 mg $g^{-1}$). There was noted as well a small amount of epicatechin gallate (42.1 mg $g^{-1}$), (+)catechin (6.5 mg $g^{-1}$) and some procyanidins (23.1 mg $g^{-1}$). Polyphenols were extracted into 75% (v/v) acetone/water solution at solid material to solvent ratio of 1:8 with the 200 ppm addition of $SO_2$.

After anaesthesia and laparotomy blood samples were taken from tail vein of rats, then internal organs were removed and weighed. The caecal and illeal pH was measured. Samples of fresh digesta were used for analysis of dry matter, ammonia and short-chain fatty acids (SCFA). Ammonia was determined according to the standard Conway's method. The SCFA were measured using gas chromatography as described previously (Juśkiewicz, Zduńczyk 2004). Mucosal disaccharidase activity in the small intestine was assayed by the method of Dahlqvist (1964). Total antioxidant status (TAS) and the activity of superoxide dismutase (SOD) and glutathione peroxidase (GPx) were determined using the kits from Randox Laboratories Ltd. Plasma integral antioxidant capacity of water soluble substances (ACW) and lipophilic substances (ACL) were determined by photochemiluminescence (Analytik Jena AG, Jena, Germany). The concentrations of glucose, cholesterol, and triacylglycerol (TAG) in the serum, as well as the activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined with commercial diagnostic kits from Alpha Diagnostics. The content of thiobarbituric acid-reactive substances (TBARS) in kidney tissue was determined according to Mihara, Uchiyama (1978).

The results were worked out statistically using one-way analysis of variance and the Duncan's multiple range test at the significance level of $P \leq 0.05$.

## Results and Discussion

In the *F* group, ALT activity was insignificantly, whereas in the *FT* group significantly increased (Table 2), which indicates that fructose and the green tea extract in combination may escalate amino acids catabolism in the liver. The high-fructose diet increased TAG level and had no influence on glucose concentration in the serum, whereas green tea extract insignificantly decreased both these parameters (Table 2). Cholesterol content was slightly higher in both experimental groups. In the study of Li et al. (2006), green tea leaves extract substantially improved lipid and glucose homeostasis in fructose-fed hamsters.

Total antioxidant status was significantly higher in the *FT* group compared to the *F* group. These results are in agreement with those obtained by Skrzydlewska et al. (2002), where healthy young rats were drinking green tea for five weeks. The *F* group was characterized by the lowest GPx and SOD activities, as well as ACW level, however, these results were not statistically substantial. The extract slightly increased the levels of ACW, ACL and GPx activity. Mohamadin et al. (2005) stated that green tea extract tangibly prevents the generation of TBARS in kidneys of rats with induced oxidative stress. It was not confirmed in our study, in which kidneys' TBARS content was slightly higher both in *F* and *FT* groups in comparison to the control

Table 2

Serum parameters and antioxidant status of rats fed with experimental diets

| | Diet | | |
|---|---|---|---|
| | *C* | *F* | *FT* |
| Glucose (mg 100 cm$^{-3}$) | 196.5±16.2 | 198.6±22.3 | 174.9±7.6 |
| Cholesterol (mg 100 cm$^{-3}$) | 79.58±5.85 | 87.44±4.85 | 89.45±5.22 |
| TAG (mg 100 cm$^{-3}$) | 146.88$^{b}$±9.73 | 257.25$^{a}$±39.16 | 215.38$^{ab}$±16.39 |
| ALT (U dm$^{-3}$) | 35.16$^{b}$±2.65 | 44.06$^{ab}$±2.78 | 47.76$^{a}$±4.81 |
| AST (U dm$^{-3}$) | 264.75±51.99 | 395.13±49.44 | 305.50±27.43 |
| TAS (mmol dm$^{-3}$) | 0.868$^{ab}$±0.032 | 0.853$^{b}$±0.020 | 0.940$^{a}$±0.021 |
| ACW[1] | 0.062±0.008 | 0.053±0.002 | 0.058±0.007 |
| ACL[2] | 0.104±0.004 | 0.105±0.004 | 0.110±0.004 |
| GPx (U cm$^{-3}$) | 64.00±2.70 | 59.04±2.18 | 65.43±3.67 |
| SOD (U cm$^{-3}$) | 343.47±15.72 | 295.98±22.19 | 296.07±13.88 |
| TBARS[3] | 9.80±0.15 | 10.72±0.46 | 10.76±0.64 |

TAG – triacylglycerol; ALT – alanine aminotransferase; AST – aspartate aminotransferase; TAS – total antioxidant status; ACW – integral antioxidant capacity of water soluble substances; ACL – integral antioxidant capacity of lipophilic substances; GPx – glutathione peroxidase; SOD – superoxide dismutase; TBARS – thiobarbituric acid-reactive substances. Mean ± standard error. Values not sharing the same superscript letters within a row are significantly different at $P \leq 0.05$.

[1] Millimoles ascorbic acid equivalent per mL of serum.

[2] Millimoles trolox equivalent per mL of serum.

[3] Micromoles per 100 g of kidney tissue.

rats. Although, these results suggested that effect of high-fructose diet on the antioxidant status of rats was not unequivocal, like in the recent studies (GIRARD et al. 2005), but green tea antioxidative properties were strongly confirmed in our study.

Liver and kidneys had a higher mass in experimental groups, probably due to excessive fructose metabolism and its metabolites (Table 3). Both ileal and caecal pH were significantly higher in experimental groups. Compared with the control group, the fructose-enriched diet insignificantly, whereas the *FT* diet significantly increased the concentration of dry matter in caecal digesta. That difference was not observed in experiment with catechin by BRAVO et al. (1994), and it may be an additional effect of high amount of fructose and green tea polyphenols.

Table 3

Body weight, internal organs mass and intestinal parameters of rats fed with experimental diets

| | Diet | | |
|---|---|---|---|
| | *C* | *F* | *FT* |
| Body weight (g) | 459.4±9.0 | 451.8±6.3 | 480.3±13.0 |
| Internal organs mass[1]: | | | |
| Liver | $3.03^{b}$±0.10 | $3.99^{a}$±0.11 | $3.97^{a}$±0.10 |
| Kidneys | $0.528^{b}$±0.012 | $0.634^{a}$±0.009 | $0.625^{a}$±0.019 |
| Small intestine parameters: | | | |
| pH of ileal digesta | $6.99^{b}$±0.16 | $7.24^{a}$±0.11 | $7.16^{a}$±0.05 |
| Sucrase activity[2] | 8.32±0.96 | 14.26±3.18 | 11.74±2.63 |
| Maltase activity[2] | 31.21±2.66 | 37.82±4.09 | 36.55±4.97 |
| Lactase activity[2] | $2.56^{b}$±0.20 | $5.00^{a}$±0.56 | $4.08^{a}$±0.42 |
| Caecal parameters | | | |
| pH of digesta | $7.00^{b}$±0.09 | $7.15^{a}$±0.13 | $7.15^{a}$±0.08 |
| Dry matter of digesta (%) | $25.5^{b}$±0.3 | $27.0^{ab}$±1.1 | $28.6^{a}$±0.4 |
| Wall mass[2] | $0.221^{b}$±0.005 | $0.245^{a}$±0.010 | $0.220^{b}$±0.007 |
| Digesta mass[2] | 0.522±0.041 | 0.556±0.037 | 0.551±0.029 |
| Ammonia[3] | 39.83±1.49 | 43.46±0.86 | 43.15±3.81 |

Mean ± standard error. Values not sharing the same superscript letters within a row are significantly different at $P \leq 0.05$.
[1] Grams per 100 g of body weight.
[2] Micromoles disaccharide hydrolyzed per min per g of protein.
[3] Milligrams per 100 g of digesta.

The highest mucosal disaccharidases activity in a second quarter of the small intestine was observed in the *F* group, whereas green tea extract slightly decreased the activities (Table 3). The lactase activity was significantly higher in both experimental groups. These results may partly explain how high fructose intake may disturbing glucose homeostasis (LI et al. 2006).

The highest concentrations of total and particular SCFA were observed in the control group (Table 4). The *F* diet was characterized by a significantly lower concentration of propionic and butyric acids, as well as an insignificantly lower level of other acids, when compared to the *C* group. A decreased

Table 4

Concentration and profiles of short-chain fatty acids (SCFA) in fresh caecum content of rats fed with experimental diets

| | Diet | | |
|---|---|---|---|
| | *C* | *F* | *FT* |
| SCFA concentration (μmol $g^{-1}$): | | | |
| Acetic acid | 81.00±8.65 | 71.11±10.47 | 66.01±3.98 |
| Propionic acid | $20.58^{a}$±1.77 | $15.79^{b}$±0.90 | $16.65^{ab}$±1.41 |
| Isobutyric acid | $1.27^{a}$±0.13 | $1.10^{ab}$±0.07 | $0.88^{b}$±0.10 |
| Butyric acid | $10.18^{a}$±0.80 | $7.26^{b}$±0.99 | $6.65^{b}$±0.97 |
| Isovaleric acid | $1.45^{a}$±0.16 | $1.40^{a}$±0.06 | $1.05^{b}$±0.08 |
| Valeric acid | $2.01^{a}$±0.18 | $1.69^{ab}$±0.16 | $1.37^{b}$±0.07 |
| Total | 116.48±11.09 | 98.36±11.88 | 92.61±6.18 |
| SCFA Profiles (%): | | | |
| Acetic acid | 69.1±0.8 | 71.3±1.3 | 71.4±0.4 |
| Propionic acid | 17.8±0.5 | 16.9± 1.2 | 17.9±0.6 |
| Butyric acid | $9.0^{a}$±0.7 | $7.4^{b}$±0.3 | $7.0^{b}$±0.6 |

Mean ± standard error. Values not sharing the same superscript letters within a row are significantly different at $P \leq 0.05$.

caecal propionate production may be one of the reasons of increased TAG level in serum of fructose-fed rats (Niskina, Freedland 1990). When compared to the *F* group, the green tea extract including mainly catechins did not change caecal concentration of acetate, propionate nor butyrate. These results are partly in agreement with *in vitro* investigation carried out by Bravo et al. (1994), in which 24 h incubation of catechin with a rat caecal inoculum did not change acetate, propionate and butyrate production. It must be mentioned, however, that catechins do not occur in plants in connection with sugars like other flavonoids (Hollman 2001). Therefore, green tea catechins are probably better absorbable in the small intestine and do not reach the caecum in quantity. Despite this, the green tea extract substantially decreased the amount of branched-SCFA in the caecum, due to diminishing the unfavourable process of peptide fermentation.

## Conclusions

Our results indicates that the addition of green tea extract to a high--fructose diet displayed a beneficial influence on blood parameters, and antioxidative properties therein, however, the extract had no essential effects both on small intestine and caecum disturbed by a high-fructose diet.

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# THE RADICAL SCAVENGING CAPACITY OF GREEN TEA

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Key words: catechins, green tea, radical scavenging activity, TEAC, total polyphenol content.

Abstract

The effect of pH on the radical scavenging activity of three different green tea aqueous extracts was investigated using the modified TEAC (trolox equivalent antioxidant capacity) assay. The results obtained show significant pH-dependent increase in the radical scavenging capacity of green tea and reveal that this effect occurs at pH range relevant for human body fluids or tissues. Furthermore, it is shown that the radical scavenging activity of green tea extracts differs among each other. The total antioxidant activity of tea extract can not be concluded based on the activity of catechins. The antioxidant properties of green tea depend mainly on the total polyphenol content.

## AKTYWNOŚĆ PRZECIWRODNIKOWA ZIELONEJ HERBATY

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Słowa kluczowe: katechiny, zielona herbata, aktywność przeciwrodnikowa, TEAC, całkowita zawartość polifenoli.

Abstrakt

Zbadano wpływ pH środowiska na aktywność przeciwrodnikową wodnych ekstraktów zielonej herbaty (badanie wykonano zmodyfikowaną metodą TEAC). Zaobserwowano, że wraz ze wzrostem pH środowiska, znacznie wzrasta aktywność przeciwrodnikowa ekstraktów zielonej herbaty. Efekt ten występuje w przedziale pH odpowiadającym pH ludzkich tkanek i płynów ustrojowych. Stwierdzono również różnice w aktywności przeciwrodnikowej badanych ekstraktów. Całkowita aktywność przeciwutleniająca ekstraktu zielonej herbaty nie może być oszacowana na podstawie aktywności poszczególnych katechin, gdyż zależy od całkowitej zawartości polifenoli w ekstrakcie.

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## Introduction

Tea is one of the most commonly consumed beverages worldwide which provide a significant amount of polyphenolic compounds in the human diet. Especially green tea contains a great number of flavonoids, among which catechins are the most abundant. The unique set of polyphenols in green tea contributes to the health benefits of this beverage (Rice-Evans et al. 1996). Drinking of green tea has been often inversely correlated to the initiation and progress of common chronic diseases such as cancer or cardiovascular diseases (Cooper et al. 2005a,b, Higdon, Frei 2003) and even neurodegenerative diseases like Parkinson's disease (Pan et al. 2003).

The broad range of biological properties of green tea is often ascribed to the antioxidant activity of catechins and other flavonoids which in fact are in much lower concentrations than catechins. Catechins may exert their antioxidant action directly as 1) scavengers of highly reactive oxygen and nitrogen species, 2) inhibitors of enzymes or 3) chelators of transition metal ions (Rice-Evans et al. 1996) or indirectly through 4) regeneration of $\alpha$-tocopherol, 5) stimulation of phase II and „antioxidant" enzymes and/or 6) inhibition of the redox-sensitive transcription factors such as nuclear factor $\kappa$B and activator protein AP-1 (Cooper et al. 2005a,b, Lambert & Yang 2003).

Since catechins, abundant in green tea, show strong pH-dependence of their radical scavenging activity (Muzolf, Tyrakowska 2006), it could be expected that also the radical scavenging activity of green tea depends on the pH of the surrounding medium. This possible pH-dependent effect on the radical scavenging ability of green tea is especially of interest since pH range of different human body fluids varies widely from pH 1 in the stomach through pH 5.3 in small intestine, pH 6.8 in mouth saliva, pH 7.4 in blood and tissue fluid, pH 8 in large intestine to pH 7–8.7 in pancreas and pH 8.3–9.3 in duodenum (Grzymisławski 2000).

Therefore, the objective of the present study was to investigate the effect of pH on the radical scavenging activity of various green tea aqueous extracts quantified by the TEAC value. Moreover, the influence of the total polyphenol and catechin contents on the radical scavenging capacity of green tea was investigated to obtain better insight in the factors determining the antioxidant activity of tea at physiological pH.

## Materials and Methods

### Tea extracts

Three different green teas (*A*, *B* and *C*) were purchased from local supermarket. Aqueous extracts were prepared by brewing 20 g of tea leaves in 300 $cm^3$ boiling demineralized water for 6 min as it is stated in PN-ISO 3130. Tea brews were filtered two times and lyophilized under vacuum.

### TEAC assay

Radical scavenging capacity of green tea aqueous extracts was determined by the modified TEAC (trolox equivalent antioxidant capacity) assay performed essentially as described previously (RICE-EVANS, MILLER 1994), with some modifications (TYRAKOWSKA et al. 1999) and expressed in the TEAC values. The major advantage of the modified TEAC assay is that it permits studying the radical scavenging activity over a wide pH range (2–9).

### Total polyphenol content

The total polyphenol content was determined according to the method of SINGLETON, ROSSI (1965) and expressed as mg of gallic acid equivalents (GAE) per 1 g of tea extract.

### Catechin content

The catechin determinations were performed using Waters high--performance liquid chromatograph equipped with a Waters Symmetry C18 column (150 x 3.9 mm, 5 μm) and a Waters μBondapack C18 guard column. Elution gradient of mobile phase composed of acetonitrile and 0.1% trifluoroacetic acid was used with a flow rate 1 $cm^3$ $min^{-1}$. The eluate was detected using a Waters 996 photodiode-array detector. Catechins were identified by comparing their UV spectra and retention times with those of corresponding standards and by the spiking of samples with appropriate standard. Quantification of catechins was done at 280 nm using the external standard method. The content of catechins was expressed in mg of appropriate catechin per 1 g of tea extract.

## Results and Discussion

Figure 1 presents the pH-dependent TEAC profiles of green tea aqueous extracts studied. For comparison, Figure 1 contains also pH-dependent TEAC profile of epigallocatechin gallate (EGCg) (TYRAKOWSKA et al. 2006) since it is one of the most abundant catechin in green tea (RICE-EVANS et al. 1996). From the plots presented it follows that the radical scavenging capacity of green tea extracts significantly increases with increasing pH of the medium. This effect occurs within pH range relevant for human body fluids. The pH-dependent increase in scavenging capacity of hydroxyflavones and anthocyanins was previously attributed to an effect on hydroxyl moiety deprotonation (LEMAŃSKA et al. 2001, BORKOWSKI et al. 2005). The catechins may

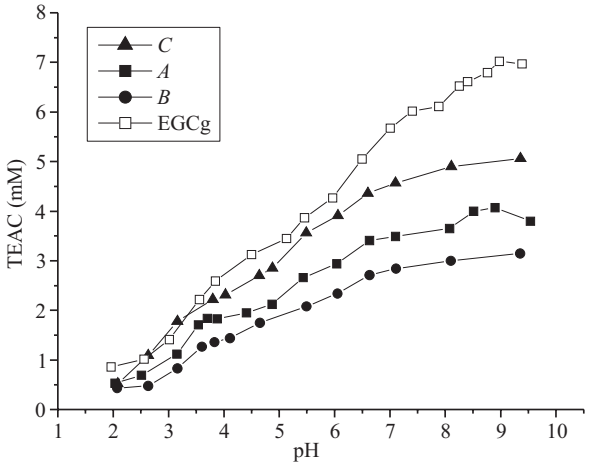


Fig. 1. pH-dependent radical scavenging capacity of green tea aqueous extracts (*A*, *B* and *C*) and EGCg as the model compound

behave in a similar way. However, further studies are needed to confirm this conclusion.

It also appears that the radical scavenging capacity of green tea extracts differs significantly among green teas studied. Extract *C* shows the highest radical scavenging activity over the whole pH range above 2.0, whereas the activity of extract *B* is about two times lower. Furthermore, the pH-dependent profile of extract *C* is very similar to that of EGCg within pH range from pH 2.0 to pH 6.0. Above pH 6.0 the radical scavenging capacity of extract *C* is lower than that of EGCg. Both *A* and *B* extracts show significantly lower radical scavenging capacity in comparison with that of EGCg over the whole pH range.

Total polyphenol and catechin contents of green tea extracts are shown in Table 1. From the data presented it follows that among all teas studied extract C contains the highest level of phenolic constituents, followed by *A* and *B* extracts (348.2, 276.5 and 220.4 mg of GAE per g, respectively). Our result showing the highest level of polyphenols (348.2 mg of GAE per g) for green tea extract C is in accordance with results reported by Gramza et al. (2006) and Satoh et al. (2005). In their works on antioxidant activity of a green tea they reported similar (to the extract *C*) level of total polyphenol content in a green tea to be 302.3 mg $g^{-1}$ and 312.5 mg $g^{-1}$, respectively. The level of total catechins also differs among green teas studied. The highest catechin content was determined in *C* and *A* extracts (152.1 mg $g^{-1}$ and 138.4 mg $g^{-1}$, respectively) and significantly lower one in extract *B* (74.8 mg $g^{-1}$). The most abundant catechin is EGCg which accounts for 64.5%, 61.8% and 46.5% for *A*, *B* and *C* extracts, respectively (Figure 2). Levels of other catechins: catechin (C), gallocatechin (GC), epicatechin (EC), epigallocatechin (EGC), gallocatechin gallate (GCg) and epicatechin gallate (ECg) vary significantly among green tea extracts studied.

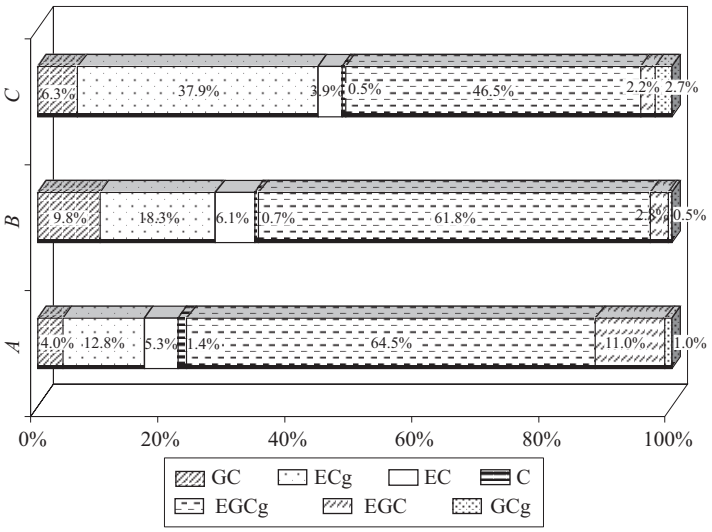


Fig. 2. Proportions of catechins (GC – gallocatechin, ECg – epicatechin gallate, EC – epicatechin, C – catechin, EGCg – epigallocatechin gallate, EGC – epigallocatechin) in green tea extracts (*A*, *B* and *C*) expressed as % of total catechin content

Total polyphenol and catechin contents correspond to the radical scavenging capacity of green tea extracts. The radical scavenging activity of green tea extracts and the level of phenolic constituents increase in the order: *B*<*A*<*C*.

In the previous study on pH-dependent radical scavenging capacity of catechins, EGCg and ECg showed the highest antioxidant activity over almost the whole pH range (TYRAKOWSKA et al. 2006, for ECg data not shown). Since EGCg is the most abundant in green tea extracts (Table 1) it could be expected that its radical scavenging activity would contribute, to the highest extent, to the antioxidant properties of green tea. However, green tea extract *C* showing the highest antioxidant activity over the whole

Table 1

Catechin and total polyphenol contents in green tea extracts

| | *A* | *B* | *C* |
|---|---|---|---|
| | mg $g^{-1}$ | | |
| C | 2.0±0.1 | 0.5±0.1 | 0.7±0.1 |
| GC | 5.5±0.5 | 7.3±0.3 | 9.6±0.8 |
| EC | 7.4±0.6 | 4.6±0.5 | 5.9±0.4 |
| EGC | 15.2±1.3 | 2.1±0.0 | 3.4 ± 0.2 |
| GCg | 1.4±0.3 | 0.4±0.1 | 4.1±0.3 |
| ECg | 17.7±0.5 | 13.7±0.6 | 57.6±1.7 |
| EGCg | 89.2±3.4 | 46.2 ± 2.3 | 70.8±5.0 |
| Total catechins | 138.4±4.6 | 74.8±3.7 | 152.1±6.5 |
| Total polyphenol content | 276.5±11.0 | 220.4±19.5 | 348.2±29.8 |

pH range has the lowest contribution of EGCg in total catechin content among all teas tested. Moreover, ECg, the second most active catechin, accounts for 57.6 mg $g^{-1}$ in green tea extract *C* what constitutes 37.9% of the total catechins in extract *C*. The content of ECg in *A* and *B* extracts constitutes only 12.8% and 18.3% of total catechins, respectively. The two most antioxidant active catechins, i.e. EGCg and ECg account, in each tea extract, for about 80% of total catechins. These results indicate that mean antioxidant activity of whole extract can not be concluded directly based on the activity of extract components. Quantitative correlation between total polyphenol content and TEAC values for various tea extracts and no correlation for individual catechins indicate that antioxidant properties of green tea depends mainly on the total polyphenol content. However, the exact contribution of selected catechins to the radical scavenging activity of green tea can not be unambiguously stated since synergistic or antagonistic interactions between phenolic constituents in tea may occur.

## Conclusions

The radical scavenging activity of green tea extracts increases with increasing pH value of the surrounding medium. These pH-dependent changes in the radical scavenging capacity of green tea may be of biological relevance since upon consumption and passing the acidic pH of the stomach, pH of the gastrointestinal tract and biological tissues may enhance significantly the radical scavenging capacity of green tea catechins. The results obtained indicate also that the total antioxidant activity of tea extract can not be concluded based on the activity of catechins. The antioxidant properties of green tea depend mainly on their total polyphenol content.

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# EFFECT OF USING HERBS IN PIG DIETS ON GROWTH PARAMETERS, CARCASS TRAITS AND DIETETIC VALUE OF PORK

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K e y  w o r d s: pigs, herbs, productivity, pork dietetic value.

A b s t r a c t

The aim of the study was to determine the effect of different levels of herbs supplemented to diets on the growth, composition and quality of carcasses in growing--finishing pigs, the level of total cholesterol and composition of fatty acids in loin meat samples. A total of 72 pigs were assigned to 3 groups differing in the amount of dietary herb supplement: group I (control) – 0; group II – 1; group III – 2% of the ration. The 16-week experimental fattening was followed by slaughter and slaughter analysis of 36 carcasses. The level of total cholesterol and the profile of higher fatty acids were determined in loin meat samples. The dietary herb supplement used had a positive effect on some productive traits of pigs and carcass muscling (meat of ham and loin). The dietary herb supplement had a positive effect on the dietetic value of pork obtained. Loin meat samples contained less total cholesterol and were characterized by a slightly higher level of unsaturated fatty acids (*n*-6 and *n*-3 PUFA) compared to the control group. The best results in this respect were obtained when the 2% dietary herb supplement was used.

## WPŁYW STOSOWANIA ZIÓŁ W PASZY DLA ŚWIŃ NA PARAMERTY WZROSTU, CECHY RZEŹNE ORAZ WARTOŚĆ DIETETYCZNĄ WIEPRZOWINY

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S ł o w a  k l u c z o w e: świnie rosnące, zioła, produkcyjność, wartość dietetyczna.

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A b s t r a k t

Celem badań było określenie wpływu różnego poziomu dodatku do paszy mieszanki ziołowej na wzrost, skład i jakość tuszy świń rosnących oraz poziom cholesterolu całkowitego i skład kwasów tłuszczowych w próbkach mięsa polędwicy. Doświadczenie przeprowadzono na 72 świniach, które przydzielono do 3 grup różniących się ilością podanego w paszy dodatku mieszanki ziołowej: I grupa (kontrolna) – 0; II grupa – 1% i III grupa – 2% dawki pokarmowej. Tucz doświadczalny prowadzono przez 16 tygodni, zakończono go ubojem i oceną rzeźną 36 tusz. Określano poziom cholesterolu całkowitego oraz profil wyższych kwasów tłuszczowych w próbkach mięsa polędwicy. Stwierdzono, że zastosowany w dawce pokarmowej dodatek ziół wpłynął korzystnie na niektóre cechy produkcyjne tuczników i umięśnienie tusz (mięso szynki i polędwicy). Obserwowano pozytywne efekty wprowadzonego dodatku ziół do paszy tuczników na wartość dietetyczną pozyskanej wieprzowiny. Próbki mięsa polędwicy zawierały mniej cholesterolu całkowitego i cechował je nieco wyższy poziom nienasyconych kwasów tłuszczowych z grupy PUFA – 6 i PUFA – 3, niż w grupie kontrolnej. Najlepsze efekty w tym zakresie uzyskano, stosując 2-procentowy dodatek ziół do dawek pokarmowych tuczników.

## Introduction

It is generally known that herbs are highly useful in human and veterinary medicine. In addition to their taste value, herbs play an important role in metabolic regulation. By acting on the immune system, they inhibit bacterial and viral infections (Cho et al. 2006). It is also suggested that biologically active substances found in herbs (secondary metabolites) show similar action to steroidal ergotropics but do not have their unfavourable properties.

The increased interest of consumers in health food of high dietetic value has encouraged scientists to investigate the use of herb mixtures, appropriately selected in terms of botanical composition, in animal nutrition. This is evidenced by experiments conducted over the last decade, when herb supplements were added to the diets of different animal species such as poultry, pigs and cows (Grela 2000, Kraszewski et al. 2002, Allan, Bilkei 2005). It is thought that a proper composition of herbs that accounts for biologically active substances can affect pig performance. In addition to botanical composition, an important role can be played by the dietary level of herb supplements (Krusiński 2004). Another reason for increased interest in dietary herb mixtures is the unconditional ban on the use of growth stimulants in the form of antibiotic feed additives in pig nutrition (Varley 2004, Stahl 2005).

The present study was aimed at determining the effect of using different levels of dietary herb supplements on the growth, composition and quality of carcasses in growing pigs, the level of total cholesterol and composition of fatty acids in loin meat samples.

## Material and Methods

A total of 72 growing pigs were investigated at the Experimental Station of the National Research Institute of Animal Production (NRIAP). Animals selected based on the analogue principle according to sex (50% gilts, 50% barrows) and physical condition were assigned at 25 kg body weight to three groups with 24 animals per group. Groups differed according to the amount of herb mixture used: group I (control) – 0; group II – 1 and group III – 2% of the ration. The composition of the herb mixture is given in Table 1. Pigs of all the groups were fed the same concentrate mixture containing 12.4 MJ ME and 171 g crude protein per kg.

Table 1

Composition of herb mixture (%)

| Item | Proportion |
|---|---|
| Peppermint Herba *Menthae piperita* | 20 |
| Chamonile Herba *Matricaria chamomillae* | 20 |
| Thyme Herba *Thymus vulgaris* | 5 |
| Coriander fruit *Fructus Coriandri* | 10 |
| Caraway fruit *Fructus Carvi* | 9 |
| Couch grass rhizoma *Rhizoma Agropyri* | 5 |
| Savory *Herba Satureia* | 15 |
| Milk thistle endosperm *Fructus Sylibum Marianu*m | 15 |
| Garlic bulb *Bulbus Allii Sativi* | 1 |

Automatic feeders were used in accordance with the passage of time and proper pig feeding standards. The 16-week experimental fattening was followed by a slaughter of 36 pigs (18 gilts and 18 barrows). The slaughter traits of the slaughtered pigs were analysed in accordance with the methods used at NRIAP Pig Testing Stations. During dissection, meat loin samples from the *m. longissimus* were taken near the $14^{th}$ rib to determine total cholesterol and the profile of higher fatty acids. Cholesterol in the loin samples was determined by the colourimetric method, using a colour reaction with 10% $FeCl_3$ solution (in acetic acid), diluted with sulphuric acid. Higher fatty acids in the homogenized samples were analysed using gas chromatography and acids in the form of methyl esters were determined. The fatty acid methyl esters produced were determined in hexane extracts using a Varian 3400 gas chromatograph with a column filled with acid-modified polyethylene glycol, an 8200 CX autosampler and computer data processing software.

The numerical data obtained were analysed statistically using one-way analysis of variance (effect of "group") using the SAS packet (SAS/STAT. 1989). In addition to arithmetic means, standard error of the mean (SEM) was calculated. Differences between the groups were determined using Duncan's multiple range test.

## Results and Discussion

The results obtained confirmed that dietary herb supplements are useful in pig fattening. The dietary herb mixture had a beneficial effect on growth of pigs and on the quantity and quality of pork obtained (Table 2). The addition of the herb mixture to the diet caused a clear improvement in weight gains of pigs from experimental groups, which had higher average daily gains compared to the control group, by over 2% compared to pigs from group II and by almost 6% compared to pigs from group III (significant differences between the control group and group III, $P \leq 0.05$). Similar tendencies occurred in our earlier studies (PASCHMA 2000) and in experiments of other authors (GRELA 2000, FALKOWSKI et al. 2004).

Table 2

Daily gains, feed conversion and selected slaughter traits in pigs (arithmetic means)

| Item | Groups | | | SEM |
|---|---|---|---|---|
| | I control | II 1% herbs | III 2% herbs | |
| No. of pigs | 24 | 24 | 24 | |
| Average daily gains (g) | $717^{a}$ | $738^{ab}$ | $756^{b}$ | 8.60 |
| Feed conversion (kg/1 kg of body gain) | 3.05 | 3.09 | 3.08 | 0.10 |
| No. of carcasses | 12 | 12 | 12 | |
| Slaughter weight (kg) | 101.0 | 101.0 | 102.3 | 4.03 |
| Dressing percentage (%) | 77.8 | 78.1 | 78.0 | 1.51 |
| Loin eye area ($cm^2$) | 43.50 | 45.84 | 47.12 | 4.77 |
| Weight of loin meat (kg) | 5.18 | 5.42 | 5.62 | 0.38 |
| Weight of ham (kg) | 8.02 | 8.05 | 8.32 | 0.41 |
| Weight of ham meat (kg) | 6.38 | 6.44 | 6.77 | 0.47 |
| Weight of belly with ribs (kg) | 7.09 | 6.96 | 7.18 | 0.21 |
| Weight of leg (kg) | 1.34 | 1.32 | 1.34 | 0.17 |
| Backfat thickness over shoulder (cm) | 2.63 | 2.78 | 2.81 | 0.39 |
| Backfat thickness at point C (cm) | 1.22 | 1.06 | 1.06 | 0.21 |
| Carcass length (cm) | 79.9 | 80.4 | 82.1 | 3.88 |

*a*, *b* – means marked by different letter differ significantly ($P \leq 0.05$)

The addition of herbs to the pig diets improved the culinary value of pork obtained. The carcasses of pigs from experimental groups were better muscled compared to those from the control group. This particularly concerned the weight of loin, loin eye area and weight of ham meat (Table 2). These results were confirmed by earlier studies in which lower fatness and greater carcass muscling were observed in pigs receiving dietary herbs (URBAŃCZYK et al. 1996, GRELA 2000, PASCHMA 2000).

The composition of meat lipid fatty acids given in Table 3 can be evidence of beneficial changes in the dietetic value of pork from the experimental groups. It is known that the presence of essential unsaturated fatty acids, especially *n-6* and *n-3* PUFA, is particularly important for a balanced human diet because they cannot be synthesized in the human body (KULASEK, BARTNIKOWSKA 1994, BAROWICZ 1997). The herb mixture used in this study had

Table 3

Groups of fatty acids (% of total fatty acids) and cholesterol content of loin muscle tissue

| Item | Groups | | | SEM |
|---|---|---|---|---|
| | I control | II 1% herbs | III 2% herbs | |
| No. of samples | 12 | 12 | 12 | |
| SFA | 43.66 | 43.52 | 43.39 | 0.611 |
| UFA | 56.34 | 56.48 | 56.61 | 0.588 |
| MUFA | 45.97 | 45.73 | 43.10 | 0.632 |
| PUFA | 10.64 | 10.87 | 13.12 | 0.596 |
| *n*-6 PUFA | 9.83 | 9.94 | 12.16 | 0.562 |
| *n*-3 PUFA | 0.69 | 0.77 | 0.85 | 0.040 |
| DFA | 66.70 | 67.19 | 66.70 | 0.329 |
| OFA | 33.30 | 32.81 | 33.30 | 0.329 |
| UFA/SFA | 1.31 | 1.31 | 1.29 | 0.019 |
| CLA | 0.106 | 0.110 | 0.118 | 0.009 |
| Total cholesterol (mg 100 $g^{-1}$) | 62.29 | 61.15 | 59.77 | 1.748 |

a positive effect on the proportion of *n-6* and *n-3* PUFA in loin samples. A similar effect was obtained by GRELA (2000).

Analysis of the dietetic value of meat from the groups studied shows that the level of undesirable hypercholesterolemic acids (OFA) responsible for atherosclerotic changes in blood vessels, and the level of desirable hypocholesterolemic acids (DFA) were, in principle, equalized, although there was a tendency showing that herbs have a positive effect on the dietetic value of pork obtained. When the level of OFA in loin samples from group II with 1% herb supplement decreased slightly, the level of DFA increased, compared to the control group, although a similar tendency was not found in group III. Likewise, the concentration of conjugated linoleic acd (CLA) in loin increased when dietary herbs were supplemented. It is known that CLA has many valuable dietetic and curative properties (CHIN et al. 1992, BELURY, KEMPA-STECZKO 1997). In model studies with laboratory animals, it was found that CLA can prevent the development of cancer and reduce the level of low-density lipoprotein (LDL) cholesterol (DECKER 1995).

The observed tendency towards lower level of total cholesterol in the loin muscles of experimental pigs confirms the positive effect of the dietary herb supplement on the culinary and dietetic value of pork obtained. It turned out that appropriately selected herbs in the mixture had a fairly efficient effect on dietetically important meat traits and on the increment in meat weight. The varied botanical composition of the dietary herb mixture and its fairly high content of components such as peppermint, chamomile, milk thistle and savory must have had an influence on growth rate by a favourable effect on the digestive processes.

It is concluded that the herb mixture used in pig diets had a positive effect on growth rate and slaughter traits. The addition of a 2% herb supplement to the diet increased average daily gains by almost 6% and a 1% herb supplement to the diet increased weight gains by approximately 2%.

The herb supplement had a favourable effect on the culinary and dietetic value of meat. Carcasses of pigs from the experimental groups were better muscled and their loin meat samples contained less total cholesterol and were characterized by a slightly higher level of unsaturated fatty acids (*n-6* and *n-3* PUFA). Of all the parameters analysed, the best results were obtained when a 2% herb supplement was added to the pig diets.

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# ANTIOXIDANT ACTIVITY OF METHYLATED FLAVONOIDS IN HYDROPHILIC AND LIPOPHILIC SYSTEMS

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K e y w o r d s: flavonoids, O-methylated flavonoids, FRAP, lipid peroxidation inhibition.

A b s t r a c t

Antioxidant properties of selected flavonols and flavones, and their metabolites in the form of *O*-methylated derivatives, were investigated in both lipophilic and hydrophilic (aqueous) systems. The antioxidant capacity observed in an aqueous phase, quantified by FRAP assay, and in a lipid phase, which was observed in the LPO-inhibition assay, were compared to theoretically calculated parameters for electron donation and hydrogen atom donation. Analysis of the experimental results obtained in this study leads to conclusion that the *O*-methylation lowers the antioxidant activity of flavonols to a significantly lower extent in the lipophilic phase than in a hydrophilic phase. In contrast, the reducing effect of *O*-methylation on the antioxidant activity of flavones studied was found to be much stronger in lipophilic phase.

## AKTYWNOŚĆ PRZECIWUTLENIAJĄCA METYLOWANYCH FLAWONOIDÓW W ŚRODOWISKU HYDRO- I LIPOFILOWYM

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S ł o w a k l u c z o w e: flawonoidy, O-metylowane flawonoidy, FRAP, inhibicja utleniania lipidów.

A b s t r a k t

Dla wybranych flawonoli i flawonów oraz ich *O*-metylowanych metabolitów zmierzono aktywność przeciwutleniającą w fazie lipofilowej i lipofobowej (wodnej). Wartości aktywności przeciwutleniającej, zmierzonej w fazie wodnej metodą FRAP oraz w fazie lipofilowej – metodą inhibicji utleniania tłuszczów, zostały porównane z teoretycznie obliczonymi

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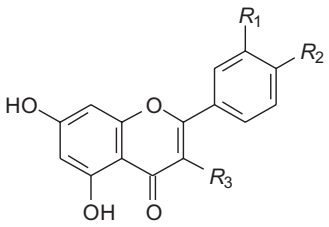
parametrami charakteryzującymi łatwość oddawania elektronu lub atomu wodoru przez cząsteczkę. Analiza otrzymanych wyników wskazuje, że *O*-metylacja grup OH w cząsteczkach flawonoli w większym stopniu obniża ich aktywność przeciwutleniającą w fazie wodnej niż w fazie lipofilowej. W przeciwieństwie do flawonoli, *O*-metylacja grup OH w cząsteczkach flawonów w większym stopniu wpływa na obniżenie ich aktywności przeciwutleniającej w fazie lipofilowej.

## Introduction

Flavonoids, important group of natural antioxidants, are an integral part of the human diet as they occur ubiquitously in food of plant origin. There is overwhelming evidence indicating that natural antioxidants as flavonoids play a role in wellness, health maintenance and prevention of chronic diseases like cardiovascular diseases and mostly types of cancer. Results of *in vitro* investigations strongly suggest that such protective effects are due to the antioxidant properties of flavonoids, manifested by their ability to scavenge free radicals and also to inhibit lipid peroxidation in plasma low-density lipoproteins (Hertog 1995, Rice-Evans 1996, Ozgocva 2006).

Therefore, it is important to find out which factors are responsible for the antioxidant efficiency of flavonoids both in aqueous and lipid cell's environment and how they can be controlled. For antioxidant activity of flavonoids it is known, that very important are specific elements of their structure, number of hydroxyl groups, their deprotonation ability, and pH of surrounding medium as well as hydrogen atom donating abilities to achieve an efficient antioxidant action (Bors 1990, Rice-Evans 1996, Lemańska 2001, Hejnen 2002). The antioxidant efficiency of flavonoids can be also modulated *in vivo* due to metabolism (Wiliamson 2000, Crespy 2003, Rufer 2006). The *O*-methylation of the catechol group in the molecule by catechol *O*-methyl transferase is one of the important metabolic pathways of flavonoids (Lemańska 2004).

The aim of this study was to determine and compare the antioxidant activity of common dietary flavonoids to the antioxidant activity of their metabolites represented by *O*-methylated derivatives of these flavonoids (Figure 1.)




| | $R_1$ | $R_2$ | $R_3$ |
|---|---|---|---|
| quercetin | OH | OH | OH |
| 3′-*O*Me-quercetin | $OCH_3$ | OH | OH |
| kaempferol | H | OH | OH |
| 4′-*O*Me-quercetin | OH | $OCH_3$ | OH |
| luteolin | OH | OH | H |
| 3′-OMe-luteolin | $OCH_3$ | OH | H |
| apigenin | H | OH | H |
| 4′-*O*Me-luteolin | OH | $OCH_3$ | H |
| 3′,5,7-trihydroksyflavone | OH | H | H |

Fig. 1. Structures of flavonols and flavones studied

The antioxidant activity was measured in both the hydrophilic and lipophilic systems and the results obtained were discussed in terms of theoretically calculated parameters predicting an electron and/or hydrogen atom donation ability of studied compounds.

## Materials and Methods

**Materials***:* Isorhamnetin (3′-*O*Me-quercetin); tamarixetin (4′-*O*Me-quercetin); chryzoeriol (3′-*O*Me-luteolin), diosmetin (4′-*O*Me-luteolin) were purchased from Indofine Chemical (Somerville, NJ, USA). Quercetin, luteolin, kaempferol and apigenin, Trolox (a water-soluble analog of vitamin E) was obtained from Fluka (Buchs, Switzerland). 3′,5,7-Trihydroxyflavone (3′,5,7--triOHflavone) was synthesised according to the method of Gaydou and Bianchini (Gaydou, Bianchini 1977). Ascorbic acid, $FeSO_4$, 2,4,6-tripyridyl-s--triazine (TPTZ), thiobarbituric acid (TBA) and 2,6-di tert-butyl-4-methylphenol (BHT), were purchased from Aldrich (Steinheim, Germany). Trichloroacetic acid, DMSO, HCl and TRIS were purchased form Merck (Darmstadt, Germany).

**Ferric reducing antioxidant power (FRAP) assay**: It was carried out by the method of Benzie and Strain (Benzie 1999) with minor modification. The method is based on the reduction of a ferric 2,4,6-tripyridyl--s-triazine complex ($Fe^{3+}$ – TPTZ) to the ferrous form ($Fe^{2+}$ – TPTZ). Flavonoids were added as 1% (v/v) solutions of 100 times concentrated stock solutions to 10 mM ferric-TPTZ reagent and increase in absorbance at 593 nm was measured at 8 min. Trolox was used as a standard. The concentrations of flavonoids and Trolox were chosen to give an absorbance not higher than 1. The FRAP value represents the ratio between the slope of the plot for reducing $Fe^{3+}$-TPTZ reagent by the flavonoid under investigation, compared to the slope of this plot for reducing $Fe^{3+}$-TPTZ by Trolox used as the antioxidant standard.

**Lipid peroxidation assay**: $Fe^{+2}$-AA-microsomal system lipid peroxidation was assayed by measuring thiobarbituric acid reactive substances (TBARS) according to Acker et al. (Acker van 1996). The absorbance of reaction mixture at 535 nm versus 600 nm was determined spectrophotometicaly. The absorbance of the $t = 0$ samples at 535 nm vs. 600 nm was subtracted from the absorbance at $t = 1$ h. The absorbance in $t = 0$ expressed the 0% inhibition of peroxidation of microsomes in the presence of iron/ascorbic acid. The $IC_{50}$ was determined with heat-inactivated microsomes by measuring the percentage of LPO-inhibition at several concentrations of flavonoid and calculating the concentration of flavonoid at which 50% inhibition was obtained.

**Theoretical mechanical calculations***:* All geometries of molecules studied were optimized with the B3LYP hybrid density functional theory (DFT) by using a 6-31G(d) basis set as implemented in the Gaussian 98

computational package (Gaussian Inc., Pittsburgh, PA, USA). Single-point energies were then evaluated by using a higher 6-311G(d,p) basis set. The calculated ionization potentials (IP) and bond dissociation energies (BDE) were not corrected for zero–point–energy assuming a negligible error. The BDE for homolytic O-H bond cleavage in the neutral flavonoid (BDE(N)) was calculated as the energy of the radical resulting from the hydrogen atom abstraction minus the energy of the neutral molecule. The IP for the neutral flavonoid (IP(N)) was calculated as the energy of the radical cation resulting from the electron abstraction minus the energy of the neutral parent molecule.

## Results and Discussion

The antioxidant activity of flavonoids as well as their *O*-methylated derivatives in the hydrophilic system (FRAP values) and in lipophilic phase ($IC_{50}$ values) are presented in Table 1. For comparison, the OH bond dissociation energies (BDE(N)) and ionization potentials (IP(N)) of the studied flavonoids in neutral (N) form are given.

For the flavonoids studied the antioxidant activity was also measured using aqueous phase TEAC assay (Lemańska 2004). The FRAP values reported in this work were found to be highly correlated with the TEAC values.

From the results obtained it follows that the most active radical scavenger in an aqueous phase is quercetin. Its relatively high antioxidant

Table 1

Experimental FRAP values and the $IC_{50}$ values of flavonoids and their *O*-methylated derivatives. For comparison theoretical parameters are shown: ionisation potentials (IP(N)) and bond dissociation energies (BDE(N)) for the neutral (N) forms of flavonoids

| | Antioxidant activity in hydrophilic phase | Inhibition of lipid peroxidation | Theoretical parameters | |
|---|---|---|---|---|
| | FRAP value | $IC_{50}$ (μM) | BDE (N)[a,b] (kcal/mol) | IP (N)[a] (eV) |
| Quercetin | 2.6±0.3 | 8.2±1.6 | 78.6(4′)[c] | 7.03 |
| Isorhamnetin | 1.4±0.2 | 4.7±0.4 | 86.9(3) | 6.93 |
| Tamarixetin | 1.5±0.0 | 7.6±0.5 | 86.8(3) | 6.92 |
| Luteolin | 1.2±0.2 | 13.0±0.8 | 80.4(4′) | 7.42 |
| Diosmetin | 0.1±0.0 | 99.1±5.2 | 88.0(4′) | 7.35 |
| Chrysoeriol | 0.6±0.1 | 87.6±5.2 | 89.0(3′) | 7.36 |
| Kampferol | 1.3±0.2 | 4.5±0.3 | 86.8(4′) | 7.08 |
| Apigenin | 0.1±0.0 | 130.6±3.9 | 89.5(4′) | 7.52 |
| 3′,5,7-tri-OH-flavone | 0.0±0.0 | 100.9±1.8 | 91.6(7) | 7.67 |

[a] (Lemańska 2004);
[b] the BDE(N) parameters refer to the weakest phenolic OH bonds;
[c] the numbers between brackets refer to the position of OH moiety in molecule

activity (FRAP = 2.6) may be related to the fact that quercetin molecule involves all important for antioxidant activity structural elements postulated by BORS (1990): the B-ring catechol group, 2,3-double bond conjugated with 4-oxo function and C3- and C5-hydroxy group, which may act as radical scavenging units contributing to the total antioxidant activity. The observed antioxidant activity of luteolin, kaempferol, apigenin and 3′,5,7-trihydroxyflavone in hydrophilic environment is markedly reduced in comparison to that of quercetin. The obtained FRAP values for these flavonoids give a support to the conclusion that removing of the one of structural element in quercetin molecule (catechol group in B ring or/and C3-OH group in C ring) significantly decreases its radical scavenging activity in an aqueous phase. Our results are consistent with earlier publications (LEMAŃSKA 2001, FIRUZI 2005). *O*-Methylation of the C4′-OH or C3′-OH position in the quercetin (giving isorhamnetin and tamarixetin, respectively) and luteolin (giving diosmetin and chrysoeriol, respectively) decreases their FRAP values (Table 1). The same effect was observed in the TEAC assay (LEMAŃSKA 2004). This is in agreement with suggestions of some other authors (BORS 1990, RICE-EVANS 1996) that for optimal antioxidant activity a functional catechol moiety with both 3′-OH and 4'-OH in their non conjugated form is of great importance.

From analysis of $IC_{50}$ values, presented in Table 1, it can be concluded that flavonoids containing the catechol moiety in the B ring and/or the hydroxyl group at C3 position are good inhibitors of microsomal lipid peroxidation. Our results are in agreement with results of van Acker (ACKER VAN 1996), which were obtained in non-enzymatic LPO-assay. The antioxidant activity reflected by the $IC_{50}$ values of quercetin, isorhamnetin, tamarixetin and kaempferol are in the same order of magnitude ($IC_{50}$<10 μM). It should be noticed that these results indicate that in a lipid phase *O*-methylation of catechol group affects the lipid peroxidation inhibiting properties of quercetin to a significantly lower extent than in a water phase.

In luteolin, a flavone without C3-OH group, the lipid peroxidation inhibiting antioxidant activity is reduced ($IC_{50}$ value is >10 μM). It can be assumed that the absence of this structural element eliminates to some extend the relative contribution of the iron chelating properties of luteolin in the LPO-inhibiting antioxidant activity.

In diosmetin and chrysoeriol – the *O*-metylated derivatives of luteolin as well as in apigenin and 3′,5,7-trihydroxyflavone the significant reduction in lipid peroxidation inhibiting properties ($IC_{50}$ values about 100 μM) (Table 1) is probably caused by the absence of both catechol moiety in the B ring and of C3-OH in the molecule.

In contrast to quercetin molecule, *O*-methylation of the C4′-OH and C3′-OH position in the luteolin molecule results in strong decrease its LPO-inhibiting activity. Possible explanation for this unexpected high LPO inhibiting activity of methylated quercetin is that iron chelation might have significant contribution in the LPO inhibition by 3′-*O*- and 4′-*O*-methylated metabolites of quercetin possibly by site-specific scavenging (ACKER VAN

1996). In other words, if the chelated by the flavonol $Fe^{+2}$ ion is still catalytically active, then the radicals are formed in the vicinity of the flavonoid and can be scavenged immediately. In such case the flavonol would have a double, synergistic function, which would make it an extremely powerful antioxidant. There is a growing body of evidence suggesting that the antioxidant activity of certain flavonoids may be originated from their metal chelating activity and radical scavenging activity (HAENEN 1993, ENGELMANN 2005). From results obtained in our work it also follows that the reducing effect of *O*-methylation on the antioxidant activity of luteolin in a lipophilic system is similar to the effect observed in the water system (Table 1). Probably in both systems luteolin, diosmetin and chrysoeriol act mainly as radical scavengers and contribution of their iron chelating properties to total antioxidant action is negligible.

To obtain better insight in the possible mechanism of the radical scavenging antioxidant activity of studied flavonoids in hydrophilic and lipophilic systems, the FRAP values and $IC_{50}$ values were compared to the

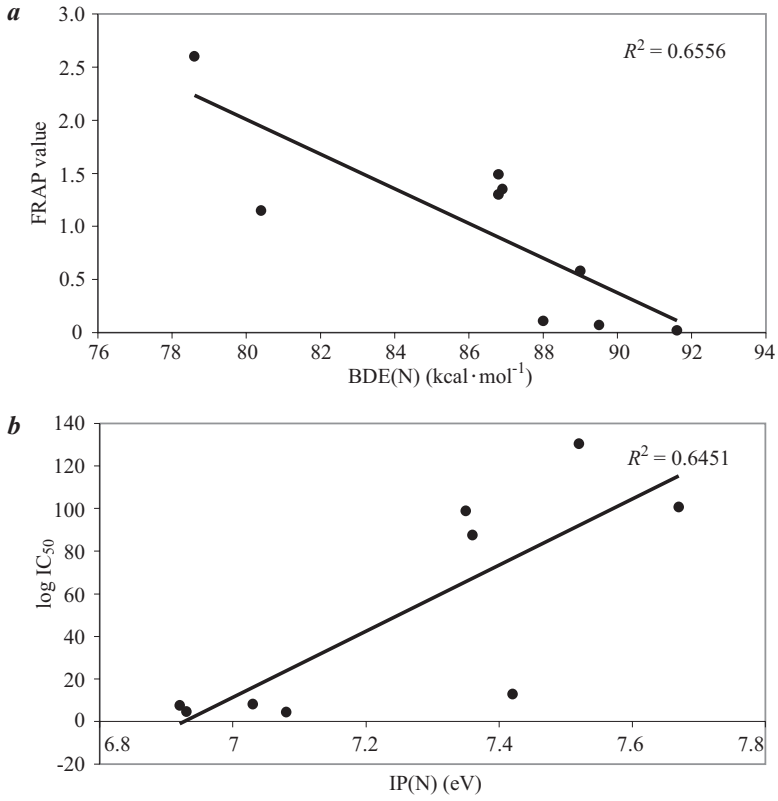



Fig. 2. Correlation between observed antioxidant activity *a* – in hydrophilic system, expressed as FRAP values and calculated OH bond dissociation energies and *b* – in lipophilic system, expressed in logarithmic scale as $IC_{50}$ and calculated ionization potentials IP(N) (eV)

theoretically calculated parameters (Table 1). The general tendency is that *O*-methylation of the OH group at the C4′ or C3′ positions in a flavonoid molecule increases the BDE(N) value of adjacent OH group in comparison to the corresponding BDE(N) value calculated for the non-methylated parent molecule. It was found the qualitative correlation ($R^2 = 0.655$) from comparison of FRAP values and bond dissociation energies (BDE)(N) (Figure 2 a). This would provide an explanation, why isorhamnetin, tamarixetin, diosmetin and chrysoeriol are less effective radical scavengers (reflected in relatively lower FRAP values) than quercetin and luteolin, respectively. BDE(N) parameter is reflecting the ease of H atom donation by the flavonoid and it is expected to be leading mechanism of antioxidant action, especially in the lipid phase (Acker van 1996, Ozgova 2006). From comparison of OH bond dissociation energy to $IC_{50}$ values (Table 1) it can be concluded that good LPO inhibitors have lower BDE values whereas less effective LPO inhibitors have higher BDE values.

From comparison of calculated IP(N) to the experimental $IC_{50}$ values the qualitative correlation ($R^2 = 0.645$) can be observed (Figure 2b). Good LPO inhibitors (quercetin, isorhamnetin, tamarixetin, kaempferol) are characterized by lower IP(N) values, whereas moderate LPO inhibitors (diosmetin, chrysoeriol, apigenin and 3′,5,7-triOH) are characterized by higher IP(N) values. Our results are supported by the fact that half peak oxidation potentials of the most of flavonoids correlate with LPO inhibition data (van Acker 1996, Hejnen 2002). It was shown that log $IC_{50}$ values of the $Fe^{+2}$/ascorbate induced lipid peroxidation of flavonoids studied decreased with decreasing their Ep/2 values.

However, from comparison of the $IC_{50}$ values to IP(N) or BDE(N) values it can be derived that neither BDE(N) nor the IP(N), as single variable, provide good parameter for description of quantitative structure antioxidant activity relationship for the antioxidant action of the studied compounds in the lipophilic system. This may be partly explained by the fact that inhibition of lipid peroxidation by flavonoids is a combined effect of radical scavenging and iron chelating properties.

## Conclusions

Variation in structural elements in a flavonoid molecule influences its antioxidant activity observed in both hydrophilic and lipophilic systems. The obtained experimental results show that *O*-methylation of flavonols influences in lesser degree their antioxidant activity in both systems than *O*-methylation of flavones. Altogether the results presented in this work point out the importance of not only chemical structure but also character of reaction medium as well as physico-chemical properties of a molecule (chelating properties, lipophilicity, deprotonation states) when considering factors influencing total antioxidant capacity of flavonoids.

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# CHANGES IN FLAVONOID CONTENTS IN RED KIDNEY BEANS UNDER THE INFLUENCE OF DIFFERENT HYDROTHERMAL PROCESSING METHODS

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K e y  w o r d s: coloured bean, autoclaving, boiling, extrusion, flavonoids.

A b s t r a c t

Changes were analyzed in contents of selected flavonoids in Red Kidney, a Polish kidney bean cultivar *(Phaseolus vulgaris* L.), during its processing to instant flour using autoclaving, boiling and extrusion.

Contents of quercetin, luteolin and kaempferol in dry seeds and after successive stages of their technological processing were determined using HPLC.

A considerable, 60% reduction was found in contents of quercetin and kaempferol in flour produced by autoclaving and boiling of beans and a slight increase of luteolin content. In the process of extrusion much smaller losses were observed in all analyzed flavonoids, amounting for quercetin, kempferol and luteolin to approx. 21, 25 and 30%, respectively.

Technological processing using extrusion seems to be the most advantageous for the preservation of flavonoids in flour.

## ZMIANY ZAWARTOŚCI FLAWONOIDÓW W FASOLI KOLOROWEJ RED KIDNEY POD WPŁYWEM RÓŻNYCH FORM OBRÓBKI HYDROTERMICZNEJ

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S ł o w a  k l u c z o w e: fasola kolorowa, parowanie pod ciśnieniem, gotowanie, ekstruzja, flawonoidy.

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A b s t r a k t

Badano zmiany zawartości wybranych flawonoidów w krajowej odmianie fasoli kolorowej (*Phaseolus vulgaris* L.) Red Kidney podczas jej przetwarzania na mąkę instant metodami parowania pod ciśnieniem, gotowania i ekstruzji.

W suchych nasionach i po kolejnych etapach ich obróbki technologicznej oznaczano zawartość kwercetyny, luteoliny i kempferolu metodą HPLC.

Stwierdzono znaczne, sięgające 60% obniżenie zawartości kwercetyny i kempferolu w mące uzyskanej metodami parowania i gotowania fasoli i niewielki wzrost poziomu zawartości luteoliny. W procesie ekstruzji obserwowano znacznie mniejsze straty wszystkich badanych flawonoidów wynoszące odpowiednio dla kwercetyny, kempferolu i luteoliny około 21, 25 i 30%.

Najkorzystniejsza dla zachowania flawonoidów w mące wydaje się obróbka technologiczna fasoli metodą ekstruzji.

## Introduction

Flavonoids belong to polyphenols – secondary plant metabolites, exhibiting antioxidant properties, significant in the prevention of cancer and cardiovascular diseases (Hollman et al. 1996, Czeczot 2000). Their rich sources are vegetables (onions, broccoli, tomatoes), fruit (citrus, blueberries, red grapes), tea and red wine (Hertog et al. 1992, Koo, Suhaila 2001). These compounds are also found in seeds of legumes. Quercetin, kaempferol and luteolin, as well as tannins found mainly in seed coats dominate (Troszyńska et al. 1997, Beninger, Hosfield 2003, Dinelli et al. 2006).

In contrast to most vegetables, dry legume seeds require hydrothermal processing to obtain a product for consumption. Such drastic procedures as sterilization, extrusion or long boiling usually result in a considerable reduction in the levels of flavonoids contained in seeds (Alonso et al. 2000a,b, Diaz--Batalla et al. 2006, Thudnatkorn, Rui 2004).

There are very few studies assessing flavonoid contents in Polish legume seeds – dry and processed, and they pertain mainly to investigations concerning their seed coats (Troszyńska et al. 1997, Drużyńska, Klepacka 2005).

The aim of the study was to investigate changes in contents of quercetin, luteolin and kaempferol in coloured bean Red Kidney, during its processing to flour with application of autoclaving, boiling and extrusion.

## Materials and Methods

Experimental material consisted of seeds of a native coloured bean Red Kidney purchased in a retail chain store. Raw material lots came from cultivations of 2004 and 2005.

Dry seeds of Red Kidney bean were processed to instant flour, using autoclaving, boiling and extrusion. The first two ways of seed technological

processing included: soaking (2 kg samples of the raw material covered with 3-fold volume of boiling water and left for 2.5 h at room temperature), thermal processing using autoclaving (discharged soaking water, laboratory autoclave, pressure 0.1 MPa, time 45 min) or boiling (in water in which beans had been soaked, time 1 h), comminution (a chopper), fluidization drying (temperature 60°C, time 30 min) and milling (flour particle size = 0.3 mm). Processing using extrusion, included comminution of dry seeds (particle size of 4-5 mm), their wetting with water to approx. 20% and conditioning (1 h), the extrusion proper in a single worm extruder (temperature 130-140/160-165/170°C in sections, worm rotations 110–120 rpm) and milling of the obtained extrudate to flour (particle size = 0.3 mm). Analyses were performed in 3 replications.

The contents of selected flavonoids: quercetin, luteolin and kaempferol were determined in dry seeds and after the successive stages of technological processing. Flavonoids were isolated from the matrix using an aqueous acetone solution (3:7,v/v) in the process of single extraction (shaking 1 h, room temperature). The method of HERTOG et al. (1992) was used to assess the qualitative and quantitative composition of these compounds. Chromatographic analysis of flavonoids was performed based on the modified method of SAKAKIBARA et al. (2003). Chromatographic separation was performed on a column Thermo Elec. Co. Hypersil GOLD, 250*4.6 mm, bed of 5 um, the mobile phase (1 ml/min flow) – gradient system: A – 0.1% formic acid in water (pH 2.5); B – 100% methanol – at first 100% of solution A (2 min), lowering to 30% for the next 24 min and constant for another 7 min. (condition time between analyses – 4 min), detection 380 nm. Identification of flavonoids was confirmed by comparing absorption spectra with standards.

Statistically significant differences between means were verified using the F Snedecor test at the significance level $\alpha = 0.05$.

## Results and Discussion

Dry seeds of a Polish cultivar of coloured bean Red Kidney exhibited higher contents of quercetin and much lower (varying, depending on the raw material lot and the season of cultivation) contents of luteolin and kaempferol (Table 1, 2).

Red Kidney beans cultivated in 2004 were hydrothermally processed using autoclaving and boiling, while for extrusion – the seed lot from 2005 was used. Beans from 2005 exhibited a 2-fold higher content of luteolin and an approx. 3.5 times lower of kaempferol in relation to seeds produced in 2004, while the content of quercetin in samples from 2005 was by approx. 10% lower (Table 1, 2). Observed differences are in agreement with literature data. OOMAH et al. (2005), investigating 6 cultivars of coloured beans grown in the course of 2 successive years, also reported differences of approx.

Table 1

Changes in contents of selected flavonoids in coloured bean Red Kidney during its processing by autoclaving and boiling

| Way of processing | Autoclaving | | | | Boiling | | | |
|---|---|---|---|---|---|---|---|---|
| Stage of processing | raw material | after soaking | after auto-claving | flour | raw material | after soaking | after boiling | flour |
| Flavonoid | mean ± SD (μg $g^{-1}$ d.m.) | | | | | | | |
| Quercetin | 245.5±3.5$^a$ | 108.4±12.3$^b$ | 80.9±4.9$^c$ | 77.7±3.4$^{bc}$ | 245.5±3.5$^a$ | 101.0±3.8$^b$ | 97.2±1.4$^b$ | 85.1±0.2$^c$ |
| Luteolin | 48.8±0.2$^a$ | 63.0±8.9$^{ab}$ | 60.1±5.1$^b$ | 53.1±24.3$^{ab}$ | 48.8±0.2$^a$ | 53.3±2.7$^{ab}$ | 56.3±12.7$^{ab}$ | 53.8±0.3$^b$ |
| Kaempferol | 81.7±5.5$^a$ | 49.2±3.9$^b$ | 40.2±1.5$^c$ | 39.1±5.4$^{bc}$ | 81.7±5.5$^a$ | 56.6±2.8$^b$ | 42.3±0.7$^c$ | 37.0±0.2$^d$ |

Statistically significant differences in rows marked with different letters ($p$<0.05)

30% in contents of quercetin within the same cultivar, while 2- to 3-fold differences were found in the content of kaempferol analyzed by Dinelli et al. in 3 bean cultivars in the course of 3 years. The effect of the place and season of cultivation or soil type on flavonoid contents in plants was also emphasized by other authors (Pei-Yin, His-Mei 2006, Wang, Murphy 1994).

Table 2

Changes in contents of selected flavonoids in coloured bean Red Kidney during extrusion

| Way of processing | Extrusion | |
|---|---|---|
| Stage of processing | raw material | after extrusion |
| Flavonoid | mean ± SD (μg $g^{-1}$ d.m.) | |
| Quercetin | 215.9±6.6$^a$ | 169.3±27.8$^b$ |
| Luteolin | 97.1±1.9$^a$ | 67.9±4.5$^b$ |
| Kaempferol | 23.4±3.1$^a$ | 17.5±2.6$^a$ |

Statistically significant differences in rows marked with different letters ($p$<0.05)

Processing dry seeds of Red Kidney beans to instant flour using autoclaving, boiling and extrusion had an effect on the gradual lowering of their flavonoid levels after successive technological stages. Losses after soaking (before autoclaving and boiling) might be the result of simple washing out of those compounds and high temperature during autoclaving (121°C) and boiling (100°C) caused probably further losses of flavonoids. Total flavonoid contents in flour produced by autoclaving and boiling were comparable, amounting to approx. 55% contents of these flavonoids in the raw material. Losses of total flavonoids observed in flour obtained by extrusion were much lower and did not exceed 25% (Figure 1). Worth to mention are results of studies by Thudnatkorn, Rui (2004) on losses of total flavonoids in green beans under the influence of boiling and autoclaving. Those authors showed that both processing methods resulted in comparable 60% losses of flavonoids in the analyzed product.

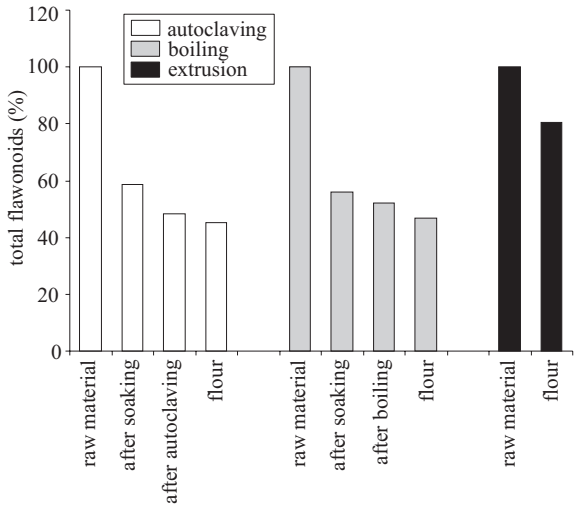


Fig. 1. Degree of preservation of total flavonoids (quercetin, luteolin, kaempferol) in Red Kidney bean after successive stages of its hydrothermal processing using different methods

While analyzing changes in individual flavonoids, it needs to be stated, that autoclaving caused slightly bigger losses of quercetin than boiling (Table 1). Quercetin content after autoclaving was 80.9 μg $g^{-1}$ d.m. and after boiling – 97.2 μg $g^{-1}$ d.m. in relation to the raw material (245.5 μg $g^{-1}$ d.m.), meaning that losses amounted to 67 and 60%, respectively. In both cases changes were statistically significant ($p<0.05$). Losses of this flavonoid during hydrothermal processing of beans were also observed by other authors. Diaz--Batalla et al. (2006) showed that losses of quercetin, in 10 cultivars of coloured beans, under the influence of boiling ranged from 12 to 49%, while in studies by Price et al. on 4 cultivars of green beans the losses of quercetin after boiling did not exceed 23%.

Changes in luteolin content, manifesting in a slight increase of content of this flavonoid (10%) in both processes were comparable. The increase of luteolin content seems to be an interesting problem, regarding of explonation, because at the same time quercetin and kaempferol contents in the same type of compounds (glycoside forms) were reduced.

Methods of processing presented in this study resulted in a gradual reduction of kaempferol content, which level in flour was twice lower in relation to the raw material, amounting to 39.1 μg $g^{-1}$ d.m. (autoclaving) and 37.0 μg $g^{-1}$ d.m. (boiling). In the above mentioned studies by Diaz-Batalla et al. (2006) losses of kaempferol ranged from 6 to 68%, depending on the cultivar, while in a study by Price et al. (1998) they did not exceed 15%.

Extrusion turned out to cause lower losses for all the analyzed flavonoids. Contents of quercetin, luteolin and kaempferol, amounting in the raw material to 215.9, 97.1 and 23.4 μg $g^{-1}$ d.m. respectively, during processing

using this method were much less reduced than in case of autoclaving and boiling, and amounted in the produced flour to 169.3, 67.9 and 17.5 μg $g^{-1}$ d.m. for quercetin, luteolin and kaempferol respectively (Table 2).

## Conclusions

1. Contents of flavonoids in the same cultivar of bean coming from cultivations of 2004 and 2005 were different.

2. Hydrothermal processing of bean seeds using autoclaving and boiling was conducive to maintenance of luteolin content in flour at the original level.

3. Extrusion seems to be the most advantageous way of hydrothermal processing of seeds in terms of the preservation of quercetin and kempferol in bean flour, because it caused the lowest losses of the flavonoids.

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# THE CONTENT OF PATULIN IN APPLE JUICES OF DIFFERENT DEGREE OF PROCESSING

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Key words: patulin, apple juices, one day juices.

In the samples of various apple juices the levels of patulin were examined. The main material was divided in 3 groups: one day juices, pasteurized pressed, clarified juices and juices based on concentrates. All analyzed apple juices were of good quality because the contained low level patulin, under 50 μg $dm^{-3}$ (recommended by WHO).

## ZAWARTOŚĆ PATULINY W SOKACH JABŁKOWYCH O RÓŻNYM STOPNIU PRZETWORZENIA

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Słowa kluczowe: patulina, soki jabłkowe, soki jednodniowe.

Patulina jest wtórnym metabolitem wytwarzanym przez grzyby rodzaju *Penicillium* i *Aspergillus*. Ma działanie toksyczne oraz negatywny wpływ na wątrobę i układ pokarmowy, ma również właściwości mutagenne. Jest wykrywana jako naturalny kontaminant, przede wszystkim w jabłkach i przetworach jabłkowych.

Celem pracy było oznaczenie zawartości patuliny w sokach jabłkowych o różnym stopniu przetworzenia oraz ocena wpływu stopnia zanieczyszczenia nią na stopień przetworzenia soku (pasteryzacja, klarowanie). Oznaczenia zawartości tego metabolitu wykonano metodą wysokosprawnej chromatografii cieczowej (HPLC) po ekstrakcji patuliny z materiału badawczego.

Przeprowadzone oznaczenia potwierdzają zależność zawartości patuliny od stopnia przetworzenia soku jabłkowego. Soki klarowane i pasteryzowane charakteryzują się niższą jej zawartością niż soki niepasteryzowane (jednodniowe). Zauważono również zróżnicowanie zawartości patuliny w sokach różnych producentów.

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## Introduction

Patulin is a toxic lactone, secondary metabolite produced by wide range of fungal species. Patulin is a natural contaminant of processed apple products and its presence may be indicative of the quality of the fruit used in production. Patulin is an important quality criteria of apple juice. While this genotoxic has no reproductive or teratogenic effects, it does, however show embryotoxicity accompanied by maternal toxicity. Owning to its toxicity a provisional maximum tolerable daily intake for patulin was established of 0.4 mg $kg^{-1}$ body weight/day. National and international groups have recommended that apple products intended for human consumption should not contain residual patulin levels ranging between 20 and 50 µg $kg^{-1}$. The World Health Organization recommends limiting its contents in foods to 50 µg $kg^{-1}$ (Gordon et al. 2000, Karadeniz et al. 1997, Gökmen et al. 1999, Gökmen et al. 1998, Gökmen et al. 2005).

The objective of this study was to screen apple juices of different degree of processing, produced in Poland for patulin contents and to evaluate the influence of the degree of patulin contamination on the juice processing.

## Materials and Methods

The samples of measurements were 3 groups of apple juices: one day juices, pasteurized pressed, clarified juices and juices based on concentrates, from different producers. Each sample was extracted in duplicate with duplicate injections into the column.

The patulin contents of the samples was determined by a liquid chromatographic method using a Varian ProStar system equipped with Rheodyne injector with a 20 µl loop and a ProStar 330 series Photodiode Array Detector. Chromatograms were recorded at 276 nm, with spectra (200-400 nm) taken continuously throughout the elution for confirmation. Varian Star Workstation for LC software was used for data processing. The analytical column (150 mm x 4 mm i.d.) obtained from Varian Chrompack was made of stainless steel, packed with Omnispher C18 stationary phase (5 µm) and operated at ambient temperature. Water: acetonitrile (90:10, v/v), at flow-rate of 1.0 ml/min. was used as mobile phase. It was filtered through a 0.45-µm regenerated cellulose acetate membrane and degassed ultrasonically just before analysis by high-performance liquid chromatography (HPLC). Water used in all experiments was generated by Milli-Q gradient A10 system from Millipore.

Extraction procedure: a 5 ml volume of apple juice was extracted 3-times with 10 m ml of ethyl acetate by shaking vigorously for 3 min. The organic phases were combined and extracted with 3 ml of 1.5% sodium carbonate solution by shaking for 1 min. The phases were allowed to separate and the aqueous phase was immediately extracted with 5 ml of ethyl acetate by

shaking for 1 min. The organic phases were dried over 3 g of anhydrous sodium sulfate. The dried extract was filtered trough a filter paper to remove the remaining particles of anhydrous sodium sulfate. A 2 ml amount of ethyl acetate was added to wash the filter cake layer and the filtrate obtained was combined with the filtered extract. Then the extract was evaporated just to dryness under reduced pressure at 40°C. The residue was immediately dissolved in 3 ml of ethyl acetate and was evaporated at 40°C under a gentle nitrogen. The residue was dissolved in 500 µl of the mobile phase and 20 µl of the solution were injected into the column.

## Results and Discussion

Among the group of apple juices on the market one day apple juices have appeared. They don't contain sugar, are naturally cloudy and are not subject to the process of pasteurization. Because the processing method they preserve natural nutritive value. However because of the lack of the pasteurization process the risk of development of pathogenic microflore exist. The analyses made proved that the one day juices under researched were characterized by an average bigger contents of patulin then pasteurized and clarified juices. In the group of apple juices produced on the basis of pasteurized concentrates only insignificant differences among various researched series observed. However, in apple juices not subject to the pasteurization process considerable differences among particular researched series were observed. However the variety of the contents of patulin regarding various juices producers was proved (Table 1, Figure 1).

Table 1

The content of patulin in apple juices

| Juice | Amount of samples | Patulin – ranges (µg $dm^{-3}$) | Patulin – mean level (µg $dm^{-3}$) |
|---|---|---|---|
| One day apple juice – 1 | 8 | 4–31 | 18 |
| One day apple juice – 2 | 16 | 6–36 | 24 |
| One day apple juice – 3 | 10 | 4–17 | 12 |
| Pasteurized, pressed, clarified apple juice – 1 | 8 | 5–15 | 9 |
| Pasteurized, pressed, clarified apple juice – 2 | 6 | 5–10 | 7 |
| Pasteurized, based on concentrates apple juice – 1 | 4 | ND | – |
| Pasteurized, based on concentrates apple juice – 2 | 4 | ND | – |
| Pasteurized, based on concentrates apple juice – 3 | 4 | 5–8 | 6 |
| Pasteurized, based on concentrates apple juice – 4 | 4 | 7–11 | 8 |
| Pasteurized, based on concentrates apple juice – 5 | 4 | ND | – |
| Pasteurized, based on concentrates apple juice – 6 | 4 | 12–15 | 14 |
| Pasteurized, based on concentrates apple juice – 7 | 4 | 6–9 | 7 |
| Pasteurized, based on concentrates apple juice – 8 | 4 | ND | – |
| Pasteurized, based on concentrates apple juice – 9 | 4 | ND | – |
| Pasteurized, based on concentrates apple juice – 10 | 4 | 20–26 | 22 |

ND – not detected

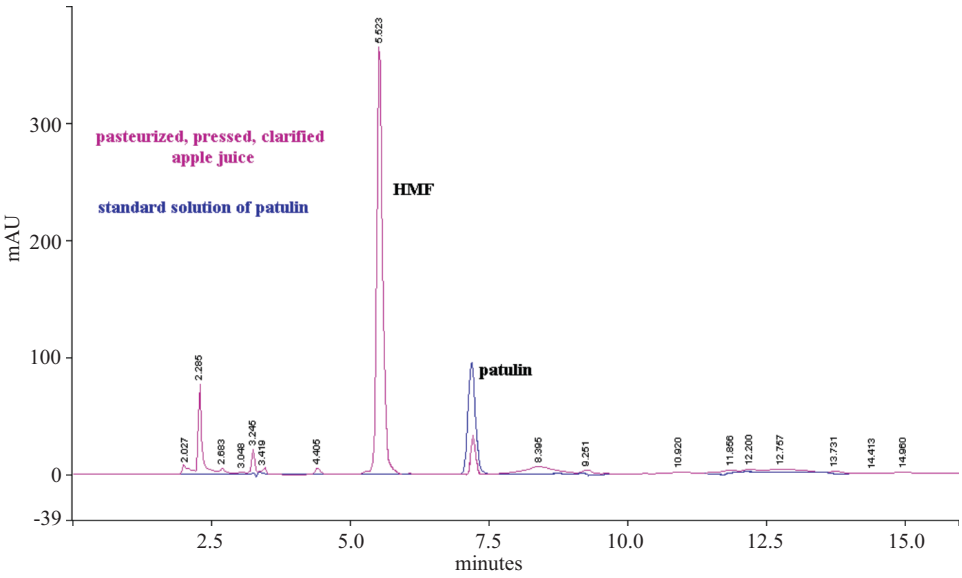


Fig. 1 Overloaded chromatograms of pasteurized, pressed, clarified apple juice and standard solution of patulin

The patulin was detected in 77% commercial apple juice samples. The limit of detection was lover then 5 μg $dm^{-3}$. The recovery of patulin in spiked apple juices was 92–121%.

## Conclusions

The markers made confirm the dependence of the contents of patulin on the dependence of apple juice processing. Clarified and pasteurized juices are characterized by lover contents of patulin than one day not pasteurized juices.

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# ACTIVITY OF $\Delta^9$-DESATURASE IN INTRAMUSCULAR FAT OF FATTENED GOAT KIDS ACCORDING TO BREED AND AGE

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Key words: kid meat, fatty acids, activity of $\Delta^9$-desaturase.

A b s t r a c t

The aim of the study was to determine the activity of the enzyme $\Delta^9$-desaturase in the meat of fattened goat kids according to their breed and age at slaughter. Intramuscular fat was analysed in 39 Saanen kids (S) and $F_1$ Saanen goats Anglo-Nubian bucks (ANxS) slaughtered at 60, 90 and 180 days of age. The breed group of kids did not result in significant differences in the ratio of fatty acid products to substrates or in the $\Delta^9$-desaturase index. The activity of $\Delta^9$-desaturase in intramuscular fat was significantly greater in kids aged 90 and 180 days than in younger kids aged 60 days.

## AKTYWNOŚĆ $\Delta^9$-DESATURAZY W TŁUSZCZU ŚRÓDMIĘŚNIOWYM TUCZONYCH KOŹLĄT W ZALEŻNOŚCI OD RASY I WIEKU

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S ł o w a  k l u c z o w e: mięso koźląt, kwasy tłuszczowe, aktywność $\Delta^9$-desaturazy.

A b s t r a k t

Celem badań było określenie aktywności enzymu $\Delta^9$-desaturazy w mięsie tuczonych koźląt w zależności od ich rasy oraz wieku uboju. Badano tłuszcz śródmięśniowy 39 zwierząt rasy Saaneńskiej (S) i mieszańców $F_1$ tej rasy z kozłami Anglo-Nubijskimi (ANxS) ubijanych w wieku 60, 90 i 180 dni. Grupa rasowa koźląt nie różnicowała istotnie stosunku kwasów tłuszczowych produktów do substratów, jak i wartości indeksu aktywności $\Delta^9$-desaturazy. Aktywność $\Delta^9$-desaturazy w tłuszczu śródmięśniowym była istotnie większa u koźląt starszych, w wieku 90 i 180 dni niż u ubijanych w wieku 60 dni.

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## Introduction

$\Delta^9$-desaturase is an enzyme that stimulates the incorporation of a double bond in fatty acids between carbon atoms 9 and 10, which is beneficial from the viewpoint of health quality of meat and other food products of animal origin (Malinowska 1999). Intensive studies are underway concerning the genetic determinants of the activity of this enzyme in both humans and animals (Dobrzyń 2006, Jelińska 2005, Smith et al. 2002). The phenotypic parameters of $\Delta^9$-desaturase activity in meat and milk are the proportions of fatty acids that are substrates and products of its activity (MUFA:SFA ratio with carbon chain length of 10 to 18 carbon atoms and the $\Delta^9$-desaturase index (DI) estimated using the formula MUFA/SFA + MUFA) (Corl et al. 2001).

The aim of the study was to determine the activity of the enzyme $\Delta^9$-desaturase in the meat of fattened goat kids according to their breed and age at slaughter.

## Material and Methods

The study analysed intramuscular fat of 39 Saanen kids (S) and $F_1$ Saanen goats x Anglo-Nubian bucks (ANS). Kids were suckled by mothers until 20 days of age. After weaning, they were fed milk replacer and concentrate mixture to 60 days of age. From 60 to 180 days of age they were fattened semi-intensively with winter feeds (hay, ensiled hay and concentrate) according to the rationed system. The experimental slaughter

Table 1

Content of fatty acids in intramuscular fat (g 100 $g^{-1}$)

| Fatty acids | Breed | | Age of slaughter; days | | | SEM |
|---|---|---|---|---|---|---|
| | S | ANxS | 60 | 90 | 180 | |
| No. of lambs | 17 | 22 | 11 | 16 | 12 | |
| C 14:0 | 1.62*a* | 2.20*a* | 1.97 | 2.07 | 1.77 | 0.122 |
| C 14:1 | 0.21 | 0.27 | 0.25 | 0.29*a* | 0.17*a* | 0.019 |
| C 15:0 | 0.52*A* | 0.65*A* | 0.59 | 0.66*A* | 0.50*A* | 0.024 |
| C 15:1 | 0.19 | 0.22 | 0.19 | 0.23 | 0.19 | 0.398 |
| C 16:0 | 19.19*A* | 20.99*A* | 19.28 | 20.61 | 20.51 | 0.349 |
| C 16:1 | 2.16 | 2.38 | 1.91*Aa* | 2.54*A* | 2.27*a* | 0.078 |
| C 17:0 | 1.66 | 1.86 | 1.57 | 1.87 | 1.83 | 0.059 |
| C 17:1 | 0.72 | 0.81 | 0.54*Aa* | 0.89*A* | 0.82*a* | 0.053 |
| C 18:0 | 17.13 | 16.81 | 18.05 | 15.92 | 17.32 | 0.480 |
| C 18:1** | 37.64 | 37.07 | 29.77*AB* | 37.82*BC* | 43.57*AC* | 1.126 |
| C 18:1T | 2.12 | 2.47 | 2.85*A* | 2.54*a* | 1.53*Aa* | 0.186 |
| CLA | 0.43 | 0.49 | 0.47 | 0.57*A* | 0.34*A* | 0.011 |
| SFA | 40.04 | 42.01 | 41.52 | 41.03 | 40.98 | 0.585 |
| MUFA | 43.22 | 44.02 | 35.68*AB* | 44.93*BC* | 49.89*AC* | 1.191 |

S – Saanen; ANxS – crossbreeds $F_1$ Anglo-Nubian x S
SFA (saturated fatty acids): Σ C10:0; C12:0; C14:0; C15:0; C16:0; C17:0; C18:0; C20:0
MUFA (monounsaturated fatty acids): Σ C14:1; C15:1; C16:1; C17:1; C18:1; C20:1
SEM – standard error means, *AA*, *BB*, *CC* – $P \leq 0.01$; *aa* – $P \leq 0.05$
Interaction breed·age of slaughter: ** – $P \leq 0.01$

was carried out using kids randomly selected from the above groups at 60, 90 and 180 days and at approx. 12, 20 and 30 kg body weight, respectively.

Intramuscular fat was extracted using the Soxhlet method from the *m. longissimus dorsi*. Fat extraction was performed according to standard procedures given by FOLCH et al. (1957). The composition of fatty acids was determined using the procedures reported by KRAMER et al. (1997) with modifications used at the Meat and Fat Research Institute in Warsaw (BORYS et al. 1999). A Hewlett Packard model 6890 gas chromatograph with a flame-ionization detector and an Rtx-2330 column (105 m x 0.25 mm x 20 μm) were used.

The activity of $\Delta^9$-desaturase was measured by the ratio of fatty acids that are substrates and products of this enzyme (from C10:1/C10:0 to C18:1/C18:0 and CLA/C18:1T). The desaturase index (DI), estimated using the MUFA/ /SFA + MUFA ratio, was also calculated (CORL et al. 2001). The fatty acids analysed are given in notes to Table 1.

## Results and Discussion

The intramuscular fat of ANS crosses compared to S kids contained more fatty acid substrates (C14:0, C15:0, C16:0, C17:0 and C18:1T) and fatty acid products of $\Delta^9$-desaturase (C14:1, C15:1, C16:1, C17:1 and CLA), with a similar content of the main fatty acids C18:0 and C18:1 and total SFA and MUFA (Table. 1). The ratios of the analysed fatty acid products to substrates and the $\Delta^9$-desaturase index (DI) did not differ significantly in the breed groups compared.

The age of kids significantly differentiated the level of individual fatty acid substrates and products of $\Delta^9$-desaturase, with varying relationships between the age categories. Overall, the intramuscular fat of kids from the age categories compared had a similar content of SFA, while MUFA content increased significantly with age, being higher at 90 and 180 days of age by 25.9 and 39.8% compared to 60 days of age (Table 1).

The ratios of fatty acid products to substrates were generally similar for the meat of kids aged 90 and 180 days and higher than for 60-day-old kids (Table 2). The corresponding differences were 18.0% for C15:1/C15:0 and C16:1/C16:0, 51.9% for C18:1/C18:0, and 32.8% for CLA/C18:1T. The intramuscular fat of older kids (90 and 180 days old) was characterized by a similar $\Delta^9$-desaturase index, which was higher than in 60-day-old kids by 15.1% on average ($P \leq 0.01$).

The available literature shows no comparable studies concerning goat meat. Studies with the meat of fattened lambs (BORYS et al. 2007a,b) showed a significant effect of the age and weight standard and no effect of breed components on the parameters of $\Delta^9$-desaturase activity in meat. The results of studies with goat's milk (IMPEMBA et al. 2005) confirmed that breed has no effect on the parameters of $\Delta^9$-desaturase activity, with a significant effect of the feeding system and stage of lactation.

Table 2

Parameters of $\Delta^9$-desaturase activity

| Fatty acid | Breed | | Age of slaughter; days | | | SEM |
|---|---|---|---|---|---|---|
| | S | ANxS | 60 | 90 | 180 | |
| C14:1/C14:0 | 0.131 | 0.129 | 0.137 | 0.144 | 0.104 | 0.008 |
| C15:1/C15:0 | 0.361 | 0.335 | 0.310 | 0.342 | 0.387 | 0.014 |
| C16:1/C16:0 | 0.114 | 0.113 | 0.100*a* | 0.124*a* | 0.112 | 0.004 |
| C17:1/C17:0 | 0.429 | 0.433 | 0.349 | 0.468 | 0.458 | 0.108 |
| C18:1/C18:0** | 2.280 | 2.312 | 1.676*AB* | 2.523*B* | 2.568*A* | 0.111 |
| CLA/C18:1T | 0.214 | 0.224 | 0.177 | 0.243 | 0.227 | 0.013 |
| DI* | 0.516 | 0.503 | 0.460*AB* | 0.520*B* | 0.539*A* | 0.009 |

The explanation of shortcuts and statistical significances as to Table 1.
DI – index of the $\Delta^9$-desaturase activity (DI = MUFA/SFA + MUFA).

## Conclusions

In the present study, the activity of $\Delta^9$-desaturase in the intramuscular fat of fattened kids was not different according to breed, but was significantly higher in older kids at 90 and 180 days of age than in kids slaughtered at 60 days of age.

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# CHARACTERIZATION OF SELECTED PHYSICO-CHEMICAL FEATURES OF BLUE HONEYSUCKLE FRUIT CULTIVAR ZIELONA

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K e y w o r d s: *Lonicera caerulea*, cultivar, fruit mass and firmness, fruit chemical composition.

A b s t r a c t

The aim of the study was to determine selected features of new cultivar Zielona honeysuckle fruit (*Lonicera caerulea* L.). The average mass of one fruit was 0.99 g and the firmness 198 G/mm. Dry weight content was 12.65%, soluble solids content 10.17%. Titratable acidity was high (2.98 g citric acid/100 g) and total sugar content was low (4.64 g/100 g – mostly reducing sugar). Nitrate content was 39.1 mg/100 g, whereas ascorbic acid content 42.7 mg/100 g. Fruit extract showed ability of scavenging ~52% of DPPH$^{\bullet}$ (2, 2-diphenyl-1-picrylhydrazyl) radicals. Berries were found rich in phenolics (total polyphenol content was 429.8 mg gallic acid/100 g). Among identified phenolic compounds anthocyanins were predominating group (84.5%), including mostly cyanidin-3-glucoside. Derivatives of hydroxycinnamic acid amounted 22.76 mg/100 g and quercetin 13.25 mg/100 g.

Because of low climatic-agronomic requirements, early fruiting and valuable chemical composition of the fruit blue honeysuckle is an interesting species both for amateur and commercial cultivation.

## CHARAKTERYSTYKA WYBRANYCH CECH FIZYKOCHEMICZNYCH OWOCÓW JAGODY KAMCZACKIEJ ODMIANY ZIELONA

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S ł o w a k l u c z o w e: *Lonicera caerulea* L., odmiana, masa i jędrność owoców, skład chemiczny owoców.

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A b s t r a k t

Celem badań było określenie wybanych cech fizykochemicznych owoców nowej odmiany jagody kamczackiej (*Lonicera caerulea* L.) Zielona. Średnia masa jednego owocu wynosiła 0,99 g, a jędrność 198 G/mm. Zawartość suchej masy w owocach wynosiła 12,65%, a ekstrakt ogólny 10,17%. Kwasowość była wysoka – 2,98 g kwasu cytrynowego 100 $g^{-1}$, a ilość cukrów ogółem – 4,64 g 100 $g^{-1}$ (głównie cukry redukujące). Zawartość azotanów kształtowała się na poziomie 39,1 mg 100 $g^{-1}$, natomiast kwasu askorbinowego 42,7 mg 100 $g^{-1}$. Wyciąg z tkanki owoców wykazywał zdolność zmiatania ~52% rodników DPPH$^{\bullet}$ (2,2-difenylo-1-pikrylohydrazylu). W jagodach stwierdzono dużą zawartość polifenoli ogółem (429,8 mg kwasu galusowego 100 $g^{-1}$). Wśród zidentyfikowanych związków fenolowych dominowały antocyjany (84,5%), w tym przede wszystkim cyjanidyno-3-glukozyd. Zawartość pochodnych kwasu cynamonowego wynosiła 22,76 mg 100 $g^{-1}$, a kwercetyny 13,25 mg 100 $g^{-1}$.

Z powodu niskich wymagań klimatyczno-agrotechnicznych, wczesnego owocowania i wartościowego składu chemicznego owoców jagoda kamczacka jest interesującym gatunkiem zarówno do uprawy amatorskiej, jak i towarowej.

## Introduction

*Lonicera* (*Caprifoliaceae*) is a genous of more than 150 species distributed chiefly in sub-tropical and temperate regions of the Northern Hemisphere. Blue honeysuckle or sweet berry honeysuckle (*L. caerulea* L.) fruits are widely cultivated in Russia, China and Japan but are practically unknown as edible berries in North America (Chaovanalikit et al. 2004). Approximately 45 species are known to grow in India and few species are used in indigenous medicine as antipyretic, stomachic and diuretic, and in dysentery. Japanese honeysuckle (*L. japonica* Thunb.) was used to treat urinary disorders, fever and headache. It has been known as anti-inflammatory agent in Korea from ancient times and used widely for upper respiratory tract infections, diabetes mellitus and rheumatoid arthritis (Kumar et al. 2005). Also, in the latest studies *Lonicera* berries were shown to possess anti-inflammatory (Park et al. 2005, Jin et al., 2005) and food allergy alleviating properties (Li, Li 2005).

In Poland, blue honeysuckle becomes more and more popular, especially in amateurish cultivation. The first reports on fruit phenolic composition were elicited by Oszmiański et al. (1995). Growing interest in the species is reflected among the others, in new cultivars breeding. Thus, the aim of the study was to evaluate fruit mass, firmness and chemical composition (dry weight, soluble solids, titratable acidity, total sugar, reducing sugar, saccharose, total polyphenol, ascorbic acid and nitrate content) of a new Polish honeysuckle cultivar Zielona. Moreover, phenolics composition (by means of HPLC) and DPPH$^{\bullet}$ radical scavenging activity of fruit extract were determined.

## Material and Methods

The experiment was undertaken in 2006 in the Experimental Station of Agricultural University of Szczecin at Rajkowo. The blue honeysuckle three-year old bushes were planted in the spring 2005 at 3 m x 1.5 m spacing in the brown soil (III quality class) rich in the nutrients. The plants were cultivated under conventional agronomic treatments adequate to low soil and water requirements of the species. The study was a randomized split--plot design with three replications (four bushes per plot). Because *Lonicera* plants are resistant to pathogen diseases 'by nature' no chemical protection was applied. The fruits (~ two-kilogram bulk sample) were collected on 28$^{th}$ June 2006.

The mass and firmness were measured on fresh fruits soon after the harvest. L-ascorbic acid and nitrate content was determined in fresh fruit stored after harvest overnight at 5ºC. Dry weight, soluble solids, titratable acidity, total sugar, reducing sugar, total polyphenol, phenolics composition and estimation of 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH˙)% inhibition were performed on fruits packed in polyethylene bags and stored at –25ºC for six months.

Fruit mass was measured with RADWAG WPX 4500 electronic scales (0.01 g accuracy), while firmness with a non-destructive computer device Firmtech 2 (BioWorks, USA). Dry weight of fruit was determined with a gravimetric method according to Polish standard PN-90/A-75101/03. Soluble solids content was determined with an Abbé refractometer (PN-90/A--75101/02). Titratable acidity was determined potentiometrically (pH-meter Orion 720 A, USA) according to PN-90/A-75101/04. Total sugar and reducing sugar content was determined according to the Loof-Schoorl method (Krełowska-Kułas 1993). Saccharose content was calculated according to the relationship: saccharose = (total sugar – reducing sugar) × 0.95. L-ascorbic acid content was determined with iodometric method (Samotus et al. 1982). Nitrate content was determined with an ion-selective electrode by means of multi-function computer device CX-741 Elmetron (Zabrze, Polska) and the data were expressed as mg $NaNO_3$ per 100 g of fruit. Total polyphenol content in the methanol (70%) extracts was estimated according to Singleton and Rossi (1965) with the Folin-Ciocalteu reagent. The data are expressed as mg of gallic acid equivalents (GAE) per 100 g of fruit tissue. Scavenging effect of chokeberry fruit on DPPH-radical was determined according to the method of Yen, Chen (1995). DPPH$^{\bullet}$ percent inhibition was calculated according to Rossi et al. (2003) from the formula: Percent inhibition = 100 – (($A_t/A_r$) x 100), where $A_t$ – absorbance of test solution and $A_r$ – absorbance of reference solution. The HPLC analyses of polyphenols were carried out on a HPLC apparatus consisting of a Merck-Hitachi L-7455 diode array detector (DAD) and quaternary pump L-7100equipped with D-7000 HSM Multisolvent Delivery System (Merck-Hitachi, Tokyo, Japan). The separation was

performed on a Synergi Fusion RP-80A 150 × 4.6 mm (4 mm) Phenomenex (Torrance, CA USA) column. Column oven temperature was set at 30°C. Aliquots of 1 g fruit tissue were extracted with methanol acidified with 0.1% HCl. The extraction was performed in ultrasonic bath for 20 min. Next, the slurry was centrifuged at 19000 × g for 10 min and the supernatant was used for HPLC analysis. The supernatant was recovered and filtered through a 0.45 mm cellulose syringe filter before analysis. The mobile phase was composed of solvent *A* (2.5% acetic acid, pH 2.9) and solvent *B* (acetonitrile). The program began with a linear gradient from 0% *B* to 25% *B* (0–36 min), followed by washing and reconditioning the column. The flow rate was 1 ml/min and the runs were monitored at the following wavelengths: chlorogenic and neochlorogenic acid at 320 nm, flavonol glycosides at 360 nm and anthocyanin glycosides at 520 nm. The Photo Diode Array spectra were measured over the wavelength range 240–600 nm in steps of 2 nm. Retention times and spectra were compared to those of pure standards within 200–600 nm.

## Results and Discussion

In the year of our experiment, Zielona cultivar yielded 825 g fruit per bush. According to Gastoł et al. (2004) 3-year old bush produces 700 g of berries whereas yielding at the level of 1000 g per bush can be obtained from 5-year old bushes (Kawecki 1996). The mean weight of one berry was 0.99 g and fruit firmness 198 G/mm. Honeysuckle cultivars selected at Czelabińsk (Siberia) (Pierzga 2001) and cultivars tested by Hummer (2006) in USA showed similar fruit mass. Moreover, in present study relatively high drop-fruit percentage was observed (18.4%).

Kawecki et al. (1997) excerpt Pietrova that *Lonicera* fruit contain 19% of dry weight, 4–12 g 100 $g^{-1}$ sugars, 2.6–3.1 g 100 $g^{-1}$ organic acids and 40–130 mg 100 $g^{-1}$ ascorbic acid. In our study, Zielona berries showed lower dry weight content (12.65%) and low total sugar content (4.64 g 100 $g^{-1}$) with predominant participation of reducing sugar and only negligible of saccharose (0.16 g 100 $g^{-1}$) (Table 1). The total acid content (2.98 g of citric acid 100 $g^{-1}$) was high and in consonance with the above reports. The berries of Zielona cv showed 39.1 mg of nitrates 100 $g^{-1}$. In Poland and other countries, there is a lack of regulations on permissible nitrate content in the fruit (except for bananas). However, Chemical-Agricultural Stations on the basis of previous surveys presume admissible content in strawberries 250 mg $NaNO_3$ per kg of fresh weight (Żurawicz 2002). Nabrzyński and Gajewska (1994) observed much higher nitrate content in strawberries (up to 360 mg $NaNO_3$/kg). Honeysuckle fruit cv Zielona were characterized by the level of nitrates comparable with low nitrate-accumulation vegetables (cucumber, parsley, broccoli and carrot – up to 400 mg $NaNO_3$/kg) whereas, vegetables with high ability of nitrate accumulation (lettuces) are allowed up to 2000–4500 mg $NaNO_3$/kg.

Table 1

Chemical composition and 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH•) % inhibition of honeysuckle fruit cultivar Zielona

| Characteristics[a] | Mean ±SD |
|---|---|
| Dry weight (%) | 12.65±0.13 |
| Soluble solids ($^0$ Bx) | 10.17±0.21 |
| Titratable acidity (g citric acid 100 g$^{-1}$) | 2.98±0.01 |
| Total sugar (g 100 g$^{-1}$) | 4.64±0.02 |
| Reducing sugar (g 100 g$^{-1}$) | 4.47±0.02 |
| Saccharose (g 100 g$^{-1}$) | 0.16±0.01 |
| Nitrate (mg 100 g$^{-1}$) | 39.1±1.05 |
| Vitamin C (mg 100 g$^{-1}$) | 42.68±1.32 |
| Total polyphenol (mg gallic acid 100 g$^{-1}$) | 429.8±39.04 |
| DPPH• % inhibitionb | 51.7±0.21 |

[a] Values are the mean of three determinations ±standard deviation and are expressed per fresh weight

[b] DPPH-radical % inhibition was calculated on the basis of DPPH• scavenging activity of fruit tissue (1g/100 mL methanol) in reaction mixture consisting of: 1 ml of fruit extract + 3 ml of methanol + 1 ml of DPPH• solution

The amount of vitamin C in Zielona fruit (42.7 mg 100 g$^{-1}$) corresponded to lower value of the range noted by KAWECKI et al. (1997). However, according to PIERZGA (2001) cultivars of Czelabińska selection had 25 mg of vitamin C/100 g.

The total polyphenol content measured for 10 genotypes of *L. caerulea* by CHAOVANALIKIT et al. (2004) ranged from 427 to 1140 mg of gallic acid equivalents 100 g$^{-1}$. In this survey, Zielona berries showed 429.8 mg GAE/100 g. The fruit extract (1 g/100 mL of methanol) displayed 51.7% inhibition of DPPH-radical (Table 1). CHAOVANALIKIT et al. (2004) confirm antioxidant activity of honeysuckle based on ORAC value (expressed as mmol of Trolox

Table 2

Phenolic profile of honeysuckle fruit cultivar Zielona

| Phenolic compounds (mg 100 g$^{-1}$) | Mean[a] |
|---|---|
| Anthocyanins | |
| Cyanidin 3-5-diglu | 17.94 |
| Cyanidin-3-glu | 221.19 |
| Cyanidin-3-rut | 18.01 |
| Peon-3-glu | 12.66 |
| Neochlorogenic acid | 2.57 |
| Chlorogenic acid | 16.65 |
| 3,5-dicaffeic chinoic acid | 3.54 |
| Unidentified flavonol | 3.09 |
| Quercetin-3-rut | 10.44 |
| Quercetin-3-glu | 2.81 |
| Unidentified flavonol | 0.81 |
| Luteolin-7-O-$\alpha$-glucoside | 9.40 |
| Total | 319.11 |

[a] Values are the mean of two determinations and are expressed per fresh weight

equivalents 100 $g^{-1}$) is comparable to that of blueberries, blackberries and black currants. Zielona fruit showed 269.8 mg 100 $g^{-1}$ anthocyanins with predominant (82%) participation of cyanidin-3-glu (Table 2). Oszmiański et al. (1995) reported cyanidin-3-glucoside constituted 91% of total anthocyanin (332.4 mg 100 $g^{-1}$) in *L. kamtschatica* fruit.

Hydroxycinnamic acid derivatives content in tested cultivar was 22.76 mg 100 $g^{-1}$ including mainly chlorogenic acid (73%) (Table 2). The amount of total flavonol in Zielona berries was 17.15 mg 100 $g^{-1}$, mostly quercetin-3-rutinoside (61%). Chaovanalikit et al. (2004) determined in blue honeysuckles higher content of hydroxycinnamic acid derivatives 30.4–156.2 mg 100 $g^{-1}$ while the quantity of flavonols was similar (12.6–32.8 mg 100 $g^{-1}$).

## Conclusions

1. The blue honeysuckle fruit of Zielona cultivar showed high amount of total acid (2.98 g citric acid 100 $g^{-1}$) and low total sugar content (4.64 g 100 $g^{-1}$).

2. Regarding antioxidant compounds content as vitamin C (42.7 mg 100 $g^{-1}$) and total polyphenol (429.8 mg of gallic acid 100 $g^{-1}$), diluted extract of fruit tissue (1 g/100 mL methanol) had ability of scavenging 51.7% of DPPH-radicals.

3. The main identified phenolic compounds content decreased in the order: anthocyanins (269.8 mg 100 $g^{-1}$) > derivatives of hydroxycinnamic acid (22.76 mg 100 $g^{-1}$) > quercetin derivatives (13.25 mg 100 $g^{-1}$).

4. Blue honeysuckle fruit are the source of dietary phytochemicals and promising source of natural antioxidants and colorants. Low soil-climatic requirements and early fruiting of the species should contribute to propagation of its growing in our country.

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# HEAVY METALS IN APPLE JUICES

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K e y  w o r d s: lead, cadmium, apple juices, one day juices.

A b s t r a c t

In the samples of various apple juices the level of heavy metals were examined. The main material were divided in 3 groups: one day juices, pasteurised freshly pressed juices and pasteurised apple juices. All analysed apple juices were of good quality because they contained low level of cadmium and lead.

## METALE CIĘŻKIE W SOKACH JABŁKOWYCH

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S ł o w a  k l u c z o w e: ołów, kadm, soki jabłkowe, sok jednodniowy.

A b s t r a k t

Soki i napoje wyprodukowane na bazie soków owocowych są coraz częściej spożywane przez konsumentów. Na rynku pojawiły się soki jednodniowe, uważane za produkty dostarczające najwięcej składników odżywczych. Stosunkowo mało jest doniesień na temat zanieczyszczeń tej grupy towarów spożywczych, w tym metalami ciężkimi. Celem pracy było zbadanie poziomu zawartości metali ciężkich (głównie ołowiu i kadmu) w sokach jabłkowych jednodniowych, sokach o większej trwałości i pasteryzowanych.

Uzyskane wyniki nie wskazują, aby soki jabłkowe były mocno zanieczyszczone ołowiem i kadmem. Poziom zawartości tych pierwiastków w badanych sokach jabłkowych jednodniowych i pasteryzowanych oraz o przedłużonej trwałości jest różny w zależności od producenta, a więc także w zależności od surowca. Soki jabłkowe zawierające miąższ miały wyższą zawartość ołowiu.

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## Introduction

Apples are the most popular fruit in Poland. They are consumed as raw fruit but as apple juices too. Nowadays in the Polish market fresh apple juices have appeared as a new product. Raw juices for instance one day juices are considered as more healthy than pasteurised ones. Therefore it is important to know about the contents of heavy metals in these juices. Heavy metals are toxic elements of food. Lead and cadmium are two important indicators of food pollution. Particularly people who are care about their health are often consumers of apple juices. The consumption of water and juices has increased in Poland lately and therefore the control of quality of this apple juices is very important.

## Materials and Methods

The 3 groups of apple juices presented in the Polish market have been materials of this experiment. This groups were: one day apple juices, pasteurised freshly pressed juices and pasteurised apple juices. The 2 cloudy (with flesh) juices were presented in the group of pasteurised juices.

The concentration of lead and cadmium has been determined by AAA method with graphite furnace with the use of spectrometer AA205 plus and GTA 100 by Varian. Before examination the samples were mineralised in microwave furnace Mars 5X by CEM. Calibrating standards were made by dilution of the high purity commercial Fluka of metal standards for atomic absorption analyses. Acceptable recoveries of 91 and 103% were obtained for cadmium and lead, respectively.

## Results and Discussion

The mean heavy metal contents and ranges in different apple juices has been presented in Table 1 and Table 2. The contents of lead and cadmium in apple juices fits standards (the permissible limit for juices in Poland: 0.1 ppm Pb, 0.01 ppm Cd) (*Rozporządzenie Ministra Zdrowia...* 2003).

The level of lead presented in Table 1 was generally low, but in a few samples it was about 100 ppb. Pasteurized apple juice 7 characterized by content of 103.7 ppm Pb (ranges 93.4–114.0). This juice had the highest level of lead. On the other hand pasteurized apple juice 5 had the smallest level of Pb – 5.7 ppb (ranges 5.3–6.1 ppb).

Some juices have presented wide ranges of lead contents for instance one day apple juice 2, 3, pasteurized apple juice 2, 4.

The contents of cadmium is presented in the Table 2. The highest level of Cd has been in pasteurized apple juice 4 – 2.92 ppb. All residual samples

Table 1

The contents of Pb in apple juices

| Juice | Amount of samples | Lead – ranges (μg $dm^{-3}$) | Lead – mean level (μg $dm^{-3}$) |
|---|---|---|---|
| One day apple juice – 1 | 8 | 15.7–24.7 | 19.4 |
| One day apple juice – 2 | 16 | 4.5–62.6 | 30.2 |
| One day apple juice – 3 | 10 | 17.8–109.1 | 52.0 |
| Pasteurised freshly pressed juice – 1 | 8 | 25.7–41.4 | 33.8 |
| Pasteurised freshly pressed juice – 2 | 6 | 10.5–23.6 | 18.8 |
| Pasteurised apple juice – 1 | 4 | 3.6–18.9 | 11.2 |
| Pasteurised apple juice – 2 | 4 | 15.1–88.0 | 51.6 |
| Pasteurised apple juice – 3 | 4 | 7.6–38.5 | 23.1 |
| Pasteurised apple juice – 4 | 4 | 15.1–112.9 | 64.0 |
| Pasteurised apple juice – 5 | 4 | 5.3–6.1 | 5.7 |
| Pasteurised apple juice – 6 | 4 | 19.8–38.8 | 30.2 |
| Pasteurised apple juice – 7 | 4 | 93.4–114.0 | 103.7 |
| Pasteurised apple juice – 8 | 4 | 4.9–51.3 | 28.1 |

Table 2

The contents of Cd in apple juices

| Juice | Amount of samples | Cadmium – ranges (μg $dm^{-3}$) | Cadmium – mean level (μg $dm^{-3}$) |
|---|---|---|---|
| One day apple juice – 1 | 8 | 0.15–1.13 | 0.71 |
| One day apple juice – 2 | 16 | 0.16–0.90 | 0.48 |
| One day apple juice – 3 | 10 | 0.15–0.84 | 0.40 |
| Pasteurised freshly pressed juice – 1 | 8 | 0.11–1.15 | 0.67 |
| Pasteurised freshly pressed juice – 2 | 6 | 0.18–0.59 | 0.39 |
| Pasteurised apple juice – 1 | 4 | 0.21–0.99 | 0.60 |
| Pasteurised apple juice – 2 | 4 | 0.53–0.67 | 0.60 |
| Pasteurised apple juice – 3 | 4 | 0.57–1.12 | 0.84 |
| Pasteurised apple juice – 4 | 4 | 1.52–4.33 | 2.92 |
| Pasteurised apple juice – 5 | 4 | 0.62–1.03 | 0.82 |
| Pasteurised apple juice – 6 | 4 | 0.16–0.92 | 0.54 |
| Pasteurised apple juice – 7 | 4 | 0.25–0.40 | 0.32 |

contained cadmium – below 1 ppb Cd. The obtained values of Pb and Cd were generally comparable to the values reported by other authors (Lo Coco et al. 2006).

The presented results of lead and cadmium doesn't indicate the relationship between the kind of packing: glass bottle, plastic bottle or cartoon.

The apple juices, particucularly cloudy juices, are considered as healthier than clear ones and they can include patulin (Baert et al. 2007, Luckow et al. 2004).

The contents of toxic metals (Cd and Pb) in juices doesn't pose the risk of intake by consumption. The provisional tolerable weekly intake (PTWI) recommended by the Joint FAO/WHO Expert Committee for Food Additives for toxic metals are: 25 μg Pb/kg body weight (1993), 7 μg Cd/kg body weight (2003) (Munoz et al. 2005).

## Conclusions

1. All analysed apple juices contained lower level of cadmium and lead than those limited by the Polish standard.

2. The results of the contents of lead and cadmium in the same group of juices are different. It results from different raw materials used.

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# THE INFLUENCE OF FREEZING STORAGE CONDITIONS OF THE ALOES PULP ON THEIR BIOSTATIC ACTIVITY FOR YEASTS

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K e y  w o r d s: aloe, pulp, yeasts, freezing, biostatic effect.

A b s t r a k t

The aloe's leaves contain many components, which have activity against yeasts and moulds as well as biostatic activity. When the aloe's pulp connecting with the air many of their active substances evaporate, therefore it seems to be important to find the effective method which would not change the biostatic proprieties of aloe's pulp.

The aim of research was to assess the influence of freezing storage conditions (–10ºC and –35ºC) on the number of yeasts settling the aloe's leaves and also biostatic activity against *Candida albicans*.

Test results showed the reduction of yeast during 60 days of storage aloe's pulp in freezing stage storage of yeasts. In result of conducted investigations it has been observed that freezing and storage aloe's pulp in freezing stage didn't cause significant lowering of aloe's biostatic activities in the face of *Candida albicans*.

## WPŁYW WARUNKÓW ZAMRAŻANIA MIAZGI ALOESOWEJ NA JEJ BIOSTATYCZNE ODDZIAŁYWANIE NA DROŻDŻE

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S ł o w a  k l u c z o w e: aloes, miazga, drożdże, zamrażanie, efekt biostatyczny.

A b s t r a k t

Liście aloesu zawierają wiele składników, które działają grzybobójczo oraz biostatycznie. Miąższ aloesowy w zetknięciu z powietrzem się rozkłada, przez co traci wiele substancji czynnych, dlatego też ważne wydaje się znalezienie skutecznej metody jego utrwalania, która jednocześnie nie zmieniałaby jego właściwości biostatycznych.

Celem podjętych badań była ocena wpływu warunków zamrażania na liczebność drożdży zasiedlających liście aloesu i na biostatyczną aktywność miazgi aloesowej w stosunku do *Candida albicans*.

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Przeprowadzone badania wykazały redukcję drożdży podczas 60-dniowego przechowywania miazgi aloesowej w warunkach zamrożenia. Wyniki dowiodły, że mrożenie i przechowywanie aloesu w warunkach zamrożenia nie powodowało znaczącego obniżenia właściwości biostatycznych miazgi wobec *Candida albicans*.

## Introduction

In last few years the interest of aloe increases, which for reason of its medical features and rich chemical composition can be a valuable component of diet. Aloe leaves besides that they are a rich source of nutritious components, they also contain components that work fungicidally and biostatically. Preparations containing a fresh aloe juice, as well as pulps from this plant's leaves, are used in treatment of burns, wounds, counteraction of alimentary tract diseases and in relapsing and lengthy bacterial infections (ALKIEWICZ 2000). It results from available literature that aloe flesh in contact with air undergoes decomposition, because of what it losses many of its active substances, so it seems important to find an efficient method of its fixation, which will simultaneously not change its biostatic features (Aloes zwyczajny…).

The aim of research was to assess the influence of freezing storage conditions (–10°C and –35°C) on the number of yeasts settling the aloe's leaves and also biostatic activity against *Candida albicans*.

## Material and Methods

The research materials were leaves of a three-year aloe (*Aloe arboresces*) given under a frozen process. A sample of 2000 g of leaves was rinsed in sterile distillated water, dehumidified and next divided into two parts. The first part was leaves given under a homogenization process with skin, while the second part were leaves prepared according to the P346068 patent application. Part of prepared pulp was given for researches before freezing, while other part was divided and was put into sterile bags PE/PA, which were next hermitically closed in the vacuous packing machine. Such prepared samples were frozen and stored in the temperature –10±0.2°C in a freezer of the Zanussi company and in –35±1°C in a freezer of the Bosch company. Freezing rate was calculated on the basis of Planck equation, generally used in practice (GRUDA et al. 1999). For the temperature of –10°C the freezing rate estimated 6 minutes and for the temperature of –35°C a 1 minute.

The effect of aloe's pulp biostatic interaction was evaluated for 10% and 20% of aloe before the freezing process and after 1, 30 and 60 days of storage in the temperature of –10°C and –35°C. The research material in an amount of about 15 g, with an appearance of a thin plate, after the freezing

process was left in the room temperature (21±2°C) for about an hour. The sizes of sample and given conditions allowed for complete defrost of pulp.

Yeasts from the species of *Candida albicans* were the testing strain. Yeasts were taken by inoculation loop from a slant culture and then they were carried over to a broth bouillon base. The culture was performed for 48 hours in the temperature of 25°C, and then they were determined on agar base YGC with a chloramphenicol of the Merck company.

Inoculums added to fresh aloe pulp and to frozen aloe, after 1 day of storage estimated 6.22 log jtk/g. Inoculums added to aloe stored in frozen conditions for 30 and 60 days estimated correspondingly: 6.61 and 6.52 log jtk/g. Selective YGC base with a chloramphenicol of the Merck company was used for evaluation of the counts of yeasts in a aloe's pulp. The incubation was performed in the temperature of 25°C for 120 hours. Microbiological analyses were performed with a traditional method. Inoculations were performed in accordance with the Rozporządzenie Mnistra Zdrowia z dn. 13.01.2003 r.

## Results and Discussion

Performed researches of the pulp microbiological state indicate a reduction of the count of yeasts living in the frozen aloes pulp during 60-day storage in frozen conditions. Yeasts population was a subject to reduction regardless the form and the temperature of aloe freezing (Table 1). Average rate of pollution with yeasts of fresh samples of homogenized aloe's pulp with skin and without skin estimated correspondingly: 3.53 log jtk/g and 2.24 log jtk/g (Table 1). Higher reduction rate of those microbes count has been observed in the aloe's pulp with skin, stored in the temperature –10°C than in the temperature of –35°C (Table 1). Reduction after 60 days of storage estimated correspondingly: about 1.8 cfu/g and 1 cfu/g. Significantly higher dynamism of reduction in researched microbes appeared after 30-day storage of the pulp in a frozen state. A pulp from aloe without skin characterized with a two times higher dynamism of yeasts reduction in the tempe-

Table 1

Count of yeasts during the storage of aloe in –10°C and –35°C (log cfug)

| Storage time | Log CFU/g | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $AS_{-10°C}$ | | | $AS_{-35°C}$ | | | $BS_{-10°C}$ | | | $BS_{-35°C}$ | | |
| | max | | min. | max | | min. | max | | min. | max | | min. |
| Control | 3.76 | 3.53 | 2.57 | 3.76 | 3.53 | 2.57 | 2.41 | 2.24 | 1.7 | 2.41 | 2.24 | 1.7 |
| 30 days | 2.66 | 2.12 | 0 | 3.04 | 2.66 | 2.17 | 2.44 | 1.93 | 1.48 | 2.76 | 2.19 | 1.3 |
| 60 days | 2.40 | 1.72 | 0 | 2.92 | 2.56 | 1.9 | 2.25 | 1.80 | 0 | 2.62 | 2.05 | 1.0 |

AS – aloe's pulp with skin
BS – aloe's pulp without skin

rature of –10°C. In the temperature of –35°C reduction of the count of yeasts was insignificant and estimated only 0.2 cfu/g. Comparing both forms of aloe which were freezing and stored for the period of 60 days in the same temperature, it can be stated that significant stoppage of the microflora is being observed in the pulp from aloe with skin and it is more intensive in comparison with the reduction stated in a pulp from aloe without skin. According to the literature data it results that yeasts more willingly develop in an environment rich in sugar. It results that aloe without skin leaves, devoid of anthraquinone compounds, will be better growth base for fungi (Burbianka et al. 1983).

However given literature indicates also a decrease of the bacterium cells growth capacities after the freezing process, resulting from crystallization of water in the environment. The reason of microbes decay is the difference of osmotic pressures between environments and those microbes (Zaleski 1985). This type of tissue can be compared with the tissue of soft berry fruit (strawberries). The Ministry of Health decree regulating the microbiological state of frozen fruits determines the threshold value of the counts of moulds and yeasts, on the level of 5.0 $10^2$ jtk/g (Rozporządzenie Ministra Zdrowia z dn. 13.01.2003). Results of herewith researches concerning the pollution rate of researched aloe pulp with yeasts population before the freezing storage, indicated exceedance of those values. Storing the homogenate in frozen conditions showed an efficient reduction of fungi living in the pulp from aloe with skin.

Results of the biostatic interaction of fresh aloe indicated an influence of the plant's components to the *Candida albicans* cells. Propriety stopping the microbes development, the aloe owes mainly to anthraquinone derivatives, such as: aloemodine, barbaloine, aloine, which are present in the leather of this plant (Smolarz et al. 2004).

It was showed that addition of aloe to the culture of fungi influenced their reduction (Figure 1). Storage of aloe's pulp for a 1 day in freezing conditions didn't cause a fall of pulp's biostatic activity, both with skin and without skin, reducing the count of yeasts from about 0.7 cfu to about 1 cfu. The aloe's pulp stored in the temperature of –10°C indicated a higher influence to the *Candida albicans* cells than the same material stored in the temperature of –35°C (Figure 2). Those are significant changes of population amount conditioning a good tissue's microbiological quality in case of adding aloe to fermented milk products.

During next 30 days of storage it was stated that there is a fall of aloe's pulp biostatic activity (Figure 2). After 60 days of storage the biggest biostatic effect has been noticed in case of aloe with skin and without skin stored in the temperature of –35°C, at higher concentration of the pulp (Figure 2).

Achieved research results concerning the biostatic influence of aloe to cells are in accordance with data presented in the literature (Celiktas et al. 2007). Data presented by Smolarz, indicate a significant anti-fungi influence

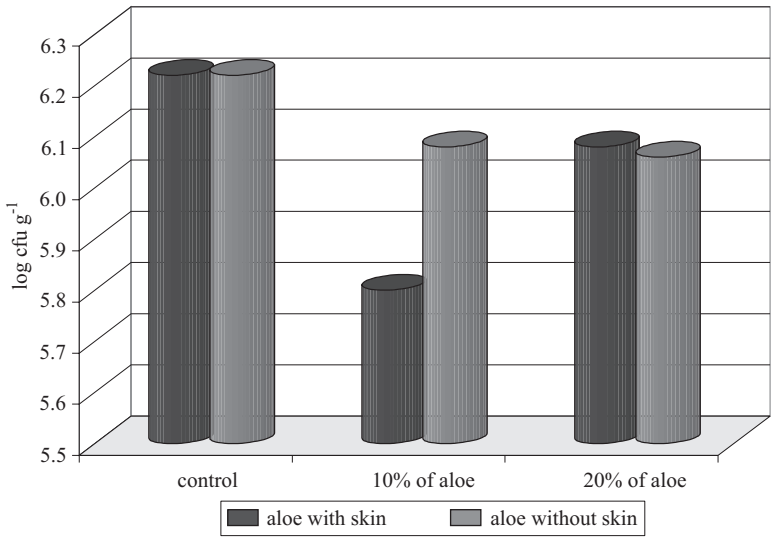


Fig. 1. Biostatic effect of the fresh aloe against *Candidia albicans*

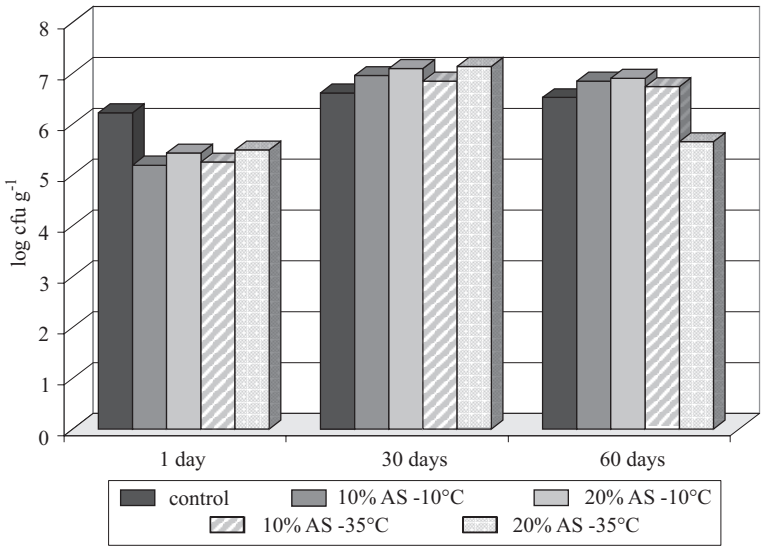


Fig. 2. Biostatic activity of the aloe's with skin, stored in the temperature of –10°C i –35°C against *Candidia albicans*

of the aleomodine in proportion to the *Candida albicans* cells (SMOLARZ et al. 2004). In the literature there is an insignificant amount of data concerning influence of the aloe's pulp to fungi. More information can be found in the literature with a subject area about aloe extracts. It results from available literature than among others: aloe lyophilizate components influence the stoppage of spores germination and shreds development *Trichophytom*

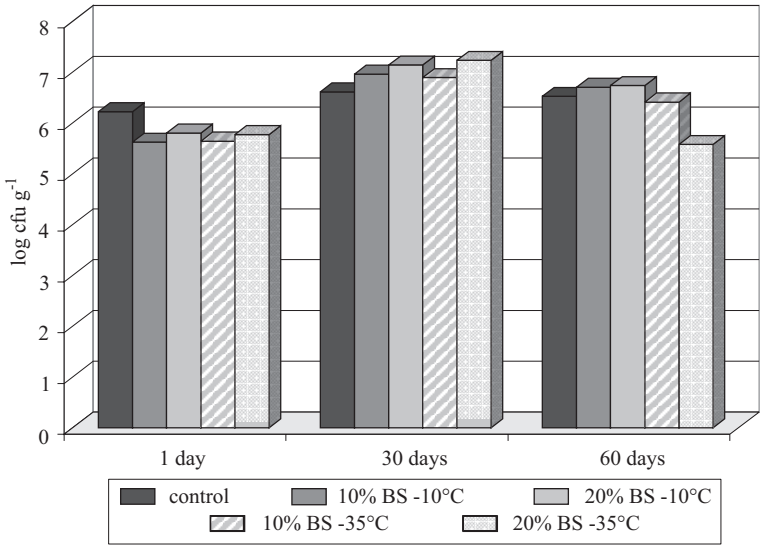


Fig. 3. Biostatic activity of the aloe's without skin, stored in the temperature of –10°C i –35°C against *Candidia albicans*

*mentagrophyles* (Fujita et al. 1978). Ali and partners however stated an activity of extract from fresh leaves of *Aloe arborescens* and *Aloe barbadensis* in stoppage of *Cl. herbarum* and *Fusarium moniliforme* (Ali et al. 1999). Research results of those authors confirmed a similar anti-fungi activity of *Aloe arborescens* and *Aloe barbadensis*.

## Conclusions

1. A higher efficiency of yeasts reduction in the aloe pulp was stated at the temperature of –10°C than at the temperature of –35°C.

2. Influence of aloe frozen in the temperature of –10°C causes yeasts reduction by 1.5 log cfu/g.

3. Freezing and storage of aloe in freezing conditions doesn't cause any significant decrease of its biostatic features.

4. Ability to stop the development of yeasts falls under the influence of aloe with skin and without skin by about 0.5 log cfu/g after 30 days of freezing the aloe pulp in both scopes of temperature.

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# THE CONTENT OF NITRATE(V) IN POTATO TUBERS STORAGE IN TEMPERATURE 4°C

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Key words: nitrates, potato tubers, herbicides, storage.

Abstract

The field experiments were carried out in 2002-2004 to evaluate the impact of weed control system with herbicides (Afalon 50 WP, Azogard 50 WP, Sencor 70 WG + Olbras 88 EC adjuvant, Apyros 75 WG + Atpolan 80 EC adjuvant) on the degree of nitrates accumulating in the Rywal and Saturn potato cultivars after harvest and storage in 4 temperature degree. It was found that the applied herbicides caused a tendency to increase of nitrates content in potato tubers in relation to control, especially Sencor 70 WG + Olbras 88 EC adjuvant (331 mg $kg^{-1}$ of fresh matter). After 3 and 6 months of storage the nitrates content decreased by 36% and 37.5%, respectively, relatively to the initial level (mean for the plots).

## ZAWARTOŚĆ AZOTANÓW(V) W BULWACH ZIEMNIAKA PRZECHOWYWANYCH W TEMPERATURZE 4°C

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Słowa kluczowe: azotany(V), bulwy ziemniaka, herbicydy, przechowywanie.

Abstrakt

Doświadczenia polowe prowadzono w latach 2002-2004 w celu zbadania wpływu metod odchwaszczania herbicydami (Afalon 50 WP, Azogard 50 WP, Sencor 70 WG + adiuwant Olbras 88 EC, Apyros 75 WG + adiuwant Atpolan 80 EC) na stopień kumulacji szkodliwych azotanów(V) w bulwach ziemniaka odmiany Rywal i Saturn po zbiorach i przechowywaniu w temperaturze 4°C. Zastosowane herbicydy wpłynęły na podwyższenie zawartości azotanów w bulwach ziemniaka w porównaniu z obiektem kontrolnym, w szczególności preparat triazynowy – Sencor 70 WG + adiuwant Olbras 88 EC (331 mg $kg^{-1}$ świeżej masy). Po 3 i 6 miesiącach przechowywania zawartość azotanów obniżyła się średnio odpowiednio o 36 i 37.5%.

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## Introduction

The content of nitrates is an important criterion for nutritional and toxicological quality of foodstuffs. These compounds are subject to the activity of the stomach bacteria to be reduced to nitrites, which are in turn precursors of nitrosoamines. The latter substances can be carcinogenic and/or have a mutagenic activity. In humans nitrates may also causa methaemoglobinemia which is the result of oxidation of the haemoglobin divalent iron to its trivalent form uncapable to bind oxygen in a reversible way. The expert committee of the World Health Organisation (FAO/WHO) worked out daily acceptable intake of nitrates and nitrites by an adult person what equals 0–5 mg $NO_3$ and 0–0.02 mg $NO_2$ per 1 kg body weight, respectively. The main source of nitrates (65–75%) are plant products (Czarniecka-Skubina, Golaszewska 2001). The occurrence of these compounds in plants is the consequence of their natural life processes connected with transformation of nitrogen to aminoacids and proteins. Their excessive amounts are often related to irrational fertilization with nitrogen as well as incorrect agrotechnology (Rogozińska et al. 2000, Wadas et al. 2005). Taking into consideration degree of accumulation of nitrates the plants can be separated into three groups; those containing more than 1000 mg $kg^{-1}$ fresh weight (lettuce – 380–3520, red beet – 150–5690, spinach – 350–5690 mg $kg^{-1}$ fresh weight, kohlrabi, garden beet, radish, rhubarb), of concentration ranging 500–1000 mg $kg^{-1}$ fresh weight (Beijing cabbage, savoy, headed cabbage, cellery, fennel, courgette), and those accumulating nitrates poorly of content below 500 mg $kg^{-1}$ fresh weight (beans – 80–820, cucumber – 20–300, tomato 10–100 mg $kg^{-1}$ fresh weight, onion, asparagus, pepper, and others) (Rogozińska 2003). The species under study, potato, is a plant poorly accumulating nitrates, however, in the contrary to many other vegetables it is a basic component of the daily diet. In Poland its consumption was assessed to be about 129 kg per person. It is eaten in periods far from the harvest time and therefore a constant monitoring of nitrate concentration in the tubers in necessary, both after the harvest and over the storage time. According to Directive of the Minister of Health (DU 2003 r. of Nr 37 pos. 306) the potato tubers should not contain more than 200 mg $NO_3$ $kg^{-1}$ in fresh mass.

The objective of the investigation was to evaluate the changes of nitrate content(V) in potato tubers cv. Rywal and Saturn in time of storage in dependence on nursing treatments with the use of herbicides in time of vegetation.

## Material and Methods

Potato tubers were collected from field experiments carried out in 2002–2004 at the Mochełek Experimental Station belonging to the University of Technology and Life Sciences in Bydgoszcz. The two-factor trials were located on a soil good for rye cultivation. They were planned as randomised sub-blocks in three replications. The first factor were ways of the potato's nurturing – Afalon 50 WP (linuron), Azogard 50 WP (prometrin), Sencor 70 WG (metribuzin) + adjuvant Olbras 88 EC, Apyros 75 WG (sulfosulfuron) + adjuvant Atpolan 80 EC, while the second one were medium--late potato varieties Rywal and Saturn. Farmyard manure (25 t $ha^{-1}$) was applied in autumn. All the mineral fertilizers were used in spring before the seeding according to nutritional needs of potato and soil resources (nitrogen – 120 kg N $ha^{-1}$ as ammonium nirate (34%), phosphorus – 110 kg $P_2O_5$ $ha^{-1}$ as triple phosphate (46%), potassium – 120 kg $K_2O$ $ha^{-1}$ as potassium sulphate (50%). Cereals were grown as forecrops. Thermal and moisture conditions over the experimental period varied (Figure 1).

After the harvest samples of mature tubers were collected according to the respective norm and than stored in chambers with fixed temperature (4°C) and relative air humidity (95%). Nitrate concentration in the tubers was assayed after harvest and after 3 and 6 months of storage with ion--selective electrode (PN-86/C-04576/10) with help of multi-functional Elmetron computerised device CX – 721.

The importance of the means was evaluated statistically with variation analysis according to the experimental design. The smallest significant difference was calculated with Tukey test.

## Results and Discussion

The results of the analyses of the tubers given in Table 1 indicated that the herbicides used on the potato plantation had a significant effect on an increase of concentration of inorganic nitrogen compounds – nitrates(V), among them triazine preparation Sencor 70 WG being the most active one. Variation analysis of the collective results showed that the varieties under study did not differ significantly in the respect of the parameter mentioned above. In 2002 the Saturn variety acummulated significantly more nitrates(V), while in 2003 less than the Rywal one. Therefore it can be concluded that thermal and moisture conditions occurring over vegetation period and individual varietal reaction in specific years were the main factors affecting nitrate concentration in potato tubers. In the 2003 vegetation period unfavourable rainfall and temperature distribution (Figure 1) could stimulate an increase of the amount of the investigated compounds. Similar results were reported by Cieślik (1995) and Frydecka-Mazurczyk (1996). The latter

Table 1

Nitrates content (mg kg of fresh matter) in Rywal and Saturn potato cultivars after harvest depending on applied herbicides

| Applied herbicides (I) | Cultivars (II) | Years | | | |
|---|---|---|---|---|---|
| | | 2002 | 2003 | 2004 | mean |
| Without herbicides (control) | Rywal | 121.0 | 356.3 | 206.7 | 228.0 |
| | Saturn | 137.0 | 349.7 | 217.3 | 234.7 |
| | Mean | 129.0 | 353.0 | 212.0 | 231.3 |
| Afalon 50 WP | Rywal | 217.7 | 423.0 | 234.0 | 291.6 |
| | Saturn | 224.3 | 354.3 | 225.7 | 268.1 |
| | Mean | 221.0 | 388.7 | 229.9 | 279.8 |
| Sencor 70 WG + adjuvant Olbras 88 EC | Rywal | 237.0 | 533.3 | 241.3 | 337.2 |
| | Saturn | 229.0 | 501.7 | 244.3 | 325.0 |
| | Mean | 233.0 | 517.5 | 242.8 | 331.1 |
| Azogard 50 WP | Rywal | 150.7 | 392.0 | 234.3 | 259.0 |
| | Saturn | 180.7 | 366.0 | 238.3 | 261.7 |
| | Mean | 165.7 | 379.0 | 236.3 | 260.3 |
| Apyros 75 WG + adjuvant Atpolan 80 EC | Rywal | 184.7 | 444.3 | 238.3 | 289.1 |
| | Saturn | 214.3 | 360.3 | 238.3 | 271.0 |
| | Mean | 199.5 | 402.3 | 238.3 | 280.0 |
| Mean | Rywal | 182.2 | 429.8 | 230.9 | 281.0 |
| | Saturn | 197.1 | 386.4 | 232.8 | 272.1 |
| | Mean | 189.6 | 408.1 | 231.9 | 276.5 |
| LSD $p$ = 0.05 | I | 6.0 | 7.3 | 4.9 | 5.2 |
| | II | 1.1 | 2.2 | n.s. | n.s. |
| | I x II | 3.5 | 7.1 | 6.4 | n.i. |

n.s. –no significant difference

author added that stress conditions, i.e. very high temperature, and lack of rain, as well as low temperature and excessive rainfall, promote accumulation of nitrates. Błoński (1973) and Sas-Piotrowska et al. (1972) found that herbicides affect transformations of nitrogen in cultivable plants. A simple consequence of those reactions is accumulation of some products in the plant. This is the case for triazine herbicides, which can change ezymatic acitivity connected with nitrogen transformations in plants (Lisińska et al. 1990). In potato nitrate reductase is the enzyme responsible for reduction of nitrates to nitrites and their further incorporation to organic compounds (Kączkowski 1987).

As compared with the results recorded after harvest (Figure 2) a significant decrease of nitrate content, even by 44% (Figure 3) was observed after three months of storage of potato tubers in the chamber with 4 temperature degree. This effect was not that strong after 6 month of incubation. Among others Cieślik (1994) and Fragasowa (1994) showed that nitrate concentration in potato tubers stored for 6 months dropped even to 59%. A decrease in

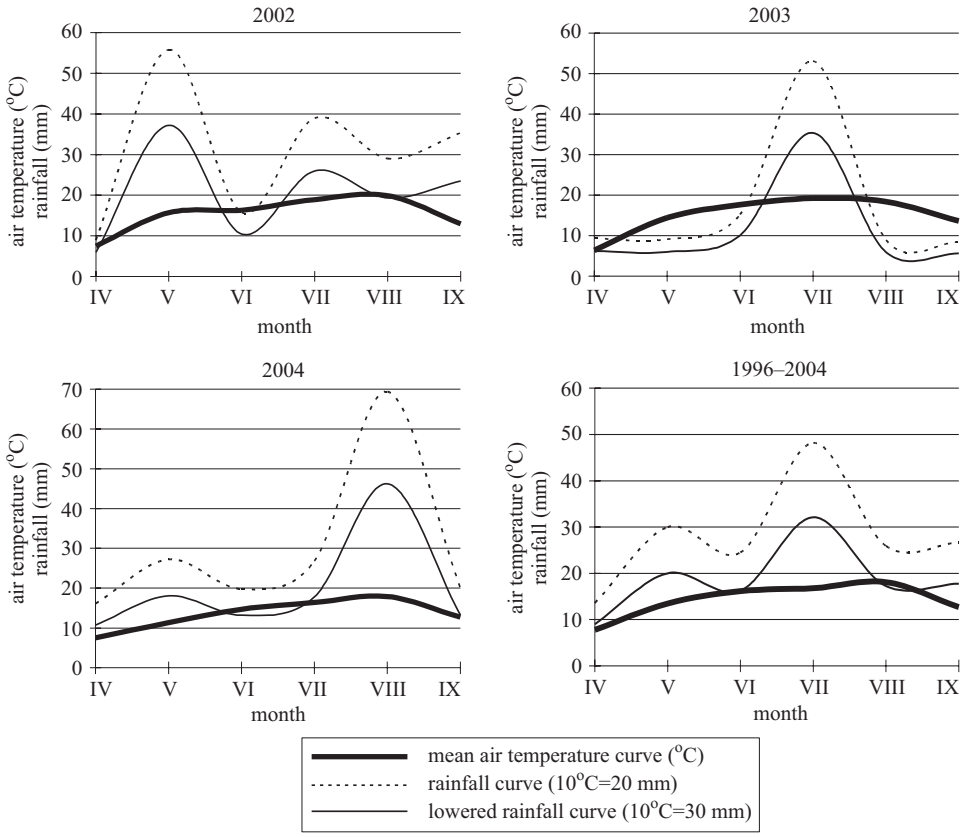


Fig. 1. Air temperature and rainfall during the potato vegetation period (WALTER 1976)

nitrate content in products of plant origin can be triggered also by other factors. Nitrates and nitrites are soluble in water, therefore peeling of potatoes and their careful washing and boiling about 43–66% of these components are disappear from potato tissues (MOZOLEWSKI, SMOCZYŃSKI 2004). On the other hand boiling time should be always limited to a minimum to avoid the transfer of a major part of vitamins and mineral components to the extract. Similarly frying causes a considerable decrease of these compounds, too, even down to 20% of the original concentration (ROGOZIŃSKA 2003, MOZOLEWSKI, SMOCZYŃSKI 2004). Despite the fact that the investigated potato tubers accumulated relatively high amounts of nitrates after the harvest, the recorded concentrations are not a threat to human health, provided that they will always undergo processing in the kitchen.

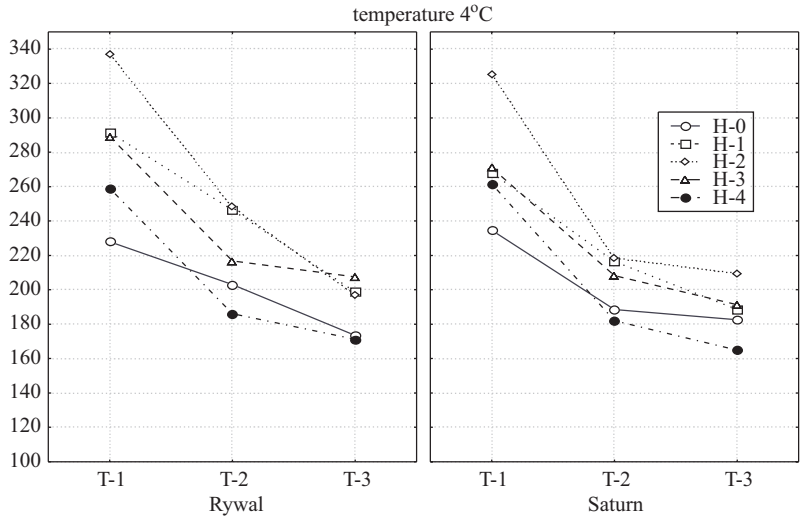


Fig. 2. The nitrates content in potato tubers in dependence on applied herbicides and measurement time (average with years 2002-2005). T1 – after harvest, T2 – after 3 months of storage, T3 – after 6 months of storage
Explanation
H-0 – without herbicides (control), H-1 – with herbicide Afalon 50 WP, H-2 – with herbicide Sencor 70 WG +adjuvant Olbras 88 EC 1.5 l $ha^{-1}$, H-3 – with herbicide Apyros 75 WG +adjuvant Atpolan 80 EC 1.5 l $ha^{-1}$, H-4 – with herbicide Azogard 50 WP

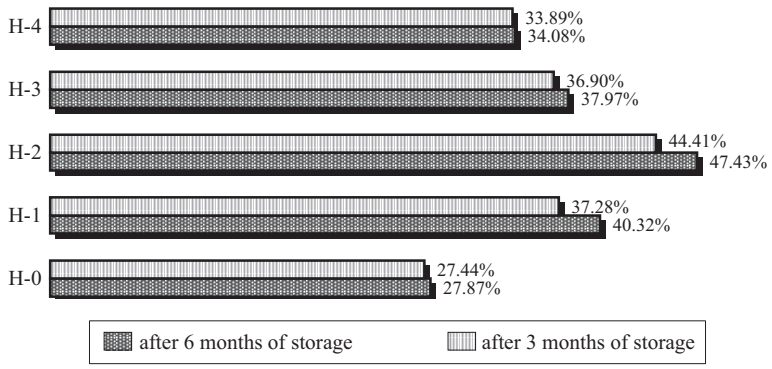


Fig. 3. The percentage losses of nitrates content in potato tubers in depending on using the herbicides after 3 and 6 months of storage (average with years 2002–2005) – explanation in Figure 2

## Conclusions

1. Herbicides used in potato cultivation, especially Sencor 70 WG, increased the content of nitrates in the tubers of varieties under study in relation to the control object.

2. Concentration of nitrates in the tubers was affected also by weather conditions occurring in specific years of plant vegetation. Prevailing dry months in one of the vegetation periods caused a more intense accumulation of nitrates than in the other years.

3. Storage of the tubers over the autumn-winter-spring period significantly reduced the content of nitrates. The highest decrease was noted after 3 months of storage (average for objects 36%).

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# EFFECT OF THERMAL TREATMENT ON CHANGES OF POLYPHENOLS CONTENT IN BROCCOLI

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K e y  w o r d s: polyphenols, thermal treatment, broccoli.

A b s t r a c t

The effect of thermal treatment on changes of polyphenols and dry mass content in broccoli depending on applied form of vegetable raw material and method of cooking were examined. The experiments were carried out on fresh and frozen broccoli delivered from the domestic, Warsaw market. Four types of thermal treatment were applied: cooking starting from cold water, cooking starting from boiled water, steam cooking and cooking with microwave oven usage. Extraction process for polyphenols determination was carried out three times by means of methanol. Both forms of raw material were substantially statistically diversified with respect to quantity of examined components. The applied culinary techniques caused significant changes in content of examined components in the final product, connected with the type and way of treatment. The thermal treatment with the use of water caused significant losses of polyphenols, whereas steam cooking caused much less ones. Less losses were observed during thermal treatment of frozen broccoli in comparison with the fresh one.

## WPŁYW OBRÓBKI TERMICZNEJ NA ZMIANY ZAWARTOŚCI POLIFENOLI W BROKUŁACH

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S ł o w a  k l u c z o w e: polifenole, obróbka termiczna, brokuły.

A b s t r a k t

Badano wpływ obróbki termicznej na zmiany zawartości polifenoli i suchej masy w brokułach, w zależności od użytej formy surowca i zastosowanej techniki kulinarnej. Przeprowadzono eksperyment ze świeżymi i mrożonymi brokułami pochodzącymi z warszawskiego rynku. Stosowano cztery rodzaje obróbki termicznej: gotowanie – brokuły wrzucano do zimnej wody, gotowanie – brokuły wrzucano do wrzącej wody, gotowanie na

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parze i gotowanie w kuchni mikrofalowej. Proces ekstrakcji w celu oznaczenia polifenoli przeprowadzono trzykrotnie z metanolem. Obydwie formy surowca były istotnie statystycznie zróżnicowane pod względem zawartości badanych składników. Stwierdzono istotne zmiany ich ilości w produkcie, w zależności od rodzaju i sposobu obróbki. Zastosowanie metody obróbki termicznej w wodzie spowodowało duże ubytki polifenoli, metody z wykorzystaniem pary spowodowały małe straty. Mniejsze straty polifenoli zaobserwowano podczas obróbki termicznej mrożonego produktu.

## Introduction

Polyphenols compounds, as food bioactive ingredients show antioxidant and germicidal properties, decrease cholesterol level and possess possibility of cancer prevention (Bravo 1998, Grajek 2004, Hanczakowski 2004).

Some polyphenols, particularly flavonoids, play significant role at a process of sealing and strengthening the capillary blood vessels, indirectly curb hialuronidase activity, show some influence on vitamin C stabilisation and may counteract the trombocite gluing (Horbowicz 2000, Janeczko 2004, Kohlmünzer 1993).

Proper function of organism on cellular and extra-cellular level is ensured owing to antioxidant components of food (Czeczot 2000, Lutomski 2003). Daily consumption of vegetables and fruits in quantity not less than 500 g have a favourable influence on organism due to positive effect of both polyphenols and different compounds existing in such a kind of food, among others; food fibre, vitamins, mineral components and the other vegetable metabolites (Zduńczyk 2001).

Broccoli is a vegetable of significant polyphenol compounds content (Gawlik-Dziki 2004). Its inflorescence is not only a good source of polyphenol compounds but also of glucosynolanes and vitamin C (Horbowicz 2005). Broccoli is attributed to an antineoplasmic action, which is connected with significant content of antioxidants (Carper 1995). This vegetable is considered as one of the main sources of flavonoles in the men's diet (Vallejo et al. 2004). Broccoli can be consumed in the raw state and/or after thermal treatment. Broccoli is easy to freeze. In culinary practice fresh and frozen broccoli are used interchangeably. So, the purpose of may research was to check the change of polyphenol content, which occur in the two forms of broccoli – raw vegetable and the frozen one – which were subjected to the typical ways of thermal treatment.

## Material and Methods

Fresh and frozen broccoli (*Brassica oleracea* var. *Italica*) were examined as raw material. Fresh broccoli were imported, each piece (of 500 g in weight) was wrapped in thin foil. Frozen broccoli of domestic origin were

packed in foil bags, each of 450 g in weight. Both forms of vegetable were bought in a supermarket.

These methods of thermal treatment were tested, which are the most often used in households applications during meals preparation, namely: cooking beginning from cold water, cooking starting from boiled water, steam cooking and cooking with microwave oven usage. To obtain more clear data, analyses of dry substance content in the raw vegetable – and in a broccoli after treatment – were performed.

Optimal time of thermal treatment was experimentally established, in such a way, that after treatment roses of broccoli preserve their original shape and proper consistency. The consistency was sensory examined, using gradual scale of category (JANICKI 1999). The vegetable was cooked with distilled water. There were the following ratio of vegetable mass ($W$) in comparison to water volume ($V$): cooking in water 1 : 4 $W/V$; cooking in microwave oven 10 : 1 $W/V$. Each time every portion of broccoli roses was 250 g in weight. Treatment time of fresh broccoli ($f$) and frozen ($c$) one: typical cooking beginning from cold water – 15 min ($f$) and 8 min ($c$); cooking starting from boiled water – 7 min ($f$) and 6 min ($c$); steam cooking – 8 min ($f$) and 8 min ($c$); cooking in microwave oven – 10 min ($f$) and 8 min ($c$).

Polyphenols extraction was carried out by means of 80% methanol solution (BARANIAK, GAWLIK-DZIKI 2004). Three weighed portions (each of 3g in weight) were taken from one sample of vegetable. Total content of phenol compounds in extracts was determined by means of spectrophotometric method. Folin-Ciocalteau's reagent was applied and measurement of absorbance was performed with the use of Specord 40, after 90 min, at wavelength 725 nm (OBOH 2004, with my own modification). Obtained results were expressed in reference to gallic acid. Dry mass content (in %) was determined by a device for relative humidity measurement (WPS 30S), so called balance-dryer, with analysis parameters programmed in accordance with the device instruction manual.

Statistical analysis was estimated by comparison of sampling variance (2 samples; test $F$) and by comparison of two samples mean value at significance level $\alpha = 0.05$.

## Results and Discussion

Both forms of raw material were substantially diversified in respect to content of examined components. Raw broccoli contained 2900 ±30 mg of polyphenols and 139.9 ±0.7 g of dry substance in kg of vegetable. Frozen broccoli respectively, contained 1080 ±20 mg of polyphenols and 90.9 ±0.03 g of dry mass in kg of raw material (Figure 1 and Figure 2). Polyphenol compounds are substances, which quantity in fresh raw material is changeable and depends on many factors. One of the important elements is a variety of tested

vegetables. This opinion is evident from results of research carried out by Borowski et al. (2005), Cieślik et al. (2006) Proteggene et al. (2002), Zhang, Hamauzu (2004), in which polyphenols level in broccoli was in the range of 34.5–290 mg $kg^{-1}$ of the fresh mass. It is also confirmed by experiments carried out by Horbowicz (2005), which present diverse concentration of flavonoids in the different sorts of broccoli. The above mentioned studies were carried out within period of two years and additionally confirmed the diverse content of flavonoids in the same species.

In frozen broccoli polyphenols content was significantly less than in the fresh broccoli. In our tests frozen broccoli – differ in variety and their cultivation conditions from the raw broccoli – was used and for that reason it is rather impossible to evaluate properly the losses that occur during blanching and freezing. There is also lack of reference experiments that could be used for comparison of our own results concerning polyphenols content and its changes occurred as an effect of freezing.

Changes of polyphenols content caused by culinary treatment are shown on Figure 1.

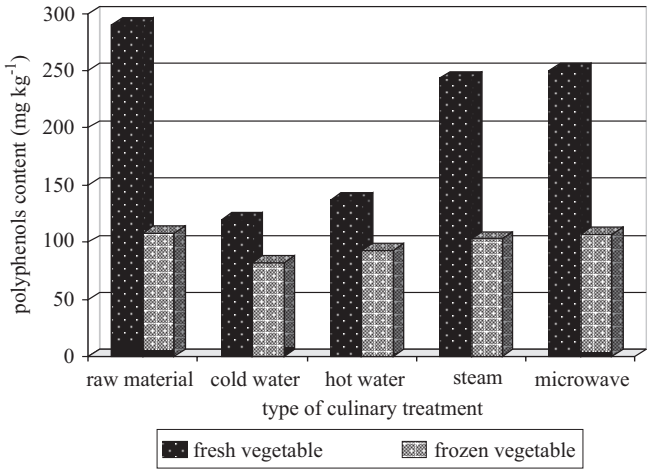


Fig. 1. Polyphenols content in broccoli subjected to culinary treatment in terms of product

Statistical analysis showed existence of statistically significant differences of polyphenols concentration in fresh broccoli subjected to culinary treatment in comparison to the raw broccoli. It proves that polyphenols content was significantly changed during thermal treatment. Simultaneously, it should be pointed out that type of applied treatment had serious influence on polyphenols content – statistically significant differences of polyphenols level in tested samples were demonstrated depending on thermal treatment method. Lack of statistically significant differences of polyphenols content in comparison to raw material was confirmed only in case of frozen broccoli cooked in microwave oven. So, such a way of treatment had no crucial influence on

polyphenols content in the frozen product. In the other methods, the statistically significant differences of polyphenols content were noticed in comparison to the raw, frozen broccoli. It proves that the three examined methods of thermal treatment substantially influenced the decrease of polyphenols content in the final product. However, it was also confirmed that in case of fresh raw material, polyphenols quantity in the final product was essentially diversified for the four tested methods of culinary treatment.

ZHANG and HAMAUZU (2004) during cooking broccoli – starting from boiled water and processing treatment in different periods of time – also stated considerable changes of polyphenols content. Drop of polyphenols content increased with the prolongation of treatment time. Similar changes have been observed during thermal treatment carried out by means of microwave. For the latter method of treatment less drop of polyphenols level was stated, what is in accordance with obtained results of tests. BOROWSKI et al. (2005) also found, that broccoli cooked in water possesses the less polyphenols content. In case of broccoli being cooked in a convection-type furnace, the only test sample, comparable to discussed experiments was the variant, in which broccoli were cooked for 5 minutes by means of steam (at a temperature of 103°C). At presented experiment an insignificant drop of polyphenols content in comparison to raw material occurred, similarly as during steam-cooking of broccoli.

Owing to diverse content of dry substance in tested samples (Figure 3) polyphenols content was recalculated in comparison to kg of dry substance. Due to low content of dry matter, both in fresh and frozen vegetable, the considerably higher values were obtained (Figure 2).

Statistical analysis of results recalculated in terms of dry substance, showed lack of substantial difference in polyphenols content, both in raw

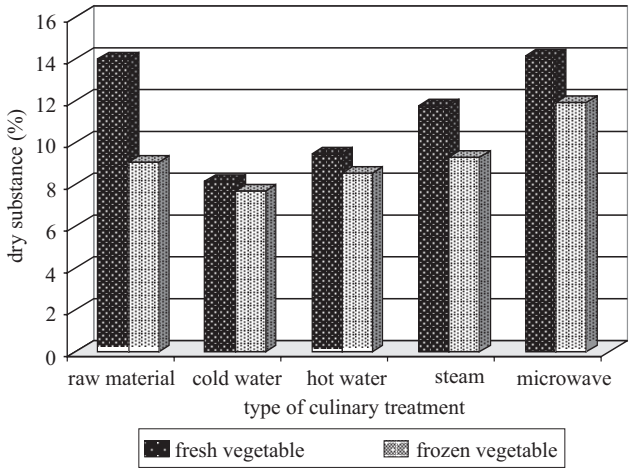


Fig. 2. Polyphenols content in broccoli subjected to culinary treatment, in terms of dry substance

broccoli and in steam-cooked broccoli. It points the slight losses of polyphenols in fresh broccoli during such a kind of culinary treatment. In the other methods of thermal treatment the substantial statistical difference in polyphenols content – both in raw broccoli and in cooked ones – were stated. Polyphenols content in dry substance of raw, frozen broccoli was considerably differ from polyphenols content in cooked – previously frozen – broccoli. So, it is evident, that culinary treatment substantially decreased polyphenols content in final product. Moreover, type of applied thermal treatment substantially influenced the polyphenols content in both tested forms of vegetable.

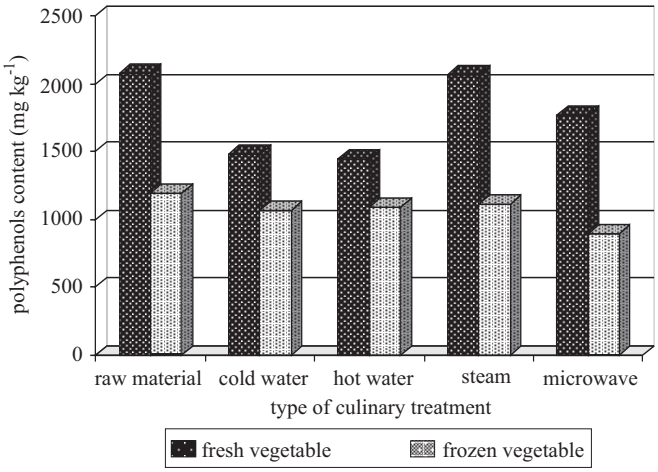


Fig. 3. Changes of dry substance content in broccoli subjected to thermal treatment

Changes of polyphenols content in broccoli subjected to thermal treatment, for both tested forms of vegetable are shown on Figure 4.

The maximal losses (59%) – as compared with started raw material – were noticed in fresh broccoli after cooking, starting from cold water. Similar, high value (53%) was stated in case of broccoli after cooking, starting from boiled water. The minimal losses (14%) were found in fresh vegetable cooked in microwave oven; losses were over 4-times less than in fresh broccoli after conventional cooking, starting from cold water. A bit more losses (16%) were noticed in steam-cooked broccoli. Above mentioned data show, that the best methods of thermal treatment of fresh broccoli are cooking by means of microwave oven (with small amount of water) and steam-cooking.

The minimal losses (1%) in comparison to the raw material were observed in frozen broccoli cooked in microwave oven and after steam--cooking (5%). The maximal losses (24%) were noticed in frozen broccoli after cooking, starting from cold water. Cooking of the frozen broccoli, starting from boiled water caused losses at the level of 14%. Results obtained for

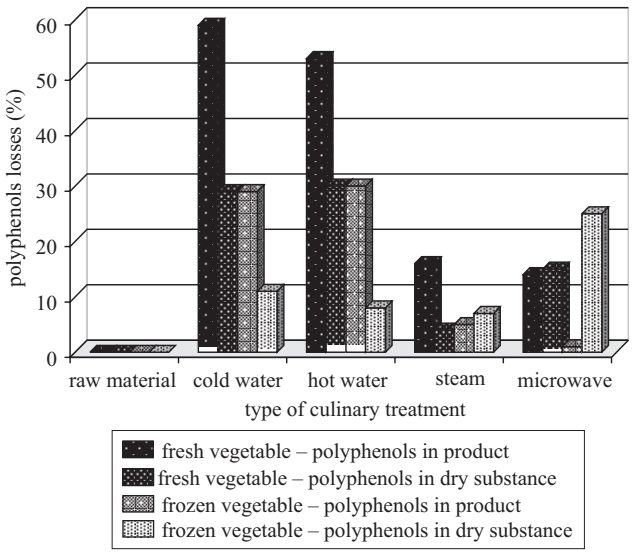


Fig. 4. Polyphenols losses in broccoli after culinary treatment – in comparison to the product and dry substance

frozen broccoli confirmed the results for raw broccoli; the best methods of thermal treatment considering the minimal polyphenols losses, are: cooking by means of microwave oven and steam-cooking.

Losses in fresh broccoli (in terms of dry substance) were as follows: cooking beginning from boiled water (30%), cooking starting from cold water (29%), steam cooking (0.4%), and cooking in microwave oven (15%). After culinary treatment of the frozen broccoli the following losses of polyphenols were stated (in terms of dry mass): in microwave oven (25%), starting from cold water (14%), beginning from boiled water (8%), after steam cooking (7%).

TURKMEN et al. (2005) who tested polyphenols content changes in green vegetables as result of thermal treatment, also presented their results of testing recalculated in terms of dry mass. Result obtained for fresh vegetables was the value almost twice less than in analysed experiment. The only losses (6%) were observed in case of broccoli cooked from boiled water. So, they were much lower than in the discussed experiment. In the remaining tests an increase of polyphenols content in dry mass was observed. In steam-cooked broccoli the increase of polyphenols content reached almost 18%, but broccoli cooked in microwave indicated much more value (25%).

## Conclusions

1. Thermal treatment diversifies polyphenols content in broccoli depending on applied form of raw material (raw vegetable or frozen one) and culinary technique.

2. During thermal treatment of broccoli less losses of polyphenols can be fund, if frozen vegetable is processed instead of the fresh one.

3. Thermal treatment in water causes significant losses of polyphenols in broccoli, whereas steam cooking causes them much less. The best quality of broccoli for the sake of keeping maximum content of polyphenols is obtained when fresh vegetable is processed by means of steam cooking.

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# INFLUENCE OF MICRO-IRRIGATION ON THE CONTENT OF VITAMIN C IN POTATO TUBERS

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Key words: irrigation, cultivars, storage, vitamin C.

Abstract

The aim of this study was to evaluate influence of drip- irrigation and micro-irrigation applied during vegetation period on changes of vitamin C content in chosen potato cultivars after harvest and 6 months storage. Applied in vegetation period irrigation combinations effected insignificantly on decrease of vitamin C content in all potato cultivars studied. Genetic factor significantly differentiated level of vitamin C content in tubers, cultivar Barycz was characterized by the highest vitamin C content to compare to the other (means from plots 268 mg $kg^{-1}$ of fresh matter). After storage content of vitamin C in tubers decreased in all of the cultivars, average 41.7% to compare to content after harvest. The biggest amounts of vitamin C content had cultivars which accumulated the highest content during the vegetation period.

## WPŁYW MIKRONAWODNIENIA NA ZAWARTOŚĆ WITAMINY C W BULWACH ZIEMNIAKA

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Słowa kluczowe: nawadnianie, odmiany, przechowywanie, witamina C.

Abstrakt

Celem pracy było określenie wpływu nawadniania kroplowego i mikrozraszania, stosowanego w okresie wegetacji ziemniaka, na zmianę zawartości witaminy C w bulwach wybranych odmian, bezpośrednio po zbiorach i po okresie 6-miesięcznego przechowywania. Zastosowane w okresie wegetacji roślin kombinacje nawadniania wpłynęły nieistotne na obniżenie zawartości witaminy C we wszystkich badanych odmianach ziemniaka. Czyn-

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nik genetyczny istotnie różnicował poziom badanego związku. Odmiana Barycz charakteryzowała się najwyższą ilością witaminy C (średnio 268 mg $kg^{-1}$ świeżej masy z obiektów). Po przechowywaniu zawartość tego składnika w bulwach uległa obniżeniu (we wszystkich badanych odmianach), średnio o 41,7% w porównaniu z zawartością oznaczoną bezpośrednio po zbiorach. Największe ilości witaminy C po przechowywaniu zawierały bulwy odmian, które w czasie wegetacji nagromadziły jej najwięcej.

## Introduction

Vitamin C content is the vitamin which can not be created by human organism because of lack of specific enzymes – L-gulono-lactone oxidase (GLO) and L-galactono-lactone dehydrogenase (GLDH). Therefore this vitamin is for man an exogenic vitamin which should be supplied with human feed (Borek-Wojciechowska 2000). Because of large consumption of potato tubers, potato is an important source of vitamin C (L-ascorbic acid and L-dehydroascorbic acid). Mean vitamin C content in fresh mass of potato tubers is about 200 mg $kg^{-1}$. But this value ranges from 30 to 300 mg $kg^{-1}$, as dependent on cultivar and year of cultivation (Leszczyński 2000, Mazurczyk and Lis 2000, Wroniak 2006), and especially depending on moisture (Głuska 1999). Long-lasting storage of potato tubers (6-7 months) can decrease the vitamin C content even by 50% (Leszczyński 2000).

Potato is described as a species sensitive to water deficit. Variable weather conditions during the vegetation period, occurring often in Poland, and especially insufficient amount of rainfall characterized by irregular course in the vegetation period, cause a decrease of potato yield and worsening of its quality. Water requirements of potato crop during the vegetation under climatic conditions of Poland range from 250 to 350 mm, and in sunny and very warm years above 400 mm (Nowacki et al. 2000). The content of vitamin C in tubers is lower when rainfall amount during the vegetation is insufficient (Mazurczyk and Lis 1999). In dry and warm years potato tubers are characterized by an increased content of vitamin C. In case of years characterized by considerable fluctuations of temperature and irregular course of rainfall, potato tubers contain the lowest amount of vitamin C (Boligłowa 1995, Zarzecka and Gąsiorowska 2000, Mazurczyk 1994, Mazurczyk and Lis 1999). Irrigation is a supplemental treatment of natural rain-precipitation by additional sprinkling of potato crops with water doses applied in adequate time in order to secure optimal conditions for plant development (Głuska 1999).

The main purpose of this trial was to determine the influence of drip irrigation and micro-sprinkler irrigation, applied in the vegetation period of potatoes, on the change of vitamin C content in tubers of chosen cultivars.

In consideration of potato consumption also in a distant period from potato-lifting (harvest), the next aim of the study was to determine the range of vitamin C content's changes in tubers after storage for 6 months.

## Material and Methods

Experimental material was constituted by potato tubers obtained from experimental field at Kruszyn Krajeński near Bydgoszcz in the years 2001––2003. Field experiment was carried out on the light soil included to V quality class. This trial was established as two-factorial experiment with split-plot design and three replications. The first-row factor was irrigation (*O* – without irrigation – control, *K* – drip irrigation, *M* – micro-sprinkler irrigation). The second-row factor was cultivar of medium-early potato: Barycz, Mors and Triada. Fertilization with nitrogen, phosphorus and potassium was done in spring. The doses applied per 1 ha were as follows: 90 kg N (urea), 80 kg $P_2O_5$ (superphosphate) and 80 kg $K_2O$ (potassium salt). Cultivation of potato was conducted according to proper agricultural recommendations. Drip irrigation was done with the use of 'T-tape' drip-line (in-line emitters spaced 20 cm apart). Output of a single emitter amounted on average 0.6 l $h^{-1}$. Micro-sprinkling was conducted with the use of micro--sprinklers 'Hadar' (nozzle diameter 1.3 mm, output 30 l $h^{-1}$). Irrigation was conducted according to tensiometer indications. Irrigation was started when soil water potential achieved – 0.03 MPa. Rainfall total during the vegetation period of potato (April-August), on average for the studied years, amounted 226 mm (Table 1). It was 95% from the long-period average

Table 1

Rainfall in Kruszyn Krajeński during vegetation period of potatoes

| Years | Rainfall (mm) | | | | | |
|---|---|---|---|---|---|---|
| | IV | V | VI | VII | VIII | IV-VIII |
| Norm | 28 | 40 | 56 | 65 | 51 | 240 |
| 2001 | 45 | 30 | 49 | 106 | 27 | 257 |
| 2002 | 13 | 50 | 40 | 108 | 41 | 252 |
| 2003 | 13 | 12 | 34 | 89 | 18 | 166 |
| Mean | 24 | 31 | 41 | 101 | 29 | 226 |

amounting 240 mm. Mean seasonal irrigation water rates amounted 54.6 mm in drip system and 130 mm in micro-sprinkling (Table 2). Single water rates, calculated as rainfall index, ranged from 2.4 to 12 mm and from 10 to 25 mm, for drip irrigation and micro-sprinkler irrigation, respectively. Experimental material (tubers) were stored for 6 months in temperature 4°C and relative

Table 2

Summary seasonal dose of in cultivation of potatoes (mm)

| Detailing | 2001 | 2002 | 2003 | Mean |
|---|---|---|---|---|
| Drip-irrigation | 39.6 | 43.2 | 81.0 | 54.6 |
| Micro-irrigation | 80.0 | 105.0 | 305.0 | 130.0 |

air humidity 95%. Directly after potato-lifting as well as after storage, the content of vitamin C was determined in this material according to TILLMANS method (PN-A-04019:1998). Results were statistically elaborated with the use of mixed model. Significance of differences was verified using Tukey's test with confidence level 95%.

## Results and Discussion

The content of vitamin C in tubers of potato grown on non-irrigated plots (control) was, on average for years and cultivars, on the level 239.2 mg $kg^{-1}$ fresh mass (Table 3). Studied irrigation systems caused not significant decrease of the vitamin C content in investigated cultivars, as compared to control and they did not change the content of this component. Obtained results are similar to those received by ROGOZIŃSKA and RZEKANOWSKI (1991).

Table 3

Influence of irrigation on vitamin C content (mg $kg^{-1}$) in potato tubers of study cultivars after harvest and 6 months storage (average with three years research)

| Irrigation | After harvest | | | | After storage | | | |
|---|---|---|---|---|---|---|---|---|
| | Barycz | Mors | Triada | Mean | Barycz | Mors | Triada | Mean |
| Control | 276.0 | 203.0 | 238.7 | 239.2 | 155.5 | 133.0 | 139.0 | 142.5 |
| Drip-irrigation | 262.3 | 194.7 | 223.7 | 226.9 | 133.5 | 127.0 | 128.5 | 129.7 |
| Micro-irrigation | 264.3 | 195.7 | 220.3 | 226.8 | 138.5 | 131.0 | 126.5 | 132.0 |
| Mean | 267.5 | 197.8 | 227.6 | 231.0 | 142.5 | 130.3 | 131.3 | 134.7 |

$LSD_{p=0.05}$ dla nawadniania – no significant
$LSD_{p=0.05}$ dla odmian – 2.3
$LSD_{p=0.05}$ dla przechowywania – 2.0

Irrigation of potato crop in the experiment conducted by MOZOLEWSKI (2003) did not increase of the vitamin C content in tubers. Genetic factor (cultivar) differentiated significantly the content of the studied component. Barycz cultivar was characterized by the highest content of vitamin C, on average 267.5 mg $kg^{-1}$ fresh mass than the other cultivars. In year 2003 the content of vitamin C in potato tubers was on the highest level (Table 4). It was

Table 4

Vitamin C content in potato tubers in dependence on cultivar and years

| Irrigation | After harvest | | | | After storage | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | Mean | 2001/02 | 2002/03 | 2003/04 | Mean |
| Barycz | 185 | 269 | 349 | 267.6±55.1 | 136 | 176 | 149 | 153.7±14.9 |
| Mors | 160 | 216 | 218 | 198.0±25.3 | 117 | 150 | 144 | 137.0±13.3 |
| Triada | 192 | 223 | 268 | 227.6±26.9 | 122 | 136 | 140 | 132.6±9.1 |
| Mean | 179.0 | 236.0 | 278 | 231.1 | 125.0 | 154.0 | 144.3 | 141.1 |

compatible with statements of ZARZECKA and GĄSIOROWSKA (2000) as well as MAZURCZYK (1994) that the highest content of vitamin C is accumulated by tubers in dry and hot years but the lowest one in a season characterized by considerable fluctuations of temperature and irregular course of rainfall. This period was also characterized by the highest losses of the studied component after six-month storage (48.2%).

After storage, the content of the vitamin C in tubers was decreased, on average by 41.7% as compared to the content determined directly after harvest (potato-lifting). In the trials carried out by ROGOZIŃSKA and RZEKANOWSKI (1991), ZGÓRSKA (1996) and WOJDYŁA (1997), the vitamin C content in potato tubers also decreased in a similar range.

## Conclusions

1. The content of vitamin C in potato tubers was significantly differentiated by genetic factor (cultivar), and the irrigation systems used in the vegetation period did not influence on the content of this ingredient.

2. The vitamin C content, after six-month period of storage, was significantly decreased in tubers of all the tested cultivars, on average by 41.7%. The highest content of vitamin C included Barycz cultivar tubers which have been accumulated the highest quantity of vitamin C during the vegetation period.

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# EFFECT OF EXTRUSION PROCESS PARAMETERS ON THE LEVEL OF METAL CONTAMINATION OF CORN-OAT EXTRUDATES

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K e y  w o r d s: extrusion cooking, metal contamination.

A b s t r a c t

Mixtures of corn grits and hulled oats whole meal were subjected to extrusion in a single-screw extruder (L:D=12:1, compression ratio 3:1), applying the following parameters: percentage of oats whole meal (3–15%), moisture content (13–16%), and profile of barrel temperature distribution (125/145/120-160/180/120°C). In the extrudates and the input mixtures the content of Fe, Mn, and Ni was determined. Extrusion of corn grits mixtures with oats whole meal resulted in only a slight increase of the content of metals in the extrudates obtained. The level of metals transition from the structural elements to the final product depended both on the type of material processed and on the technological parameters applied in the processing of the particular mixtures of raw materials. Only a several-percent increase was observed in the content of Fe, Mn and Ni as compared to the expected values resulting from the raw material composition. Increase in the level of contamination was related in particular to increased process temperature and reduced moisture content of the extruded material. The highest increase in the content of iron, 14% was observed for barrel temperature of 175°C, material moisture content of 13.5% and 9% share of oats whole meal. No effect, however, was shown of the content of dietary fibre in the extruded material on the level of metal contamination in the extrudate.

## WPŁYW PARAMETRÓW PROCESU EKSTRUZJI NA WIELKOŚĆ ZANIECZYSZCZEŃ METALICZNYCH EKSTRUDATÓW KUKURYDZIANO-OWSIANYCH

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A b s t r a k t

Mieszaniny kaszki kukurydzianej i razówki owsa obłuszczonego poddano ekstruzji na ekstruderze jednoślimakowym (L:D=12:1, stopień sprężania 3:1). Udział razówki owsianej wynosił od 3 do 15%, wilgotność surowca od 13 do 16%, a profil rozkładu temperatur cylindra – 125/145/120-160/180/120°C. W ekstrudatach oraz mieszankach wyjściowych badano zawartość Fe, Mn, Ni. Ekstruzja mieszanek kaszki kukurydzianej z razówką owsianą tylko w nieznacznym stopniu wpłynęła na wzrost zawartości metali w otrzymanych ekstrudatach. Zakres przechodzenia metali z elementów konstrukcyjnych do produktu gotowego zależał zarówno od rodzaju przetwarzanego materiału, jak i parametrów technologicznych stosowanych w czasie przetwarzania poszczególnych mieszanek surowców. Odnotowano tylko kilkuprocentowy wzrost zawartości Fe, Mn i Ni w porównaniu z wartościami oczekiwanymi wynikającymi ze składu surowcowego. Na wzrost zanieczyszczeń metalami szczególny wpływ miała podwyższona temperatura procesu oraz obniżona wilgotność ekstrudowanego surowca. Najwyższy wzrost zawartości żelaza wynoszący 14% obserwowano dla temperatury cylindra 175°C, wilgotności surowca 13,5% oraz 9% udziału razówki owsianej. Nie wykazano natomiast wpływu zawartości błonnika pokarmowego w ekstrudowanym surowcu na wzrost zanieczyszczeń metalicznych w ekstrudacie.

## Introduction

The extensive application of the technology of extrusion in the food industry for the production of breakfast cereals, snacks, crunchy baked products, instant pasta etc., results from the unquestionable advantages of that technology. Primary among those include the possibility of creating a variety of products, ease of modification of final product traits, possibility of ensuring high quality of end product, possibility of full automation of the process etc. (HUBER 2001). Considering the advantages following from the application of the technology, one cannot neglect the fact that it is a technology of highly intensive processing of materials. As a result of intensive effect of temperature, pressure, moisture and shear stress significant transformations are observed in the processed material, both in terms of its physical and chemical properties. The process of extrusion may result in a rather considerable increase in the water solubility index (WSI) of the extrudates as compared to the raw material. In some cases the WSI of extrudates reaches even up to 50% d.b. The range of the changes depends both on the process parameters and on the raw material composition of the mixtures (RZEDZICKI 2005, RZEDZICKI, ZARZYCKI 2005b). Also, a decrease is observed in the content of total dietary fibre and of the insoluble fraction, with simultaneous increase in the content of the soluble fraction (RZEDZICKI, ZARZYCKI 2005a, RZEDZICKI, ZARZYCKI 2006b, LARREA et al. 2005).

Intensive action of shear stresses in the extruded material may lead to increased wear of the structural elements of the extruder (screw, barrel, head, dies), and thus to an increase in the content of metals in the final product (ARTZ et al. 1992, SZPENDOWSKI et al. 1996, CAMIRE et al. 1993, CAMIRE 2001, CARDOSO-SANTIAGO, AREAS 2001). ARTZ et al. (1992) recorded an even

6-fold increase in the content of iron in extrudates as related to the input raw material. The process temperature proved to be of particular importance here. Increase of process temperature from 115 to 175°C caused the content of iron in the extrudate to nearly double. SZPENDOWSKI et al. (1996) noted a significant, almost 5-fold increase in the content of Fe in the extrudate as compared to the raw material. A notably lower increase in iron content due to extrusion was recorded in a study by ALONSO et al. (2001). Depending on the raw material used, the increase in the content of Fe was 32-35%. PINTO et al. (1997) recorded lower values; the content of iron increased by 14-28% in comparison to the raw material. Decrease in the moisture content of the extruded mass was much less conducive to increase in the iron content in the product. CAMIRE et al. (2001, 1993) claim that increase in the level of metal contamination, apart from the moisture of the extruded mass and the barrel temperature, is also related, to a significant extent, to the content of dietary fibre in the extruded material.

The objective of the undertaken study was to determine the effect of the share of oats components, of the moisture of the extruded raw material, and of the profile of barrel temperature distribution on the possibility of increase in the level of metal contamination in extrudates.

## Materials and Methods

The materials used in the study were corn grits and hulled oat grain. The chemical composition of the raw materials is given in Table 1. Oat grain was ground by means of a H-111/3 impact crusher to obtain the equivalent diameter of $\Phi_z = 0.35$ mm. The raw materials were mixed and wetted in accordance with the allied model of the experiment (Table 2), then conditioned for 12 h. The tests were made with a single-screw extruder (L:D = 12:1), using a screw with compression ratio of 3:1, die diameter of 3.5 mm, and screw rotation speed of 110 rpm.

The content of iron, manganese and nickel in the particular samples was determined with the method of atom absorption spectrophotometry (ASA) using the Unicam 939 apparatus in accordance with the AOAC Method 975.03. The determinations were made at the Central Analytical Laboratory of the Lublin University of Agriculture in Lublin. Also determined was the content of ash (AACC, Method 08-01), proteins (AACC, Method 46-08) and free fats (AACC, Method 30-26). Total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) were determined following the AOAC and AACC methods (Method 991.43; AOAC Method 985.29; AACC, Method 32-07; AACC, Method 32-21; AACC, Method 32-05) using Megazyme sets of enzymes and procedures. All the AACC and AOAC methods were taken from Approved Methods of AACC (1).

Table 1

Chemical composition of the raw materials (% d.b.)

| Component | Protein (%) $x$±SD | Fat (%) $x$±SD | TDF (%) | IDF (%) $x$±SD | SDF (%) $x$±SD | Ash (%) $x$±SD | Fe mg kg$^{-1}$ s.m. $x$±SD | Mn mg kg$^{-1}$ s.m. $x$±SD | Ni mg kg$^{-1}$ s.m. $x$±SD |
|---|---|---|---|---|---|---|---|---|---|
| Corn semolina | 9.96±0.2 | 1.09±0.05 | 6.31 | 5.26±0.03 | 1.05±0.12 | 1.43±0.04 | 12.75±0.01 | 1.85±0.08 | 0.24±0.02 |
| Oat meal | 14.25±0.3 | 6.70±0.15 | 21.05 | 15.49±0.1 | 5.56±0.08 | 2.22±0.01 | 40.2±0.12 | 39.21±0.06 | 0.72±0.009 |

TDF – Total dietary fibre,
IDF – Insoluble dietary fibre,
SDF – Soluble dietary fibre

Table 2

Model of the experiment and chemical composition of the extrudates

| No. | Model of experiment | | | Protein (% d.b.) $x$±SD | Fat (% d.b.) $x$±SD | Ash (% d.b.) $x$±SD | TDF (% d.b.) | SDF (% d.b.) $x$±SD | IDF (% d.b.) $x$±SD |
|---|---|---|---|---|---|---|---|---|---|
| | oat meal (%) | moisture content (%) | temp. (°C) | | | | | | |
| 1 | 3 | | | 9.78±0.18 | 0.89±0.05 | 1.52±0.15 | 4.31 | 1.91±0.05 | 2.40±0.18 |
| 2 | 6 | | | 10.19±0.05 | 0.92±0.2 | 1.52±0.13 | 4.66 | 1.97±0.16 | 2.69±0.09 |
| 3 | 9 | 13.5 | 145/165/120 | 10.32±0.14 | 1.05±0.12 | 1.54±0.09 | 5.41 | 2.04±0.16 | 3.37±0.09 |
| 4 | 12 | | | 10.50±0.07 | 1.2±0.18 | 1.56±0.22 | 5.86 | 2.62±0.11 | 3.24±0.27 |
| 5 | 15 | | | 10.59±0.13 | 1.31±0.08 | 1.62±0.09 | 6.42 | 2.90±0.09 | 3.52±0.22 |
| 6 | | 13 | | 10.29±0.05 | 1.05±0.11 | 1.55±0.06 | 5.1 | 2.01±0.12 | 3.09±0.1 |
| 7 | | 13.5 | | 10.32±0.22 | 1.05±0.12 | 1.54±0.09 | 5.41 | 2.04±0.16 | 3.37±0.09 |
| 8 | | 14 | | 10.30±0.18 | 1.04±0.09 | 1.53±0.12 | 5.15 | 2.04±0.06 | 3.11±0.18 |
| 9 | 9 | 14.5 | 145/165/120 | 10.33±0.12 | 1.09±0.1 | 1.53±0.2 | 4.83 | 1.89±0.24 | 2.94±0.14 |
| 10 | | 15 | | 10.31±0.12 | 1.12±0.21 | 1.54±0.12 | 4.65 | 1.95±0.06 | 2.7±0.17 |
| 11 | | 15.5 | | 10.29±0.15 | 1.15±0.2 | 1.55±0.05 | 4.77 | 2.18±0.09 | 2.59±0.12 |
| 12 | | 16 | | 10.30±0.11 | 1.13±0.07 | 1.56±0.18 | 4.84 | 2.23±0.14 | 2.61±0.17 |
| 13 | | | 125/145/120 | 10.37±0.11 | 1.15±0.06 | 1.52±0.14 | 4.79 | 2.1±0.17 | 2.69±0.19 |
| 14 | | | 130/150/120 | 10.36±0.09 | 1.16±0.12 | 1.53±0.08 | 5.36 | 2.1±0.16 | 3.26±0.15 |
| 15 | | | 135/155/120 | 10.31±0.13 | 1.14±0.13 | 1.57±0.15 | 5.35 | 2.13±0.13 | 3.22±0.17 |
| 16 | 9 | 13.5 | 140/160/120 | 10.32±0.14 | 1.10±0.1 | 1.54±0.18 | 5.22 | 2.12±0.15 | 3.1±0.13 |
| 17 | | | 145/165/120 | 10.30±0.03 | 1.05±0.12 | 1.54±0.09 | 5.41 | 2.04±0.16 | 3.37±0.09 |
| 18 | | | 150/170/120 | 10.29±0.02 | 1.07±0.32 | 1.56±0.05 | 5.3 | 2.12±0.07 | 3.18±0.09 |
| 19 | | | 155/175/120 | 10.31±0.25 | 1.02±0.16 | 1.56±0.17 | 4.84 | 2.03±0.18 | 2.81±0.17 |
| 20 | | | 160/180/120 | 10.32±0.17 | 1.03±0.17 | 1.57±0.07 | 4.59 | 1.94±0.19 | 2.65±0.14 |

Analyses were made in three replications; the mean values, standard deviations and coefficients of variation were calculated. If the coefficient of variation exceeded the error margins estimated for a given method, the analyses were repeated until correct scatter of results was obtained. Conclusions on the direction of changes in the results obtained were formulated on the basis of determined equations of regression and of calculated determination coefficients $R^2$.

## Results and Discussion

Increased share ratios of oats whole meal in the extruded mixtures caused an increase in the content of ash and of the particular mineral components (Fe, Mn, Ni) in the products obtained (Table 2, Figure 1). Such a direction of changes is fully justified by the increase content of those elements in the oats whole meal as compared to corn grits (Table 1). Attention is drawn to the slight differences between the shapes of curves of expected values, resulting from the raw material composition, and the

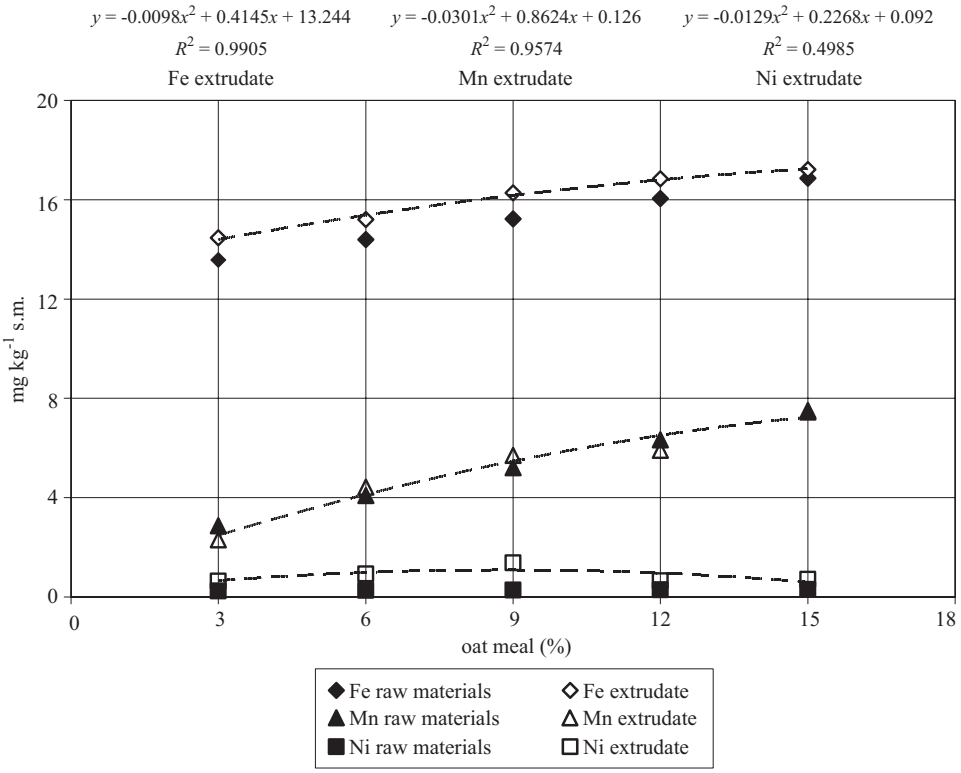


Fig. 1. Influence of oat whole grain meal on mineral content

curves of values determined in the extrudates (Figure 1). The maximum increments of the content of metals did not exceed the level of about a dozen percent or so. Thus the theses posed by CAMIRE et al. (2001, 1993), that an increase in the content of dietary fibre should be accompanied by an increase in the level of metal contamination, did not find support. No such direction of changes was observed in the study reported herein. Undoubtedly, the effect of fibre on the rate of wear of elements of the extruder is dependent on the fraction composition of the fibre. In this study, the main source of dietary fibre was the oats whole meal, rich in mucous soluble fractions. These fractions play the role of grease in the extruder, reducing friction and thus lowering the shear stresses and protecting the cylinder and screw surfaces.

No increase in the level of metal contamination was observed also in the case of samples extruded at raw material moisture varying within the range of 13–16% at a constant profile of barrel temperatures 140/165/120°C (Figure 2). The highest increase in the content of iron, at the level of 10%, was recorded in samples extruded at the lowest level of raw material moisture of 13%. Further increase in moisture was accompanied by a reduction in the level

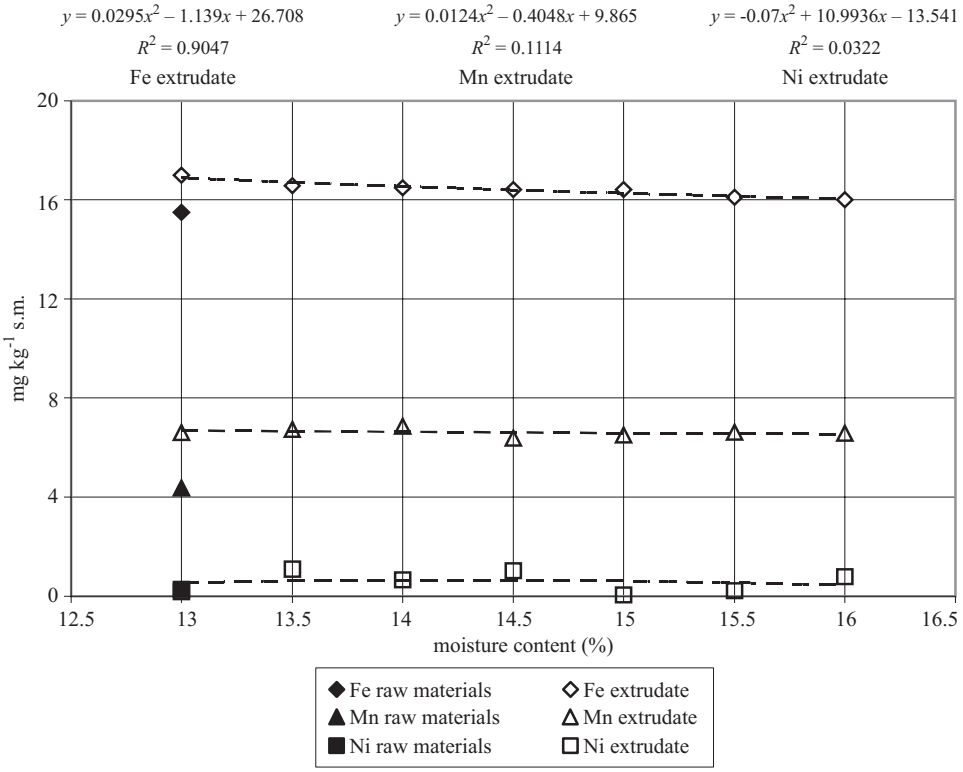


Fig. 2. Influence of moisture content on mineral content

of contamination. We can conclude, therefore, that the increase in metal contamination was caused by increased intensity of the process and growing level of shear stresses, stimulated by the decreasing moisture of the extruded mass. The range of the observed changes, however, was very low.

The study included also determination of the effect of variable barrel temperatures within the range of 125/145/120-160/180/120°C at constant moisture of the extruded mixture, equal to 13.5% (Figure 3). With increasing barrel temperature, greater increments of metal contamination were observed. The maximum increment of iron content in the extrudate, 14%, was recorded at temperatures of the particular sections of the barrel of 155/175/120°C and at raw material moisture of 13.5%. Although the range of the recorded increments of contamination was low, a very interesting regularity can be noted here. Increase in barrel temperature undoubtedly caused a drop in viscosity of the extruded mass and thus a reduction of shear stresses, which should result in reduced wear of the extruder due to a reduction in the wear the screw and cylinder surfaces. However, an

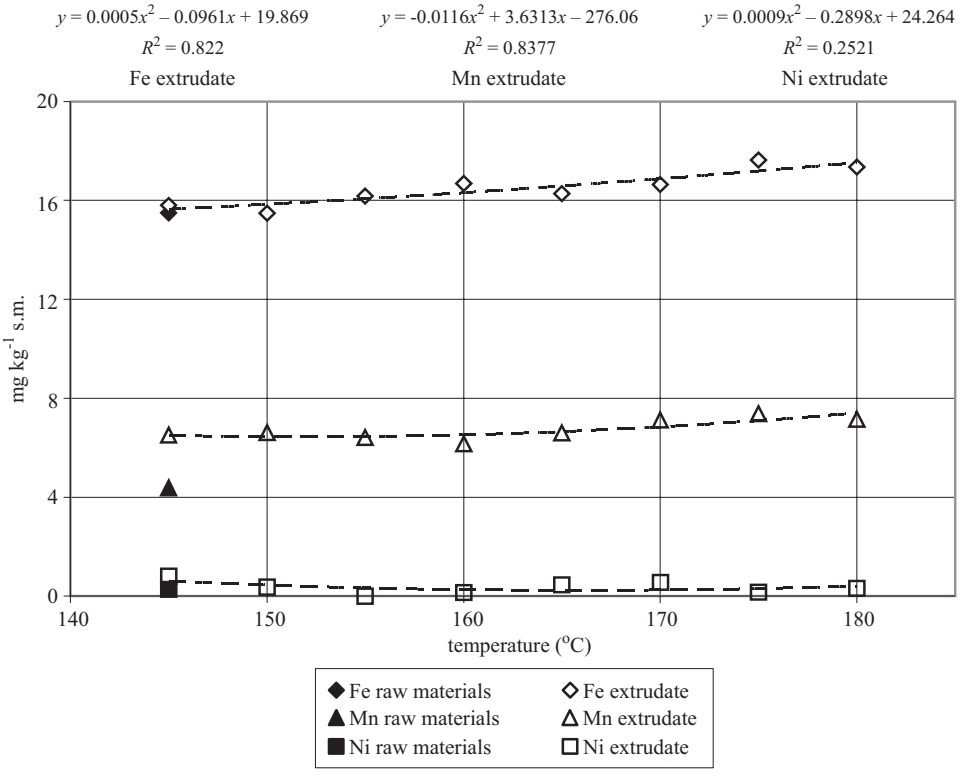


Fig. 3. Influence of barrel temperature on mineral content

opposite tendency was noted – increase in temperature was also accompanied by an increase in the level of metal contamination. This recorded regularity permits the formulation of the thesis that at increased temperatures the dominant cause for the increase in the level of metal contamination is not the mechanical erosion of the screw and barrel surfaces but, intensifying with increase in temperature, chemical reactions between steel and the components of the extruded mass. A similar direction of changes was noted in a study on the extrusion of mixtures of corn grits with gymnospermous oats whole meal (RZEDZICKI, ZARZYCKI 2006a).

The research results presented herein confirm the possibility of transition of metals to the end product of extrusion, reported also by other authors (ARTZ et al. 1992, SZPENDOWSKI et al. 1996, CAMIRE et al. 1993, PINTO et al. 1997, CARDOSO-SANTIAGO, AREAS 2001, ALONSO et al. 2001). The level of metal contamination observed in our study is, however, several times lower than that presented in reference reports, especially when compared to the results obtained by ARTZ et al. (1992), where an almost 6-fold increase in iron content was recorded. The results of our study are closer to those obtained by PINTO et al. (1997) and ALONSO et al. (2001).

According to CAMIRE et al. (1993, 2001), increased content of fibre in raw materials may be conducive to intensified migration of microelements to extrudates. The performed studies showed that such tendencies need not occur at all times. In our study, in spite of increase in the content of dietary fibre with growing share of oats whole meal, no greater increase was observed in the level of metal contamination (Figure 1). The regularity observed by CAMIRE (2001) and by CAMIRE et al. (1993) does not hold true in the case of mixtures including oats whole meal.

Fat present in oats products in the amount of about 7% d.b. and mucous fractions of soluble fibre, at about 6% d.b., provide protection for the working elements of the extruder, thus permitting safe application of the technology of extrusion in the processing of oats components.

## Conclusions

1. Extrusion of mixtures of corn grits and oats whole meal entailed only a slight increase in the level of metal contamination in the extrudates.

2. The level of such contamination was affected the most strongly by the temperature of the process.

3. The greatest increment of iron content, at the level of 14%, compared to the expected values resulting from the raw material composition was recorded for the barrel temperature profile of 155/175/120°C and raw material moisture content of 13.5%

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# THE INFLUENCE OF AGE AND SEX ON DIETARY ATTITUDES OF POLES IN RELATION TO PLANT ORIGIN PRODUCTS. POFPRES STUDY

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K e y w o r d s: preferences, frequency of consumption, plant origin products, nutritive value.

A b s t r a c t

The study was conducted on a group of 9339 individuals aged 13 to 75 years, living in 6 macro regions of Poland. The preferences and frequency of consumption were determined for cereal products, vegetables and fruit. The analysis of preferences included cereal products with high and low dietary fiber contents, as well as vegetables and fruit with high $\beta$-carotene and/or vitamin C contents. High-fiber cereal products and vegetables, including vegetables rich in $\beta$-carotene and/or vitamin C, were relatively little liked, especially by adolescents and males. A too low average frequency of consumption was shown for plant origin products, especially vegetables and fruit, in case of students, and for fruit in the group of males. Results suggest that dietary attitudes of Poles towards plant origin products are disadvantageous in view of the dietary recommendations concerning the prevention of civilization-related diseases.

## WPŁYW WIEKU I PŁCI NA POSTAWY ŻYWIENIOWE POLAKÓW DOTYCZĄCE PRODUKTÓW POCHODZENIA ROŚLINNEGO. BADANIA POFPRES

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S ł o w a k l u c z o w e: preferencje, częstość spożycia, produkty roślinne, wartość odżywcza.

A b s t r a k t

Badaniami objęto 9339 osób w wieku od 13 do 75 lat mieszkających w 6 makroregionach Polski. Oceniono preferencje oraz częstość spożycia produktów zbożowych, warzyw i owoców. W analizie preferencji wzięto pod uwagę produkty zbożowe z wysoką i niską zawartością błonnika pokarmowego oraz warzywa i owoce bogate w $\beta$-karoten i witaminę C lub tylko w jeden z tych wymienionych składników. Produkty zbożowe wysokobłonnikowe oraz warzywa (w tym warzywa zawierające dużo $\beta$-karotenu i/lub witaminy C) były relatywnie mało lubiane, zwłaszcza przez młodzież szkolną oraz mężczyzn. Wykazano zbyt niską średnią częstość spożycia produktów pochodzenia roślinnego, szczególnie warzyw i owoców w grupie studentów oraz owoców w badanej grupie mężczyzn. Uzyskane wyniki sugerują, że zachowania żywieniowe Polaków odnośnie produktów pochodzenia roślinnego są niekorzystne z punktu widzenia zaleceń żywieniowej profilaktyki chorób cywilizacyjnych.

## Introduction

Results of studies on the consumption of nutrients by Poles indicate several irregularities. One of the problems is the too low intake of dietary fiber, resulting from the low share of whole meal products (Szponar et al. 2003, Gronowska-Senger 2005). According to the current WHO recommendations (2003) the intake of dietary fiber should be at least of 25 g/day. A frequent dietary error made by Poles is insufficient consumption of vegetables and fruit (Cieślik et al. 2001, Szponar et al. 2003, Kazimierczak 2004, Gronowska-Senger 2005). The current state of knowledge on nutrition and medicine shows clearly that these products need to be consumed several times a day for health reasons (Dixon et al. 2001, Krebs-Smith, Kantor 2001, WHO 2003).

Each individual satisfies their dietary requirements individually, which is manifested in specific dietary preferences, expressing relatively stable culinary tastes (Babicz-Zielińska 1999). Studies on preferences, in combination with the analysis of frequency of consumption of different groups of products, especially those of special importance for health, play an essential role in the assessment of diet. Results of those studies may be used to estimate risk factors for diet-dependent diseases, as well as promote appropriate dietary behavior.

Taking the above in consideration, the aim of the study was to analyze preferences and frequency of consumption for plant origin products by Poles depending on their age and sex. In the study three groups of plant origin products were included: cereal products, vegetables and fruit. In the analysis of preferences cereal products with high and low dietary fiber contents were included, together with vegetables and fruit with high contents of $\beta$-carotene and/or vitamin C.

## Materials and Methods

Investigations were conducted on a group of 9339 Poles aged 13 to 75 years. They included school children, students and adults living in 6 macro regions of Poland: the Kaszuby, Kujawy, Małopolska, Pomorze Zachodnie, Warmia and Wielkopolska regions. Respondents were selected at random, with requests to participate in the study sent to pupils of primary schools, secondary school and university students, employees of enterprises, individuals working in freelance professions and the unemployed.

Preferences were determined for 22 cereal products, 30 raw vegetables and 28 raw fruits, based on a 5-point hedonic scale, containing margin points from "I dislike it very much" to "I like it very much", with a neutral field of "I neither like nor dislike it". Mean preferences (x) and standard deviations (SD) were determined for individual products, and next mean values were calculated for whole groups of products, as well as their respective subgroups. When establishing subgroups the dietary fiber content in cereal products was taken into consideration, together with contents of $\beta$-carotene and/or vitamin C in vegetables and fruit (KUNACHOWICZ et al. 1998). Explanations of criteria applied within a given subgroup are given under Table 1. The frequency of consumption was determined only for groups of products. When assessing the frequency of consumption for cereal products an 8-point scale was applied, containing margin denotation from "never" to "at least 4 times a day". In turn, the frequency of consumption for vegetables and fruit was assessed based on a 7-point scale, containing margin points from "never" to "at least 3 times a day".

Due to the application of different scales in the study, results were converted into a uniform scale with the score range of 0÷100 points. Statistical analysis was conducted using the KRUSKAL-WALLIS (K-W) test and the KOŁMOGOROW-SMIRNOW (K-S) test. All calculations were performed using STATISTICA PL v.6.0 software by StatSoft.

## Results and Discussion

As it results from Table 1, the highest preferences were found for the group of fruit (81 points) and the subgroup of fruit rich in $\beta$-carotene and/or vitamin C (80 points), which indicates that they were much liked. The other groups and subgroups of products turned out to be liked and their mean preferences fell within the range of 65 points to 71 points. Lower preferences for cereal products and vegetables could have resulted from the little liked assortments of products found in these groups, e.g. buckwheat and barley groats among cereal products, or spinach among vegetables (CZARNOCIŃSKA et al. 2002a,b). The mean rate of liking for fruit was markedly higher than that for vegetables (81 points vs. 67 points), which was also

Table 1

Mean preferences and frequency of consumption (score of range 0÷100 points) of analyzed groups of products in the entire population and in terms of age and sex (x±sd)

| Preferences and frequency of consumption | In total | Age group | | | | Sex | | |
|---|---|---|---|---|---|---|---|---|
| | | adolescents | students | adults | K-W test | women | men | K-S test |
| | *N* = 9339 | *N* = 3710 | *N* = 3000 | *N* = 2629 | *p* | *N* = 5200 | *N* = 4139 | *p* |
| Preferences for cereal products | 68±13.3 | 68±14.7 | 69±11.7 | 66±12.6 | <0.0001 | 69±12.5 | 67±14.0 | <0.0001 |
| Preferences for high-fiber cereal products[1] | 65±15.7 | 65±16.6 | 67±14.4 | 63±15.6 | <0.0001 | 67±15.0 | 64±16.4 | <0.0001 |
| Preferences for low-fiber cereal products[2] | 71±13.0 | 71±14.5 | 71±11.4 | 69±12.1 | <0.0001 | 71±12.5 | 70±13.6 | <0.05 |
| Preferences for vegetables | 67±15.1 | 62±17.1 | 71±13.4 | 70±13.4 | <0.0001 | 69±14.6 | 66±15.4 | <0.0001 |
| Preferences for vegetables rich in carotene and/or vitamin C[3] | 70±15.0 | 66±16.3 | 73±13.3 | 72±13.7 | <0.0001 | 72±14.5 | 68±15.3 | <0.0001 |
| Preferences for fruit | 81±14.3 | 82±16.1 | 82±12.1 | 78±13.2 | <0.0001 | 81±14.3 | 81±14.4 | ni |
| Preferences for fruit rich in carotene and/or vitamin C[3] | 80±14.8 | 82±16.5 | 81±12.7 | 78±13.7 | <0.0001 | 80±14.7 | 81±14.8 | ni |
| Consumption frequency for cereal products | 80±18.6 | 80±15.7 | 82±15.1 | 78±18.7 | <0.0001 | 79±18.5 | 81±18.6 | <0.0001 |
| Consumption frequency of vegetables | 54±29.1 | 57±30.5 | 38±27.1 | 67±29.4 | <0.0001 | 54±29.5 | 54±28.6 | ni |
| Consumption frequency of fruit | 73±19.9 | 78±19.1 | 68±18.9 | 70±20.2 | <0.0001 | 74±19.4 | 71±20.3 | <0.0001 |

[1] with fiber content >5 g 100 $g^{-1}$;
[2] with fiber content ≤5 g 100 $g^{-1}$;
[3] with carotene content >300 µg 100 $g^{-1}$ and/or vitamin C>30 mg 100 $g^{-1}$

indicated in other studies (Domel, Baranowski 1993, Babicz-Zielińska 1999). The high preference for fruit may be connected with their sweet taste, which is definitely the most preferred taste by most people. High-fiber cereal products were preferred to a slightly lower degree that low-fiber products (65 points vs. 71 points). Results correspond well to those of studies published by other authors, indicating low frequencies of consumption for whole meal cereal products (Ilow et al. 1998, Przysławski et al. 1999, Wądołowska 2000, Gronowska-Senger 2005). In turn, vegetables rich in $\beta$-carotene and/or vitamin C were preferred to a slightly higher degree that all vegetables jointly (70 points vs. 67 points), but the difference was not as obvious as in case of cereal products. The mean frequency of consumption for cereal products and fruit was "once a day" (80 points and 73 points, respectively), while for vegetables it corresponded to the frequency of "5-6 times a week" (54 points), which does not comply with the recommendations of diet-based disease prevention (Ziemlański, Panczenko-Kresowska 1998, WHO 2003, Gronowska-Senger 2005).

Dietary preferences and the frequency of consumption for all groups and subgroups of products were significantly dependent on age ($p<0.0001$). The biggest differences were recorded for vegetables and fruit. Students and adults, in comparison to adolescents, had higher preferences for vegetables (by 9 points and 8 points, respectively) and vegetables rich in $\beta$-carotene and/or vitamin C (by 7 and 6 points, respectively). The frequency of consumption for vegetables was highest in the group of adults, while it was lowest in the group of students (67 points vs. 38 points). In case of the group of students the lowest frequency of consumption was also found for fruit, which in turn were consumed most often by school children and secondary school students (68 points vs. 78 points). Age is considered a very important variable explaining not only the attitudes in relation to food, but also the consumption of food (Shepherd 1999, Babicz-Zielińska 2006). It was shown that after adolescence food aversions disappear and the range of more preferred and more frequently consumed products increases (Rozin 1996). Moreover, it was observed that preferences for vegetables increase with age (Nicklaus et al. 2004), which is unambiguously confirmed by the results of this study.

Food preferences and the frequency of consumption in most groups and subgroups of products were significantly dependent on the sex of respondents ($p<0.05$, $p<0.0001$). Women showed higher preferences for vegetables and vegetables rich in $\beta$-carotene and/or vitamin C than males (by 3 and 4 points, respectively), as well as cereal products and high-fiber cereal products (by 2 and 3 points, respectively). The frequency of consumption for cereal products was markedly higher in the group of men (by 2 points), while the frequency of consumption of fruit was significantly higher for women (by 3 points). It may not be excluded that the more advantageous dietary attitudes of women could have resulted from their more extensive knowledge on nutrition (Narojek 1993, Turrell 1997, Fagerli, Wandel 1999). The effect of sensory attributes, including taste, being the primary determi-

nants for selection in case of most products, may be another explanation here (Babicz-Zielińska 1999). In the opinion of many authors sex significantly differentiates both attitudes towards food and food consumption (Satia et al. 2002, Baker, Wardle 2003, Jeżewska-Zychowicz 2004). Differences in dietary behavior of women and men only partly result from the different requirements of energy and individual nutrients. To a large extent they are also affected by such factors as cultural customs and fashion.

## Conclusions

1. High-fiber cereal products and vegetables, including vegetables rich in $\beta$-carotene and/or vitamin C, were relatively little liked, especially by adolescents and men.

2. An insufficient mean consumption frequency was shown for plant origin products, especially vegetables and fruit in the group of students and fruit in the group of men.

3. Results suggest that dietary attitudes of Poles towards plant origin products are disadvantageous in view of the recommendations of diet-based prevention of civilization-related diseases.

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# THE PREFERENCES OF ECOLOGICAL FOOD CONSUMERS

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K e y  w o r d s: ecological food, expenditure on ecological food, the place of ecological food purchase, the attributes of ecological food.

A b s t r a c t

The research included households located in different parts of the country, where ecological food is consumed. The subject of the research concentrated on consumption of certified ecological food. Expenditure on ecological food was analyzed, with particular attention being paid to structuring the kinds of food produce. Regardless of the level of expenditure on ecological food, the respondents consume mainly products of plant origin, because they are easily accessible and in a wider range of goods. The interest in buying ecological food in supermarkets is increasing, which can turn them into one of the main ecological products trade places. The main features attributed to ecological food by respondents are its healthy and nutritional values.

## PREFERENCJE KONSUMENTÓW ŻYWNOŚCI EKOLOGICZNEJ

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S ł o w a  k l u c z o w e: żywność ekologiczna, wydatki na żywność ekologiczną, miejsce zakupu żywności ekologicznej, spożycie żywności ekologicznej.

A b s t r a k t

Badaniami objęto gospodarstwa domowe znajdujące się w różnych częściach kraju, w których konsumuje się żywność ekologiczną. Przedmiotem badań było przede wszystkim spożycie certyfikowanej żywności ekologicznej. Poddano analizie skalę wydatków na nią, uwzględniając strukturę rodzajową produktów żywnościowych. Niezależnie od poziomu wydatków na żywność ekologiczną badani głównie spożywają produkty pochodzenia roślinnego, ponieważ są dostępne i jest ich większy wybór. Wzrasta również zainteresowanie zakupem żywności ekologicznej w supermarketach. Placówki te mogą stać się w przyszłości jednym z głównych miejsc handlu żywnością ekologiczną.

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## Introduction

In a market economy, the consumer is placed in the center of attention. Producers are becoming more and more aware of the fact that the efficiency of their market activities depends mainly on the ability to recognize and satisfy consumers' needs and to adjust their market offer to them. The awareness of consumers' needs and actions determines success in market activities and is one of the conditions for economically effective functioning of a company.

When buying a certain product, Polish consumers take into account its price, but they also attach great importance to its quality. The choice of food products is more and more determined by such factors as: their freshness, nutritional value, dietary properties, health value, ecological requirements, high quality and comfort of consumption as well as the amount of chemical additives.

Large part of society is greatly interested in healthy food. With regard to this, as URBAN indicates (1999) requirements on lowering fat content and raising protein content are formed, along with the requirement on food being produced in an ecological way, which ensures it contains more vitamins and nutritional values. Among products with the most wanted pro-health qualities, ecological food is of greatest importance.

This research aimed to identify and analyze factors determining the market behaviour of ecological food consumers.

An attempt was done to verify the assumption that small number of shops and high price of products have a negative impact on the consumers' interest in this kind of products. According to consumers, the most valuable feature of ecological food is its pro-health influence, which is also one of the main reasons motivating to purchase these products.

## Methodology of Research

The research included households located in different parts of the country, where ecological food is consumed. The subject of the research concerned the consumption of certified ecological food.

Empirical research concerning the consumption of ecological food were conducted in three geographical areas of Poland, varying in terms of their environmental features, namely: 1) in southern Poland – Kraków, Katowice and the surrounding area, 2) in central Poland – Warsaw and its neighbourhood, 3) in northern Poland – Trójmiasto, Olsztyn, Łomża and the surrounding areas. These regions also constitute the main centers of ecological food consumption in Poland (ZYSNARSKA 1997).

The source materials were gathered by means of direct standardized interviews, with a detailed interview questionnaire. People purchasing food mainly for their families were chosen as the respondents.

The research was conducted in November 2005. All in all, 142 interviews conducted with ecological food consumers were adopted for analysis.

For the purpose of the analysis, the examined households were divided into groups according to the following criteria: the level of consumption, the level of income, social and demographic features as well as the frequency and the place of food purchase.

The analysis took into account certain factors determining the market behaviour of ecological food consumers, that is: sources of information about ecological products, reaction to a price change, and the assessment of ecological food attributes.

## The results of the Research

The consumers of ecological food taking part in the research were mainly young people, who were the most numerous group of customers; and so people below 30 years old constituted 37% of all respondents, the average age of respondents being 39.8 years. It is worth noticing that the respondents were well educated, since people with university degrees were the most numerous group at 47%, and their average income was 1838 zł a month per person.

According to 28% of respondents, periodicals were the most significant sources of information about the produce of ecological farming, while 27% of respondents got most information from advertising materials in the places where they did their shopping. 15% of those polled remained under the influence of issues broadcast by television, whilst 20% relied on information from friends and family.

### The Level and Structure of Ecological Food Consumption Among Respondents

Among the examined households, consuming ecological food, the average annual expenditure on it amounted to 718.82 zł.

Taking into account the levels of ecological food consumption, on average the respondents' expenses were predominantly directed towards grain products. As far as plant products are concerned, regardless of the level of their consumption, vegetables have the greatest share (especially fresh), grain products, potatoes, and fruit (especially fresh). Among the animal products, on the other hand, the most important is cow's milk, dairy produce, eggs and meat (Table 1).

Along with the increase of expenditure on ecological food generally, decrease in consumption of plant products is observed. Among the respondents with higher levels of expenditure, purchases of animal produce and such products as honey, soy or lentil are on the increase. The research by Runowski (1998) also confirms this.

Table 1

The expenditure on ecological products in a given group (zł per person annually)

| Characteristcs | Total | Consumption level | | |
|---|---|---|---|---|
| | | low (do 400 zł) | average (401–650 zł) | high (pow. 650 zł) |
| I. Products of plant origin | 456.01 | 163.82 | 283.36 | 563.34 |
| II. Productst of animal origin | 240.50 | 82.19 | 167.20 | 350.84 |
| III. Other products | 22.31 | 0.00 | 5.55 | 43.26 |
| IV. The total average level of expenditure on food consumption in population | 718.82 | 246.01 | 455.91 | 957.45 |
| The structure of respondents | 100% | 35.8% | 31.7 % | 32.5% |

Source: the author's own research

As for the place of ecological food purchase, 53% of respondents indicated healthy food shops as their most preferable places; about 43% of their total expenditure is spent in these shops.

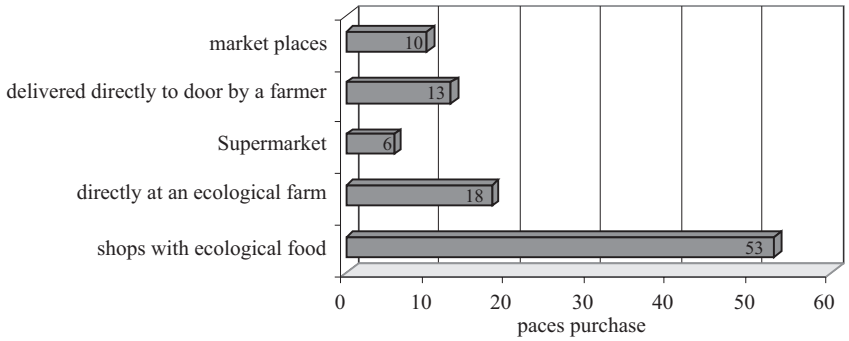


Fig. 1. The places of ecological food purchase in the respondents' opinion (%)
Source: the author's own research

For 18% of respondents, it is a commonplace to buy ecological products directly from a farm, and in case of 6% of respondents, a farmer delivers the products to their households.

The results of the research indicate that the most popular places for ecological food purchase are still healthy food shops. However, it is worth widening the range of products available in supermarkets, thanks to which ecological food becomes more accessible to the average consumer.

## The Attributes of Ecological Food in the Respondents Opinion

The process of assembling specific elements of a product that fulfill the needs of individual recipients underlies the choice of a particular product and the will to buy it. As Wier and Calverley (2002) indicate, in choosing

a particular offer, the customers pick the collection of the most attractive features that a given product possesses, predicting this product will fully satisfy them. That is why the attributes of a given product will have a specific value for an individual consumer or for a group of consumers whose market behaviour is similar.

The assessment of ecological food qualities was taken into consideration in the research; the respondents were asked to indicate the most valuable attributes of products of this kind. The main feature attributed to ecological food by the polled consumers is its health value, which, along with the nutritional value, received the most points

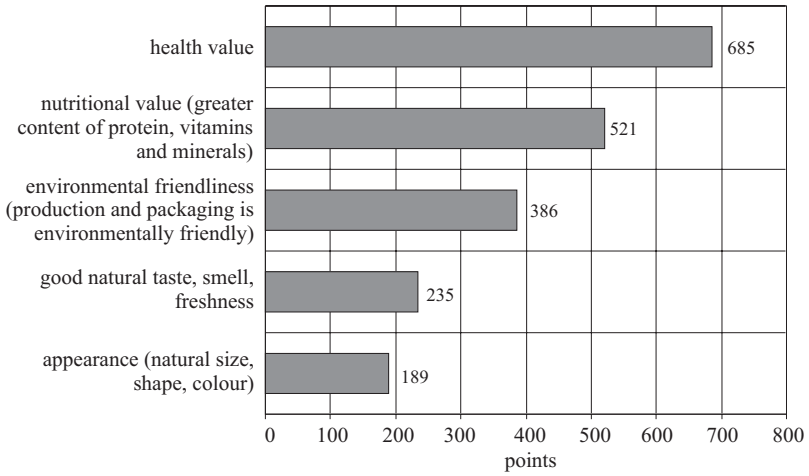


Fig. 2. The assessment of attributes of ecological food (max 710 points)
Source*:* the author's own research

The consumers definitely value those qualities that prove the healthiness of these products and expect some personal benefits, for which they are prepared to pay a higher price.

Zanoli and Naspetti (2002), assessing the motives for purchase of ecological food among European consumers, also emphasize the importance of health and nutritional values of this kind of food.

In order to identify the market behaviour of buyers, it is crucial to determine the frequency with which consumers buy certain products. Due to a much richer range of ecological products of plant origin on offer, those polled purchase them on a regular basis. Thus, 63% of respondents bought them several times a week, and 34% declared they did their grocery shopping several times a month. The frequency with which ecological products of animal origin are purchased is much lower in comparison with plant products, which proves that there are some shortages in assortment of this kind.

### The Perception of Ecological Food Prices

One of the crucial elements determining the demand for ecological food is the level of its prices, especially as it is higher than the price level for conventional food. The research assessed the acceptance level of ecological food prices, and then compared it with the attributes of this kind of food. It shows that 54% of respondents consider the prices of the goods from ecological farms too high in comparison with their values. 31% of respondents accept the prices, and the remaining claim not to have any views on this issue.

The analysis took into account the sensitivity of respondents to the increase of ecological food prices. Thus, more than 40% of those polled declared that they were prepared to pay 10% more for ecological food, and 25% were prepared to pay 5% higher prices (Table 2).

Table 2

The acceptable higher level of ecological food products as declared by respondents (%)

| Characteristics | Percentage of respondents (%) |
|---|---|
| 0 | 3 |
| 5 | 40 |
| 10 | 40 |
| 15 | 6 |
| 20 | 6 |
| > 20 | 5 |

Source: the author's own research

Żakowska-Biemas and Gutowska (2003) indicate that the price level of ecological farming produce varies greatly. According to the authors, farmers declare that they establish their prices at the level of conventional products wholesale, at a 10% higher level than the price level of conventional products, or at the same level as conventional products. With regard to establishing prices of ecological products, the situation has not changed in recent years. Therefore, the price level of ecological products depends on the price level of conventional products, and is regulated depending on the margin.

## Conclusions

The ecological food market in Poland is in its infancy, which causes constant disturbances of its functioning. Producers complain about problems with selling their produce, whilst customers as the main problem indicate

insufficient organization of trading. It is possible to improve the effectiveness of economical production of ecological food if goods are produced and provided to customers in accordance with their expectations. The efficiency of ecological food market functioning depends on the level of producers' awareness of their clients' preferences. The following conclusions can be drawn on the basis of the conducted research:

1. Regardless of the level of expenditure on ecological products, respondents consume mainly food of plant origin, because it is easily accessible and has a wider assortment. The opportunities for development of ecological food market can be seen in widening the offer of ecological products and making ecological products of animal origin more accessible.

2. Important places for purchasing ecological produce are healthy food shops and direct sale – on a farm, at a local market place or by means of deliveries to consumers. The availability of ecological products in supermarkets is limited, which hinders the increase of demand for this kind of products.

3. According to respondents, the most conspicuous features of ecological food are its technological and nutritional values, the perceptive features being much less noticeable, and its trading attractiveness being the least important. The polled respondents consider the health values of ecological food to be its most valuable attribute. Consumers taking part in the research find its healthiness most attractive, and expect some personal benefits, for which they are prepared to pay higher prices.

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# WHAT DO POLISH AND DUTCH CONSUMERS THINK ABOUT DRIED FRUIT AND PRODUCTS WITH THEM – CREATIVE GROUP DISCUSSIONS AS A MEANS OF RECOGNITION CONSUMERS' PERCEPTIONS

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K e y  w o r d s: Group discussions, dried fruits, projective technique, Kelly repertory grid.

A b s t r a c t

The main aim of the study was to get insight into consumers' perception towards dried fruit and products with them, thus the exploratory study designed as a group discussion took place. While group discussions association (as one of the projective technique) and Kelly repertory grid were used to make the discussions more creative and lively. The discussions were held in Poland and in the Netherlands. It was found that Polish consumers perceive dried fruits mainly as convenient product while according to Dutch consumers dried fruit are old – fashioned. If it comes to the products with dried fruits, Polish consumers seem appreciate the presence of fruits in the product as the source of better taste and diversity. Both Polish and Dutch consumers seem pay attention to the nutritional value of the products but they are not convinced whether information on the package is true.

## JAK POLSCY I HOLENDERSCY KONSUMENCI POSTRZEGAJĄ SUSZONE OWOCE I PRODUKTY JE ZAWIERAJĄCE? – WYKORZYSTANIE METODY KREATYWNYCH GRUP DYSKUSYJNYCH

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A b s t r a k t

Badano wymagania i oczekiwania konsumentów wobec owoców suszonych oraz produktów je zawierających. W doświadczeniu wykorzystano metodę kreatywnych grup dyskusyjnych. Porównaniu stosunku konsumentów z różnych rejonów Europy do suszonych owoców i odbioru przez nich tego typu produktów służyły badania przeprowadzone w dwóch odmiennych kulturowo krajach – w Polsce i w Holandii. W dyskusjach wykorzystywano metodę skojarzeń jako technikę projekcyjną oraz technikę Kelly repertory grid.

Zarówno polscy, jak i holenderscy respondenci nie mieli zdania na temat wartości odżywczych i kalorycznych suszu owocowego, nie byli też przekonani o jego naturalności. Holendrzy nie widzieli powodu, dla którego mieliby kupować owoce suszone, skoro na rynku dostępne są świeże. W większości postrzegali je jako produkt staromodny, mało przydatny zarówno do bezpośredniej konsumpcji, jak i jako półprodukt. Polscy ankietowani owoce suszone uważali za produkty wygodne, tzn. łatwe do przechowywania, o długim okresie trwałości, ale jednocześnie rzeczy luksusowe. Zarówno polscy, jak i holenderscy respondenci zwracali zaś uwagę na wartość odżywczą i kaloryczność artykułów spożywczych zawierających susz owocowy, deklarowaną na opakowaniu, ale nie do końca ufali zawartym tam informacjom. Polscy respondenci uważali, że dodatek suszonych owoców do produktów polepsza ich smak oraz daje urozmaicenie. Opinii tej nie podzielali konsumenci holenderscy.

Na podstawie danych zebranych w kreatywnych grupach dyskusyjnych można powiedzieć, że produkty zawierające owoce suszone mogą mieć szansę powodzenia, o ile ich walory prozdrowotne zostaną odpowiednio wypromowane.

## Introduction

Nowadays food products should not only be in accordance with nutritional guidelines but also satisfy the needs of consumers who more often are interested in convenience (Mermelstein 2001, Jaeger 2006). Thus snack products with dried fruit, characterized with high retention of biologically active compounds, seem fulfil these requirements. The consumers' needs should be taken as a starting point for the new product development process (van Trijp and Steenkamp 1998), because it can enhance the success of the product on the market (van Kleef et al. 2002).

The presented study are part of ISAFRUIT project, which main aim is to increase fruit consumption among European citizens through a trans disciplinary approach. Therefore, in developing new attractive products with dried fruit, consumer research were undertaken to support technologist in their decisions. A quantitative research designed as a questionnaire was planned. However, the initial studies of literature revealed that there is no data about consumers' perception of dried fruits and products with them. Thus, it was decided to perform firstly qualitative research which is more exploratory and diagnostic than quantitative approach and involves small number of people (Sampson 1986). The group discussions were chosen over individual interviews because of their interactive effect (statements of one participant can trigger comments by others) (van Kleef et al. 2005). They provide a potentially higher chance of getting new ideas or uncovering opinions than individual interviews (Costa 2003). However, the projective

techniques (association) and Kelly repertory grid were included into research, because they are useful to discover feelings, beliefs or attitudes difficult to articulate (COSTA 2003, DONOGHUE 2000, VAN KLEEF et al., 2005).

The main aim of this study was to recognize perception of dried fruit and products with them in two different culturally countries by performing creative group discussion. The associations and Kelly repertory grid method were used to make the discussions more lively and creative.

## Materials and Methods

The group discussions were held in Poland and in the Netherlands. Because they were treated as a preliminary study of a quantitative research, the number of respondents was not so high (16 in Poland and 12 in the Netherlands). The interviewees represented men and women, mostly highly educated, single or married. Among them were persons with children in their households. Some of them were responsible for the everyday purchase of fruits and vegetables.

The discussions lasted always 2 hours, and was conducted by a panel leader. The whole session was recorded. In the Table 1 the detailed instruction according to which each group discussion was performed is displayed.

The first part of discussion was the association with application of postcards. After the introduction, the range of postcards were presented to the interviewees. The postcards displaying foods were purposely excluded to make the discussion more creative. The respondents had to chose these postcards which they associate with fresh fruit. Then they had to explain the motives of their choice. On the base of this discussion a few questions concerning fresh fruit perception and consumption were asked.

The next part of the discussion was devoted to consumers' perception of different products with dried fruit, which where demonstrated in assortment groups (Kelly repertory grid method). Firstly, the set of breakfast cereals was presented. The products differed in the content (especially presence of fruits), package and presence of nutritional or health claims. The interviewees could look at the products or even touch them if necessary. Then the discussion leader asked the participants to group the products. The participants decided themselves how many groups they want to form, according to criteria relevant to them. The same procedure was applied with bars and sweets containing dried fruit. At the end of the session the postcards were once more presented. This time respondents were choosing postcards which they associate with dried fruit. They were also asked about few issues concerning dried fruit perception and consumption. The whole session was finished by rewarding the interviewees for their participation and explaining the aim of the research.

Some opinions concerning dried fruit expressed during group discussions were ordered and group into thematic categories (Table 2).

Table 1

The detailed instruction (for the panel leader) according to which the group discussion were held

| |
|---|
| Introduction<br>– A few words about the ISAFRUIT project and the explanation that discussion concerns perception of different food products<br>– Introduction of the discussion' s participants<br>– Questions about breakfast cereals and cereal bars consumption and preferences (to make the respondents more relaxed)<br>– The statement that every answer is correct and every reaction is more than welcome |
| A. Fruit perception (accessories – post cards)<br>– Respondents are choosing postcard which they associate with fresh fruit<br>– The interviewees explain why they choose the particular postcard<br>– On the base of the discussion with postcards respondents answers the following questions:<br>How often do you eat fruit?<br>When you do not eat fruit?<br>Which type of fruit do you prefer and why these?<br>What do you think are advantages and disadvantages of eating fruits?<br>Can you tell something about how you feel while eating fruit or after eating fruit? |
| B. Breakfast cereals perception (accessories – a set of breakfast cereals) – application of Kelly repertory grid method<br>– Different versions of a product are placed on the table<br>Everybody can look at the products or even touch them if necessary, if participants don't know the products for example.<br>Then the discussion leader will ask the participants to group the products. The participants can decide themselves how many groups they want to form. Participants make the groups according to the criteria which are relevant to them.<br>– Different questions about the chosen criteria are possible:<br>Can you tell more about this?<br>What does it mean to you and your family?<br>Is it important for you?<br>Do you look at healthy ingredients?<br>Do you look at to what extent the product is convenient for you?<br>– When it is not specifically mentioned the following questions can be asked:<br>Which product do you prefer: with or without dried fruit in it? Can you explain why?<br>What is it that makes the dried fruit product more or less attractive?<br>Is the product with dried fruit in it healthier than products that have no dried fruit in it? |
| C. Muesli bars perception (accessories – a set of muesli bars)<br>– the methodology the same as for breakfast cereals |
| D. Perception of sweets with dried fruit (accessories – a set of sweets with dried fruit)<br>– the methodology the same as for breakfast cereals |
| E. Dried fruit perception (accessories – postcards)<br>– the methodology the same as for breakfast cereals |
| F. Termination<br>– The detailed explanation of the discussion aim<br>– The deliver of reward for the participation in the discussion |

Table 2

The opinions concerning dried fruit expressed during group discussions by Polish and Dutch consumers

| Category | Polish interviewees | Dutch interviewees |
|---|---|---|
| Healthiness/naturalness | – I think that raisins can be used against heartburn<br>– I think that dried fruit have positive influence on health but in less degree than fresh fruit<br>– I have health association with gut function<br>– Dried fruit have preservatives, otherwise they would be spoiled<br>– Dried fruit does not have such nutritional value as fresh ones<br>– I think that they are healthy because of presence of dietary fibre and vitamins<br>– I think that dried fruit are healthy snack for children | – I am positive about dried fruit, although it is old fashioned way of fruits storage but dried fruit are healthy<br>– I think that dried fruit are unhealthy because it is produced in a way that all vitamins are out of it<br>– I have no idea whether dried fruit are healthy but probably they are not complete unhealthy<br>– Dried fruit are more healthy than crisps |
| Convenience | – Dried fruit have a long shelf – life<br>– I can take easily dried fruit when I go out<br>– Dried fruit are available at any moment and they are not susceptible to spoilage | – Drying from former days is a method to store fruit for a long time<br>– Dates, figs, apricots and plums are sticky |
| Certain dried fruits mentioned by respondents | – Raisins<br>– Plums<br>– Apples<br>– Apricots<br>– Dried apples | – Dried bananas<br>– Dried raisins<br>– Plums<br>– Apricot<br>– Pieces of apples<br>– Pieces of bananas |
| Certain product with dried fruits mentioned by respondents | – Cakes (for example keks)<br>– Muesli<br>– Christmas Eve compote<br>– Dried raisins/plums in chocolate | – Tutti – frutti<br>– Turkish fruits<br>– Muesli/cruesli<br>– Student mix |
| Consumption moment | – I eat dried fruit as a snack between meals<br>– I eat dried fruit during watching TV<br>– Dried fruit are at hand in my house and I eat them when I prepare cake<br>– I eat dried fruit with alcohol or coffee | – I eat dried fruit in my parents house<br>– I eat dried fruit with wine or bear<br>– I eat dried fruit as a dessert |
| Others | – Dried fruit are available in the winter when fresh fruit are not so available | – Dried fruit are no longer necessary in this these times<br>– Why should we dry apples?<br>– Drying is an old – fashioned method to conserve |

## Results and Discussion

Dried fruit in Poland are mostly associated with dried raisins, dried plums and raisins in chocolate as well as Christmas Eve compote. They are often added to cakes and meat, what is in consistency with Euromonitor (2006), which indicated that dried fruit in Poland are mostly added to cakes and breads. The Dutch consumers mostly associated dried fruit with such products as raisins, bananas, muesli and student mix. Although Polish consumers mentioned many positive influences which dried fruit have on human health (presence of vitamins, influence the digestion), in the discussions they were not sure that dried fruit are wholesome and doubted whether dried fruit are as healthy as fresh ones. The same was observed for the Dutch consumers. Moreover, Dutch respondents perceived drying as an old – fashioned method of fruit preservation and dried fruit as products which are not so important nowadays, when fresh fruit are easy available. On the contrary, in the opinion of Polish consumers dried fruit are convenient, easy to store product with long shelf – life. It occurred that dried fruit are at hand in Polish houses but simultaneously they are perceived as luxury.

The great difference was observed between perception of fresh and dried fruit in both countries. Fresh fruits were associated with bright, vivid colours and nature, whereas postcards selected in connection with dried fruit were rather in dull colours.

If it concerns products with dried fruit, the taste of it seemed to be important for Polish as well as Dutch respondents. According to Bobicz-Zielińska (1999) Polish students indicated taste as one of the most important factors influencing choice of fruit. In this research healthiness of fruit also was rated very high. If it comes to the products with dried fruit, Polish and Dutch consumers paid attention to the content of calories and nutritional ingredients, however, truthfulness of information placed on the packages was not so obvious in both countries. According to most of Polish interviewees, addition of dried fruit to the products make them more tasteful and diversified. This opinion did not prevail among Dutch consumers. Polish respondents were particularly interested in apple crisps but they were curious about naturalness of such products. Some of Dutch respondents paid attention to the raisins packed in small boxes which resembled them their childhood.

The perceptions, attitudes and expectations towards evaluated products identified within creative group discussions indicated that irrespectively of nationality and cultural differences, the interviewees paid attention to nutritional value of purchased products. It means that wholesomeness of newly designed product should be taken into consideration during technology development. It should be also emphasised within novel product promotion, preferably by using health claims, to strengthen the consumer confidence in positive influence of such products on health.

## Conclusions

Although association concerning dried fruit are similar in Poland and in the Netherlands, the perception of them is totally different. Polish consumers perceive dried fruit mainly as convenient product while according to Dutch consumers dried fruits are old – fashioned. On the base of results from the creative group discussions it can be stated that products with dried fruit can succeed on the market, however their wholesomeness must be properly promoted.

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# FOOD CONSUMPTION AND SELECTED INDICATORS OF FAMILY SITUATION IN THE RESPONDENTS' OPINIONS

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Key words: subjective evaluation, food consumption, indicators of family situation.

Abstract

The aim of the work was to investigate relations between subjective evaluation concerning the amount of consumption of various groups of food products in the families represented by respondents with at least secondary education and subjective evaluation of the selected indicators of family situation and also the socio-demographic characteristics of the population. Some positive correlations were revealed between the subjective evaluation of the family situation and the evaluation of consumption of eight out of thirteen groups of the food products. The opinion concerning family income, the working status and the level of education differentiated the respondents' opinions on food consumption and family situation in a statistically significant way.

## SPOŻYCIE ŻYWNOŚCI A WYBRANE WSKAŹNIKI SYTUACJI RODZINNEJ W OPINII BADANYCH

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Słowa kluczowe: subiektywna ocena, spożycie żywności, wskaźniki sytuacji rodzinnej.

Abstrakt

Celem badań była analiza relacji między subiektywnymi ocenami wielkości spożycia różnych grup produktów żywnościowych a ocenami wybranych wskaźników własnej sytuacji rodzinnej, a także cechami demograficzno-społecznymi ankietowanej populacji. Badania przeprowadzono w rodzinach o wykształceniu co najmniej średnim. Wykazano istnienie związku między ocenami sytuacji rodzinnej a ocenami spożycia w przypadku ośmiu spośród trzynastu ocenianych grup produktów żywnościowych. Informacja o dochodzie rodzin, ich aktywność zawodowa oraz wykształcenie istotnie statystycznie różnicowały prezentowane opinie.

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## Introduction

The standard of family living, similarly as the standard of living in general (KĘDZIOR 1999), should be understood as a degree of fulfilling the financial and cultural needs. One of the measures of needs fulfilling is the subjective evaluation and the feeling of satisfaction about needs fulfilling, i.e. the subjective measures of the standard of living which comprise individual criteria of assessing in the form of self-evaluation of various elements of living conditions. In many investigations so far performed these measures were applied for the evaluations of selected aspects of living standards of various groups of people (JEŻEWSKA-ZYCHOWICZ et al. 2000, GUTKOWSKA et al. 2001, GIERAS, GUTKOWSKA 2005, GRZEGA, 2006, JEŻEWSKA-Zychowicz 2006). The subjective evaluations do not always reflect the true state but they are valuable source of information about the respondents' situation.

The aim of the work was to investigate relations between subjective evaluation concerning the amount of consumption of various groups of food products in the families which were represented by respondents with at least secondary education and subjective evaluation of the selected indicators of family situation and also the socio-demographic characteristics of the population.

## Material and Methods

The survey was carried out in the autumn 2005 and included 378 people living in mazowieckie province. The criterion of choosing the investigated population was the at least secondary education.

The respondents were asked to evaluate the amount of consumption of 13 groups of food products (bread, cereals, meat and meat products, fish, milk, dairy products, butter, oil and margarine, vegetables, fruits, sweets, juices and mineral water). The assessment of their consumption were marked on a 5-point scale, the extreme points of which were described as very small (1) and very large (5). The 5-point scale was also used for collecting opinions describing family situation (family income, employment of adults, health status of family members, quality of consumed food, food expenditures, recreation and relaxation, and the interfamily relations) where "1" was described as "very bad" and "5" as "very good". The questionnaire included also questions which allowed performing the socio-demographic characteristics of the population.

In order to analyze the empirical material the frequency analysis was used as well as cross tabulation, $Chi^2$ test ($p \leq 0.05$) and cluster analysis in order to separate groups which were homogenous in relation to the evaluations concerning family situation. Two clusters were separated with the present iteration amounting to 5. The first cluster (185 people) was

characterized with lower evaluations of particular indicators (the cluster centers amounted to "3" with the exception of the situation concerning recreation and relaxation where it amounted to "2") as compared to the cluster 2 (193 people) where the cluster centers amounted to "4" with the exception of recreation and relaxation where it amounted to "3". Cluster 1 was represented by a higher percentage of people who assessed their family income negatively, who had secondary education, pensioners, and labourers. Cluster 2 was represented by a higher percentage of people who evaluated their family income positively, who had higher education and are self--employed – Table 1.

Table 1

Social and demographic characteristic of the sample (%)

| Criterium | | Total | Cluster | |
|---|---|---|---|---|
| | | | 1 | 2 |
| Gender | female | 58.2 | 59.5 | 57.0 |
| | male | 41.8 | 40.5 | 43.0 |
| Place of living | urban | 74.3 | 70.3 | 78.2 |
| | rural | 25.7 | 29.7 | 21.8 |
| Age | 30 years and less | 37.3 | 36.2 | 38.3 |
| | 31–45 years over | 29.6 | 30.3 | 29.0 |
| | 45 years | 33.1 | 33.5 | 32.6 |
| Education (IS) | secondary | 54.2 | 62.7 | 46.1 |
| | higher than secondary | 45.8 | 37.3 | 53.9 |
| Working status (IS) | blue-collar worker | 17.5 | 21.6 | 13.5 |
| | white-collar worker | 56.9 | 56.2 | 57.5 |
| | non-working person | 11.6 | 11.4 | 11.9 |
| | self-employed | 8.5 | 2.2 | 14.5 |
| | pensioner | 5.6 | 8.6 | 2.6 |
| Opinion on family income (IS) | generally insufficient | 9.5 | 13.5 | 5.7 |
| | allows to fulfill only basic needs | 24.9 | 35.7 | 14.5 |
| | covers some, but not all expenses | 49.7 | 45.4 | 53.9 |
| | we can afford anything | 10.8 | 3.8 | 17.6 |
| | we can afford anything and put some money away | 5.0 | 1.6 | 8.3 |

IS – statistically significant differences at $p \leq 0.05$ ($Chi^2$ test)

## Results

Respondents' opinions concerning selected indicators characterizing their families and their functioning are presented in Table 2.

A majority of respondents assessed the family situation within the scope of the selected indicators as "neither good nor bad" or "good" with the exception of worse result concerning recreation and relaxation. The presented evaluations demonstrated significant statistical correlations ($p \leq 0.05$) with

Table 2

Subjective evaluation according to selected indicators of the family situation of the sample (%)

| Indicators of the family situation | Subjective evaluation | | | | | |
|---|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | $X$±SD |
| Family income[a,b,d] | 1.1 | 11.1 | 45.5 | 38.4 | 4.0 | 3.33±0.77 |
| Employment of adults[a,b,d] | 0.8 | 15.6 | 38.9 | 38.4 | 6.3 | 3.34±0.84 |
| Health status of family members[d] | 0.3 | 8.7 | 36.5 | 48.9 | 5.6 | 3.51±0.74 |
| Quality of consumed food[a,b,c,d] | 0.0 | 8.5 | 36.2 | 52.1 | 3.2 | 3.50±0.70 |
| Food expenditures[a,b,d] | 0.3 | 15.3 | 46.6 | 36.5 | 1.3 | 3.23±0.73 |
| Recreation and relaxation[a,b,d] | 5.3 | 30.4 | 33.3 | 28.0 | 2.9 | 2.93±0.95 |
| Interfamily relations[b,d] | 0.3 | 9.8 | 27.8 | 49.2 | 13.0 | 3.65±0.84 |

*1 – very bad, 2 – bad, 3 – neither bad nor good, 4 – good, 5 – very good
[a] statistically significant correlation after considering the respondent education
[b] statistically significant correlation after considering working status
[c] statistically significant correlation after considering the place of living
[d] statistically significant correlation after including the opinion on income

the opinions referring to the family income, then with the respondents' education, working status, and with the place of living in the case of the health status (Table 2). No statistically significant correlations were revealed between presented opinions and gender of respondents as well as their age. Opinions on family income, education and working status were the variables which in statistically significant way differentiated the clusters separated on the basis of opinions on particular indicators of the family situation (Table 1).

Opinions concerning the amount of consumption of particular food products demonstrated the most statistically significant correlations with opinions on income – bread, cereals, meat and meat products, fish, dairy products, vegetables, fruits, juices and mineral water consumption (Table 3).

Table 3

Subjective evaluation of the amount of consumed groups of food products according to income of the sample (%)

| Food products | Income* | Subjective evaluation | | | | |
|---|---|---|---|---|---|---|
| | | 1** | 2 | 3 | 4 | 5 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Bread (IS) | 1 | 4.6 | 13.8 | 64.6 | 16.2 | 0.8 |
| | 2 | 1.1 | 10.6 | 51.7 | 24.5 | 2.1 |
| | 3 | 3.3 | 6.7 | 48.4 | 38.3 | 3.3 |
| Cereals (IS) | 1 | 3.1 | 28.5 | 57.6 | 10.0 | 0.8 |
| | 2 | 2.1 | 17.0 | 64.4 | 16.0 | 0.5 |
| | 3 | 3.3 | 16.7 | 50.0 | 26.7 | 3.3 |
| Meat and meat products (IS) | 1 | 2.3 | 24.6 | 50.0 | 21.6 | 1.5 |
| | 2 | 1.1 | 9.6 | 67.0 | 19.6 | 2.7 |
| | 3 | 0.0 | 10.0 | 41.7 | 41.7 | 6.6 |

cont. Table 3

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Fish (IS) | 1 | 17.7 | 40.8 | 33.8 | 7.7 | 0.0 |
| | 2 | 15.4 | 34.6 | 37.8 | 12.2 | 0.0 |
| | 3 | 8.3 | 21.7 | 45.0 | 23.3 | 1.7 |
| Dairy products (IS) | 1 | 5.4 | 20.8 | 49.2 | 23.8 | 0.8 |
| | 2 | 3.2 | 11.7 | 45.7 | 37.3 | 2.1 |
| | 3 | 1.7 | 10.0 | 31.6 | 46.7 | 10.0 |
| Vegetables (IS) | 1 | 3.1 | 18.5 | 50.8 | 25.3 | 2.3 |
| | 2 | 2.1 | 13.3 | 4.5 | 31.9 | 3.2 |
| | 3 | 0.0 | 1.7 | 26.7 | 56.6 | 15.0 |
| Fruits (IS) | 1 | 3.1 | 21.6 | 41.5 | 31.5 | 2.3 |
| | 2 | 2.1 | 17.6 | 42.0 | 34.6 | 3.7 |
| | 3 | 0.0 | 3.3 | 18.4 | 63.3 | 15.0 |
| Juices (IS) | 1 | 6.9 | 30.0 | 46.9 | 16.2 | 0.0 |
| | 2 | 8.0 | 19.1 | 46.8 | 21.8 | 4.3 |
| | 3 | 3.3 | 16.7 | 31.7 | 38.3 | 10.0 |
| Mineral water (IS) | 1 | 7.7 | 16.2 | 47.6 | 22.3 | 6.2 |
| | 2 | 9.0 | 13.3 | 36.2 | 33.5 | 8.0 |
| | 3 | 3.3 | 6.7 | 35.0 | 33.3 | 21.7 |

IS – statistically significant differences at $p \leq 0.05$ ($Chi^2$ test)
*1 – generally insufficient or allows to fulfill only basic needs;
2 – covers some, but not all expenses;
3 – we can afford anything or we can afford anything and put some money away
**1 – very small, 2 – small, 3 – neither small nor large, 4 – large, 5 – very large

After taking into consideration the clusters, statistically significant differences were demonstrated concerning the opinions on consumed amount of eight groups of products (Table 4). People representing cluster 2, i.e. those expressing more positive opinions on particular indicators of family situation, assessed the amount of consumption of eight food products as bigger than people from cluster 1.

Table 4

Subjective evaluation of the amount of consumed groups of food products according to clusters of the sample (%)

| Food products | Cluster | Subjective evaluation | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1* | 2 | 3 | 4 | 5 | $\bar{X}$±SD |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Bread (IS) | 1 | 4.3 | 16.2 | 62.2 | 15.1 | 2.2 | 2.95±0.76 |
| | 2 | 1.0 | 6.2 | 59.1 | 32.1 | 1.6 | 3.27±0.64 |
| Cereals | 1 | 3.8 | 25.9 | 55.1 | 14.1 | 1.1 | 2.83±0.75 |
| | 2 | 1.6 | 16.1 | 64.2 | 17.1 | 1.0 | 3.00±0.66 |
| Meat and meat products (IS) | 1 | 2.7 | 21.6 | 58.4 | 15.1 | 2.2 | 2.92±0.75 |
| | 2 | 0.0 | 8.3 | 56.6 | 32.1 | 3.6 | 3.31±0.67 |

cont. Table 4

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Fish (IS) | 1 | 20.0 | 36.8 | 34.6 | 8.1 | 0.5 | 2.32±0.91 |
| | 2 | 10.4 | 32.6 | 40.4 | 16.6 | 0.0 | 2.63±0.88 |
| Milk | 1 | 5.9 | 21.6 | 47.0 | 22.7 | 2.7 | 2.95±0.89 |
| | 2 | 4.1 | 16.1 | 42.5 | 32.1 | 5.2 | 3.18±0.91 |
| Dairy products (IS) | 1 | 5.9 | 20.0 | 51.9 | 20.0 | 2.2 | 2.92±0.80 |
| | 2 | 1.6 | 9.3 | 37.8 | 47.7 | 3.6 | 3.42±0.77 |
| Butter | 1 | 7.0 | 19.5 | 63.2 | 9.2 | 1.1 | 2.78±0.75 |
| | 2 | 6.7 | 16.6 | 60.1 | 16.1 | 0.5 | 2.87±0.78 |
| Oil and margarine (IS) | 1 | 7.0 | 20.0 | 63.8 | 8.6 | 0.5 | 2.76±0.70 |
| | 2 | 1.0 | 19.2 | 64.2 | 15.5 | 0.0 | 2.94±0.62 |
| Vegetables (IS) | 1 | 4.3 | 20.0 | 51.4 | 21.6 | 2.7 | 2.98±0.84 |
| | 2 | 0.0 | 6.7 | 41.5 | 45.1 | 6.7 | 3.52±0.72 |
| Fruits (IS) | 1 | 4.3 | 23.8 | 43.2 | 25.4 | 3.2 | 2.99±0.89 |
| | 2 | 0.0 | 9.8 | 33.2 | 50.3 | 6.7 | 3.54±0.76 |
| Sweets | 1 | 9.2 | 20.5 | 54.1 | 13.0 | 3.2 | 2.81±0.89 |
| | 2 | 6.2 | 25.4 | 42.5 | 20.7 | 5.2 | 2.93±0.96 |
| Juices (IS) | 1 | 9.7 | 28.1 | 47.0 | 13.5 | 1.6 | 2.69±0.98 |
| | 2 | 4.1 | 17.1 | 42.0 | 31.1 | 5.7 | 3.17±0.92 |
| Mineral water | 1 | 10.3 | 16.2 | 39.5 | 25.9 | 8.1 | 3.05±1.08 |
| | 2 | 5.2 | 10.4 | 40.4 | 33.2 | 10.9 | 3.34±0.98 |

IS – statistically significant differences at $p \leq 0.05$ ($Chi^2$ test)
*1 – very small, 2 – small, 3 – neither small nor large, 4 – large, 5 – very large

## Discussion

The basic factor determining food consumption is income, the statistical significant and strong effect of which is noted in many areas of family functioning (Bryant 1990, Panek 2003), also in food sphere (Kwasek 2000, Gutkowska et al. 2001, Witek 2005). With the increase of income the tendency for expressing more favourable opinions on the financial situation and on the needs fulfilling in the sphere of food also increases (Kosicka 2004, Gieras, Gutkowska 2005, Gutkowska, Banasiak 2005), which was proved in our survey.

It results from households' budget investigations carried out in 2004 that drastic inequality in incomes are not accompanied by similar differences in food consumption which proves functioning of the Engel law. With a 7 fold range in the average incomes between the extreme groups of household income, there was only a 2 fold difference in expenses on food and even smaller difference in the total mass of consumed food and energy value of an average diet. The inequality of incomes did not significantly affect the amount and distribution of consumption of such products as bread, flour,

animal fats (except butter), vegetable fats, milk and potatoes (SEKUŁA et al. 2006). It was demonstrated in our investigation that differences in opinions concerning the family income and also other indicators of family situation were accompanied by different evaluations of consumption of bread and vegetable fats but also some other products. However, the lack of data concerning amount of food consumption in the investigated population does not allow for comparing the obtained results with results concerning households' budgets (SEKUŁA et al. 2006).

## Conclusions

It can be stated that subjective evaluations of consumed amount of selected food products statistically significant correlated with the subjective evaluations of family situation indicators. In order to verify the usefulness of the subjective measures in the evaluation of food consumption, in the future investigations the character of the relations between the results obtained through the application of subjective and objective measures should be determined. Finding the statistically significant correlations between them would allow the use in some investigations only the subjective measures of consumption, especially in the investigations of interdisciplinary character.

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# ECONOMIC ASPECTS OF SHEEP MILK PRODUCTION IN THE MOUNTAIN REGIONS OF POLAND

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K e y w o r d s: milk utilization, mountain sheep, economic efficiency.

A b s t r a c t

The aim of the study was to evaluate the economic efficiency of a mountain sheep farm based on its accounting data. The analysis showed that milk production may account for over 30% of the farm income. The estimation of the economic efficiency per ewe in different experimental groups showed that the highest income was obtained in the group of Bergschaf ewes and $F_1$ crosses (TB POG). This was due to the high milk and lamb production in these groups and the considerable proportion of subsidies in the case of the alpine breed. It was shown that the use of sheep for milk affects the profitability of sheep production in the mountain areas of Poland.

## EKONOMICZNE ASPEKTY MLECZNEGO UŻYTKOWANIA OWIEC W GÓRSKICH REJONACH POLSKI

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S ł o w a k l u c z o w e: użytkowanie mleczne, owca górska, efektywność ekonomiczna.

A b s t r a k t

Celem pracy była ocena efektywności ekonomicznej gospodarstwa rolnego (na podstawie danych z jego rachunkowości), w którym utrzymywano owce górskie. Przeprowadzona analiza wykazała, że produkcja mleka może stanowić ponad 30% dochodów gospodarstwa. Szacując efektywność ekonomiczną (w przeliczeniu na maciorkę w poszczególnych grupach doświadczalnych, wykazano najwyższy przychód w grupie maciorek bergschaf oraz mieszańców $F_1$ (TB x POG), co było związane z wysoką produkcją mleka i jagniąt w tych grupach, a także znacznym udziałem subwencji w przypadku rasy alpejskiej. Wykazano, że użytkowanie mleczne owiec jest czynnikiem mającym wpływ na opłacalność produkcji owczarskiej w górzystych rejonach kraju.

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## Introduction

In Poland, the use of sheep for milk production is of regional importance and is practically confined to the mountain regions of Podhale and Beskidy. For centuries, local inhabitants have relied on sheep production for their living, and the wool, skins and milk sold provided a source of income. Polish Mountain sheep, which are a dual-purpose breed used for milk and wool, represent an inseparable part of the region. The relatively low milk productivity of ewes (50–70 l of milk obtained after weaning) considerably limits the profitability of using this breed for milk production. An efficient way of improving milk production is to cross mountain ewes with rams of high-producing breeds. Alpine Bergschaf sheep (Tiroler Bergschaf) have performed well under the harsh conditions of the Carpathian region. Similar to Polish Mountain sheep, this breed is extremely resistant to harsh environmental conditions and makes good use of mountain pastures, while showing high prolificacy and milk yield and producing good slaughter lambs (Paraponiak, Kawęcka 2004). Crossbred ewes derived from rams of the same breed were characterized by high parameters of milk performance (Kawęcka, Paraponiak 2005). The aim of the study was to evaluate the economic efficiency of using sheep for milk production on a mountain sheep farm.

## Material and Methods

The analysis was performed based on accounting data of a farm located in the Beskid Sądecki area. The farm kept mountain breeds of sheep: Polish Mountain sheep (POG), Alpine Mountain sheep (Tiroler Bergschaf – TB) and $F_1$ crosses (TB POG). The normative calculus was used in the calculations and direct income was estimated. The analysis accounted for the value of commercial production of lamb livestock, slaughter sheep (culled rams and ewes), breeding material (ram-lambs and ewes), wool, milk (cheese) and subsidies. Data on milk yield and oscypek production efficiency, obtained for different breed groups, were used to calculate the economic efficiency per ewe (Table 1).

Table 1

Yield of milk and oscypek cheese production according to breed group

| Parameter | Breed group | | |
|---|---|---|---|
| | POG | TB | TB × POG |
| Milk yield per lactation (l) | 73.3 | 130.9 | 131.8 |
| Oscypek production efficiency (%) | 11.05 | 11.62 | 10.82 |
| Amount of cheese (kg) obtained per season and ewe | 8.1 | 15.2 | 14.3 |

## Results and Discussion

The structure of subsidies for different groups is shown in Figure 1. The highest proportion of milk income (40%) per ewe was estimated for crossbred ewes, and the lowest for Polish Mountain sheep (30%). In the TB breed, subsidies accounted for over 15% of the income. Analysis of the production value per ewe showed significant differences in income according to breed group. The simulation showed that the highest income (758 zloty)

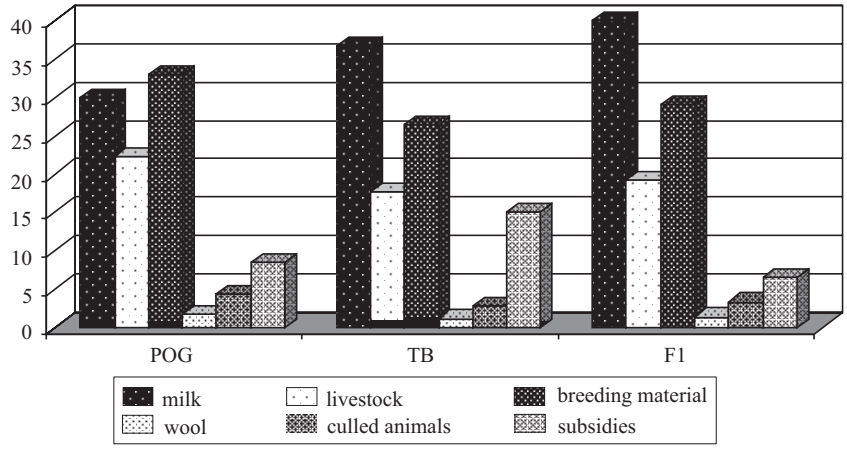


Fig. 1. Structure of income per ewe

was obtained in the group of TB ewes (Table 2). Cheese production value was the highest for TB ewes and crosses derived from TB rams and POG ewes. It was almost twice that of the income obtained from Polish Mountain sheep. The advantage of TB ewes and the crossbreds over the POG breed in terms of the analysed parameter was due to the high production of milk and lambs, which, in turn, was related to the higher prolificacy of ewes. This parameter was 1.3, 1.6. and 1.5 lambs per litter for POG, TB and crossbreds derived from TB rams, respectively. Prolificacy is one of the most important

Table 2

Income per ewe

| Income (zloty) | Breed group | | |
|---|---|---|---|
| | POG | TB | TB × POG |
| Milk – cheese | 149 | 278 | 262 |
| Lamb livestock | 109 | 134 | 126 |
| Breeding material | 162 | 200 | 188 |
| Wool | 9 | 9 | 9 |
| Culled animals | 22 | 22 | 22 |
| Subsidy | 42 | 115 | 42 |
| Total income | 493 | 758 | 649 |

factors of sheep production efficiency, because an increase in flock prolificacy results in lower unit costs for the production of one lamb (TRZYBIŃSKA 2001). These costs include the costs of labour, supervision, veterinary care, depreciation and others.

Clear differences in the financial value of production according to sheep breed was found by BORYS (1999). In crossbred ewes derived from Merino ewes and Romanov, Finn or prolific Merino-Finn rams, the high production value resulted from the high production of lambs, while in the case of crossbreds derived from Friesian rams, it was due to the highest milk production. The proportion of milk income in this group was twice that of milk income in the other groups. However, the author concluded that the use of sheep for milk can be economically justified even when the milk production level is low. Similar observations were made by JAVOR and LAKATOS (1993), who analysed the efficiency of using Hungarian Merinos for meat and milk.

The economic result obtained in the farm is shown using the parameter of direct income. The proportion of direct income from cheese production in total farm income was over 30% and exceeded the income from other sources. The proportion of milk income (Figure 1) in the total farm income was similar to that reported by GUT et al. (1997) for a flock of synthetic lines of sheep with Friesian inheritance. The proportion of income from milk production was 33% for Spanish farms and 40% for Greek farms, where sheep with medium milk production potential are kept. Milk accounts for 57% of farm income in France and for over 70% in Germany and Great Britain, where highly productive Friesian sheep are the main breed used for milk.

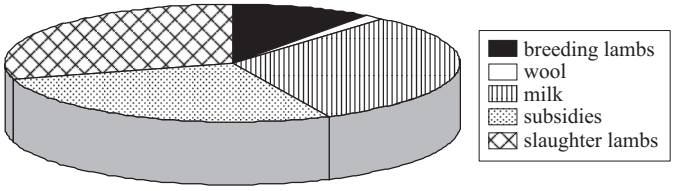


Fig. 2. Structure of farm costs

The analysis showed that it is economically justified to use sheep for milk production, as evidenced by a considerable proportion of income from this production in the structure of all farm income. The greater income from the sale of cheese in groups TB and $F_1$ (TB POG) resulted from the high milk yield of the ewes. This clearly shows that the efficiency of milk utilization is determined by ewe productivity, because sheep production is characterized by high labour requirements and high costs related to the purchase and depreciation of milking and milk processing equipment in the case of mechanization.

## Conclusions

1. The estimation of the economic efficiency per ewe showed that the highest income was obtained for Bergschaf ewes and $F_1$ crossbreds, which was related to the high production of milk and lambs in these groups.

2. Analysis of the economic efficiency of the farm showed that milk production can account for over 30% of farm income.

3. The use of sheep for milk is one of the major factors improving the profitability of sheep production in the mountain regions of Poland.

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# CHANGES OF THE FRUIT AND VEGETABLES CONSUMPTION LEVEL IN POLISH HOUSEHOLDS IN CONTEXT OF DIET-RELATED DISEASES PREVENTION

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Key words: fruit, vegetables, households, consumption.

Abstract

Present state of knowledge indicates that vegetables and fruit are indispensable elements of the proper diet. Their nutritional value is connected with high content of vitamins, fiber, minerals, organic acids and bioactive substances.

Analysis of consumption in different socio-economic groups in Poland showed, that retirees and pensioners consume the biggest amount of vegetables and fruit, while the consumption level of these groups of products is the lowest among employees. In the structure of fruit consumption dominated fresh fruit, especially apples. Second place had southern fruit and berries. At the same time, dominating position in the structure of vegetable consumption had cabbage, carrot, tomatoes, cucumbers and onion.

Household budget analysis conducted in years 1993–2005 confirmed the food balance data indicating significant increase of fruit consumption and decrease of vegetable consumption in polish households.

The level of fruit and vegetable consumption in Poland is much lower in comparison to recommended level, therefore it is desirable to enhance consumption and the assortment of consumed vegetables and fruit.

## ZMIANY W POZIOMIE SPOŻYCIA OWOCÓW I WARZYW W POLSKICH GOSPODARSTWACH DOMOWYCH W KONTEKŚCIE PROFILAKTYKI CHORÓB DIETOZALEŻNYCH

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A b s t r a k t

Współczesny stan wiedzy jednoznacznie wskazuje, że warzywa i owoce są niezbędnymi elementami prawidłowo zbudowanej diety. Ich wysoka wartość żywieniowa wynika m.in. z zawartości witamin, błonnika pokarmowego, składników mineralnych, kwasów organicznych oraz substancji bioaktywnych.

Analiza spożycia warzyw i owoców w grupach społeczno-ekonomicznych gospodarstw wykazała, że najwięcej tych produktów jedzono w gospodarstwach emerytów i rencistów, a najmniej w gospodarstwach pracowników. Wśród spożywanych owoców dominowały owoce świeże, głównie jabłka, następnie owoce południowe i jagodowe, natomiast w strukturze spożycia warzyw – kapusta, marchew, pomidory, ogórki i cebula.

Badania budżetów gospodarstw domowych z lat 1993–2005 potwierdziły, wynikający również z danych bilansowych, wzrost spożycia owoców oraz obniżenie spożycia warzyw.

Wielkość spożycia owoców i warzyw w stosunku do zalecanego optymalnego spożycia jest w Polsce zbyt niska, dlatego jest pożądany jego wzrost oraz urozmaicenie struktury asortymentowej.

## Introduction

Present state of knowledge indicates that vegetables and fruit are indispensable elements of the proper diet. Regular consumption of fruit and vegetables, in accordance with nutritional recommendation of many countries, is indispensable to keep high efficiency of the organism and is of great importance in prevention of many diet-related diseases. Practically, the importance in prevention and combating disorders in the organism is mainly connected with the fact, that fruit and vegetable are rich sources of dietary fiber, organic acids, vitamin C and E, carotenoids (licopen and lutein) and bioflavonoids (anthocyanins, quercetin, kempferol), which have strong antioxidant activity and can protect body cells against cancerogenic effect of free radicals and lipid peroxide (Ziemlański 2001, Szponar, Nadolna 1998). Fruit and vegetables are generally considered to prevent diseases such as tumours, atherosclerosis, other diseases of blood circulation system and obesity. When eaten according to the recommended levels, they can enhance immunity and reduce the risk of above-mentioned diseases. It is also proved, that fruit and vegetables reduce the risk of malicious tumour of the digestive system (especially of stomach, oral cavity, throat, gullet, colon and pancreas), lungs, breast and urinary bladder (Jarosz 2004, *Food, nutrition and the prevention...* 1997). Diet abounding in fruit and vegetables not only reduce the risk of cancerogenesis and tumour recurrence, but also enhance the efficiency of surgical treatment (Hasik and Gawęcki 2004).

According to the recommendations of World Health Organization, consumption of fruits and vegetables should come to at least 400 g/person per day (WHO 2003), what gives 146 kg/person per year. However, optimal consumption level of these products resulting from 'Nutritional Pyramid' come to 300 g/person of fruits and 500 g/person of vegetables per day, whereas in the average household in Poland consumption of fruits comes to

130 g/person per day and consumption of vegetables riches about 180 g/person per day (*National Food and Nutrition Institute* 2001).

The aim of this study was to analyze and to assess the changes of the level and the structure of fruit and vegetables consumption in polish households in years 1993–2005, against the background of consumption of these products in other countries of the European Union and actual nutritional recommendations. The analysis was made on the basis of secondary data sources derived from Central Statistical Office (CSO), Food and Agriculture Organization (FAO) and literature.

## Material and Methods

Material of the study included secondary data derived from the literature, Central Statistical Office (*Budżety gospodarstw domowych 1993…2005, Roczniki Statystyczne* 1994…2006) and from FAO database (*Food Balance Sheets* 2003) regarding vegetables and fruit consumption in Poland and other EU Countries.

Field of study included quantitative analysis, analysis of structure and specific determinants of fruit and vegetable consumption in Poland in years 1993–2005.

Balance data and household budget analysis made by Central Statistical Office were used in this study in order to evaluate the changes in fruit and vegetables consumption level and structure. The balance data were presented against the background of information from FAO database, regarding consumption of discussed groups of products in Poland and other EU Countries. The data derived from household budget study have been used to analyze mean consumption, structure and changes of the fruit and vegetables consumption in polish households in years 2001–2005 with reference to years 1993–2000. Moreover, these data have been used to analyze the fruit and vegetable consumption issue with reference to different socioeconomic groups in Poland.

## Results and Discussion

According to FAO data fruit- and processed fruit products consumption in Poland was the lowest in the European Union and reached only 47.6 kg/person/year in 2003, compared to 117.4 kg/person/year in the EU (Food Balance Sheets, 2003). It means, that Poles consumed less than half of fruit and processed fruit products than average EU citizens. On the other hand, the Netherlands were characterized by the highest fruit and processed fruit products consumption, amounted to 182 kg/person/year, that is close to four times more than the consumption level in Poland.

In case of vegetables, according to FAO data, mean yearly consumption level in Poland was lower than in other EU Countries (125,6 kg/person/year) and has been estimated at 100.3 kg/person/year, while the highest consumption level has been recorded in Greece (275 kg/person/year) (*Food Balance Sheets* 2003).

According to the balance data derived from the Central Statistical Office (CSO), fruit and processed fruit products consumption in Poland have been increasing systematically, beginning from 1993, and reached 54.1 kg/person/year in 2005, that means a 20% increase in analyzed period. At the same time consumption level of vegetables decreased from 122 kg/person/year to 110 kg/person/year (Figure 1).

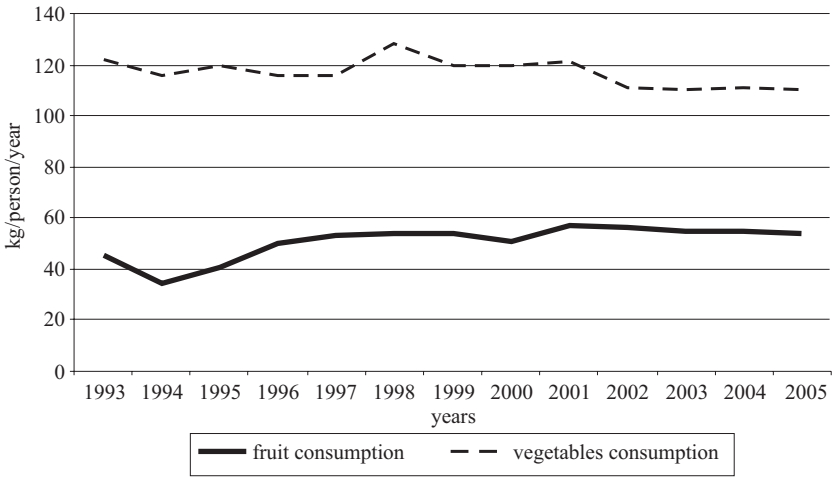


Fig. 1. Consumption of fruit and vegetables in Poland in 1993-2000
Source of data: Statistical Yearbooks from years 1994-2005, GUS

General increase of fruit consumption and general decrease of vegetable consumption per capita doesn't show the specific aspects of consumption of these products in polish households. Household budget analysis made by Central Statistical Office don't give information about the real consumption level, but about the quantity of food acquired by the households. Therefore, the results achieved using this method are lower than the balance data. According to these data, total consumption of fruit and processed fruit products in polish households amounted to an average of 46.40 kg/person/year in years 1993–2000 and increased to the level of 47.45 kg/person/year in years 2001–2005, what was related to increase of consumption of stone fruits, southern fruits and berries (*Budżety gospodarstw domowych 1993...2005*). Fresh fruits constituted more than 90% in the structure of fruit consumption. In this structure dominated apples, the second place had southern fruits and the third place – berries (Table 1).

Table 1

Changes of fruit and processed products consumption level in Polish households in 1993–2000 and 2001–2005

| Specification | Fruit consumption | | | | Change rate (%) |
|---|---|---|---|---|---|
| | 1993–2000* | | 2001–2005* | | |
| | kg/person/year | % | kg/person/year | % | |
| Fruit and processed products | 46.40 | 100 | 47.45 | 100 | 102.3 |
| Fruits from trees, shrubs and berries, incl.: | 34.46 | 74.3 | 36.60 | 77.1 | 106.2 |
| – apples | 22.07 | 47.6 | 22.13 | 46.6 | 100.3 |
| – pears | 1.30 | 2.8 | 1.32 | 2.8 | 101.5 |
| – plums | 2.42 | 5.2 | 2.52 | 5.3 | 104.1 |
| – other stone fruit | 2.63 | 5.7 | 3.00 | 6.3 | 114.1 |
| – berries | 5.54 | 11.9 | 5.98 | 12.6 | 107.9 |
| Southern fruits | 9.13 | 19.7 | 9.89 | 20.8 | 108.3 |

* average of years
Source of data: Own calculations based on Household budget analysis conducted in years 1993–2005, GUS

Household budget data presented in Table 2 confirm a decrease of vegetable – and processed vegetable products consumption in Poland in years 1993–2005. In years 1993–2000 mean level of vegetable consumption amounted to 68 kg/person/year, whereas in years 2001–2005 reached 64.92 kg/person/year.

Table 2

Changes of vegetables and processed products consumption level in Polish households in 1993–2000 and 2001–2005

| Specification | Vegetables consumption | | | | Change rate (%) |
|---|---|---|---|---|---|
| | 1993–2000* | | 2001–2005* | | |
| | kg/person/year | % | kg/person/year | % | |
| Vegetables and mushrooms (fresh, chilled of frozen, processed[1]) | 68.00 | 100 | 64.92 | 100 | 95.5 |
| Fresh vegetables and mushrooms[1] incl.: | 60.66 | 89.2 | 59.57 | 91.6 | 98.2 |
| cabbage | 10.47 | 15.4 | 8.66 | 13.3 | 82.7 |
| tomatoes | 8.64 | 12.7 | 10.15 | 15.6 | 117.5 |
| cucumbers | 7.80 | 11.5 | 7.80 | 12.0 | 100.0 |
| beetroots | 5.22 | 7.7 | 4.37 | 6.7 | 84.0 |
| carrots | 8.97 | 13.2 | 8.09 | 12.5 | 90.2 |
| onions | 6.81 | 10.0 | 6.24 | 9.6 | 91.6 |
| others | 12.75 | 18.7 | 14.26 | 22.0 | 111.8 |
| Processed vegetables and mushrooms | 7.40 | 10.8 | 5.38 | 8.3 | 72.7 |

* average of years
[1] without leguminous; since 2001 r.: fresh, chilled of frozen processed
Source of data: Own calculations based on Household budget analysis conducted in years 1993–2005, GUS

Despite an increase of vegetable assortment on polish market, connected with import development in '90, the structure of vegetable consumption wasn't diversified. Tomatoes, cabbage, carrot, cucumbers, onion and red beets constituted close to 80% of all consumed vegetables. In years 2001–2005 consumption of red beets, cabbage, carrot and onion decreased, while the consumption of tomatoes, cucumbers and other vegetables increased in reference to the previous years (Table 2).

The quantity and assortment of consumed fruits depend on the socio--economic group. Data presented in Table 3 indicate that retirees and pensioners consume the biggest amount of vegetables and fruit while the consumption level of these groups of products is the lowest among employees. In years 1993–2005 the consumption of fruits increased in most groups (except employees and of the self-employed), while the consumption of vegetables decreased in all groups.

Table 3

Average yearly per capita consumption level of fruit and vegetables and processed products in households (kg/person/year)

| Years | Households | | | | | |
|---|---|---|---|---|---|---|
| | grand total | of employees' | of employees – farmers' | of farmers' | of the self-employed | of retirees and pensioners |
| Fruit consumption | | | | | | |
| 1993–2000* | 46.4 | 43.9 | 41.8 | 43.2 | 50.4 | 55.0 |
| 2001–2005* | 47.4 | 43.0 | 46.3** | 48.3 | 47.4 | 56.4 |
| Vegetables consumption | | | | | | |
| 1993–2000* | 68.0 | 57.7 | 73.2 | 79.2 | 58.9 | 85.2 |
| 2001–2005* | 64.9 | 54.5 | 70.9* | 77.7 | 57.4 | 81.2 |

* average of years
** data from 2001–2004 (the group of employee-farmers has been not distinguished since 2005)
Source of data: Own calculations based on Household budget analysis conducted in years 1993–2005, GUS

Fruit- and vegetable consumption in polish households is characterized by seasonal fluctuations. It results from seasonal differences in supply of fruit and vegetables dominating in the structure of consumption. In accordance with earlier study of an author (Kazimierczak 2004) and Halicka and Kowrygo (2002) the highest level of vegetable consumption in polish households was observed in August while the lowest level was noticed in the first three months of each year. Similar tendency was observed in case of fruits – the highest consumption level was noticed during berries harvest season (since June to July) and during apple harvest season (September and October), and the lowest level in May. Nowadays, as a result of fresh fruit- and vegetable import increase, especially during winter and spring, the observed seasonal fluctuations are smaller and the structure of consumed

fruits and vegetables is more diversified. In spite of this tendency the seasonal fluctuations of fruit and vegetable consumption in polish households are still significant (HALICKA and KOWRYGO 2002, KAZIMIERCZAK 2004).

## Conclusions

Presented analysis of fruit and vegetable consumption model in Poland in years 1993–2005 indicated relatively small changes.

It is possible to observe a positive growth tendency of fruit consumption level in Poland (from 45.2 to 54.1 kg/person/year), however the fruit consumption in Poland is still the lowest in the European Union and still to low in comparison to nutritional recommendations.

Negative tendency manifesting in 10% decrease was observed in vegetable consumption in the same period. This tendency is opposite to increase of vegetable consumption level observed in all developed countries.

The data presenting fruit- and vegetable consumption per capita indicated that the vegetable consumption level in Poland is slightly lower than the mean level in EU Countries, while the fruit consumption level is twice as low comparing to the mean level in EU. These data indicate that polish diet is poor in vegetables and fruit and, thus, poor in nutrients such as vitamins, minerals and fiber.

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# SENSORY CHARACTERISTIC AND PRODUCT PALATABILITY OF SOFT FAT SPREADS DIFFERING IN FAT LEVEL

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K e y  w o r d s: fat level, spreads, sensory profile, palatability.

A b s t r a c t

Sensory profile and product palatability of commercial soft fat spreads were studied. Two samples of fat spreads of 75 and 55% fat content and four samples of low fat products of 25 and 20% fat content were used as material. A sensory characteristic was performed by Quantitative Descriptive Analysis using 16 quality attributes. Semi-consumer evaluation of odour, flavour, consistency and overall palatability was conducted using 9-point hedonic scale. The samples differ considerably regarding all quality attributes except for sweet odour and other flavour. The high-fat spreads showed substantially higher intensity of butter-like note (attribute positively correlated with overall quality) and considerably lower hydrogenated fat flavour intensity (attribute negatively correlated with overall quality) and were characterized by considerably higher meltiness and seemingly lower fatness than reduced-fat spreads. Differences in sensory quality between the samples of higher and lower fat level was also confirmed in semi-consumer research. Changes in sensory profile and palatability of fat spreads depended probably not only fat level but also on concentration of fat milk, presence of stabilizers and quality/level of butter flavour.

## CHARAKTERYSTYKA JAKOŚCI SENSORYCZNEJ I POŻĄDALNOŚCI KONSUMENCKIEJ PRODUKTÓW O RÓŻNEJ ZAWARTOŚCI TŁUSZCZU PRZEZNACZONYCH DO SMAROWANIA PIECZYWA

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A b s t r a k t

Celem badań było określenie, jak wpływa poziom tłuszczu oraz ewentualne różnice w składzie na profil sensoryczny i pożądalność konsumencką produktów przeznaczonych do smarowania pieczywa. Materiał stanowiły 2 próbki miksów tłuszczowych o zawartości tłuszczu 75 i 55% oraz 4 próbki produktów niskotłuszczowych o 25 i 20% poziomie tłuszczu. Przeprowadzono ich szczegółową charakterystykę sensoryczną metodą ilościowej analizy opisowej wg 16 wyróżników jakościowych. Ocenę semikonsumencką zapachu, smaku, konsystencji i pożądalności ogólnej wykonano metodą skalowania (9-stopniową skalą hedoniczną). Stwierdzono, że próbki różniły się istotnie w profilu sensorycznym pod względem wszystkich wyróżników jakościowych, z wyjątkiem zapachu słodkiego i smaku innego. Zdecydowanie wyższą jakość ogólną, która była dodatnio skorelowana z wyraźnie zaznaczoną notą maślaną i rozpływalnością oraz odwrotnie zależna od intensywności noty margarynowej i wrażenia tłustości, wykazywały próbki o wyższym udziale tłuszczu (75 i 55%). Dystans w jakości sensorycznej między próbkami o wyższym i niższym udziale tłuszczu był znaczący i został potwierdzony w badaniach semikonsumenckich. Zmiany w profilu sensorycznym próbek i pożądalności prawdopodobnie zależały nie tylko od poziomu tłuszczu, ale też składu produktów, w tym udziału tłuszczu mlecznego w próbkach z 75 i 55% zawartością tłuszczu, poziomu emulgatorów i stabilizatorów w produktach niskotłuszczowych oraz jakości użytego aromatu maślanego.

## Introduction

Quality has many aspects (nutritional, psychological, sensory, safety, convenience), and flavour quality is a fundamental part of quality parameters (PIGGOT 1994). According to TUORILLA and PANGBORN (1988), sensory quality is the most important factor of food choice and subsequent food intake, with all consequences for consumer health and psychological satisfaction. The critical factors which influence food selection by consumers are sensory characteristics of the products – appearance, aroma and most of all, taste and flavour (LAU, KRONDL, COLEMAN 1984).

Both consumers and health educators view the consumption of reduced-fat products as a way of reducing the fat and energy content of diets as required in health recommendations (KÄHKÖNE, TUORILA 1999). Reduced-fat foods are believed to improve healthiness of diets, help control body weight and have beneficial effects on physical well-being (ALEXANDER, TEPPER 1995). Literature data stresses that the perception of flavours in the food system is greatly altered when fat is removed.

It is believed that fats are responsible for the sensory properties of many foods (such as dairy products, cakes, cheese, meat, fat spreads) and affect food texture, aroma and taste and thus greatly contribute to eating pleasure (DREWNOWSKI 1997, TUORILA, CARDELLO, LESHER 1994). According to some authors, fat influences the qualitative, quantitative and temporal perception of flavour, whereby flavour release and distribution in reduced-fat product are modified (PLUG, HARING 1994, TUORILA, SOMMARDAHL, HYVÖNEN 1995).

The study was aimed to determine which quality attributes, their intensity and mutual proportions play a significant role in forming overall sensory quality of the spreads differing in composition and decide of its palatability.

## Materials and Methods

*Fat spreads.* The materials used in the study were 6 commercial soft fat spreads. Characteristics of the material are given in Table 1. The samples were stored at 4°C until the day of sensory analysis.

Table 1

Declare fat spreads components

| Sample symbol | Fat content (%) | Milk fat (%) | Emulgators | Butter flavour | NaCl content (%) |
|---|---|---|---|---|---|
| Full-fat soft margarines | | | | | |
| F-FM | 75 | 11 | x | x | 0.6 |
| Medium-fat soft margarines | | | | | |
| M-FM | 55 | 25 | x | x | 0.2 |
| Low-fat soft margarines | | | | | |
| L-FM 1 | 25 | – | x | x | 0.6 |
| L-FM 2 | 20 | – | x | x | 0.5 |
| L-FM 3 | 20 | – | x | x | 0.8 |
| L-FM 4 | 20 | – | x | x | 0.8 |

*Sensory analytical analysis.* Quantitative Descriptive Analysis (QDA) was performed (ISO 13299:1998) to find the influence of fat level on the sensory profile of soft margarines. 16 attributes were chosen using the QDA procedure. The intensity of attributes was measured on a linear scale, anchored "none" to "very strong" (aroma, flavour and taste) and "low" to "high" (firmness, meltiness, fatness); the results were then converted into numerical values (10 units).

*Semi-consumer analysis.* Hedonic assessments were performed to find the influence of fat level on palatability of odour, taste, consistency and overall palatability of the soft margarines. The palatability was measured using a 9-point hedonic scale, anchored "none palatable" to "very palatable"

*Subjects and testing condition.* A trained and experienced panel of eight members with good knowledge of sensory methodology (ISO 8586-2:1994) performed the sensory assessments by QDA. All assessments were made in two replications; 16 individual results were used for statistical data processing. 44 untrained consumers (20–21 years old) performed hedonic assessment of palatability of odour, taste, consistency and overall palatability of spreads.

Assessment was conducted in the Laboratory of Sensory Analysis of accredited Laboratory of Food Evaluation and Health Diagnostics. The sessions were performed in the morning and afternoon, two sessions per day in the sensory laboratory room, fulfilling general requirements for sensory testing conditions (ISO 8589: 1988) in individual booths equipped with a computerized system for data acquisition.

*Samples preparation and presentation.* 20-gram samples were presented to the panellists at room temperature (21±2°C) in plastic beakers, covered with a watch glass and coded with random numbers.

*Data analysis* Analysis of variance was performed to check the significance of differences in attributes intensity among fat spreads and Least Significant Difference (LSD) as a multiple range test. Principal Component Analysis was applied for the assessment of similarities and differences of sensory profiling characteristics in the evaluated samples.

Correlation coefficient was calculated to determine whether there was a relationship between overall palatability and palatability of odour, consistency and taste.

## Results and Discussion

The average results of soft fat spreads assessment were presented in Table 2 and the significance of differences in the intensity of attributes between samples was established based on the results of variation analysis for particular attributes. Significant influence of the session (independent replications of assessments) on the results of sensory evaluation was not observed, which confirms positive verification of the qualifications of assessment panel and assessment conditions.

Significant differences between samples were noticed for almost all quality attributes except for sweet odour and "other" flavour (Table 2). The lowest intensity of sharp and acid odour was characteristic of F-FM sample of 75% of fat content (Table 2). The intensity of butter-like odour was present in all samples at a similar level in contrast to hydrogenated fat odour, whose intensity was generally higher in the samples of lower fat content (especially in L-FM3 and L-FM4 samples). Fat content in samples influenced perception of butter-like and hydrogenated fat flavour to a greater extent. The intensity of butter-like flavour decreased and hydrogenated fat flavour increased with decreasing fat level in the sample (Table 2). The results of the study seem to suggest that fat level may be responsible for flavour perception. It should be emphasised that the samples of higher fat content contained milk fat (Table 1), which probably advantageously influences sensory profile.

Literature suggests that removing fat from foods results in the lack of flavour and thus fat soluble flavour constituents normally present in a lipid phase may stand out of the profile. However, fat level is not the only variability factor which may contribute significantly to flavour characteristics of fat spreads. It is important to know that perception of flavour arises from complex interactions between flavourants and fat-associated components of food (Shamil, Wyeth, Kilcast 1991/92). Another aspect of aromatization process is the sensory quality of flavourings and good matching with the

Table 2

Quantitative descriptive analysis (profiling) of commercial fat spreads – means and significance of differences

| Attributes | F-FM 75%fat | M-FM 55%fat | L-FM 1 25%fat | L-FM 2 20%fat | L-FM 3 20%fat | L-FM 4 20%fat |
|---|---|---|---|---|---|---|
| Odour (o.) | | | | | | |
| O.acid | $2.57^{a}$* | $3.54^{b}$ | $3.50^{b}$ | $3.09^{ab}$ | $3.68^{b}$ | $3.52^{b}$ |
| O.sharp | $2.04^{a}$ | $3.18^{c}$ | $2.38^{ab}$ | $2.48^{abc}$ | $3.12^{bc}$ | $3.06^{bc}$ |
| O.butter-like | $2.24^{a}$ | $2.94^{ab}$ | $3.06^{b}$ | $3.04^{ab}$ | $2.43^{ab}$ | $2.43^{ab}$ |
| O.hydrogenated fat | $3.26^{a}$ | $3.73^{ab}$ | $3.99^{ab}$ | $3.48^{ab}$ | $4.82^{c}$ | $4.27^{bc}$ |
| O.sweet | $1.42^{a}$ | $1.62^{a}$ | $1.57^{a}$ | $1.35^{a}$ | $1.44^{a}$ | $1.38^{a}$ |
| O.other | $0.38^{ab}$ | $0.68^{abc}$ | $0.28^{ab}$ | $0.22^{a}$ | $0.85^{c}$ | $0.74^{bc}$ |
| Consistency | | | | | | |
| Firmness | $4.55^{b}$ | $2.59^{a}$ | $4.64^{b}$ | $2.82^{a}$ | $3.03^{a}$ | $3.31^{a}$ |
| Meltiness | $6.64^{c}$ | $7.06^{c}$ | $3.24^{a}$ | $3.33^{a}$ | $4.66^{b}$ | $3.44^{a}$ |
| Fatness | $3.87^{a}$ | $3.61^{a}$ | $4.93^{b}$ | $5.28^{b}$ | $4.59^{b}$ | $5.54^{b}$ |
| Taste (t.), flavour (f) | | | | | | |
| T.acid | $1.81^{a}$ | $1.46^{a}$ | $1.67^{a}$ | $1.48^{a}$ | $2.39^{b}$ | $1.84^{a}$ |
| T.salty | $3.28^{c}$ | $1.98^{a}$ | $2.54^{ab}$ | $2.47^{ab}$ | $3.09^{bc}$ | $2.99^{bc}$ |
| F.butter-like | $3.34^{b}$ | $4.16^{c}$ | $2.18^{a}$ | $1.77^{a}$ | $2.21^{a}$ | $1.66^{a}$ |
| F.hydrogenated fat | $3.53^{ab}$ | $2.90^{a}$ | $4.68^{cd}$ | $4.13^{bc}$ | $5.04^{d}$ | $5.14^{d}$ |
| T.sweet | $1.34^{ab}$ | $1.79^{b}$ | $1.22^{ab}$ | $0.87^{a}$ | $1.23^{ab}$ | $1.14^{a}$ |
| F.other | $0.63^{a}$ | $0.21^{a}$ | $0.53^{a}$ | $0.39^{a}$ | $0.39^{a}$ | $0.44^{a}$ |
| Overall quality | $5.69^{c}$ | $6.04^{c}$ | $4.13^{b}$ | $3.93^{ab}$ | $4.29^{b}$ | $3.29^{a}$ |

* $^{a,b}$ – mean values with different letter in rows are significantly different at $p \leq 0.05$

product. The perception of flavour during eating depends also on the nature and intensity of the volatile aroma and non-volatile taste compounds (SALVADOR et al. 1994). Mentioned factors should be taken into consideration while designing new products, especially these of lowered fat content.

In the present study, samples of fat spreads showed different intensity of salty flavour connected with varied percentage content of salt and the participation of fat and water phase. The highest intensity of salty flavour was found in the sample of 75 % fat and 0.6 % salt intensity (Table 2). Similar saltiness had the samples of the highest salt content (0.8%) and 20% fat level (L-FM3 and L-FM4), whereas the next sample of 0.6% salt content and 25% fat level was definitely less salty than the sample of the same salt content and higher fat participation (F-FM 75% fat) (Table 1,2). The lowest intensity of salty flavour showed the sample of 0.2% salt content and 55% fat content (M-FM).

Literature data points out that one of the factors which may influence the perception of salty flavour is fat level (PANGBORN 1988). It is possible that

various types of fat release sodium at a different rate (TUORILA et al. 1989). According to authors, slow melting may reduce the perception of saltiness. It seems that the intensity of saltiness was low in the sample with high sodium content and a slow melting rate. It is also worth to take into consideration other interactions, e.g. the enhancement of saltiness due to butter flavour (TUORILA et al. 1989). This work seems to show that the major factor influencing the perception of salty flavour was the percentage content of water phase in examined spreads: sample with lower water phase showed higher saltiness intensity (F-FM 75% fat) than sample of higher water phase (L-FM 25% fat). Of course, other factors influencing the perception of salty flavour, e.g. the differences if fat spreads' consistency, especially meltiness, cannot be excluded (Table 2).

Meltiness of examined samples depended on percentage fat content: high fat spreads (75 and 55%) were perceived as more meltiness in comparison with reduced fat spreads (25 and 20%) (Table 2). Interestingly, that higher perception of fatness was observed in the samples of lower fat content, which is probably connected with the feeling of "stickiness" and cleaving of the sample to palate, which could result in seemingly higher perception of fatness.

Observed differences in fat spreads' consistency of higher and lower fat content were possibly connected with their ingredients. It should be noted that high amounts of water and proteins (the latter used as stabilizers) evidently reduced the glossiness and smoothness of low-fat products (TUORILA et al. 1989). According to MADSEN (1987) mono- and diglycerides which are used to keep water droplets separate in water-in-oil emulsions, presumably affect the consistency and mouthfeel.

The highest sensory quality, expressed as harmonisation level of particular attributes in the product, was noticed in high fat spreads (F-FM 75% fat and M-FM 55% fat). Overall quality of samples depended to a large extent on intensity and proportion of two attributes – butter-like and hydrogenated fat flavour. It was stated that overall quality was positively correlated with butter-like flavour and negatively with hydrogenated fat flavour (Figure 1).

The results of the descriptive analysis (QDA) of six fat spreads are displayed in Figure 2 as PCA biplot. Differences in intensity of butter and hydrogenated fat flavour, meltiness and fatness perception are loaded mainly along PC1 (72,67%). It might be observed that the samples form two distinctive clusters: high fat spreads (right cluster) with flavour butter-like attribute, meltiness and overall quality are clearly separated from the reduced fat spreads (left cluster) situated nearly hydrogenated fat flavour and odour and fatness.

The results obtained in this study have shown that the differences in sensory quality between high and reduced fat spreads were considerable and concerned mostly taste/flavour attributes and consistency. In the literature it is underlined that changes in the sensory properties of food caused by fat

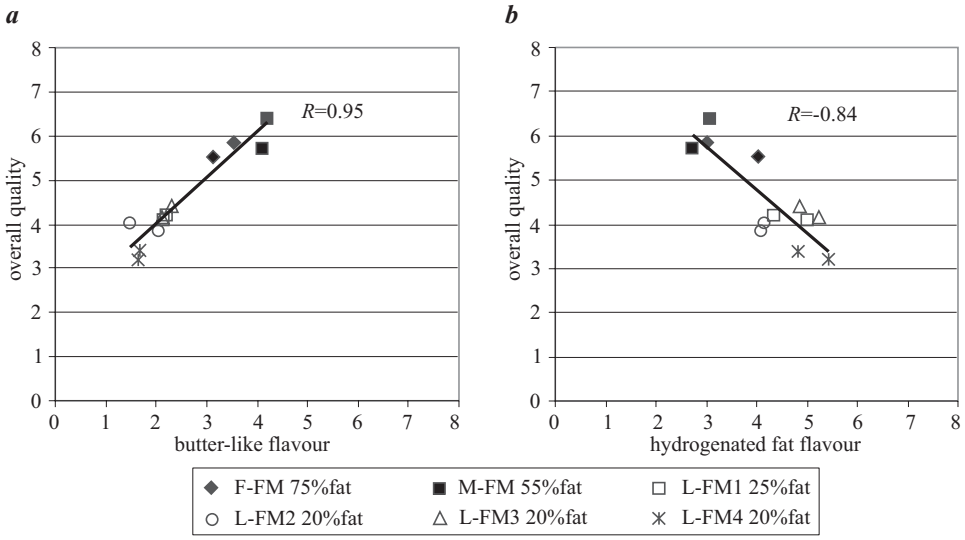


Fig. 1. Relation between overall quality of fat spreads and intensity of butter-like flavour (*a*) and hyfrogenated fat flavour (*b*) (means value, two sessions)

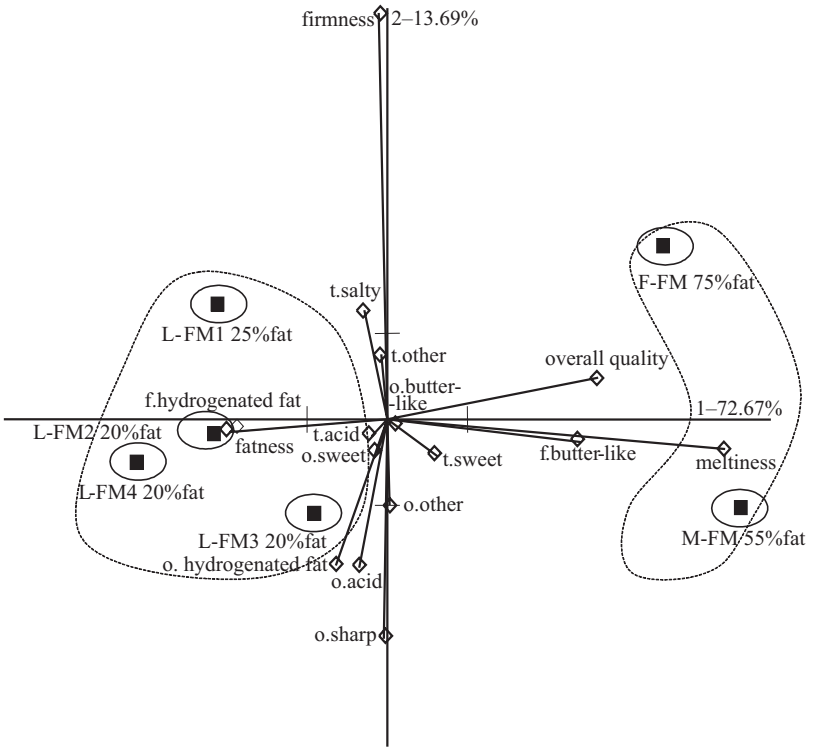


Fig. 2. Principal component analysis plot of similarities and differences in sensory profiling characteristics in the evaluated fat spreads

reduction are difficult or impossible to avoid and the quality of reduced-fat foods is usually somewhat different from its regular-fat counterparts (KÄHKÖNEN, TUORILA 1999).

This study stated that quality attributes (also their intensity and mutual proportions) played a significant role both in shaping overall quality of fat spreads as well as overall palatability. High fat spreads were distinctly more desirable in consistency, flavour and overall palatability in comparison reduced fat spreads (Figure 3). It must be emphasised that M-FM 55% fat

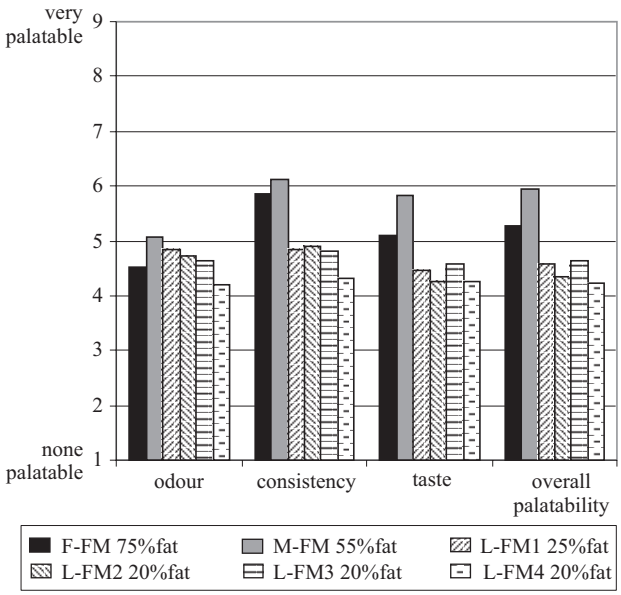


Fig. 3. Semi-consumer evaluation of fat spreads (mean value)

sample of the highest intensity of butter flavour and the lowest intensity of hydrogenated fat flavour was characterised by the highest palatability of flavour and overall palatability. The palatability of odour was on a similar level in spreads, however, it was the highest in spread of 55% fat content. Consumers remarked that the spreads suited them, if characterised by a delicate butter flavour and a low intensity of hydrogenated fat and acid flavours, had proper consistency, including meltiness, and did not cause the sensation of "stickiness" and greasiness.

The relationship between overall palatability of fat spreads and palatability of odour, flavour and consistency (Table 3) was also analysed. The highest correlation coefficient was found between flavour palatability and overall palatability ($R$ from 0.85 to 0.94). It emphasises the importance of flavour in shaping overall degree of liking of products for bread spreading in consumers' view.

Table 3

Relationship between overall palatability and palatability of odour, consistency and taste of fat spreads (correlation coefficient $R$)

| Sample symbol | Correlation coefficients | | |
|---|---|---|---|
| | odour | consistency | taste |
| F-FM 75% fat | 0.75 | 0.85 | 0.94 |
| M-FM 55% fat | 0.72 | 0.74 | 0.91 |
| L-FM1 25% fat | 0.69 | 0.73 | 0.85 |
| L-FM2 20% fat | 0.66 | 0.68 | 0.87 |
| L-FM3 20% fat | 0.58 | 0.74 | 0.93 |
| L-FM4 20% fat | 0.64 | 0.80 | 0.93 |

In the literature it is underlined that even though consumers demand food products with a low fat content, they still want sensory properties like the original product with the high fat content (RNN 1998). Designing products of lowered or low fat content similar sensorically to the products of normal fat content still remains an open issue, crucial from nutritional and health point of view and concerns a wide variety of products – not only fat spreads. Also, such things should be taken into consideration as: qualitative/ quantitative relationship between raw material, ingredients and additives and processing parameters to obtain optimal and satisfactory for consumers sensory quality of product.

## Conclusions

The results showed that the differences in sensory characteristics between high and reduced fat spreads were considerable and concerned mostly taste/flavour attributes and consistency. The high fat spreads (75 and 55%) showed considerable higher intensity of butter-like flavour (positive attribute) and significantly lower intensity of hydrogenated fat flavour (negative attribute) and were characterized by higher meltiness and lower fatness than reduced fat spreads (25 and 20%). The highest overall quality expressed as harmonization intensity and proportion of attributes was noticed in high fat spreads which contained considerable amount of milk fat. The differences in sensory quality of fat spreads were also confirmed in semi-consumer research: high fat spreads had more palatable flavour, consistency and overall palatability that reduced fat spreads. Changes in sensory characteristics and palatability of fat spreads depended probably not only fat level but also on concentration of fat milk, presence of stabilizers and quality/level of butter flavour.

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# ECONOMICAL ASPECTS OF CATERING SERVICES IN PLACES OF COLLECTIVE NUTRITION

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Key words: catering, collective feeding, HACCP.

Abstract

The work presents examination results pertaining to the financial burdens of the nutrition divisions in kindergartens and their comparison with the costs which would have been incurred when a cooperation with an outsourced children meals supplier – a catering company – was undertaken.

## ASPEKTY EKONOMICZNE ŚWIADCZENIA USŁUG ŻYWIENIOWYCH W PLACÓWKACH ŻYWIENIA ZBIOROWEGO

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Słowa kluczowe: catering, żywienie zbiorowe, HACCP.

Abstrakt

W pracy przedstawiono wyniki badań dotyczących obciążeń finansowych pionów żywieniowych w placówkach przedszkolnych oraz porównanie ich z kosztami, jakie musi ponieść przedszkole, gdy podejmie współpracę z dostawcą zewnętrznym posiłków dla dzieci (firmą cateringową).

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## Introduction

A very important element of a child's proper development is his adequate diet. Majority of children in the age between 3 and 6 years attends kindergartens, where they consume meals matching their needs. Most of the kindergartens in Poland have nutrition divisions, whose task is to prepare meals calculated especially for children. Meals preparation in kindergartens is connected with certain financial burdens related to power supply, employment of properly qualified staff as well as adaptation of kitchen, warehousing, social and sanitary infrastructure to the requirements imposed by the HACCP system *(EU Regulation 852/2004)*.

Nevertheless, there are also institutions where children's feeding was conferred on outsourced companies. The kindergartens are supplied with ready-made, hot meals, placed on disposable plates and they are eaten with disposable cutlery. Calculation of energetic and nutritive values is done by the supplier who must also give a full guarantee of safety and hygiene when preparing and transporting the meals Kindergarten staff is supervising the delivery conditions and presents instructions concerning the menu.

In case of kindergarten cooperation with a catering company, costs of the nutrition division are almost none. Also, the expenditures for maintenance of the HACCP system are reduced. Out of the system obligatory when the nutrition division is functioning (receiving and storage of products, technological treatment, meals distribution, washing and storage of dishes), only the meals distribution phase remains and it has to be controlled. Therefore, in practice, we meet with premises about liquidation of nutrition divisions and ordering the services of catering companies. Not all kindergartens managers are willing to effect such changes, they prefer having a full control over the pupils' feeding, but the economical factors may prevail here.

## The Aim of the Work

The aim of this work is to present the general values of costs related to the functioning of nutrition divisions in kindergartens, according to the HACCP system requirements. Taking into consideration the views of the kindergartens managers, the work contains also the costs comparison of preparation of meals by the kindergarten kitchen staff on one hand and by a catering company on the other.

The research was done in five kindergartens in Gdynia, characterised with the following parameters:

1. the number of children attending the kindergarten – 90–100, including, on average, ca. 70 children taking meals in the institution,

2. employment in the nutrition division – 1 post of a cook, 1.5 post of a cook helper and 0.5 post of a steward *(Resolution No. IX/195/2003)*,
3. the institutions work according to HACCP system what is confirmed by the control protocols of the local Sanitary Station,
4. tested institutions are located in premises of a similar area and similar layout of inner rooms, including production and warehouse facilities,
5. in all kindergartens there are 2 kitchen stoves, electrical frying pan, gas cooker, three refrigerators, dish-washer.

The research presents the data of annual financial expenditures related to power, gas, water consumption and sewage and rubbish removal services and rooms heating (so called administrative costs) and data pertaining to nutrition division staff remunerations. The value of the current kitchen exploitation expenditures was also taken into consideration – called in this work "remaining costs" – which are related to purchase of cleaning agents, working clothes, kitchen equipment and appliances according to the post-control recommendations of the Sanitary Station and according to the current needs – following from the permanent improving of the HACCP system.

Financial burdens presented in the work pertain to 2005. The information about their value was acquired directly from the directors of the examined kindergartens. The forecasts of carriers consumption in the *B*, *C*, *D*, and *E* variants presented in the work were settled with the administrations of the kindergartens, whereas the employment forecasts – with kindergartens managers.

## Results

The research assumed five variants of meals preparation for children. Factors influencing costs generation in individual variants are presented in Table 1.

Monthly financial expenditures of the feeding variants described in the work are presented in Table 2.

According to the assumption, the monthly costs of delivering the feeding services are as follows: basic variant – meals preparation by the staff employed in the kindergarten makes the institution expenditures on the level of PLN 7958.61 monthly (100%); passing the preparation of full daily feeding to an outsourced company would generate the costs on the level of PLN 1499.51 monthly, which is hardly 19% of the basic variant costs. Monthly amounts in the remaining variants make respectively: 33.19%, 57.10% and 59.19% of the *A* variant costs.

Table 1

Factors influencing cost generation in *A, B, C, D and E* variants

| | *A* variant (basic) | *B* variant | *C* variant | *D* variant | *E* variant |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| Variant description | meals preparation (breakfasts, brunches, 2-course lunches, afternoon snacks) by the kitchen staff employed in the kindergarten | meals preparation (breakfasts, brunches, 2-course lunches, afternoon snacks) by a catering company | meals preparation (breakfasts, brunches, 2-course lunches, afternoon snacks) by a catering company | preparation and delivery of 2-course lunch and breakfast semi-products (f.e. fish spread, egg paste, cut sausages and cheese) and vegetables, fruit, other products ready for brunch and afternoon snacks – by a catering company | preparation and delivery of 2-course lunch and breakfast semi-products (f.e. fish spread, egg paste, cut sausages and cheese) and vegetables, fruit, other products ready for brunch and afternoon snacks – by a catering company |
| | mills are served on the kindergarten plates | meals are served on disposable plates which are removed by the kindergarten staff | mills are served on the kindergarten plates | mills are served on the kindergarten plates | meals are served on disposable plates which are removed by the kindergarten staff |
| Staff employment | 1 cook, 1.5 cook helper, 0.5 steward | 0.5 steward[1] | 0.5 cook helper 0.5 steward[3] | 1 cook, 0.5 steward[1] | 1 cook, 0.5 stweard[1] |
| Sources of administrative costs | electric power, gas and water consumption, sewage services, heating, rubbish removal | rubbish removal | electric power[4] and water consumption, sewage services | electric power[6], gas and water consumption, sewage services[7], heating, rubbish removal | electric power[9], gas and water consumption, sewage services, heating, rubbish removal |

cont. Table 1

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Sources of remaining costs | purchase of cleaning and disinfection agents for dish washing and kitchen appliances and equipment, for preparation and storage rooms, occasional purchase of control-measuring equipment for kitchen equipment, of working clothes, fees for sanitary training | purchase of control-measuring equipment for kitchen equipment, of working clothes, fees for sanitary training[2] | purchase of cleaning and disinfection agents for dish and cutlery washing, cleaning and disinfection agents for preparation rooms, purchase of control-measuring equipment, of tableware, working clothes, fees for sanitary training[5] | purchase of cleaning and disinfection agents for dish washing and kitchen appliances and equipment, preparation and storage rooms, occasional purchase of control-measuring equipment for kitchen equipment, of working clothes, fees for sanitary training8 | purchase of cleaning and disinfection agents for dish washing and kitchen appliances and equipment, for preparation and storage rooms, occasional purcha[se] of control-measuring equipment for kitchen equipment, of working clothes, fees for sanitary training[10] |

Source: individual study
Table explanation:
[1] steward's duties: supervision of meals delivery, keeping systematic records,
[2] as follows from the above mentioned settlements made with the kindergartens staff, it was assumed that the remaining costs make 15% in relation to the *A* variant costs.
[3] it was assumed in the research, that the organ supervising the institution should agree for employment of 1 cook helper instead of the cook, whose task would be plates preparation, washing, steward's duties – as in the *B* variant,
[4] costs related to power consumption are estimated for 50% in relation to the value of power consumption of the *A* variant,
[5] remaining costs are estimated on the level of 30% in relation to the basic variant,
[6] consumption of energy carriers: electricity (bread cutting, for instance), gas (water, milk heating) – 20% in relation to the basic variant; estimation adopted on the basis of previously mentioned settlements with the kindergartens staff,
[7] costs related to water consumption and sewage services – 20% in relation to the *A* variant,
[8] 50% of the value of remaining costs in the basic variant,
[9] it is assumed that in relation to the basic variant, 70% are the expenditures for the consumed energy,
[10] 80% of the value of remaining costs given in the basic variant.

Table 2

Monthly financial expenditures of the feeding variants

| Incurred costs | | Variant | | | | |
|---|---|---|---|---|---|---|
| | | *A* | B | C | D | E |
| Administrative costs (PLN) | Power consumption | 244.09 | – | 122.05 | 48.82 | 170.87 |
| | Gas consumption | 155.5 | – | – | 31.11 | 31.11 |
| | Water consumption and sewage services | 3.29 | – | 3.29 | 0.66 | 3.29 |
| | Rubbish removal | 2.60 | 2.60 | – | 2.60 | 2.60 |
| | Heating | 764.78 | – | – | 764.78 | 764.78 |
| Remuneration (PLN) | Cook (1 post) | 2 025.28 | – | – | 2 025.28 | 2 025.28 |
| | Cook helper (1 post) | 1 902.02 | – | – | – | – |
| | Cook helper (0.5 post) | 939.26 | – | 939.26 | – | – |
| | Steward (0.5 post) | 1 389.60 | 1 389.60 | 1 389.60 | 1 389.60 | 1 389.60 |
| | Additional remuneration | 394.37 | 86.76 | 145.91 | 212.96 | 212.96 |
| Remaining costs (PLN) | | 137.77 | 20.55 | 41.1 | 68.89 | 109.99 |
| Totally | | 7 958.61 | 1 499.51 | 2 641.21 | 4 544.70 | 4 710.48 |
| Percentage share | | 100.00 | 18.84 | 33.19 | 57.10 | 59.19 |

Source: individual study

## Resume and Conclusions

On the basis of the received results it may be stated that for the institution manager, the employment of a catering company preparing and delivering meals to the kindergarten is the most advantageous. A virtue of such an approach is the reduction of administrative fees, reduction of employment of kitchen staff from three posts to a half of the steward's post. The vice is lack of a full control of meals preparation. In order to have a partial control over the feeding of the pupils, the institution manager may decide about selection of the *D* or *E* variant. According to the conditions assumed in these cases, the administrative costs would be reduced and they would be 72% for the *D* variant – in relation to the *A* one, and 83% for the *E* variant also related to the A variant.

Because of the above, it could be stated that:

– one of the factors which lower the costs of feeding in the collective feeding places may be ordering of the meals preparation at an outsourced supplier – a catering company,

– employing of a catering company does not release the institutions managers from the responsibility for the quality and safety of meals consumed by their clients,
– cooperation with a catering company should be a subject to a constant hygienic-sanitary monitoring,
– the economic factor should be a vital, but no a single criterion of feeding services planning, particularly in case of children.

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EU Regulation 852/2004 (O. J. 226, 25.06.2004),
Resolution No. IX/195/2003 of the Gdynia City Council.

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# EVALUATION OF LAMB MEAT QUALITY FROM SHEEP OF DIFFERENT BREEDS AND PRODUCTION EFFICIENCY

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Key words: lamb meat quality, production efficiency, crossbreeding.

Abstract

The effects of crossbreeding on the quality of slaughter material obtained and improvement of lamb meat production profitability were investigated.

Meat samples taken from Polish Mountain sheep (PMS), Austrian Mountain sheep (AMS), White Alpine sheep (SWA) and $R_2$ crosses AMS (AMS PMS) and SWA (SWA PMS) were studied using 20 animals of breed. Basic determinations of physico-chemical traits and sensory evaluation of meat were performed. The value of commercial production was calculated per animal.

The physico-chemical parameters of all meat samples were at an appropriate level from the technological and consumer viewpoint. The sensory score in all the groups exceeded 4 points, being indicative of the high eating value of meat obtained from the lambs studied. The crossbreeding scheme used resulted in a considerable increase in the commercial production of lamb meat.

## OCENA JAKOŚCI JAGNIĘCINY POCHODZĄCEJ OD OWIEC RÓŻNYCH RAS ORAZ EFEKTYWNOŚCI JEJ PRODUKCJI

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Słowa kluczowe: jakość jagnięciny, efektywność produkcji, krzyżowanie międzyrasowe.

Abstrakt

Celem badań była ocena wpływu krzyżowania międzyrasowego na jakość pozyskanego surowca rzeźnego oraz na poprawę opłacalności produkcji jagnięciny.

Materiał doświadczalny stanowiły próbki mięsa pobrane od tryczków ras: polska owca górska (POG), austriacka owca górska (AMS), biała owca alpejska (SWA) oraz od mie-

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szańców $R_2$ : AMS x (AMS x POG) i SWA x (SWA x POG), po 20 sztuk z każdej z grup. Przeprowadzono oznaczenia podstawowych cech fizykochemicznych oraz ocenę sensoryczną mięsa. Obliczono wartość produkcji towarowej w przeliczeniu na 1 sztukę.

Wartości parametrów fizykochemicznych wszystkich próbek mięsa kształtowały się na pożądanym – patrząc od strony technologicznej i konsumpcyjnej – poziomie. Rezultaty oceny sensorycznej we wszystkich grupach przekroczyły wartość 4 pkt., co wskazuje na wysokie walory konsumpcyjne jagnięciny pozyskanej od owiec objętych badaniami. Rezultatem zastosowanego schematu krzyżowania był znaczny wzrost produkcji towarowej jagnięciny.

## Introduction

The traditional method of improving production traits in sheep is to cross ewes of improved breeds with rams of breeds characterized by favourable parameters of meat or milk productivity. To this end, Polish Mountain ewes and rams of highly productive breeds kept in the Alps were crossed.

The aim of the study was to evaluate the effect of crossbreeding on the quality of slaughter material obtained and on the improvement of lamb meat production profitability in southern Poland.

## Material and Methods

Meat samples from 100 rams of Polish Mountain sheep (PMS), Austrian Mountain sheep (AMS), White Alpine sheep (SWA) and $R_2$ crosses AMS× ×(AMS×PMS) and SWA×(SWA×PMS) were studied using 20 animals of each breed. All the animals were kept under production conditions in the semi-intensive feeding system (rearing on pasture with concentrate supplementation) and slaughtered at the age of 180 days. The basic physico-chemical traits of meat determined were the water to protein (W/P) and fat to protein (F/P) ratios, water holding capacity and $pH_{24}$ of the *Musculus longissimus dorsi*. Sensory analysis of meat (*Musculus semimembranosus*; 5-point scale) included the determination of meat aroma, consistency and palatability. The results were analysed statistically using a multifactorial analysis of variance. The value of commercial production was calculated per animal assuming 5.75 zloty as the price of 1 kg live lamb, which was the average purchase price of slaughter lambs (body weight 31–40 kg) in January 2007 (KORYTKOWSKA 2007).

## Results and Discussion

The highest W/P value was found in the SWA group (3.86) and the lowest (3.76) in the group of $R_2$ crosses AMS×(AMS×PMS) ($P>0.05$, Table 1). These results were similar to the findings of KĘDZIOR (1995). W/P was 3.3–3.9

Table 1

Empty body weight of lambs and basic physico-chemical parameters of meat

| Trait | Experimental groups | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PMS | | AMS | | AMS × (AMS × PMS) | | SWA | | SWA × (SWA × PMS) | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| *n* | 20 | | 20 | | 20 | | 20 | | 20 | |
| Empty body weight of rams (kg) | 30.9*Aa* | 1.73 | 39.1*Cc* | 2.42 | 35.6*Bb* | 2.86 | 44.9*Dd* | 2.35 | 41.1*Cc* | 1.87 |
| Water to protein ratio (W/P) | 3.77 | 0.10 | 3.79 | 0.11 | 3.76 | 0.09 | 3.86 | 0.09 | 3.84 | 0.14 |
| Fat to protein ratio (F/P) | 0.09 | 0.01 | 0.09 | 0.01 | 0.11 | 0.01 | 0.10 | 0.01 | 0.10 | 0.01 |
| Water holding capacity (%) | 26.07*b* | 2.79 | 24.95*b* | 4.22 | 19.11*a* | 1.84 | 24.78*b* | 4.27 | 20.10*a* | 2.00 |
| pH | 5.57*a* | 0.15 | 5.63*b* | 0.16 | 5.69*b* | 0.09 | 5.54*a* | 0.08 | 5.66*b* | 0.04 |

*a*, *b*, *c* – the same letter symbol following arithmetic means designates qualification to a uniform group based on post-hoc analysis at $\alpha = 0.05$.
*A*, *B*, *C* – the same letter symbol following arithmetic means designates qualification to a uniform group based on post-hoc analysis at $\alpha = 0.01$.

in adult slaughter animals and 4.1 in very young animals (Pieniak-Lendzion et al. 2000). The F/P ratio ranged from 0.09 (PMS and AMS) to 0.11 [AMS×(AMS×PMS)] ($P>0.05$). The level of W/P and F/P ratios indicates that the meat originated from animals of normal somatic maturity.

The lowest pH, measured 24 h postmortem, was characteristic of the meat of purebred SWA (5.54) and PMS rams (5.57). These values were significantly lower than those obtained in all of the other rams. The highest pH (5.69) was found in the meat of $R_2$ crosses AMS×(AMS×PMS) (Table 1). Despite statistically significant differences, mean pH values were typical of normal meat (5.4–5.8) (Looft, Kalm 2000), and the results presented are similar to those reported by Kędzior (1995).

The meat of rams from particular groups differed significantly in water holding capacity (ability of meat to retain water during application of pressure), and the results obtained in the range of 19.11 [AMS×(AMS×PMS)] to 26.07 (PMS) were at a desirable level.

The results of sensory analysis of meat, which exceeded 4 points in all the groups (Table 2), were higher than those reported in the study of Pieniak-Lendzion et al. (2000), in which rams were fed complete CJ mixture.

Statistically significant differences were found in the consistency and palatability of the analysed samples. The meat of PMS rams received the lowest scores for aroma, tenderness and juiciness (4.47, 4.30 and 4.31 points, respectively). The lowest score for taste intensity was awarded to the meat of SWA rams (4.09 points) and this value was highly significantly lower than the values obtained in the other experimental groups ($P\leq0.01$). The best score for taste intensity was awarded to the meat of $R_2$ crosses SWA×(SWA×PMS) – 4.58 points and AMS×(AMS×PMS) – 4.54 points (Table 2). The results of meat taste quality were similar to the results of taste intensity. The meat of WAS rams was characterized by a significantly lower taste quality (4.08 points) compared to all of the other experimental groups. Roborzyński et al. (2000) confirmed poorer sensory value of the meat of SWA lambs. The most beneficial level of this trait was obtained by SWA×(SWA×PMS) rams – 4.59 points and AMS×(AMS×PMS) rams – 4.54 points. Differences in this trait between these experimental groups and SWA and PMS animals were statistically significant (Table 2).

The empty body weight, both in purebred AMS and SWA (39.1 and 44.9 kg), and in crossbred AMS×(AMS×PMS) and SWA×(SWA×PMS) rams (35.6 and 41.1 kg, respectively) was highly significantly higher than the respective value measured in the PMS group (30.9 kg), as reflected in considerable differences in the commercial production values obtained per animal (Table 1, Figure 1). The value of this economic parameter for PMS rams (177.67 zloty/animal) was lower than that obtained in the groups of $R_2$ crosses, where it was 204.70 [AMS×(AMS×PMS)] and 236.32 zloty/animal [SWA×(SWA×PMS)], being evidence of the favourable effect of the crossbreeding scheme used on the improvement of live lamb production productivity.

Table 2

Results of sensory analysis of lamb meat

| Trait | Experimental groups | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PMS | | AMS | | AMS × (AMS × PMS) | | SWA | | SWA × (SWA × PMS) | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| *n* | 20 | | 20 | | 20 | | 20 | | 20 | |
| Aroma intensity | 4.65 | 0.20 | 4.72 | 0.28 | 4.54 | 0.21 | 4.68 | 0.25 | 4.54 | 0.17 |
| Taste quality | 4.47 | 0.25 | 4.62 | 0.35 | 4.52 | 0.14 | 4.64 | 0.36 | 4.58 | 0.18 |
| Tenderness | 4.30*a* | 0.39 | 4.43*ab* | 0.37 | 4.53*b* | 0.23 | 4.36*a* | 0.35 | 4.52*b* | 0.33 |
| Juiciness | 4.31*a* | 0.33 | 4.40*ab* | 0.36 | 4.58*b* | 0.21 | 4.15*a* | 0.47 | 4.52*b* | 0.31 |
| Taste intensity | 4.31*Bb* | 0.31 | 4.44*Bbc* | 0.41 | 4.54*Bc* | 0.20 | 4.09*Aa* | 0.38 | 4.58*Bc* | 0.18 |
| Taste quality | 4.29*Bb* | 0.33 | 4.43*Bbc* | 0.45 | 4.54*Bc* | 0.21 | 4.08*Aa* | 0.31 | 4.59*Bc* | 0.17 |

For explanations see Table 1

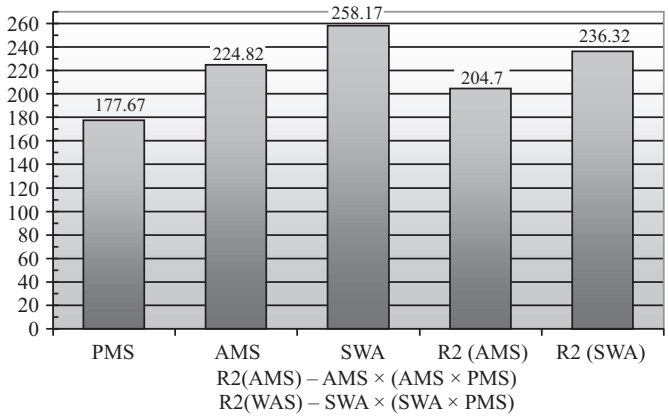


Fig. 1. Value of lamb meat commercial production per animal (zloty)

## Conclusions

1. Both physico-chemical parameters and results of sensory evaluation of the meat samples studied were at an appropriate level from the technological and consumer viewpoint.

2. The higher scores for consistency and taste awarded to the meat of PMS ewes crossed with AMS and SWA rams compared to the maternal breed are evidence that crossbreeding has a beneficial effect on the sensory quality of lamb.

3. The value of commercial production showed that $R_2$ crosses are more suitable than the maternal breed for the production of live lambs.

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# CUSTOMER SATISFACTION MEASUREMENT AS A FACTOR OF IDENTIFICATION OF CUSTOMER SATISFACTION ATTRIBUTES IN CASE OF A FOOD PRODUCT

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Key words: customer satisfaction attributes, food products.

Abstract

The paper presents the results of own studies on identification and assessment of customer satisfaction attributes that can influence the level of customer satisfaction with a food product in Polish food enterprises covered. The study covered 55 enterprises that declared conducting customer satisfaction measurement. The enterprises considered the hygienic and nutritive values (particularly chemical and microbiological safety of the product) to be the most important customer satisfaction attribute. It was followed by sensor values.

## POMIAR SATYSFAKCJI KLIENTA CZYNNIKIEM IDENTYFIKUJĄCYM ATRYBUTY SATYSFAKCJI KLIENTA Z PRODUKTU SPOŻYWCZEGO

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Słowa kluczowe: atrybuty satysfakcji klienta, produkt spożywczy.

Abstrakt

W artykule zaprezentowano wyniki badań własnych dotyczące rozpoznania i oceny atrybutów satysfakcji klienta z produktu w badanych polskich przedsiębiorstwach przemysłu spożywczego. W badaniu uczestniczyło 55 zakładów, które zadeklarowały, iż prowadzą tego typu pomiar. Za najistotniejszy atrybut satysfakcji klienta uznały one walory higieniczno-żywieniowe (szczególnie chemiczne i mikro-biologiczne bezpieczeństwo produktu), a następnie walory sensoryczne.

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## Introduction

In the present times, identification of product attributes important for the customer is the key issue for a market-focused organization to translate the customer needs into specific products offers in an effective and efficient manner. Sensor analysis studies on a product should be combined with modern market studies to create a fully integrated approach capable of assessment of both all attributes of products and possible interactions among them (CHENG et al. 1989, MOSKOWITZ 1994, ENNEKING et al. 2007). Understanding of the relative importance of products' attributes influencing the choice of a food product is a success factor in development of a new product (ENNEKING et al. 2007). In addition to product high sensor quality, the customers expect a product possessing additional attributes related to health, safety and environment quality (HEUVEL et al. 2007).

Possessing satisfied customers is the key factor of enterprise success in the market (RAMPERSAD 2001, FEČIKOVÁ 2004). Customer satisfaction measurement is, at the present times, an important tool that allows obtaining valuable information that enterprises are frequently unable to obtain in any other way. That information forms the base for specification and determining the customer product satisfaction attributes that become an important guideline for the enterprise to maintain the attributes indicated by the customer as a level highly satisfactory for the customers, a level higher than offered by potential competitors. Knowledge of customer satisfaction attributes allows effective focusing of the internal enterprise procedures to achieve effective customer focus in them.

In view of the above, this study attempted identification of important customer satisfaction attributes for a food product in four groups of product value determinants. Those four groups cover determinants related to the: general looks of the product, sensor qualities, hygienic and nutritive values and commercial values.

## Methodology of Study

Effective identification and assessment of customer satisfaction attributes can influence the customer product satisfaction level in the covered Polish food industry enterprises.

The study was carried out in Polish food industry enterprises possessing certified quality systems compliant with the ISO 9001:2000 standard. The ISO 9001:2000 standard requires the companies to implement processes that are effective and efficient in the context of gathering, analyzing and using the information on customer satisfaction to improve results of the enterprise, i.e. requires the enterprises to carry out customer satisfaction measurement. As a consequence, possessing a certified system was the criterion of targeted

selection of enterprises for customer satisfaction studies. That offered the guaranty that entities covered really carry out customer satisfaction measurements.

The study was carried out by applying the questionnaire-based methodology. The questionnaires were targeted at plenipotentiaries for quality systems in the enterprises covered. The list (documentation) of the population studied was the content of the National Register of Quality System Certificates maintained by the Center of Education and Quality Promotion of the Institute of Organization and Management in Industry 'Orgmasz' in Poland. That list was supplemented with letters of reference obtained from quality systems certification bodies operating in Poland, i.e. 13 organizations certifying enterprises, which made their reference lists available. On those basis 197 food enterprises possessing certified quality systems qualified for the study were selected (they were all food industry enterprises that were included in all the abovementioned lists).

The required number of elements in the sample considering the allowed error and assumed confidence coefficient is presented in Table 1. The estimated average values are the average values obtained from the area of customer satisfaction management.

Table 1

Calculation of the sufficient number of elements in the sample

| Area | m | Standard deviation | $n_0$ | $S^2$ | $p = 0.05$ | | $p = 0.05$ | |
|---|---|---|---|---|---|---|---|---|
| | | | | | $d = 0.1$ | $d = 0.15$ | $d = 0.1$ | $d = 0.15$ |
| Customer satisfaction | 3.2 | 0.487 | 60 | 0.238 | 63 | 34 | 88 | 53 |

The table presented shows the sufficient sample size considering the confidence coefficient of $1 - \alpha = 0.95$ and accuracy with which we want to calculate the average value $d = 0.1$. As a consequence the group of 60 enterprises was considered sufficient for the studied population of food enterprises possessing certified quality systems.

Among 60 enterprises covered, 53 organizations declared conducting customer satisfaction measurement, 5 enterprises intend to carry such studies in the future while 2 enterprises declared that they made a partial measurement and those were classified in the group of enterprises that carry out customer satisfaction measurement. Finally, the study was participated in by $N = 55$ enterprises that declared that they carried customer satisfaction measurement. According to the Statistical Classification of Economic Activities in the European Community – NACE effective in Poland as of 1.01.2001 the study covered enterprises from the area of entire Poland classified in section D – industrial enterprises; subsection DA, part 15 – production of food products and beverages. On the basis of employment size, the enterprises covered were classified by NACE as medium and large enterprises.

The organizations covered operated mainly in the regional and domestic markets and only 18% of them operated in the international market.

The plenipotentiaries for quality systems in the enterprises covered assessed own activities in identification of customer satisfaction attributes. The scoring was based on 0 to 5 scale where 0 meant that the activity does not take place, 1 that it is present at a very low level and 5 that it is present at a very high level. Next the plenipotentiaries for quality systems were asked to assess a given customer satisfaction attribute based on 1 to 5 scale where 1 means that a given attribute is unimportant, 2 that it is of low importance, 3 that it is quite important, 4 that it is important and 5 that it is very important. The results obtained from individual enterprises were averaged applying the arithmetic average value.

## Assessment of Customer Satisfaction With a Product Attributes – Results of the Study

The study results obtained indicate that enterprises covered represented a moderate level of identification of major customer satisfaction attributes concerning their products (average score 3.28). The scores for individual activities are presented in Table 2.

Employees of enterprises covered had little knowledge on customer satisfaction attributes (average score 2.98), which should be considered a difficult situation that required fast improvement as currently personalization of the customer possible through higher involvement of employees in the process of customer winning and retaining is a vary important factor influencing fulfillment of customer expectations.

Table 2

Scores for individual activities in the area of identification of customer satisfaction attributes

| Activities in the area of identification of customer satisfaction attributes | Average score |
|---|---|
| Management identifies new trends concerning customer needs and satisfaction | 4.29 |
| Management believes in importance of customer satisfaction measurement | 3.99 |
| Customer satisfaction is a part of the enterprise strategy | 3.90 |
| A database covering complaints is maintained | 3.59 |
| Customer suggestions are used for improvement of customer focus | 3.38 |
| Attributes of optimum customer satisfaction are known | 3.28 |
| All employees know the optimum customer satisfaction attributes | 2.98 |
| Satisfaction measurement involves customers in development of new products and processes | 2.95 |

Source: own development based on the results of questionnaire based study

Assessment of individual customer satisfaction attributes is presented in Table 3. The enterprises considered hygienic and nutritive values of the product the most important customer satisfaction attribute (average score 4.39). It was followed by sensor attributes (average score 3.95), commercial values (average score 3.78) and the general looks of the product (average score 3.67).

In the group of hygienic and nutritive values all items were considered important. Chemical (average score 4.94) and microbiological (average score 4.91) safety of products were particularly important customer satisfaction

Table 3

Specification of scores of identified customer satisfaction attributes in the enterprises covered

| Customer satisfaction attribute (product value determinant) | Average score of the attribute in the covered enterprises | Average score of the attribute as compared to the strongest competitor |
|---|---|---|
| A. General looks of the product | 3.67 | 4.03 |
| Color | 4.17 | 4.50 |
| Surface looks | 3.74 | 4.17 |
| Shape | 3.57 | 4.36 |
| Product volume in unit package | 3.54 | 3.50 |
| Cross-section looks | 3.20 | 3.11 |
| B. Sensor values | 3.95 | 3.81 |
| Taste | 4.71 | 4.67 |
| Fragrance | 4.49 | 4.25 |
| Aroma | 4.15 | 3.90 |
| Humidity | 3.80 | 3.44 |
| Sweetness | 3.79 | 3.50 |
| Tenderness | 3.69 | 3.10 |
| Acidity | 3.58 | 2.89 |
| Hardness | 3.57 | 3.44 |
| Bitterness | 3.53 | 2.89 |
| Saltiness | 3.41 | 3.00 |
| C. Hygienic and nutritive values | 4.39 | 4.37 |
| Product chemical safety | 4.94 | 4.83 |
| Product microbiological safety | 4.91 | 4.75 |
| Raw material | 4.06 | 4.25 |
| Nutritive value | 4.03 | 3.83 |
| Additives | 4.0 | 4.18 |
| D. Commercial values | 3.78 | 3.96 |
| Product quality | 4.32 | 4.75 |
| Price | 4.24 | 4.45 |
| Product brand | 3.91 | 4.25 |
| Product shelf life | 3.88 | 4.08 |
| Package type | 3.82 | 3.91 |
| Ease of preparation | 3.74 | 3.92 |
| Package functionality | 3.71 | 3.75 |
| Ease of preparation for consumption | 3.27 | 3.27 |
| Multiple uses | 3.15 | 2.75 |

Source: own development based on the results of questionnaire based study

attributes according to enterprises covered. Among the sensor values the taste and fragrance were considered the important customer satisfaction attributes. In the group of commercial values product quality and price were considered important from customer satisfaction point of view. In the group of characteristics determining the general looks of the product only the color was considered an important attribute of product value.

Comparing the determinants of product value in relation to the strongest competitor the enterprises were concerned of competition in general looks of product and in commercial values of it. The brand of a strong competitor is perceived as a threat by enterprises covered in the group of commercial values.

## Conclusion

In the conclusion of the above-presented studies it should be pointed out that customer satisfaction measurement is currently becoming an important instrument allowing efficient identification of important customer satisfaction attributes. The study carried out in Polish food industry enterprises allowed identifying product value determinants that is customer satisfaction attributes important for the customers mainly in the group of hygienic and nutritive values and sensor values. Nevertheless, knowledge of all groups of attributes provides the complete image of customer expectations. Knowledge of those attributes allows enterprises focusing their efforts on achievement of the product characteristics in demand among customers that represent the highest value for the customer. Correct identification of customer satisfaction attributes results in market success of the entire enterprise. Polish food industry enterprises should in particular take special effort to identify those attributes well to meet the increasingly fierce competition in food products market.

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# EFFECT OF DIETARY HERB SUPPLEMENTS ON ECONOMIC EFFICIENCY OF PIG FATTENING AND PORK QUALITY

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Key words: economic efficiency, fattening pigs, herbal mixtures.

A b s t r a c t

The aim of the study was to determine the effect of a herbal mixture added to the diet on the production and economic efficiency of pig fattening and pork quality. Analysis of the results obtained showed that regardless of the season of the experiment, an increase in the proportion of dietary herbs was paralleled by increases in growth rate and mean daily weight gains. Due to a slightly higher price of herbal diets, the economic efficiency of fattening experimental groups was lower than in the control group.

## EFEKTYWNOŚĆ EKONOMICZNA TUCZU ŚWIŃ PO ZASTOSOWANIU DODATKU ZIÓŁ W DAWKACH POKARMOWYCH W ŚWIETLE JAKOŚCI POZYSKIWANEGO PRODUKTU

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Słowa kluczowe: efektywność ekonomiczna, tuczniki, mieszanki ziołowe.

A b s t r a k t

Celem badań było określenie wpływu dodatku mieszanki ziołowej w dawce pokarmowej na efektywność produkcyjno-ekonomiczną tuczu trzody chlewnej oraz jakość wytworzonego produktu. Analizując uzyskane wyniki, stwierdzono, że niezależnie od sezonu doświadczenia wraz ze wzrostem udziału mieszanki ziołowej w dawce zwiększało się tempo wzrostu zwierząt oraz średnie dzienne przyrosty. Z uwagi na nieco wyższą cenę mieszanek z dodatkiem ziół efektywność ekonomiczna tuczu grup doświadczalnych była niższa niż grupy kontrolnej.

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## Introduction

The majority of Polish farms are adjusting to increasingly difficult economic conditions of farming. To improve farm management, farmers have to increase production efficiency and market competitiveness. The high rate of unemployment and the resultant decrease in the purchasing power of the population reduce the demand for food (Okularczyk 2000). The emergence of a demand barrier for agricultural products made it necessary to reduce production costs, increase efficiency and make changes to the structure and organization of production in accordance with market signals (Domagalska, Strzelczak 2000). Consumers pay increasing attention not only to taste, aroma, appearance and nutritive value, but also to health, functional and dietetic characteristics (Paschma, Wawrzyński, 2003) and uniqueness of the product, for which they are ready to pay a higher price. Health-promoting traits of meat can be affected by supplementing pig diets with herbs, which will improve production and economic results and pork quality (Osek et al. 2006). Herbs used in the diets are increasingly an alternative to traditional growth stimulants (Józefiak et al. 2002).

The aim of the study was to determine the effect of adding a herbal mixture to the diet on the production and economic efficiency of pig fattening and pork quality.

## Material and Methods

A total of 72 pigs were assigned to three groups: group I (control) without herb supplement, group II – 1% herb supplement and group III – 2% herb supplement. The experiment was conducted in three replicates in different seasons of the year (summer, winter and transition period). Pigs were fattened for approximately 16 weeks. After slaughter, carcasses were dissected to analyse slaughter traits and meat samples were taken for physicochemical analyses. The herb mixture contained garlic, savory, couch grass rhizome, caraway, coriander, thyme, peppermint, and milk thistle endosperm. Prices of the herb-free and herbal diets were calculated. The production results obtained were used to calculate the value of a fattener at the end of fattening, the value of weight gain for the fattening period, the value of feed used per kg weight gain, and the value of feed used during the whole fattening period. These data were used to calculate feeding efficiency and the economic efficiency of fattening.

## Results and Discussion

Pork livestock, which is the final product of pig fattening, is the main source of meat and meat products in Poland (BUCZYŃSKI 1999). The production and economic efficiency of fattening depends largely on feeding, the quantity and quality of slaughter products obtained, and the rate of their production (SOKÓŁ et al. 1999).

The percentage and monetary value of experimental diets are shown in Table 1. The price of 1 kg diet is 0.62, 0.65 and 0.70 zloty/kg for diets with 0 (control group), 1 and 2% herbs, respectively.

Table 1

Percentage composition and value of experimental diets

| Item | Price 1 zl/kg | Groups | | | | | |
|---|---|---|---|---|---|---|---|
| | | control | | 1% herbs | | 2% herbs | |
| | | composition (%) | value (zl) | composition (%) | value (zl) | composition (%) | value (zl) |
| Complete diet | 0.62 | 100 | 0.62 | 99.0 | 0.61 | 98.0 | 0.61 |
| Herb diet | 4.5 | – | – | 1.0 | 0.04 | 2.0 | 0.09 |
| Price per kg | – | 100 | 0.62 | 100 | 0.65 | 100 | 0.70 |

Analysis of the results of pig fattening performance (Figure 1) shows that regardless of the season of the experiment, the increase in the proportion of dietary herbs was paralleled by the increased rate of growth (by 1.6–4.1%) in relation to the control group receiving no herbs. Mean daily gains of the experimental animals according to percentage of dietary herbs ranged from

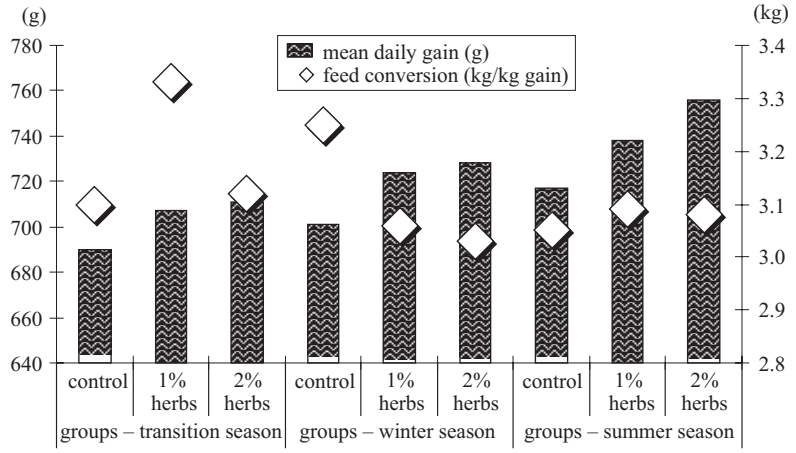


Fig. 1. Some production results

Table 2

Economic efficiency of fattening

| Item | Groups – transition season | | | Groups – winter season | | | Groups – summer season | | |
|---|---|---|---|---|---|---|---|---|---|
| | control | 1% herbs | 2% herbs | control | 1% herbs | 2% herbs | control | 1% herbs | 2% herbs |
| Final weight (kg) | 96.90 | 100.30 | 101.30 | 99.20 | 102.10 | 100.80 | 99.90 | 99.20 | 99.80 |
| Value of pig, start of fattening (zl) * | 94.38 | 93.25 | 94.38 | 93.62 | 94.75 | 94.38 | 93.25 | 93.25 | 92.87 |
| Value of pig, end of fattening (zl) | 364.34 | 377.13 | 380.89 | 372.99 | 383.9 | 379.01 | 375.62 | 372.99 | 375.25 |
| Value of gain during fattening period (zl) | 269.97 | 283.88 | 286.51 | 279.37 | 289.15 | 284.63 | 282.37 | 279.74 | 282.38 |
| Value of feed used per kg gain (zl) | 1.92 | 2.16 | 2.18 | 2.01 | 1.99 | 2.12 | 1.89 | 2.01 | 2.16 |
| Value of feed used for gain throughout fattening (zl) | 137.86 | 163.08 | 166.12 | 149.34 | 153.03 | 160.48 | 141.94 | 149.54 | 162.22 |
| Economic efficiency of fattening (zl) ** | 132.11 | 120.8 | 120.39 | 130.03 | 136.12 | 124.15 | 140.43 | 130.2 | 120.16 |
| Feeding efficiency index *** | 1.96 | 1.74 | 1.72 | 1.87 | 1.89 | 1.77 | 1.99 | 1.87 | 1.74 |

* price per kg pork livestock = 3.76 zl acc. to "Rynek Mięsa", October 2005
** difference between weight gain value and value of feed used for that gain
***gain value/value of feed used for that gain

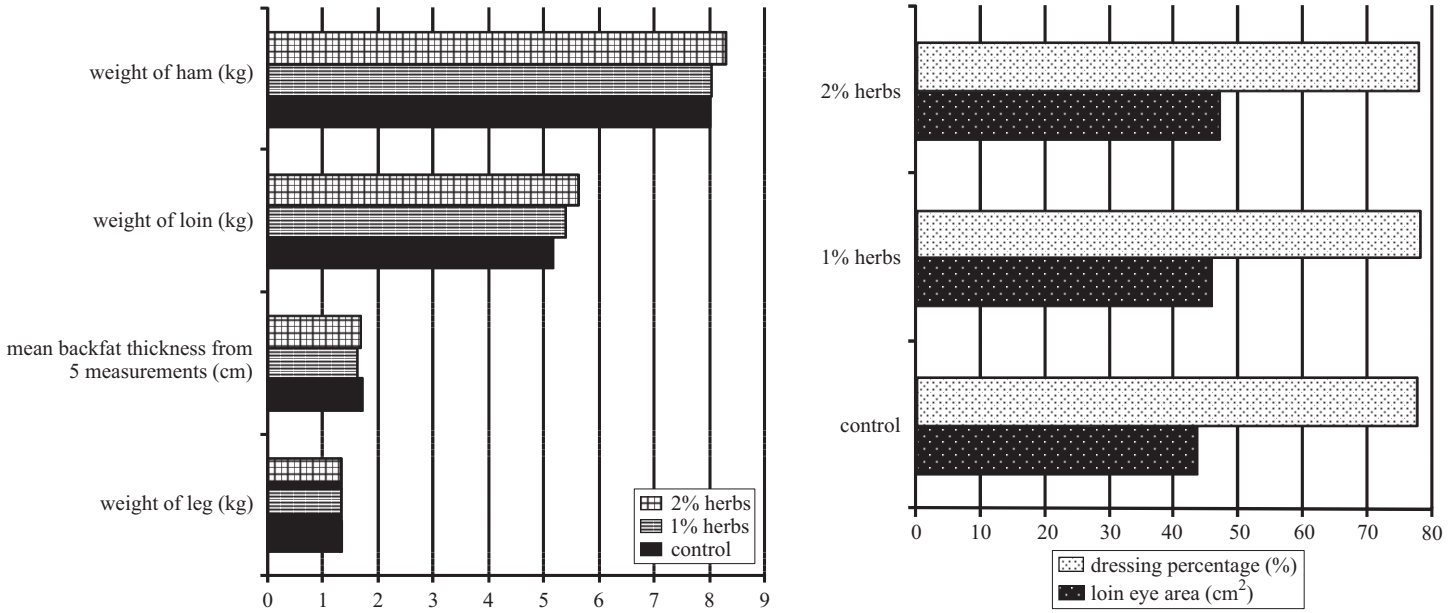


Fig. 2. Some indicators of slaughter value

714 to 732 g (means from three seasons) compared to 703 g in the control group. The feed conversion of experimental animals in the transition and summer seasons in particular experimental groups was poorer than in control animals. Only in the winter season, feed conversion (kg/kg gain) by experimental animals was 5.2–6.8% better as the herb supplements increased.

Because of more expensive diets and generally poorer feed conversion (especially in the transition and summer seasons), the mean efficiency of feeding herbal diets, calculated for all the periods, was lower by 5–13 zloty (5.2–9.7%) compared to the control group (Table 2). Because of the higher quality of the product obtained, the purchase price should be slightly increased to approximately 4 zloty/kg to increase production profitability and to set the production efficiency index at 140 zloty. Also the feeding efficiency index was 0.07–0.2 lower on average in the experimental groups than in the control group, and decreased from 1.94 (control group) to 1.74 (group with 2% herbs) as the herb supplement increased.

Figure 2 gives the results of selected postslaughter traits. Slaughter analysis showed better muscling in the carcasses from experimental groups receiving herb supplements. This particularly concerns the weight of loin, for which statistically significant differences were found between the 2% herb group and the control group ($P \leq 0.05$). This tendency also occurred for loin eye area and the meat of ham, although the relationship between the amount of herbs and meatiness was not significant. The use of the herb supplement did not negatively affect pork carcass fatness and the results obtained were similar. The results of some slaughter value parameters obtained are consistent with the findings of Paschma and Wawrzyński (2003) and Grela (2000), although the composition of the diets was slightly different.

## Conclusions

Fattening results obtained in three replicates in different seasons show that herbs supplemented to pig diets increased daily weight gains as the proportion of herbs in the diets increased.

Because of the more expensive herb diets and periodically poorer feed conversion, the economic results of fattening decreased (the economic efficiency of fattening deteriorated and the feeding efficiency index decreased). However, this should not preclude the use of herbs in pig diets because:

– the herb supplement had a positive effect on slaughter performance and meat quality
– the herb supplement may act like probiotics, which is important for health food production

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# ECONOMIC ASPECTS OF PRODUCTION OF COTTAGE CHEESE DEPENDING ON TECHNOLOGY OF PRODUCTION

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K e y  w o r d s: cottage cheeses, production cost of cottage cheeses, production technology.

A b s t r a c t

Cottage cheeses constitute a highly nutritious component of our daily diets. Records from market research have shown a considerable increase both in terms of production volumes and a number of varieties of all kinds of cottage cheeses. Poland's accession to the European Union will open access, for theses products, to the new selling markets. However, this only will be possible once their quality has satisfied high requirements. Production coast of cottage cheese include coast of raw material, production technology, and the form of applied leavening, level of production line automation, production volume and other. Low quality of raw material, bacteriophages and secondary infections in the process of production may lead to high financial losses of creameries. This article constitutes an attempt to estimate likely financial losses of a creamery depending on methods of cottage cheese production.

## EKONOMICZNE ASPEKTY PRODUKCJI SERÓW TWAROGOWYCH W ZALEŻNOŚCI OD TECHNOLOGII PRODUKCJI

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S ł o w a  k l u c z o w e: sery twarogowe, koszty produkcji serów twarogowych, technologia produkcji serów twarogowych.

A b s t r a k t

Sery twarogowe stanowią wysokowartościowy składnik codziennej diety. Obserwuje się zarówno wzrost produkcji, jak i znaczne rozszerzenie asortymentu obecnych na rynku serów twarogowych, serków i twarożków.

Przystąpienie Polski do Unii Europejskiej umożliwiło dostęp tych produktów do nowych rynków zbytu. Będzie to możliwe wówczas, gdy spełnią one wysokie wymagania jakościowe.

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Na koszty produkcji serów twarogowych wpływa wiele elementów, m.in. koszty surowca, technologia produkcji, forma stosowanego zakwasu, stopień zautomatyzowania linii produkcyjnej i wielkość produkcji. Zła jakość surowca, infekcja bakteriofagowa i wtórne zakażenia w procesie produkcji mogą być przyczyną znacznych strat finansowych zakładów mleczarskich. W pracy podjęto próbę ich oszacowania w zależności od metody produkcji serów twarogowych.

## Introduction

Cottage cheese as a highly nutritious element of the daily diet is the essential item in the production process and consumption. There is both a rise in production and considerable extension of assortment of cottage cheeses and flavored cheeses (SZPENDOWSKI et al. 2007).

After the recession in years 1990–1992 there was an increase in the production and consumption of cottage cheese. The production of cottage cheese amounted to 197.500 tons in 1995, 281.400 tons and 156.100 tons in 2004 and in the first half of 2005 respectively (SMOLEŃSKI et al. 2005).

The average per capita cottage cheese consumption amounted to 6.4 kilograms per year in Poland and it was over twice as high as rennet cheese intake. In the following years this product group intake showed general upward trends reaching 8 kg per capita per year in 2003.

Poland's accession to the EU provided the increased access to new market for Polish cottage cheese on condition that product fulfills the high quality demands.

## Aim and Method of Work

The aim of the research was to estimate the probable losses of the creameries in relation with the production method. Data was collected within 2 creameries equipped with automated production line and 3 creameries equipped with traditional line. The method of direct interview was got data these.

## Costs of Cottage Cheese Production

Costs of cottage cheese production include a range of elements such as: raw material costs, applied production technology, a form of leavening agent, a level of production process automation, a size of production and others. Taking into consideration exclusively the production technology a raw material is the most essential among costs and one of the factors creating the level of individual cost components is the kind production line. It is estimated that raw material costs for the majority of dairy products may constitute up 50–60% of prime costs. The contribution may be even higher in case of so called "resource-intensive products" (GORNOWICZ et al. 1999).

Thriving dairy enterprise produce good products at best price and optimal quality, produced on technological lines complying with hygiene and EU technology standards (AXEL VON WANDENBURG 1999).

## Costs of Cottage Cheese Production in Dairy Enterprises Equipped with Modern Automated Production Lines

Water and energy consumption costs, that is costs of the processing of the coagulated curd in a caldron or a cheese-making container and pasteurization costs constitute about 12% of general costs in dairy enterprises equipped with automated production lines. Other cost components include: 2% of applied additive costs such as leavening agents, rennin, calcium chloride, storage costs (2%), packing understood as labour (3%) and wrapping constituting 6% of general costs of cottage cheese production (Figure 1).

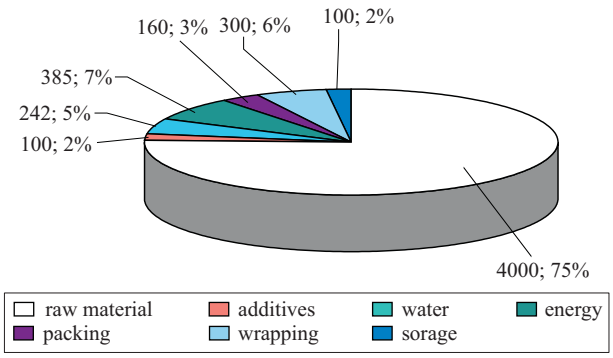


Fig. 1. Production cost of batch of cottage cheese on automated line in PLN/1000 kilograms
Source: personal elaboration on the basis for collected data on creameries

## Costs of Cottage Cheese Production in Dairy Enterprises Conducting Production Applying Traditional Methods

Cottage cheese production applying traditional methods is based on the usage of open cottage cheese making containers, cheese clothes and simple presses and the product is packed manually in parchment paper. Due to such a low level of the production automation and not complying with the hygiene standards cottage cheese is characterized by low standards, poor organoleptic features and packaging (ŚMIETANA et al. 1999). The energy and water consumption costs (pasteurization and processing in a cheese-making container) during the production of a batch of cottage cheese (1000 kg) constitute 9% of the general costs. Other cost elements are: storage (3%),

additive costs (3%), packing of a product understood as labour (4%) and wrapping constituting 8% of general costs of producing cottage cheese on a traditional production line (Figure 2).

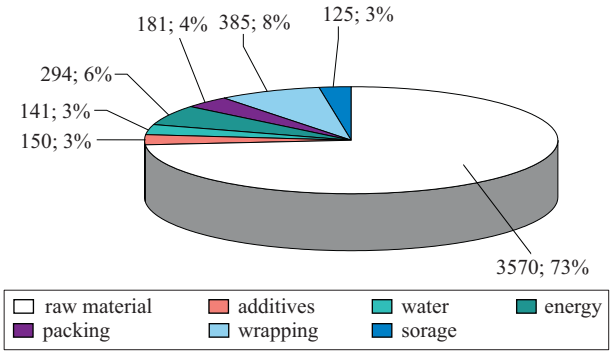


Fig. 2. Production cost of batch of cottage cheese on traditional methods in PLN/1000 kilograms
Source: personal elaboration on the basis for collected data on creameries

## The Loss of the Dairy Enterprise Resulting From Law Quality of Raw Material and Infections in the Course of a Production Process

Raw material as the most essential component affecting the cost of curd production should meet appropriate organoleptic and microbiological criteria. The loss of the dairy enterprises resulting from low quality of raw material, infection bacteriophages and recurring infection in a production process may have negative financial effects. According to Kołakowski 60–70% technological disturbances in the production process of cottage cheese in Poland results from bacteriophages infections (Kołakowski et al. 2001). New technologies using automated production lines are used only in 40% of cottage cheese production (Śmietana et al. 2003). Low hygiene quality of raw material may lead to not achieving and product or achieving products of lower quality features. It may result in rejecting the batch of milk for processing, which eventually caused the financial loss of the dairy enterprise.

## Conclusions

Provided data indicates that rejecting certain amount of milk essential for production of cottage cheese could cost an estimated 4000 PLN. However, the production of cottage cheese of qualities not meeting commercial requirements costs 5000–6000 PLN depending on applied production technology.

These losses in scale of level of domestic production which is estimated to be 300000 tons of cottage cheese per annum could reach the amount between 1.5 and 1.8 MLD PLN considering the production technology.

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# DIFFERENCES IN FREQUENCY OF FRUIT AND VEGETABLES INTAKE AMONG OLDER EUROPEANS – FOOD IN LATER LIFE PROJECT*

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K e y  w o r d s: fruit, vegetables, frequency, elderly, meals, snacking.

A b s t r a c t

The frequency of fruit and vegetables consumption by 484 older people (aged 65–74 or 75+) living in western and central Europe, was analyzed in regard with selected demographic and socioeconomic factors. Data were collected using 7-day food records. If a fruit/fruit product (dried or raw fruit, fruit in syrup, juice or jam) or vegetable (raw or cooked vegetables and small salad, excluding potatoes) was recorded it was assumed as one serving regardless of the portion size. In general, the respondents consumed 2.6 servings of fruit and vegetables per day. Older women ate significantly more fruit and more vegetables than older men. Those respondents who were older (75+) and those living alone consumed less frequently vegetables when compared to those being younger and those living together. Also, well-educated subjects were eating fruit/fruit products more frequently when compared to those with basic education. BMI and self-perceived health appeared to have significant impact for daily vegetables consumption only. Moreover, for lunch and dinner eaters, nearly ¾ of older people consumed vegetables every day as part of those meals, but only less than half included fruit/fruit products. However, fruit and vegetables consumption with other meals e.g. breakfast and evening meal were minimal. The older Europeans used to snack fruit more often than vegetables. Our findings indicated that daily frequency of fruit and vegetables consumption was too low in regard to nutritional recommendations; demographic factors such as gender, age and social network and other factors, e.g. BMI and self-perceived health significantly affected respondents' daily frequency of fruit and vegetables consumption.

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## CZĘSTOTLIWOŚĆ SPOŻYCIA OWOCÓW I WARZYW WŚRÓD STARSZYCH EUROPEJCZYKÓW

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S ł o w a k l u c z o w e: owoce, warzywa, częstotliwość, osoby starsze, posiłki, pojadanie.

A b s t r a k t

Przedmiotem badania była analiza częstotliwości dziennego spożycia owoców i warzyw przez 484 osoby powyżej 65. roku życia, mieszkające w ośmiu krajach zachodniej i centralnej Europy, na podstawie 7-dniowego bieżącego notowania.

Wykazano, że badane starsze osoby zwykły jeść średnio trzy razy dziennie owoce i warzywa. Zarówno owoce, jak i warzywa mężczyźni spożywali statystycznie istotnie rzadziej w ciągu dnia niż kobiety. O ile nie stwierdzono istotnego wpływu wieku i samotności na częstotliwość spożycia owoców, o tyle okazały się one istotne statycznie, biorąc pod uwagę częstotliwość spożycia warzyw. Ponadto, osoby z nadwagą i z niską samooceną swojego stanu zdrowia zwykły spożywać istotnie częściej warzywa w ciągu dnia niż te z właściwą masą ciała i dobrą samooceną. Zaobserwowano, że osoby lepiej wykształcone częściej sięgały po owoce w porównaniu z tymi z wykształceniem podstawowym.

Wśród osób zwyczajowo jedzących „lunch" i/lub obiad zdecydowanie więcej niż połowa spożywała warzywa prawie codziennie podczas tych posiłków, natomiast jedynie około 40% z nich sięgało po owoce. Uzyskane wyniki pokazują, że spożycie owoców i warzyw podczas śniadania czy wieczornego posiłku było minimalne. Zaobserwowano, że o ile większość osób badanych nie miało w ogóle zwyczaju jeść warzyw w formie przekąski między posiłkami, o tyle dość często prawie połowa z nich pojadała owoce w ciągu dnia.

Zaprezentowane badania pokazały, że częstotliwość spożycia owoców i warzyw przez osoby starsze wydaje się za niska w świetle zaleceń żywieniowych, aczkolwiek niezbędne jest przeprowadzenie tego typu badań z uwzględnieniem również ilości spożytych owoców i warzyw. O częstotliwości ich konsumpcji decydowały zarówno czynniki demograficzne, jak płeć, wiek i sytuacja socjalna, jak i inne, typu wskaźnik BMI czy samoocena swojego stanu zdrowia.

## Introduction

Epidemiological data show a protective effect of fruit and vegetable consumption against a number of chronic diseases, including coronary heart disease, certain cancers, diabetes, and hypertension (Key et al. 2004, Riboli, Norat 2003). Unfortunately, many individuals are still not meeting the recommended five or more servings of fruit and vegetables a day (Johnston et al. 2000, Ford, Mokdad 2001). Guenther et al. (2006) reported that only up to 17% of American elderly meet the recommendations.

The present study describes average daily frequency of fruit and vegetables intake in a cohort of older European people, living in the western and central Europe. Those Europeans took part in the EU-funded project "Food in Later Life (QLK1-CT-2002-02447)", carried out during years 2003–2005.

We examined fruit and vegetables consumption using two indicators: (1) average daily frequency of fruit and vegetables consumption (times per day), (2) the pattern of fruit or vegetables consumption with typical meals and as snacks. A correlation between the fruit and vegetables intake of older Europeans by demographic and other variables was analyzed.

## Material and Methods

***Participant and recruitment procedure***. Eight countries participated in the project: Sweden, Denmark, Poland, Germany, Portugal, Spain, Italy and UK. All partners were using a variety of mixed purposeful sampling. Otherwise, General Practitioners registers, local senior centers and medical schools, seniors meeting venues, associations for pensioners, telephone recruitment and regional and national registers were used to gain initial contacts and this was then expanded using a snowball method.

***Subjects***. To cover the project purposes, in each of eight countries about 80 men and women, aged 65–74 or 75+ and either living alone or with

Table 1

Demographic and other characteristics of the study sample ($n$ = 484)

| Demographic and other variables | $n$ (%) |
|---|---|
| Gender | |
| man | 246 (50.8) |
| women | 238 (49.2) |
| Age (years) | |
| 65–74 (younger) | 280 (57.9) |
| 75+ (older) | 204 (42.1) |
| Social network | |
| living alone | 239 (49.4) |
| living together | 245 (50.6) |
| Educational level[1] | |
| basic | 153 (31.6) |
| secondary | 163 (33.7) |
| higher | 168 (34.7) |
| BMI[2] | |
| normal weight | 197 (40.7) |
| overweight /obese | 287 (59.3) |
| Self-perceived health | |
| excellent | 128 (26.4) |
| good | 193 (39.9) |
| poor | 163 (33.7) |

[1] basic = no formal schooling/less than primary school/primary school completed, secondary = secondary school completed and higher = college/university completed/post graduate degree completed;
[2] normal weight = body mass index (BMI) ≤25 kg/m$^2$, and overweight and obese = body mass index (BMI)> 25 kg/m$^2$

others, in equal proportion, were recruited. However, due to exclusions that must have been made, the analysed dataset is based on information from 484 older Europeans only. A detailed characteristic of the study population is presented in Table 1.

***Measurements and procedure***. This research was carried out in spring-summer of year 2004. The tools relevant to the present report were the *Background Questionnaire*, *Household Composition Questionnaire*, *SF-36 Health Survey* and the *7-day consumption diary*. The *Background questionnaire* was about food, general health, and social characteristics, whereas the *Household Composition questionnaire* focused on respondents' living situation. *SF-36 Health Survey* was a 36-item generic measure of health status. A *7-day food record* was used to get information relating to the types of meals and snacks consumed over the week. If a fruit/fruit product (dried or raw fruit, fruit in syrup, juice or jam) or vegetable (raw or cooked vegetables and small salad, excluding potatoes) was recorded it was regarded as one serving, regardless of the portion size. For the study purposes only a few data were extracted from all questionnaires.

***Data analysis***. Analyses were conducted using SPSS, version 12.0. For each respondent, total weekly servings of fruit and vegetables were computed. A mean number of servings per day was calculated by multiplying the frequency of fruit or vegetables intakes by the portions consumed per week and then divided by seven. Mean servings of fruit and vegetables were analyzed separately because factors affecting inclusion or exclusion of fruit/fruit products in the diet were likely to be different from those for vegetables. Mean daily frequencies of fruit and vegetables intakes were compared with demographic and other factors using multifactor ANOVA as appropriate.

## Results

Table 2 shows mean daily frequencies of fruit and vegetables intakes by demographic and other variables. On average, older Europeans ate about three servings of fruit/fruit products and vegetables per day. The men who participated in the study consumed fruit and vegetables significantly less often than women did. While other demographic variables such as age and social network, remained insignificant with respect to the frequency of fruit intakes, they appeared important as far as the frequency of vegetables was concerned. It was evident that when age increased, frequency of vegetable consumption decreased significantly. Moreover, those living alone consumed less vegetables than those living together, whereas those better educated used to eat more fruit/fruit products daily when compared to those with lower education. It is worth noting that while the BMI and self-perceived health were not significant factors for frequency of fruit intake, they were significant for the frequency of vegetables intakes. Overweighed persons and

Table 2

Mean daily frequency of fruit and vegetables intakes (with ± SE) and ANOVA results according to demographic and other factors

| Variables | Fruit | | Vegetables | |
|---|---|---|---|---|
| | mean number of servings times/day | *F*, *p*-value | mean number of servings times/day | *F*, *p*-value |
| Gender | | 6.59** | | 5.17* |
| men | 1.24 (0.06) | | 1.24 (0.04) | |
| women | 1.43 (0.05) | | 1.38 (0.04) | |
| Age | | NS | | 5.15** |
| younger | 1.38 (0.05) | | 1.37 (0.04) | |
| older | 1.26 (0.06) | | 1.24 (0.04) | |
| Social network | | NS | | 6.40** |
| living alone | 1.33 (0.06) | | 1.25 (0.04) | |
| living together | 1.33 (0.05) | | 1.37 (0.04) | |
| Educational level | | 3.11* | | NS |
| basic | 1.20 (0.07) | | 1.24 (0.05) | |
| secondary | 1.36 (0.06) | | 1.36 (0.05) | |
| higher | 1.41 (0.07) | | 1.33 (0.04) | |
| BMI | | NS | | 6.13** |
| normal weight | 1.30 (0.06) | | 1.21 (0.04) | |
| overweight/obese | 1.36 (0.05) | | 1.38 (0.04) | |
| Self-perceived health | | NS | | 7.26*** |
| excellent | 1.31 (0.08) | | 1.22 (0.05) | |
| good | 1.32 (0.06) | | 1.25 (0.04) | |
| poor | 1.35 (0.06) | | 1.46 (0.05) | |
| Total | 1.33(0.04) | | 1.31(0.03) | |

*** for $p \leq 0.001$; **for $p \leq 0.01$; * for $p \leq 0.05$; NS – not significant

respondents who perceived their health as poor ate vegetables more frequently than those having normal weight and excellent health. Such relationships were not observed for frequency of fruit/fruit products consumption.

The patterns of fruit/fruit products and vegetable intakes as part of a meal and as snacks are presented in Figure 1 and 2. Among lunch and dinner eaters, less than half of older Europeans used to consume fruit/fruit products every day as part of a meal. A clearly better situation was observed for vegetables intakes: most of lunch and dinner eaters ate vegetables in meals every day. Our results revealed that fruit and vegetables intake with other main meals i.e., breakfast and evening meal were minimal. Moreover, it is interesting to see that people who used to snack were not in habit to consume vegetables as snack. Fruit and fruit products were chosen as snacks more frequently than vegetables.

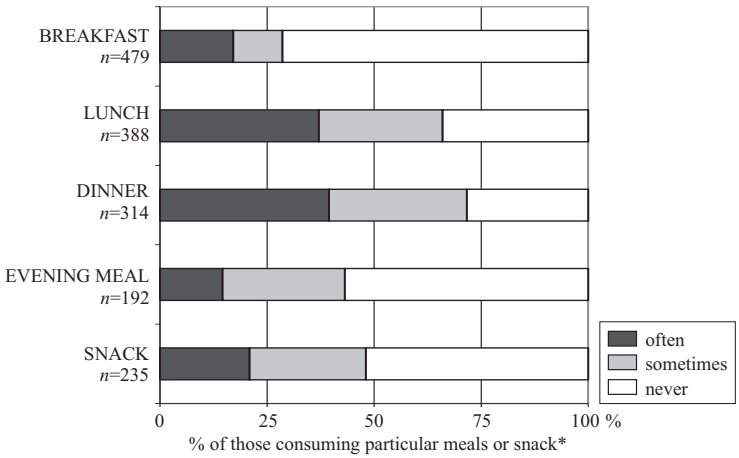


Fig. 1 The pattern of fruit intake with the meals and as snacks

* total number of older people who declared eating breakfast, lunch, dinner, evening meal or snack; this figure is the same for fruits and vegetables.
** often = percentage of respondents having one serving almost every day during the week as part of particular meals or snacks;
sometimes = percentage of respondents having one serving 3–4 times during the week as part of particular meals or snacks;
never = percentage of respondents no having any servings or very ocassionally during the week as part of particular meals or snacks

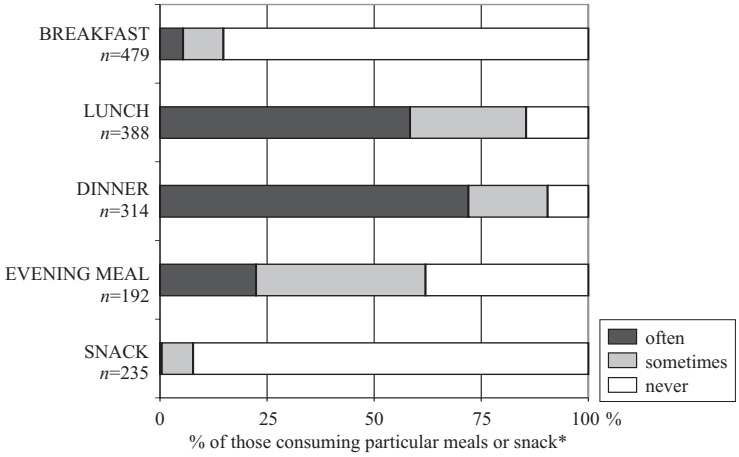


Fig. 2. The pattern of vegetables intake with the meals and as snacks

* total number of older people who declared eating breakfast, lunch, dinner, evening meal or snack; this figure is the same for fruits and vegetables.
** often = percentage of respondents having one serving almost every day during the week as part of particular meals or snacks;
sometimes = percentage of respondents having one serving 3–4 times during the week as part of particular meals or snacks;
never = percentage of respondents no having any servings or very ocassionally during the week as part of particular meals or snacks

## Discussion

In general, this paper reported some clear demographic relationships with fruit and vegetables consumption among older Europeans. Fruit consumers were more likely to be well-educated women whereas those who consumed vegetables more frequently seemed to be overweighed women, usually aged 65–74 years, living together with at least 1 person in a common household and with poor health. The findings were consistent with other studies. Baker, Wardle (2003) revealed that women ate significantly more fruit and more vegetables than men due to their higher awareness of the health recommendations or health benefits. Based on Donkin et al. (1998) results it can also be seen that both gender and living status affected the consumption of fruit and vegetables of older people; especially the living status had different effects depending on the gender of the subject. The results indicated that, in this cohort, living in a household without women resulted in decreased fruit and vegetable consumption. On the other hand, Pollard et al. (2001) noted that a woman's marital status was significantly associated with her fruit and vegetables intake: those married used to consume fruit and vegetables more often. To summarize, these results pointed out that married subjects adopted healthier behaviours by consuming more fruit and vegetables. Our results reflected the relation found in previous studies. In general, the consumption of all food products decreased in the 75+ age group due to both physiological and demographic factors. The reduced appetite, decreasing energy needs, poor physical condition, living alone and other factors were seen as potential reasons for those observations (Cooper, Kohlmann 2001, Marcus, Berry 1998). Our results also demonstrated a clear relation between age and frequency of fruit or vegetables intake. Regarding other associations between education level and frequency of fruit and vegetables intake, other studies confirmed the observation that higher education levels led to higher incomes and wage potential, and consequently, to greater access to a wider variety of foods (Dixon et al. 2001, Erkkila et al. 1999, Prattala et al. 1992). Higher education levels were also thought to be related to increased awareness and practice of healthy behaviours (Frazeo 1996). However, our findings are in accordance with those of the cited studies with regard to frequency of fruit intake only. There could be some possible explanations for this fact. Cox et al. (1996) noticed that 32% of a stratified random sample of British adults saw the cost of fruit as a barrier to consumption compared with only 23% finding the cost of vegetable dishes as a barrier to consumption (quoted after Donkin et al. 1998). There was no doubt that socioeconomic status strongly correlated with education. When faced with such founding it was really not surprising that the price of fruit for better educated people with higher pension seemed to be not important. Vegetables were seen as a low-calorie food and overweighed people were significantly more concerned about loosing their weight. Therefore it was not surprising that overweighed older respondents

tended to consume more vegetables. On the other hand, some evidence suggested that vegetables, and not fruit, were important for cancer prevention (Steinmetz, Potter 1996), particularly for cancers of the digestive tract and colon (quoted after Trudeu et al. 1998).

It is of interest to note that reported total frequency of fruit and vegetable intake within the cohort under study were rather low (2.6 times/day). However, consistent findings have been obtained when examining elderly Taiwanese, aged 53 years and over (Tsai et al. 2006) and older adults aged 55–64 years in the UK (Baker, Wardle 2003). In contrast to these results, Donkin et al. 1998 showed that older people living in Nottingham, UK, consumed fruit and vegetables 4.1 times per day on the average. At the same time, American adults ate 3.75 servings (1.75–2 cups or 400–455g) of fruit and vegetables per day (Li et al. 2000).

In the present study, our findings showed that older individuals preferred to eat fruit than vegetables as a snack. It can probably be explained by the "sweet tooth" hypothesis regarding sweet foods and fruit. Since fruit/fruit products taste in general sweeter than vegetables, it would be expected that fruit would be more frequently consumed as sweet snacks. Wansink et al. (2006) confirmed that sweet snack lovers ate more fruits than salt snack lovers and fruit lovers ate more sweet snacks than vegetable lovers.

Our findings did not fully represent all older national populations because this was a non-randomized sample population. Further detailed studies in this field are required, including monitoring of fruit and vegetables portion size consumed by the elderly.

## Conclusions

Our findings indicated that (1) daily frequency of fruit/fruit products and vegetables consumption within the cohort under study was too low; (2) gender differences were evident for daily frequencies of fruit/fruit products and vegetables intake; (3) a clear age-associated shifts towards less frequent consumption of vegetables was found; (4) a living status was a significant predictor for vegetables consumption; (5) the effect of health-status or BMI was stronger for vegetables intakes than for fruit/fruit products consumption; (6) eating lunch and dinner was associated with adopting healthier behaviours as far as regarding fruit/fruit products and vegetables as snacks.

## Acknowledgements

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from the Commission of the European Communities, specific RTD programme *Quality of Life and Management of Living Resources*, *QLK1-CT-2002-02447*, *Choosing foods, eating meals: sustaining independence and quality of life in old age*. It does not necessarily reflect its views and in no way anticipates the Commission's future policy in this area.

We are deeply grateful to all older people who took part in the study.

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# DETERMINATION OF THE RELATIONSHIP BETWEEN THE MILK PURCHASE PRICE AND RETAIL PRICE OF SOME DAIRY PRODUCTS

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Key words: raw milk price, retail price, price relationships, dairy products, Pearson's correlation.

Abstract

Milk purchase prices and retail prices of dairy products were analyzed, and the percentage of raw milk purchase prices in the retail prices of some dairy products was calculated. The milk purchase price averaged 0.97 zloty/l and was 6.52% higher in 2006 than in 2004. The highest mean proportion of raw milk purchase price in the retail price of dairy products was found for 2% fat pasteurized drinking milk (plastic pouches). It was 77.92% in 2006, a reduction of 3.83% in relation to 2004. The lowest mean proportion of raw milk in the retail price of dairy products was found for maturing Edam cheese (8.67%) in 2006, an increase of 1.15% in relation to 2004. In 2004, milk purchase price had a considerable effect on the retail prices of dairy products: 0.9493 (Pearson's correlation coefficient) for dried skim milk, 0.9301 for 30% milk fat cream and sweet cream, and 0.7337 for 82% fat butter. In 2005, Pearson's correlation coefficient was 0.9674 for Edam cheese and 0.6910 for 40% fat curd cheese. In 2006, there were considerable negative relationships for 82% fat butter (–0.8961), dried skim milk (–0.7730), and 2% fat pasteurized drinking milk (–0.6774).

## OKREŚLENIE ZALEŻNOŚCI POMIĘDZY CENĄ SKUPU MLEKA A CENĄ DETALICZNĄ WYBRANYCH PRODUKTÓW MLECZARSKICH

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Słowa kluczowe: cena surowca, cena detaliczna, relacje cen, produkty nabiałowe, korelacja Pearsona.

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A b s t r a k t

Poddano analizie ceny skupu mleka, ceny detaliczne nabiału oraz obliczono procentowy udział ceny skupu surowca (mleka surowego) w cenach detalicznych wybranych produktów nabiałowych. Średnia cena skupu mleka wynosiła 0,97 zł/l i była wyższa w roku 2006 niż w 2004 o 6,52%. Najwyższy średni udział ceny skupu mleka surowego w cenie detalicznej produktów nabiałowych wykazano dla mleka spożywczego pasteryzowanego o 2% zaw. tłuszczu (folia), a najniższy – dla dojrzewającego sera Edamskiego. Wynosił on dla pierwszego produktu 77,92% (w 2006 r. był niższy o 3,83% niż w roku 2004), a dla drugiego – 8,67 (był wyższy w 2006 r. niż 2 lata wcześniej o 1,15%). Wpływ ceny skupu mleka na ceny detaliczne produktów nabiałowych w 2004 r. był duży: wsp. korelacji Pearsona dla odtłuszczonego mleka w proszku, śmietany i śmietanki (30% tł.) oraz masła (82 % tł.) wynosił odpowiednio 0,9493; 0,9301 i 0,7337; w 2005 r. dla sera Edamskiego współczynnik ten przybrał wartość 0,9674, a dla twarogu (40 % tł.) – 0,6910. W 2006 r. zaobserwowano dużą zależność ujemną dla masła o zaw. 82% tł. (–0,8961), mleka odtł. w proszku (–0,7730) oraz mleka spoż. past. 2% tł. (–0,6774).

## Introduction

Relationships between prices at different levels of the marketing chain play a major role in market price trends (Juchniewicz 2002). Farmers are particularly interested in the relationships between raw material purchase prices and final product prices. Middlemen are interested in price fluctuations in the industry, which lead to changes in processing profitability and determine its economic condition, and these have an effect on retail prices. Bazydło and Szczubełek (2003) reported that in Poland, milk purchase prices depend increasingly on changes in the level of dairy product market prices. Small dairy plants are eliminated by large and modern dairies. Dairy plants are being restructured and install new processing lines for production of highly-processed dairy products. Świetlik (2004) stressed that changes in the level and structure of food products determine trends in food demand. The diminishing proportion of raw material purchase price in the retail price of animal food in Poland has negatively affected the profitability of animal breeding and reduced livestock numbers.

## Material and Methods

The aim of the present research and analysis was to obtain numerical data on the contribution of agricultural producers to the retail price of dairy products. The analysis was performed in 2004–2006 in dairy plants and trade outlets all over Poland. The following dairy products were investigated: dried skim milk, creamery block butter (82% fat), maturing Edam cheese, curd cheese (40% fat), pasteurized drinking milking (2% fat; plastic pouch), UHT drinking milk (2% fat; carton), natural yoghurt (2% fat), kefir (2% fat), cream and sweet cream (30% milk fat). The data studied included milk

purchase prices, retail prices of dairy products, and percentage of milk purchase prices in the retail prices of selected dairy products. Means for different months and the dynamics of changes were calculated for 2004–2006. Pearson's correlation coefficients, which show relationships between two parameters and the degree of these relationships, were used to determine the relationship between milk purchase prices and retail prices of dairy products (RÓSZKIEWICZ 2002).

## Results and Discussion

In 2004, the mean purchase price of raw milk was 0.92 zloty/l (Table 1). In the same year, the retail prices of dairy products were as follows: 2% fat drinking milk (plastic pouch) – 1.16 zloty/l, 2% fat UHT milk – 1.64 zloty/l, 2% fat kefir – 2.52 zloty/l, 2% fat natural yoghurt – 3.86 zloty/l, 30% fat cream and sweet cream – 5.20 zloty/l, 40% fat curd cheese – 7.37 zloty/kg,

Table 1

Milk purchase prices (zloty/l, zloty/kg) in 2004-2006

| Item | 2004 | 2005 | 2006 | 2006/2004 (%) |
|---|---|---|---|---|
| Raw milk | 0.92 | 1.00 | 0.98 | 6.52 |

Source: author's own research data.

dried skim milk – 7.36 zloty/kg, 82% fat butter – 10.80 zloty/kg, maturing Edam cheese – 11.60 zloty/kg (Table 2). In 2004, the highest proportion of milk purchase prices in the retail prices of dairy products was found for 2% fat drinking milk (plastic pouch) – 79.73%, followed by 2% fat UHT milk – 56.23%, 2% fat kefir – 37.30%, 2% fat natural yoghurt – 26.54%, 30% fat cream and sweet cream – 17.86%, 40% curd cheese – 12.67%, dried skim milk – 12.12%, and 82% fat butter – 8.44%. The lowest proportion of raw milk price in retail price (7.90%) was shown for maturing Edam cheese (Table 3). In 2005, the raw milk purchase price averaged 1.00 zloty/l (Table 1). Compared to 2004, the milk purchase price in 2005 increased by 8.69%. In 2005, the retail price of dairy products was 1.27 zloty for 2% fat drinking milk (plastic pouch), 1.77 zloty for 2% UHT milk, 2.36 zloty for 2% fat kefir, 2.69 zloty for 2% natural yoghurt, 5.46 zloty for 30% fat cream and sweet cream, 7.31 zloty for 40% fat curd cheese, 7.73 zloty for dried skim milk, 10.54 zloty for 82% fat butter, and 11.05 zloty for Edam cheese (Table 2). In 2005, the largest proportion of milk in the retail price of dairy products was found for 2% fat drinking milk (plastic pouch) – 78.13%, followed by 2% UHT milk – 56.24%, 2% fat kefir – 42.15%, 2% fat natural yoghurt – 36.83%, 30% fat cream and sweet cream – 18.30%, 40% fat curd cheese – 13.59%, dried skim milk – 12.89%, and 82% fat butter – 9.49%. The lowest percentage of raw milk price in retail price (9.06%) was found for Edam cheese (Table 3).

Table 2

Retail prices of dairy products (zloty/l, zloty/kg) in 2004–2006

| Item | 2004 | 2005 | 2006 | 2006/2004 (%) |
|---|---|---|---|---|
| Dried skim milk | 7.63 | 7.73 | 7.42 | –2.75 |
| Butter, 82% fat | 10.80 | 10.54 | 9.45 | –12.50 |
| Maturing Edam cheese | 11.60 | 11.05 | 10.85 | –6.46 |
| Curd cheese, 40% fat | 7.37 | 7.31 | 7.40 | 0.41 |
| Drinking milk, 2% fat (plastic pouch) | 1.16 | 1.21 | 1.29 | 11.21 |
| UHT drinking milk, 2% | 1.64 | 1.77 | 1.75 | 6.71 |
| Natural yoghurt, 2% fat | 3.86 | 2.69 | 2.83 | –26.68 |
| Kefir, 2% fat | 2.52 | 2.36 | 2.40 | -4.76 |
| Cream and sweet cream, 30% fat | 5.20 | 5.46 | 5.11 | –1.73 |

Source: author's own research data.

In 2006, the raw milk purchase price averaged 0.98 zloty/l (Table 1). Compared to 2004, the milk purchase price in 2006 increased by 6.52%. In 2006, the retail prices of dairy products were as follows: 2% fat drinking milk (plastic pouch) – 1.29 zloty/l, 2% fat UHT milk – 1.75 zloty/l, 2% fat kefir – 2.4 zloty/l, 2% fat natural yoghurt – 2.83 zloty/l, 30% fat cream and sweet cream – 5.11 zloty/l, 40% fat curd cheese – 7.4 zloty/kg, dried skim milk – 7.42 zloty/kg, 82% fat butter – 9.45 zloty/kg, Edam cheese – 10.85 zloty/kg (Table 2). Compared to 2004, the retail price of dairy products in 2006 increased by 11.21% for 2% fat drinking milk (plastic pouch), by 6.71% for 2% fat UHT milk, and by 0.41% for 40% fat curd cheese. In the same

Table 3

Proportion of milk purchase prices in retail prices of dairy products (%) in 2004–2006

| Item | 2004 | 2005 | 2006 | 2006/2004 (%) |
|---|---|---|---|---|
| Dried skim milk | 12.12 | 12.89 | 13.25 | 1.13 |
| Butter, 82% fat | 8.44 | 9.49 | 10.40 | 1.96 |
| Maturing Edam cheese | 7.90 | 9.06 | 9.05 | 1.15 |
| Curd cheese, 40% fat | 12.67 | 13.59 | 13.28 | 0.61 |
| Drinking milk, 2% fat (plastic pouch) | 79.73 | 78.13 | 75.90 | –3.83 |
| UHT drinking milk, 2% fat | 56.23 | 56.24 | 56.18 | –0.05 |
| Natural yoghurt, 2% fat | 26.54 | 36.83 | 34.75 | 8.21 |
| Kefir, 2% fat | 37.30 | 42.15 | 40.91 | 3.61 |
| Cream and sweet cream, % fat | 17.86 | 18.30 | 19.22 | 1.36 |

Source: author's own research data.

period the retail price decreased for dried skim milk by 2.75%, for 82% fat butter by 12.50%, for Edam cheese by 6.46%, for 2% fat natural yoghurt by 26.68%, for 30% milk fat cream and sweet cream by 1.73%, and for 2% fat kefir by 4.76%. In 2006, the largest proportion of milk in the retail price of dairy products was found for 2% fat drinking milk (plastic pouch) – 75.9%, followed by 2% fat UHT milk – 56.18%, 2% fat kefir – 40.91%, 2% fat natural yoghurt – 34.75%, 30% fat cream and sweet cream – 19.22%, 40% fat curd cheese – 13.28%, dried skim milk – 13.25%, and 82% fat butter – 10.4%. The lowest proportion of raw milk price in retail price (9.05%) was found for Edam cheese (Table 3). Compared to 2004, the proportion of raw milk purchase price in the retail price of dairy products in 2006 decreased by 3.83% for 2% fat drinking milk (plastic pouch) and by 0.05% for 2% fat UHT milk. In the same period, the increased proportion of raw milk purchase price in the retail price of dairy products was found for dried skim milk (by 1.13%), 82% fat butter (by 1.96%), Edam cheese (by 1.15%), 40% fat curd cheese (by 0.61%), 2% fat natural yoghurt (by 8.21%), 2% fat kefir (by 3.61%), and 30% fat cream and sweet cream (by 1.36%) (Table 3). In 2002, the effect of milk purchase price on the retail price of dairy products was considerable for dried skim milk (Pearson's correlation coefficient of 0.9493), 30% milk fat cream and sweet cream (0.9301), and 82% fat butter (0.7337). Milk purchase prices were highly negatively correlated with the retail prices

Table 4

Pearson's correlation coefficients for relationships between milk purchase price and retail prices of dairy products in 2004–2006

| Item | 2004 | 2005 | 2006 |
|---|---|---|---|
| Milk purchase price<br>Dried skim milk | 0.9493 | 0.1139 | -0.7730 |
| Milk purchase price<br>Butter, 82% fat | 0.7337 | 0.5484 | -0.8961 |
| Milk purchase price<br>Maturing Edam cheese | -0.5249 | 0.9674 | -0.0560 |
| Milk purchase price<br>Curd cheese, 40% fat | 0.4697 | 0.6910 | 0.1976 |
| Milk purchase price<br>Drinking milk, 2% fat (plastic pouch) | 0.5581 | -0.6785 | -0.6774 |
| Milk purchase price<br>UHT drinking milk, 2% fat | -0.8357 | -0.9055 | -0.4931 |
| Milk purchase price<br>Natural yoghurt, 2% fat | -0.8417 | -0.8626 | -0.3864 |
| Milk purchase price<br>Kefir, 2% fat | -0.8848 | 0.5447 | 0.0147 |
| Milk purchase price<br>Cream and sweet cream, 30% fat | 0.9301 | 0.1368 | -0.1282 |

Source: author's own research data.

of 2% fat UHT milk (–0.8357), 2% fat natural yoghurt (–0.8417), and 2% fat kefir (– 0.8848). In 2005, the positive value of the correlation coefficient for the relationship between milk purchase price and retail price was high for Edam cheese (0.9674) and 40% fat curd cheese (0.6910). There were very strong and negative correlations between the purchase price of raw milk and the retail price of 2% fat UHT milk (–0.9055), 2% fat natural yoghurt (–0.8626), and 2% fat pasteurized drinking milk (–0.6786). In 2006, there was a high negative correlation for 82% fat butter (–0.8961), dried skim milk (–0.7730), and 2% fat pasteurized drinking milk (–0.6775). The high and positive correlation coefficient means that the higher milk purchase prices increased the retail prices of these products. The strong negative correlation shows that the increase in milk purchase price did not translate into the increase in retail prices (Table 4).

## Conclusions

1. The economic status of milk producers in relation to processors is determined by the proportion of milk purchase price in the retail price of dairy products.

2. The proportion of milk purchase prices in the retail prices of dairy products depends mainly on the degree of raw milk processing. The more the products are processed during manufacture (e.g maturing Edam cheese), the lower their proportion in the price of raw milk. Low-processed products (e.g. 2% fat pasteurized drinking milk; plastic pouch) form a very large proportion of the raw milk price.

3. Milk purchase prices were strongly and positively correlated with dried skim milk, 82% fat butter, 30% fat cream and sweet cream (2004), and maturing Edam cheese and 40% fat curd cheese (2005), which shows that changes in purchase prices translated into retail prices to a large extent.

4. Highly significant and negative correlations were found for 2% fat UHT milk, 2% fat natural yoghurt, 2% fat kefir (2004), 2% fat pasteurized drinking milk, 2% fat UHT milk, 2% fat natural yoghurt (2005), dried milk, 82% fat butter, and pasteurized drinking milk (2006). This shows that the increased milk purchase price did not translate into the retail price increase.

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