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BODY WEIGHT, SELECTED BLOOD PARAMETERS AND SEMEN QUALITY IN TWO AGE GROUPS OF POLISH LANDRACE ARTIFICIAL INSEMINATION BOARS

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K e y w o r d s: pigs, artificial insemination boars, Polish Landrace.

A b s t r a c t

Polish Landrace (PL) boars are most widely used for artificial insemination (AI) in Poland. The objective of this study was to determine the body weights, the values of selected hematological and biochemical blood parameters and semen quality of PL boars used in two AI Stations. The experimental materials comprised 32 boars, 16 from each Station. The boars were divided into two equal subgroups, younger boars – aged up to two years, and older boars – aged above two years.

The average age of younger boars was 414 days, and their average body weight was 237 kg. The average age of older boars was 1167 days, and their average body weight was 344 kg. Both age and age-related body weight positively influenced the total number of spermatozoa in the ejaculate and the number of insemination doses that could be obtained from a boar. The analyzed group of AI boars included five mature boars, aged 1309 to 1571 days and weighing 352 – 375 kg, that produced high-quality ejaculates.

MASA CIAŁA, WYBRANE WSKAŹNIKI KRWI I JAKOŚĆ NASIENIA KNURÓW INSEMINACYJNYCH RASY POLSKIEJ BIAŁEJ ZWISLOUCHEJ

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S ł o w a k l u c z o w e: świnie, knury inseminacyjne, rasa polska biała zwisłoucha.

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Abstrakt

Knury rasy polskiej białej zwisłouchej (pbz) są najczęściej wykorzystywane w inseminacji świń w Polsce. W badaniach analizowano masę ciała, wartość niektórych wskaźników hematologicznych i biochemicznych krwi oraz jakość nasienia knurów rasy pbz użytkowanych w dwóch stacjach unasieniania loch (SUL). Badaniami objęto łącznie 32 knury, po 16 szt. z każdej stacji. Knury podzielono na 2 równe pod względem liczebności podgrupy: knury młodsze, w wieku do 2 lat, i knury starsze, w wieku powyżej 2 lat.

Średni wiek knurów młodszych wynosił 414 dni i średnia masa ciała 237 kg, natomiast średni wiek knurów starszych – 1167 dni, a średnia masa ciała odpowiednio 344 kg. Wiek i związana z nim masa ciała korzystnie wpływają na liczbę plemników w ejakulacie i liczbę dawek inseminacyjnych możliwych do uzyskania.

W analizowanej grupie znajdowało się 5 dojrzałych knurów w wieku od 1309 do 1571 dni o masie ciała wynoszącej 352-375 kg, których ejakulaty bardzo dobrze oceniono pod względem analizowanych cech.

Introduction

In the process of improving pig performance traits, the growing popularity of artificial insemination is a highly desirable and inevitable phenomenon because biotechnology techniques are essential in modern pig breeding (MERKS 2000). The most popular pedigree breeds in Poland are Polish Landrace (PL) and Polish Large White (PLW). The majority of inseminations are performed with the use of semen obtained from PL and PLW boars (MUCHA and TYRA 2013). Artificial insemination (AI) boars are selected for improved growth and meatiness, whereas ejaculate traits that determine their reproductive value are analyzed only in the AI station. According to numerous authors (KAWĘCKA 2002, KOKETSU and SASAKI 2009, MILEWSKA 2007, MILEWSKA 2008, ROBINSON and BUHR 2005), the high fattening performance and slaughter value (in particular high meatiness) of boars are negatively correlated with semen quality. Semen traits are also determined by breed, and in crossbreeds – by crossbreeding variant, as well as by the boar's age and the season during which ejaculates are obtained (CIERESZKO et al. 2000, KOĆWIN-PODSIADŁA et al. 1990, MILEWSKA 2008). The breeding suitability of boars is also evaluated based on the weight and size of the testes and enzyme activity levels (GĄCZARZEWICZ et al. 2000, GLOGOWSKI et al. 1997, KAPELAŃSKI 1995, RATHJE et al. 1995). In addition to age, body weight is a key determinant of growth and development in pigs. Breeding farms perform general in vivo evaluations of animals, but the body weights of AI boars are rarely monitored. Recent publications offer scant information about the body weights of purebred and crossbred pigs (SULABO et al.).

The objective of this study was to determine the body weights, selected blood parameters and semen quality of Polish Landrace artificial insemination boars from different age groups.

Materials and Methods

The experiment was performed in two Artificial Insemination Stations – AIS_1 and AIS_2. It involved 32 Polish Landrace (PL) boars, 16 from each station. The animals were divided into two subgroups: group I of 16 young boars (aged up to 2 years and weighing less than 300 kg) and group II of 16 mature boars (older than 2 years and weighing more than 300 kg). The animals' performance traits, ejaculate traits, blood morphology and biochemistry profiles were determined. The evaluated performance traits were: age, body weight, lifetime daily gains, standardized daily gains at 180 days, meat content, selection index and number of teats. The evaluation was performed during the rearing period in pig farms. Semen traits were analyzed in 3108 ejaculates based on ejaculate volume, sperm concentrations, number and percentage of live spermatozoa and number of insemination doses per ejaculate. Influence of the season of the year on semen quality was also studied. Blood for morphology and biochemistry tests was sampled from the vena cava cranialis. The following morphological blood parameters were determined: white blood cell counts (Leu), red blood cell counts (Ery), mean corpuscular volume (MCV), hematocrit values (Ht), hemoglobin concentrations (Hb) and thrombocytes (Tro). The serum biochemistry profile involved the determination of total protein, glucose and urea concentrations, as well as the activity levels of the following enzymes: alkaline phosphatase (ALP), alanine aminotransferase (ALT) and aspartate aminotransferase (ASP). Blood tests were performed with the use of the end-point assay in the Veterinary Diagnostics Laboratory in Gietrzwałd.

The results were processed by one-way ANOVA for orthogonal designs, and the significance of differences between groups was verified by Tukey's test. Statistical calculations were performed in the Statistica 10.0 application.

Results and Discussion

The performance traits of boars are presented in Table 1. On the day of the test, the age of boars was determined at 279 to 667 days in group I and 820 to 1571 days in group II. The average age was 414 and 1167 days in groups I and II, respectively, and the difference was statistically significant ($P \leq 0.01$). Significant differences in average body weight were also noted between groups ($P \leq 0.01$). In group I, the average body weight was 237 kg (in the range of 190 to 299 kg), and in group II – 344 kg (310–379 kg). As a result, significant differences between groups were also reported in lifetime daily gains that reached 598 g in group I and 304 g in group II ($P \leq 0.01$).

Table 1

Performance traits of boars

Traits	Statistics	Groups	
		I	II
Standardized daily gains [g]	$\bar{x} \pm s$	845 ± 47	830 ± 49
Meat content [%]	$\bar{x} \pm s$	$61.7^{a} \pm 0.7$	$60.9^{b} \pm 1.1$
Selection index [points]	$\bar{x} \pm s$	144 ± 7	138 ± 8
Number of teats	$\bar{x} \pm s$	15.2 ± 0.7	15.2 ± 1.1
Age [days]	$\bar{x} \pm s$ min-max	$414^{B} \pm 130$ 279–667	$1167^{A} \pm 233$ 820–1571
Body weight [kg]	$\bar{x} \pm s$ min-max	$237^{B} \pm 36$ 190–299	$344^{A} \pm 23$ 310–379
Lifetime daily gains [g]	$\bar{x} \pm s$	$598^{A} \pm 84$	$304^{B} \pm 49$

^{A,B} – differences significant at $P \leq 0.01$
^{a,b} – differences significant at $P \leq 0.05$

The age and body weights of AI boars before maturity have been scantly researched. In a study by KAPELAŃSKI (1995), the average weight of 24-month-old PL boars was 275 kg. In a feeding trial involving F1 crossbreeds (♀ PL x ♂ PLW) aged 4 months to 2 years, average daily gains were estimated at 411–425 g. The average body weights were determined at 208 kg for one-year-old boars and 295 kg for two-year-old animals (FALKOWSKI et al. 1997). In a US study of 214 crossbred boars from various age groups, average daily gains reached 363 g in younger animals (aged 220–620 days) and 227 g in older boars (aged 620–1000 days) (SULABO et al. 2006).

In the present experiment, boars were characterized by a high breeding value, as demonstrated by the selection index that reached 138 to 144 points (Table 1). The above trait is highly correlated with daily weight gains that ranged from 830 to 845 g. Both groups of animals were characterized by a high meat content in excess of 60%. Meatiness values were significantly higher in young boars ($P \leq 0.05$) than in older animals. In this experiment, standardized daily gains and meat content were significantly higher than those reported by BLICHARSKI et al. (2014) in a study of young PL boars, which indicates that the evaluated animals were characterized by a high breeding value. KONDRACKI et al. (2002), who analyzed AI boars characterized by high fattening performance and slaughter value, demonstrated that the highest-quality semen was obtained from boars with average values of the performance index in the range of 121 to 140 points.

The number of teats is an important consideration in pig breeding, and it is one of the key criteria in the selection for reproductive performance. In our study, the average number of teats was 15.18 (Table 1). The results reported by

GRUDNIEWSKA et al. (1999) indicate that the number of teats in the evaluated breed has remained high for many years.

In the work of MILEWSKA (2008), PL boars produced ejaculates of higher quality than PLW animals, which partially explains the leading role of the PL breed in artificial insemination. The high quality of ejaculates obtained from PL boars was validated by the results of this study. The ejaculates of group II boars were characterized by a highly significantly higher volume in comparison with group I boars (Table 2). As a result, the number of insemination doses per ejaculate was also higher in group II ($P \leq 0.01$). A total of 26.97 and 28.07 insemination doses per ejaculate were reported in young and older boars, respectively, and similar results were noted by WYSOKIŃSKA and KONDRACKI (2002), and BRUCKA-JASTRZĘBSKA et al. (2008). The number of insemination doses per ejaculate significantly determines the economic efficiency of boar semen production. Ejaculates containing more insemination doses can be used to inseminate more sows, which increases the breeding efficiency of the boar.

Table 2

Ejaculate traits ($\bar{x} \pm s$)

Traits	Groups	
	I	II
Volume [ml]	$288^{B} \pm 82$	$318^{A} \pm 94$
Sperm concentration [ths/mm^3]	$380^{A} \pm 131$	$358^{B} \pm 145$
Percentage of live spermatozoa	$72.5^{A} \pm 4.3$	$71.3^{B} \pm 3.4$
Number of spermatozoa in ejaculate [mld]	77.4 ± 27.6	78.7 ± 31.1
Number of insemination doses	$26.9^{B} \pm 8.8$	$28.1^{A} \pm 9.0$

^{A,B} – differences significant at $P \leq 0.01$

According to PATTERSON et al. (2002), POPWELL and FLOWERS (2002), KOZDROWSKI and DUBIEL (2004), the individual traits of boars can also affect semen quality. The traits of ejaculates obtained from five boars with the longest insemination history are presented in Table 3. Each of those boars produced ejaculates with the most desirable characteristics for artificial insemination. The volume of ejaculates obtained from three boars reached 620–650 ml. Similarly to ejaculate volume, significant fluctuations were noted in sperm concentrations (10,000–1 million/ mm^3), and the highest sperm concentrations were determined in the ejaculates of F2 (911,000–985,000/mm^3), G2 (781,000–799,000/mm^3) and A4 (732,000/mm^3) boars. The highest number of spermatozoa was reported in ejaculates from boar G2 (204–275 billion), whereas the highest number of insemination doses was obtained from the ejaculates of A4 (62 doses) and G2 (60 doses) boars. The analyzed animals included brothers, boars G2 and G3, but the ejaculates

obtained from G2 were characterized by a significantly higher number of spermatozoa and yielded more than 33 insemination doses per ejaculate on average. The above results indicate that G2 was individually predisposed to produce high-quality semen. In a Japanese study of 108 pig herds, boars were used for insemination purposes for 781 to 984 days on average, but the best performers were used until 1200 days of age (KOKETSU and SASAKI 2009). In a study by SZOSTAK and PRZYKAZA (2011), boars older than 36 months were characterized by a significantly shorter time between phantom mounting and the beginning of ejaculation than younger males. Sperm quality traits should be regularly monitored – MAZEIKA et al. (2012) reported high coefficients of correlation between pathological changes in the testes and semen quality in boars culled at 34.9 ± 10.7 months of age.

Table 3

Ejaculate traits of oldest boars

Boars	Statistics	Volume [ml]	Sperm concentration [ths/mm^3]	Number of spermatozoa in ejaculate [mld]	Number of insemination doses
A4	$\bar{x}$+s min-max	$332^{BC} \pm 82$ 110–620	$349.1^{BDE} \pm 116.8$ 102–732	$79.2^{BC} \pm 31.4$ 9.4–183	$28.1^{BCE} \pm 8.9$ 8–62
F2	$\bar{x}$+s min-max	$288^{BD} \pm 73$ 90–650	$401.0^{BC} \pm 129.2$ 124–985	$76.5^{BC} \pm 21.8$ 11.3–153.4	$26.8^{BCF} \pm 6.7$ 12–45
G2	$\bar{x}$+s min-max	$362^{A} \pm 81$ 150–570	$408.0^{BC} \pm 122.0$ 111–799	$102.4^{A} \pm 37.3$ 12.7–275.6	$33.6^{A} \pm 8.3$ 10–60
G3	$\bar{x}$+s min-max	$359^{A} \pm 92$ 130–650	$252.1^{BDF} \pm 106.2$ 80–608	$60.1^{BD} \pm 23.6$ 19.5–145.8	$22.2^{BD} \pm 7.5$ 10–49
M1	$\bar{x}$+s min-max	$226^{BD} \pm 64$ 100–420	$449.0^{A} \pm 63.0$ 280–590	$79.59^{BC} \pm 25.9$ 27.3–161.3	$29.9^{BCE} \pm 9.3$ 10–61

^{A,B} – differences significant at $P \leq 0.01$

Significant differences were also noted between the traits of ejaculates obtained in successive seasons of the study, which corroborates the findings of other authors (CIERESZKO et al. 2000, KOZDROWSKI and DUBIEL 2004, MILEWSKA and FALKOWSKI 2004). Higher-quality ejaculates were obtained in the fall and winter, and they were characterized by the highest number of insemination doses (28–30 on average) per ejaculate ($P \leq 0.01$) – Table 4. FLOWERS (2008) observed that boars can also be selected for heat tolerance, but according to HUANG et al. (2010), this trait is reduced with age.

Blood morphological parameters were similar in both groups (Table 5). Biochemical tests revealed highly significant differences in total protein levels, glucose concentrations and ALP activity between the groups. Group I boars were characterized by lower protein levels, higher glucose concentrations and

higher ALP activity. In both groups, total protein levels and ALT activity were somewhat above the reference ranges (WINNICKA 2011). Lower serum glucose levels in group II boars could be attributed to higher ejaculate volume.

Table 4

Ejaculate traits in consecutive seasons ($\bar{x} \pm s$)

Season	Volume [ml]	Sperm concentration [ths/mm^3]	Number of spermatozoa in ejaculate [mld]	Number of insemination doses
Spring	$306^B \pm 76$	355 ± 147	$72.88^B \pm 27.03$	$26.4^B \pm 7.7$
Summer	$312^B \pm 81$	355 ± 123	$72.74^B \pm 28.23$	$25.9^B \pm 8.5$
Fall	$344^A \pm 100$	360 ± 128	$85.76^A \pm 39.00$	$28.6^A \pm 9.5$
Winter	$349^A \pm 85$	367 ± 123	$87.71^A \pm 31.74$	$30.6^A \pm 9.1$

^{A,B} – differences significant at $P \leq 0.01$

Table 5

Hematological and biochemical blood parameters of boars ($\bar{x} \pm s$)

Specification	Reference ranges [acc. to 29]	Groups	
		I	II
Leu [m/mm^3]	10–20	18.7 ± 3.2	17.1 ± 3.1
Ery [M/mm^3]	5–8	6.7 ± 0.6	6.7 ± 0.7
MCV [FL]	50–68	63.7 ± 2.6	65.9 ± 5.3
Ht [%]	23–50	42.9 ± 3.7	43.9 ± 3.2
Hb [g/dl]	10–16	14.6 ± 1.1	14.7 ± 1.1
Tro [m/mm^3]	120–450	272.7 ± 87.6	197.7 ± 25.5
Total protein[g/dl]	5.9–7.4	$7.5^B \pm 5.5$	$7.9^A \pm 4.7$
Glucose[mg/dl]	45–100	$85.7^A \pm 0.4$	$75.2^B \pm 0.3$
Urea [mg/dl]	20–40	32.1 ± 9.5	33.6 ± 5.6
ALT [U/l]	9–43	66.2 ± 17.9	58.6 ± 2.5
ASP [U/l]	16–65	33.2 ± 7.7	45.4 ± 34.4
ALP [U/l]	92–294	$111.8^A \pm 34.5$	$71.8^B \pm 45.3$

$^{A, B}$ – differences significant at $P \leq 0.01$

In the current study, the average age of younger boars was 414 days, and their average body weight was 237 kg. The average age of older boars was 1167 days, and their average body weight was 344 kg. The heaviest animal weighed 379 kg. Blood morphological parameters were within the reference ranges. Biochemistry tests revealed that serum protein concentrations and ALT activity were somewhat above the reference values. Both age and age-related body weight positively influenced the total number of spermatozoa in the ejaculate and the number of insemination doses that could be obtained from a boar. The analyzed group of AI boars included five mature boars, aged 1309 to 1571 days and weighing 352–375 kg, that produced high-quality ejaculates.

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References

Blicharski T., Ptak J., Snopkiewicz M. 2014. *Wyniki oceny trzody chlewnej w 2013 roku*. POLSUS, Warszawa.

Brucka-Jastrzębska E., Białek M., Brzezińska M., Krawczuk D., Drewnowski W., Lisiecki L. 2008. *Parametry ejakulatu w zależności od rasy świń*. Medycyna Wet. 64, 10: 1248–1251.

Ciereszko A., Ottobre J.S., Glogowski J. 2000. *Effects of season and breed on sperm acrosin activity and semen quality of boars*. Anim. Reprod. Sci., 64: 89–96.

Falkowski J., Glogowski J., Rotkiewicz T., Kozłowski M., Kozera W., Bugnacka D., Bomba G. 1997. *Wpływ długotrwałego podawania mieszanek z udziałem poekstrakcyjnej śruty lub nasion rzepaku na wzrost knurów i jakość ich ejakulatów*. Acta Acad. Agricult. Tech. Olst. Zootechnica, 46: 43–51.

Flowers W.L. 2008. *Genetic and phenotypic variation in reproductive traits of AI boars*. Theriogenology., 70: 1297–1303.

Gączarzewicz D., Udała J., Lasota B., Błaszczyk B. 2000. *Kształtowanie się wybranych wskaźników oceny jakościowej i biochemicznej nasienia knurów eksploatowanych w zakładzie unasieniania zwierząt*. Zesz. Nauk. Prz. Hod., 48: 93–101.

Glogowski J., Falkowski J., Rotkiewicz T. 1997. *Aktywność fosfataz w plazmie nasienia knurów w cyklu rocznym i ich związek z podstawowymi wyznacznikami jakościowymi ejakulatów*. Rocz. Nauk Zoot., 24(3): 85–95.

Grudniewska B., Milewska W., Eljasiak J., Lewczuk A. 1999. *Performance traits of the Polish Landrace boars born and used on the territory of the OSHZ in Olsztyn from 1986-1995*. Natur. Sc., 2: 47–61.

Huang Y.H., Lo L.L., Liu S.H., Yang T.S. 2010. *Age-related changes in semen quality characterics and expectations of reproductive longevity in Duroc boars*. Animal Science Journal, 81: 432–437.

Kapelański W. 1995. *Wielkość i sprężystość jąder knurków ras polskiej białej zwisłouchej i duroc oraz ich mieszańców jako wczesny wskaźnik przydatności do rozpłodu*. ATR Bydgoszcz, Rozprawy, 67.

Kawęcka M. 2002. *Zależności między tempem wzrostu i mięsnością młodych knurów populacji ojcowskich a ich przydatnością do rozrodu*. Rozpr., 206, AR Szczecin.

Koćwin-Podsiadła M., Polańska E., Dziadek K. 1990. *Właściwości podstawowych i biochemicznych cech nasienia knurków ras wbp, duroc i mieszańców wielorasowych*. Zesz. Probl. Post. Nauk Roln., 384: 63–69.

Koketsu Y., Sasaki Y. 2009. *Boar culling and mortality in commercial swine breeding herds*. Theriogenology, 71: 1186–1191.

Kondracki S., Wysokińska A., Banaszewska D., Biercuk M. 2002. *Quality of ejaculates of Polish Large White and Polish Landrace boars in relation to their performance index*. Ann. Anim. Sci., Suppl., 2: 137–142.

Kozdrowski R., Dubiel A. 2004. *Właściwości nasienia mieszańców dzika ze świnią domową w cyklu rocznym*. Medycyna Wet., 60(1): 57–61.

Mazeika K., Sutkeviciene N., Zilinskas H., Riskeviciene V., Aniuliene A., Juodziukyniene N. 2012. *Relationship between sperm quality and testicular lesions in culled AI boars*. Veterinarija Ir Zootechnika, 59(81): 52–57.

Merks J.W.M. 2000. *One century of genetic changes in pigs and the future needs*. Occ. Publ. British Society. Anim. Prod., 27: 8–19.

Milewska W., Falkowski J. 2004. *Effect of season on selected semen traits in purebred and crossbred boars*. Animal Science Papers and Reports, 22, suppl., 3: 289–295.

Milewska W. 2007. *Ocena przyżyciowa knurów rasy hampshire i pietrain oraz mieszańców dwurasowych a efekty użytkowania rozpłodowego w stacjach unasienniania loch*. Medycyna Wet., 63(6): 708–711.

Milewska W. 2008. *Przydatność do rozpłodu knurów ras – wielka biała polska i polska zwisłoucha oraz loch rasy wielka biała polska, selekcjonowanych w kierunku zwiększenia mięsności*. Rozpr. i Monogr. 137, UWM Olsztyn.

Mucha A., Tyra M. 2013. *Inseminacja trzody chlewnej*. Stan hodowli i wyniki oceny świń w roku 2012. Inst. Zoot. Kraków.

Patterson J.L., Wllis H.J., Kirkwood R.N., Foxcroft G.R. 2002. *Impact of boar exposure on puberty attainment and breeding outcomes in gilts*. Theriogenology, 57: 2015–2025.

POPWELL J.M., FLOWERS W.L. 2004.*Variability in relationships between semen quality and estimates of in vivo and in vitro fertility in boars*. Animal Reproduction Science, 81: 97–113.

RATHJE T.A., JOHNSON R.K., LUNSTRA D.D. 1995. *Sperm production in boars after nine generations of selection for increased weight of testis*. J. Anim. Sci., 73: 2177–2185.

ROBINSON J.A.B., BUHR M.M. 2005. *Impact of genetic selection on management of boar replacement*. Theriogenology, 63: 668–678.

SULABO R.C., QUACKENBUSH J., GOODBAND R.D., TOKACH M.D., DRITZ S.S., DEROUCHEJ J. M., NELSSEN J.L. 2006. *Predicting growth rates of adult working boars in a commercial boar stud*. Kansas State Swine Day, pp. 13–18.

SZOSTAK B., PRZYKAZA Ł. 2011. *The influence of breed, age of boars and exploitation season on their libido in conditions of the insemination station*. J. Cent. Eur. Agr., 12(1): 124–134.

WINNICKA A. 2011. *Wartości referencyjne podstawowych badań laboratoryjnych w weterynarii*. Wyd. SGGW Warszawa.

WYSOKIŃSKA A., KONDRACKI S. 2013. *Assessment of the effect of heterosis on semen parameters of two-breed crosses of Duroc, Hampshire and Pietrain boars*. Archiv Tierzucht., 56(7): 65–74.

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THE METHOD OF CLASSIFICATION OF CONSUMER ATTITUDE ACCESSIBILITY IN RELATION TO INHERENT PRODUCT FEATURES

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K e y w o r d s: inherent product feature, inherent perceived product quality, attitude accessibility, class of attitude accessibility.

A b s t r a c t

This article is to present a method of classification of consumer attitude accessibility in relation to inherent perceived product features. The method has been adapted to a multidimensional, indirect way of measuring this variable. The underlying principle of this classification is statistical deduction about the quantity of sums of inversions in ordering decisions made by consumers on a sample of products with respect to a given product feature and perceived product quality. The proposed method classifies attitude accessibility into: very high, high, medium, low and very low. The method has been applied to the classification of consumer attitude accessibility of consumers with low cognitive involvement into four products: orange juice, a package of toothpaste, packaged hard toilet soap and apple juice. Various classes of attitude accessibility have been found in relation to particular inherent features of these products, however attitude accessibility tended to be always very high when it came to product packaging.

METODA KLASYFIKACJI DOSTĘPNOŚCI POSTAW KONSUMENTÓW WOBEC INHERENTNYCH WŁAŚCIWOŚCI PRODUKTÓW

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S ł o w a k l u c z o w e: inherentna właściwość, jakość postrzegana, dostępność postawy, klasa dostępności postawy.

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Abstrakt

Opracowano metodę klasyfikacji dostępności postaw konsumentów wobec inherentnych właściwości postrzeganych produktów dostosowaną do wielowymiarowej, pośredniej metody pomiaru tej wielkości. Zasadą klasyfikacji jest tu wnioskowanie statystyczne na temat liczebności sum inwersji uporządkowań dokonywanych przez konsumentów na zbiorze produktów odpowiednio ze względu na daną właściwość i jakość postrzeganą. Opracowana metoda umożliwia klasyfikację dostępności postaw na: bardzo wysoką, wysoką, umiarkowaną, niską i bardzo niską. Metodę tę wykorzystano do klasyfikacji dostępności postaw konsumentów z małym zaangażowaniem poznawczym wobec czterech produktów, tj. soku pomarańczowego, opakowania pasty do zębów, opakowanego, twardego mydła toaletowego oraz soku jabłkowego. Wobec poszczególnych inherentnych właściwości tych produktów stwierdzono różne klasy dostępności postaw, przy czym wobec opakowań produktów – zawsze bardzo wysoką.

Introduction

While designing the quality of their product range, companies operating on the B2C market face a few issues that need to be addressed, usually falling into the following categories:

– the dimensional characteristics of a product determined by the set of its inherent features, especially the features perceived by consumers in a given market segment;

– the weight of its inherent features;

– the model of complex product quality.

It may be assumed that the product to be developed is likely to attract little cognitive involvement of its potential users, what is more, the price itself will bear minimum impact on the buying decisions. As a result, it may be reasoned that the consumer judgement concerning the perceived product quality will become a decisive factor when making a purchase decision. Let us also assume that based on the conducted consumer interviews and the analysed findings inherent product features perceived by an „average consumer" of a selected market segment have been established and that the weight of these features as declared by consumers is known too. Thus, formal assumptions for the construction of a complex product quality model are available. This model is usually developed in an arbitrary fashion as a polynomial of degree 1.

It seems, however, that a declarative model of complex product quality, especially the perceived quality established this way, can only ostensibly indicate the way consumers evaluate product quality. The formulation of consumer judgement will also be conditioned by the ease of consumer evaluation of particular inherent product features, by the degree to which consumers' evaluative judgements (CZAPIŃSKI 1988) of the perceived features have been rooted in their experience and by the fact of how much the assessment of a given feature is tied to its perception.

According to the concept of human cognitive schemes, objects are recognised based on such components of the scheme as constructionism, hypothesis of use, argument of stimulus scarcity, memory stereotypisation, lenient degradation of result and cognitive frugality (NAJDER 1997). Following this, whenever a person perceives an object (a consumer perceives product features) they create an internal representation of this object by integrating external and internal information – default values stored in their memory. It happens this way because the signal reaching the receptors constitutes an insufficient premise to recognise an object and assess its value, which means that the result will be determined chiefly by internal information recall. Whenever during information processing the premises received are insufficient to correctly recognise an object (scarce external signal or poorly defined default values), despite highly uncertain input information, a person will engage in a reasoning process arriving at a result which more or less deviates from reality – called a degraded result.

Moreover, information processing scheme is conditioned, among others, by the principle of cognitive frugality. Human cognitive system has to analyse multiple signals in short periods of time, so it always tends to minimise the number of operations leading to the creation of judgement, as a consequence, it minimises the time in which the result of perception can be obtained (identification and evaluation of an object). Specifically, when the cognitive involvement is low, the internal representation of a perceived object is created by way of recalling only the most deeply embedded and easy to reach bits of information.

Therefore, in the process of formulating an attitude towards product quality, whenever consumers show low cognitive involvement, their real judgement, due to the factors in the cognitive process presented above, may significantly deviate from the one defined by the declarative model of perceived quality. This may be further aggreviated by poorly defined default values corresponding to some inherent features of the perceived object. In an outline, if a consumer is unable to assess product quality based on individual assessment of inherent product features – he has low attitude accessibility towards some of the object features, then according to the principle of memory stereotypisation, lenient result degradation and cognitive frugality he will formulate judgement according to easily perceived external premises and relatively strongly embedded, stereotypical and immediately accessible internal values. It means that in such cases evaluative judgement of product quality will be formulated based on the perception of some situational factors and such product features towards which consumer attitudes tend to be fairly accessible, known as possessing chronic accessibility (BOEHNER and WAENKE 2004).

Thus, if we aim to establish a model of perceived complex product quality, the information on consumer attitude accessibility in a given market segment in relation to individual inherent features of a product at the development stage or already on offer seems indispensible, as only the features towards which consumer attitude accessibility remains high will determine their judgement of perceived complex quality. Being aware of the values or classes of attitude accessibility towards individual features making up dimensional product characteristics makes it possible to verify the initial declarative model of perceived product quality and as a result enables to define and practically employ the knowledge of how consumers really assess product quality.

The aim of this study is to present the method of classification of consumer attitude accessibility in relation to individual product features perceived in a situation of low cognitive involevement. The secondary goal is to apply the above mentioned method for the classification of consumer attitude accessibility in relation to inherent features of selected products for everyday use.

Method and Materials

Method

A multi-position method of analysing consumer attitude accessibility in relation to inherent product features determining the perceived product quality (DOROSZEWICZ 2010, DOROSZEWICZ at al. 2009, DOROSZEWICZ at al 2010, DOROSZEWICZ and KOBYLIŃSKA 2010) has been created in the Institute of Quality Management of the Warsaw School of Economics. The correlation of relations used to arrange a set of products of the same type which consumers arranged according to a given inherent feature and perceived complex quality of the product was adopted as a measure of ease of evaluation of particular product features. These are the underlying assumptions underpinning the method:

1. The object of direct measurement are consumer attitudes in relation to the set of inherent features $X_{i = 1, k; j = 1, m}$ as well as to the total quality $Q_{j = 1, m}$ („m" – various products of the same type, „i" – type of feature, „j" – type of product).

2. Measurements of attitudes towards features $X_{i = 1, k; j = 1, m}$ and quality $Q_{j = 1, m}$ are conducted on ordering ranges by way of comparison of product pairs; a consumer evaluating two products with respect to a given feature X_i or quality Q assigns the value $x_{i,j} = 1$ to the product valued higher and the value $x_{i,j+1} = 0$ to the alternative product; the task of a consumer, as a result, is to complete a matrix of such comparisons.

3. The measure of congruity of orderings of the sums $\sum_{i=2}^{m} x_{i,j}$ (with respect to feature X_i) and $\sum_{j=2}^{m} Q_j$ (with respect to perceived complex quality) are the sums $S_{i,L}$ of position inversions in the ordering with respect to feature X_i as compared to the ordering with respect to perceived quality (L – stands for the consumer) [Ferguson, Takane 2003].

4. Relative consumer attitude accessibility as to the feature X_i is determined by the degree of congruity of the orderings created based on the consumer assessment of the feature X_i and perceived quality Q. The bigger the value of the sum $S_{i,L}$ the higher is the consumer attitude accessibility „L" with respect to the feature X_i.

As a result of the measurements performed using the method in question for each of the analysed features X_i we arrive at a set of sums of inversions $S_{i,L}$ of quantity n (the quantity of the consumer sample studied). The scope R of divergence of the sums $S_{i,L}$ depends on the number of products evaluated by the consumer, e.g. if $m = 7$ products it equals $-21 \leq S_{i,L} \leq 21$. For the purpose of classification of these sums it has been assumed that their scope of divergence should be divided into four equal independent parts delineated by the mid-range M and the quarters – the lower quarter Kd = $0{,}25R$ and the upper quarter Kg = $0{,}75R$. Following this analysis, five classes of consumer attitude accessibility in relation to a given feature X_i may be identified:

1. If above the mid-range, i.e. when $S_{i,L} \geq M$ there are n_1 statistically significantly more sums $S_{i,L}$ than $0{,}5n$ and at the same time above the upper quarter, i.e. when $S_{i,L} \geq$ Kg, there are n_2 statistically significantly more sums $S_{i,L}$ than $0{,}25n$ (distribution $f(S_{i,L})$ strongly left skewed), then the consumer attitude accessibility relative to a given feature X_i is considered very high. E.g. if $m = 7$, $M = 0$, Kd = -10,5, Kg = 10,5 i $n = 40$, and in the bracket $\langle 0;21 \rangle$ there appeared n_1 statistically significantly more results than $0{,}5n = 20$ and at the same time in the bracket $\langle 10{,}5;21 \rangle$ there appeared n_2 statistically significantly more results than $0{,}25n = 10$, then the consumer attitude accessibility relative to this feature is considered very high;

2. If above M there are n_1 statistically significantly more sums $S_{i,L}$ than $0{,}5n$ and at the same time above Kg the quantity of sums $S_{i,L}$ is $n_2 \approx 0{,}25n$ (there is statistically no significant difference between n_2 and $0{,}25n$ – distribution $f(S_{i,L})$ moderately left skewed), then the consumer attitude accessibility relative to a given feature X_i is considered high. E.g. if $m = 7$, $M = 0$, Kd = -10,5, Kg = 10,5 i $n = 40$, and in the bracket $\langle 0;21 \rangle$ there appeared n1 statistically significantly more results than $0{,}5n = 20$ and at the same time in the bracket $\langle 10{,}5;21 \rangle$ there appeared results then the consumer attitude accessibility regarding this feature is considered high.

3. If above M the quantity of sums $S_{i,L}$ equals $n_1 \geq 0{,}5n$ (there is no statistically significant difference between n_1 i $0{,}5n$ – distribution $f(S_{i,L})$ is symmetrical or slightly left skewed), then the consumer attitude accessibility relative to a given feature is considered medium. E.g. if $m = 7$, $M = 0$, Kd = -10,5, Kg = 10,5 i $n = 40$, and in the bracket $\langle 0;21 \rangle$ there appeared $n_1 = 21$ results, then the consumer attitude accessibility relating to this feature is considered medium.

4. If below M the quantity of sums $S_{i,L}$ equals $n_3 > 0{,}5n$ (but there is no statistically significant difference between n_3 i $0{,}5n$ – distribution $f(S_{i,L})$ is right skewed), then the consumer attitude accessibility relative to a given feature is considered **low.** E.g. if $m = 7$, $M = 0$, Kd = -10,5, Kg = 10,5 i $n = 40$, and in the bracket $\langle -21;0 \rangle$ there appeared $n_3 > 20$ results, then the consumer attitude accessibility relating to this feature is considered low.

5. If below M there are n_3 statistically significantly more sums $S_{i,L}$ than $0{,}5n$ (distribution $f(S_{i,L})$ strongly right skewed), then the consumer attitude accessibility relative to a given feature is considered very low. E.g. if $m = 7$, $M = 0$, Kd = -10,5, Kg = 10,5 i $n = 40$, and in the bracket $\langle -21;0 \rangle$ there appeared $n_3 >> 20$ results, then the consumer attitude accessibility relating to this feature is considered very low.

Statistical significance of divergence between quantities of sums $S_{i,L}$ remaining in the brackets $\mathrm{Kg} \leq S_{i,L} \leq \mathrm{MAX}$, $\mathrm{Me} \leq S_{i,L} \leq \mathrm{MAX}$ oraz $\mathrm{MIN} \leq S_{i,L} < \mathrm{Me}$ accordingly, and the criteria $0{,}5n$ lub/i $0{,}25n$ accordingly is unilaterally verified with the test χ^2 at the level $\alpha = 0.05$.

The following pairs of hypothesis are subsequently subject to verification:

$$H_0: n_{1(S_{i,L} \geq M)} = 0{,}5n$$

$$H_1: n_{1(S_{i,L} \geq M)} = 0{,}5n$$

$$H_0: n_{2(S_{i,L} \geq \mathrm{Kg})} = 0{,}25n$$

$$H_1: n_{2(S_{i,L} \geq \mathrm{Kg})} = 0{,}25n$$

$$H_0: n_{3(S_{i,L} < M)} = 0{,}5n$$

$$H_1: n_{3(S_{i,L} < M)} = 0{,}5n$$

Rejection of H_0: $n_{1(S_{i,L} \geq M)} = 0{,}5n$ and acceptance of H_1: $n_{1(S_{i,L} \geq M)} = 0{,}5n$ as well as simultaneous rejection of H_0: $n_{2(S_{i,L} \geq \mathrm{Kg})} = 0{,}25n$ and acceptance of H_1: $n_{2(S_{i,L} \geq M)} = 0{,}25n$ means that the consumer attitude accessibility relating to a given feature X_i is considered very high. Lack of grounds for the rejection of

H_0: $n_{2(S_{i,L} \geq \mathrm{Kg})} = 0{,}25n$ and simultaneous rejection of H_0: $n_{(S_{i,L} \geq M)} = 0{,}5n$ as well as acceptance of and acceptance of H_1: $n_{1(S_{i,L} \geq M)} = 0{,}5n$ means that the consumer attitude accessibility is considered high. Rejection of H_0: $n_{3(S_{i,L} < M)} = 0{,}5n$ and acceptance of H_1: $n_{3(S_{i,L} < M)} = 0{,}5n$ means that the consumer attitude accessibility is considered very low.

Materials

The above explained method of measuring consumer attitude accessibility with respect to inherent perceived product features and the presented principles of classification of this variable have been applied subsequently in the study of the following four objects:

a) orange juice packaged in Tetra-pack;
b) a package of toothpaste;
c) packaged hard toilet soap;
d) a sample of apple juice in an open container made of transparent glass.

In the case of orange juice the object of the study were consumer attitudes towards $k = 5$ following inherent features and perceived quality of the product:

– smell – X_1;
– appearance – X_2;
– colour – X_3;
– packaging – X_4;
– taste – X_5.

The object of the study were $m = 6$ different products of the same type. The quantity of the consumer sample tested was $n = 40$, but due to the results of a preliminary analysis of facade coherence of the obtained orderings the sample quantity was reduced to $n = 33$ persons.

In the case of a package of tooth paste the subject matter of the study were consumer attitudes towards $k = 7$ following inherent features and perceived quality of the object:

– ecological function – X_1;
– information function achieved through inscriptions – X_2;
– information function achieved through symbols – X_3;
– protective function – X_4;
– aesthetic function – X_5;
– logistic function – X_6;
– manipulative function – X_7.

The object of analysis were $m = 7$ different packages of toothpaste (tubes). The quantity of the consumer sample tested was $n = 16$.

In the case of hard toilet soap perceived in a shopping situation the object of the study were consumer attitudes towards $k = 5$ following inherent features and perceived quality of the product:

– colour – X_1;
– individual packaging – X_2;
– smell – X_3;
– shape – X_4;
– appearance – X_5.

The object of the study were 7 hard toilet soaps in individual packaging. The quantity of the tested consumer sample was $n = 17$.

In the case of a sample of apple juice the object of the study were consumer attitudes towards $k = 3$ following inherent features of the object appearance:

– consistency – X_1;
– colour – X_2;
– transparency – X_3.

The object of the study were 7 samples of orange juice prepared in such a way that they differed in appearance. The quantity of the tested consumer sample was $m = 36$.

Results and Discussion

Classification of consumer attitude accessibility relating to inherent features of selected product samples.

In the case of orange juice the divergence scope R of the sums of inversions $S_{i = 1,5,\ L = 1,33}$ of orderings equals $15 \leq S_{i,L} \leq 15$, $M = 0$, Kd = -7,5, Kg = 7,5. In Table 1, for particular features $X_{i = 1,5}$ the obtained quantities were presented $n_{2(S_{i,L} \geq \mathrm{Kg})}$ of the sums $S_{i,L}$ in the brackets $7{,}5 \leq S_{i,L} \leq 15$, the quantities $n_{1(S_{i,L} \geq \mathrm{M})}$ of the sums in the bracket $0 \leq S_{i,L} \leq 15$ and the quantities $n_{3(S_{i,L} \geq \mathrm{M})}$ of the sums in the bracket $-15 \leq S_{i,L} < 0$.

Table 1

Orange juice. The quantities of sums $S_{i,L}$ in the change brackets $7{,}5 \leq S_{i,L} \leq 15$, $0 \leq S_{i,L} \leq 15$ and $-15 \leq S_{i,L} < 0$ accordingly

Features X_i	$n_{2(S_{i,L} \geq \mathrm{Kg})}$ in the bracket $7{,}5 \leq S_{i,L} \leq 15$	$n_{1(S_{i,L} \geq \mathrm{M})}$ in the bracket $0 \leq S_{i,L} \leq 15$	$n_{3(S_{i,L} < \mathrm{M})}$ in the bracket $-15 \leq S_{i,L} < 0$
Smell – X_1	2	14	19
Appearance – X_2	7	24	9
Colour – X_3	8	27	6
Packaging – X_4	14	29	4
Taste – X_5	11	30	3

In the case of the tested sample $n=33$ the criterial quantities are $0{,}25n = 8{,}25 \approx 8$ and $0{,}5n = 16{,}5 \approx 16$ accordingly. In Table 2 for particular features $X_i = 1{,}5$ the results of hypothesis testing were presented concerning the significance of quantity divergences, obtained and criterial, for the sums $S_{i,L}$ and the corresponding categories of attitude accessibility. The critical value of the test χ^2 for one degree of freedom ($v = 1$) and level of significance $\alpha = 0{,}05$ – $\chi^2_{(\alpha = 0{,}05,\ v = 1)} = 3{,}84$.

Table 2

Orange juice – sums $S_{i,L}$. The results of hypothesis testing concerning the significance of quantity divergences, obtained and criterial, and the class of attitude accessibility relating to the feature $X_{i = 1{,}5}$

Feature – X_i	H_0: $n_{2(S_{i,L} \geq \mathrm{Kg})} = 8$		H_0: $n_{1(S_{i,L} \geq \mathrm{M})} = 16$		H_0: $n_{3(S_{i,L} \geq \mathrm{M})} = 16$		Class of attitude accessibility
	$\chi^2_{\mathrm{obl.}}$	p	$\chi^2_{\mathrm{obl.}}$	p	$\chi^2_{\mathrm{obl.}}$	p	
Smell – X_1	$n_2 < 8$	–	$n_1 < 16$	–	0,5625	0,547	low
Appearance – X_2	$n_2 \approx 8$	–	4	0,0455	$n_1 < 16$	–	high
Colour – X_3	0	1	7,56	0,006	$n_1 < 16$	–	high
Packaging – X_4	4,5	0,034	10,56	0,0012	$n_1 < 16$	–	very high
Taste – X_5	1,125	0,289	12,25	0,00046	$n_1 < 16$	–	high

χ^2_{obl} means the calculated value of statistics χ^2, and p – probability of the test error.

In the case of a package of tooth paste the divergence scope R of the sums of inversions $S_{i = 1{,}7,\ L = 1{,}16}$ of orderings equals $-21 \leq S_{i,L} \leq 21$, $M = 0$, the Kd = -10,5, Kg = 10,5. In Table 3, for particular features $X_{i = 1{,}7}$ the obtained quantities were presented $n_{2(S_{i,L} \geq \mathrm{Kg})}$ of the sums $S_{i,L}$ in the brackets $10{,}5 \leq S_{i,L} \leq 21$, the quantities $n_{1(S_{i,L} \geq \mathrm{M})}$ of the sums in the bracket $0 \leq S_{i,L} \leq 21$ and the quantities $n_{3(S_{i,L} \geq \mathrm{M})}$ of the sums in the bracket $-21 \leq S_{i,L} < 0$.

Table 3

A package of toothpaste. The quantities of sums $S_{i,L}$ in the change brackets $10{,}5 \leq S_{i,L} \leq 21$, $0 \leq S_{i,L} \leq 21$ and $-21 \leq S_{i,L} < 0$ accordingly

Features X_i	$n_{(S_{i,L} \geq \mathrm{Kg})}$ in the bracket $10{,}5 \leq S_{i,L} \leq 21$	$n_{(S_{i,L} \geq \mathrm{M})}$ in the bracket $0 \leq S_{i,L} \leq 21$	$n_{3(S_{i,L} < \mathrm{M})}$ in the bracket $-21 \leq S_{i,L} < 0$
Ecological function – X_1	1	11	5
Information function (inscriptions) – X_2	1	12	4
Information function (symbols) – X_3	6	13	3
Protective function – X_4	2	12	4
Aesthetic function – X_5	8	15	1
Logistic function – X_6	3	14	2
Manipulative function – X_7	10	15	1

In the case of the tested sample $n = 16$ the criterial quantities are $0{,}25n = 4$ and $0{,}5n = 8$ accordingly. In Table 4 for particular features $X_{i\,=\,1,7}$ the results of hypothesis testing were presented concerning the significance of quantity divergences, obtained and criterial, for the sums $S_{i,L}$ and the corresponding categories of attitude accessibility. The critical value of the test χ^2 for one degree of freedom ($\nu = 1$) and level of significance $\alpha = 0{,}05$ – $\chi^2_{(\nu\,=\,0{,}05,\ \nu\,=\,1)} = 3{,}84$.

Table 4

A package of toothpaste – sums $S_{i,L}$. The results of hypothesis testing concerning the significance of quantity divergences, obtained and criterial, and the class of attitude accessibility relating to the feature $X_{i\,=\,1,7}$

Feature – X_i	H_0: $n_{2(S_{i,L}\,\geq\,\mathrm{Kg})} = 8$		H_0: $n_{1(S_{i,L}\,\geq\,\mathrm{M})} = 16$		H_0: $n_{3(S_{i,L}\,\geq\,\mathrm{M})} = 16$		Class of attitude accessibility
	$\chi^2_{\mathrm{obl.}}$	p	$\chi^2_{\mathrm{obl.}}$	p	$\chi^2_{\mathrm{obl.}}$	p	
Ecological function – X_1	$n_2 < 4$	–	1.125	0,289	$n_1 < 8$	–	medium
Information function (inscriptions) – X_2	$n_2 < 4$	–	2,000	0,157	$n_1 < 8$	–	medium
Information function (symbols) – X_3	1	0,317	3,125	0,077	$n_1 < 8$	–	medium
Protective function – X_4	$n_2 < 4$	–	2,000	0,157	$n_1 < 8$	–	medium
Aesthetic function – X_5	4	0,045	6,125	0,013	$n_1 < 8$	–	very high
Logistic function – X_6	$n_2 < 4$	–	4,500	0,034	$n_1 < 8$	–	medium
Manipulative function – X_7	9	0,003	6,125	0,013	$n_1 < 8$	–	very high

In the case of hard toilet soap perceived in a shopping situation the scope of divergence R of the sums $S_{i,L}$ as well as the positions of M, Kd, Kg – the same as in the case of toothpaste. In Table 5 for particular features $X_{i\,=\,1,5}$ the obtained quantities $n_{2(S_{i,L}\,\geq\,\mathrm{Kg})}$ of the sums $S_{i,L}$ were presented in the bracket $10{,}5 \leq S_{i,L} \leq 21$, the quantities $n_{1(S_{i,L}\,\geq\,\mathrm{M})}$ of the sums in the bracket $0 \leq S_{i,L} \leq 21$ and quantities $n_{3(S_{i,L}\,\geq\,\mathrm{M})}$ of the sums in the bracket $-21 \leq S_{i,L} < 0$ accordingly.

Table 5

Hard toilet soap. The quantities of sums $S_{i,L}$ in the change brackets $10{,}5 \leq S_{i,L} \leq 21$, $0 \leq S_{i,L} \leq 21$ and $-21 \leq S_{i,L} < 0$ accordingly

Features X_i	$n_{2(S_{i,L}\,\geq\,\mathrm{Kg})}$ in the bracket $10{,}5 \leq S_{i,L} \leq 21$	$n_{1(S_{i,L}\,\geq\,\mathrm{M})}$ in the bracket $0 \leq S_{i,L} \leq 21$	$n_{3(S_{i,L}\,<\,\mathrm{M})}$ in the bracket $-21 \leq S_{i,L} < 0$
Colour – X_1	7	12	5
Packaging – X_2	15	17	0
Smell – X_3	1	13	4
Shape – X_4	3	9	8
Appearance – X_5	3	12	5

The criterial figures here were $0{,}25n = 4{,}25 \approx 4$ and $0{,}5n = 8{,}5 \approx 8$ accordingly. In Table 6 for particular features $X_{i = 1,5}$ the results of hypothesis testing were presented concerning the significance of quantity divergences, obtained and criterial, for the sums $S_{i,L}$ and the corresponding categories of attitude accessibility. The critical value of the test χ^2 for one degree of freedom ($v = 1$) and level of significance $\alpha = 0{,}05$ – $\chi^2_{(v = 0{,}05,\ v = 1)} = 3{,}84$.

Table 6

Hard toilet soap – sums $S_{i,L}$. The results of hypothesis testing concerning the significance of quantity divergences, obtained and criterial, and the class of attitude accessibility relating to the feature $X_{i = 1,5}$

Feature – X_i	H_0: $n_{2(S_{i,L} \geq \text{Kg})} = 4$		H_0: $n_{1(S_{i,L} \geq \text{M})} = 8$		H_0: $n_{3(S_{i,L} \geq \text{M})} = 8$		Class of attitude accessibility
	$\chi^2_{\text{obl.}}$	p	$\chi^2_{\text{obl.}}$	p	$\chi^2_{\text{obl.}}$	p	
Colour – X_1	2,25	0,134	2,000	0,157	$n_2 < 8$	–	medium
Packaging – X_2	30,25	0,000	10,125	0,0015	$n_2 < 8$	–	very high
Smell – X_3	$n_2 < 4$	–	3,125	0,077	$n_2 < 8$	–	high
Shape – X_4	$n_2 < 4$	–	0,125	0,724	0	1	medium
Appearance – X_5	$n_2 < 4$	–	2,000	0,157	$n_2 < 8$	–	medium

In the case of a sample of apple juice the scope of divergence R of the sums $S_{i,L}$ as well as the positions of M, Kd, Kg – the same as in the case of toothpaste. In Table 7, for particular features $X_{i = 1,3}$ the obtained quantities $n_{2(S_{i,L} \geq \text{Kg})}$ of the sums $S_{i,L}$ were presented in the bracket $10{,}5 \leq S_{i,L} \leq 21$, the quantities $n_{1(S_{i,L} \geq \text{M})}$ of the sums in the bracket $0 \leq S_{i,L} \leq 21$ and quantities $n_{3(S_{i,L} \geq \text{M})}$ of the sums in the bracket $-21 \leq S_{i,L} < 0$.

Table 7

Apple juice. The quantities of sums $S_{i,L}$ in the change brackets $10{,}5 \leq S_{i,L} \leq 21$, $0 \leq S_{i,L} \leq 21$ and $-21 \leq S_{i,L} < 0$ -15 ($S_{i,L} < 0$ accordingly

Features X_i	$n_{2(S_{i,L} \geq \text{Kg})}$ in the bracket $10{,}5 \leq S_{i,L} \leq 21$	$n_{1(S_{i,L} \geq \text{M})}$ in the bracket $0 \leq S_{i,L} \leq 21$	$n_{3(S_{i,L} < \text{M})}$ in the bracket $-21 \leq S_{i,L} < 0$
Consistency – X_1	17	30	6
Colour – X_2	13	26	10
Transparency – X_3	6	17	19

The criterial figures here were $0{,}25n = 9$ oraz $0{,}5n = 18$ accordingly. In Table 8 for particular features $X_{i = 1,3}$ the results of hypothesis testing were presented concerning the significance of quantity divergences, obtained and criterial, for the sums $S_{i,L}$ and the corresponding categories of attitude accessibility. The critical value of the test χ^2 for one degree of freedom ($v = 1$) and level of significance $\alpha = 0.05$ – $\chi^2_{(v = 0{,}05,\ v = 1)} = 3{,}84$.

Table 8

Apple juice – sums $S_{i,L}$. The results of hypothesis testing concerning the significance of quantity divergences, obtained and criterial, and the class of attitude accessibility relating to the feature $X_{i=1,3}$

Feature – X_i	H_0: $n_{2(S_{i,L} \geq \text{Kg})} = 9$		H_0: $n_{1(S_{i,L} \geq \text{M})} = 18$		H_0: $n_{3(S_{i,L} \geq \text{M})} = 18$		Class of attitude accessibility
	$\chi^2_{\text{obl.}}$	p	$\chi^2_{\text{obl.}}$	p	$\chi^2_{\text{obl.}}$	p	
Consistency – X_1	7,11	0,008	8,000	0,005	$n_2 < 18$	–	very high
Colour – X_2	1,78	0,182	3,56	0,059	$n_2 < 18$	–	medium
Ttransparency – X_3	$n_2 < 9$	–	$n < 18$	–	0,0555	0,814	low

Conclusions

1. The presented method allows to independently classify attitude accessibility into five categories. The study results of four objects have been classified into four categories of consumer attitude accessibility in relation to particular features of product samples, i.e. very high, high, medium and low. Very low category of attitude accessibility was not found.

2. In the case of consumer attitude accessibility relating to the features of the orange juice packaged in Tetra-pack, attitude accessibility proved very high with respect to packaging, it was high relating to colour, appearance and taste and low for smell. Thus, it may be assumed that while assessing the perceived value of the object consumers predominantly do so based on the packaging.

3. In the case of consumer attitude accessibility in relation to the inherent individual features of the package of toothpaste, very high consumer attitude accessibility was found with respect to the manipulative and aesthetic function. Hence, it should be assumed that while evaluating the perceived quality of a package of toothpaste consumers do so predominantly based on how easy it is to manipulate the packaging and how aesthetic the packaging appears to be.

4. When it comes to the consumer attitude accessibility with respect to the inherent features of hard toilet soap in individual packaging very high accessibility was found in relation to packaging and high when it comes to smell. Hence, it should be assumed that in a buying situation while assessing the perceived value of hard toilet soap, consumers do so predominantly based on packaging, to a lesser degree based on the smell of the soap.

5. In the case of consumer attitude accessibility relating to the features detrmining the appearance of apple juice, very high attitude accessibility was found with respect to consistency, low with respect to the transparency of a sample of juice in a container made of transparent glass. Thus, it may be assumed that while assessing the perceived value of the appearance of apple juice, consumers predominantly do so based on consistency.

6. Whenever consumers make their decisions about products with low cognitive involvement, following the principles of lenient result degradation and cognitive frugality, they most often assess product quality based on packaging, specifically its manipulative and aesthetic function.

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References

BOEHNER G., WAENKE M. 2004. *Postawy i zmiana postaw*. Gdańskie Wydawnictwo Psychologiczne, Gdańsk, p. 104.

CZAPIŃSKI J. 2004. *O naturze i funkcji procesów wartościowania*. [In:] *Studia nad procesami wartościowania*. Red. B. Wojciszke, Ossolineum, Wrocław 1988, p. 13–35.

DOROSZEWICZ S. 2010. *Metoda badania dostępności postaw wobec jakości postrzeganej produktów*. [In:] *Zarządzanie jakością wybranych procesów (modelowanie – doskonalenie – metody – bezpieczeństwo – satysfakcja)*. Red. J Żuchowski. Wyd. Politechnika Radomska, Radom, pp. 136–144.

DOROSZEWICZ S., KOBYLIŃSKA A., MILLER P., ZBIERZCHOWSKA A. 2009. *Badania postaw konsumentów wobec jakości wyrobów i usług*. Warszawa (praca statutowa nr 04/S/0005/09, Kolegium Zarządzania i Finansów, SGH).

DOROSZEWICZ S., KOBYLIŃSKA A., MILLER P., ZBIERZCHOWSKA A. 2010. *Badania postaw konsumentów wobec jakości wyrobów i usług – etap 2*. Warszawa (praca statutowa nr 04/S/0008/10, Kolegium Zarządzania i Finansów, SGH).

DOROSZEWICZ S., KOBYLIŃSKA A. 2010. *Badania dostępności postaw konsumentów wobec inherentnych właściwości opakowania pasty do zębów*. [In:] *Wybrane problemy jakości kosmetyków i wyrobów chemii gospodarczej*. Red. M.W. Sułek, R. Zieliński. Wyd. Politechnika Radomska, Radom, pp. 15–22.

FERGUSON G.A., TAKANE Y. 2003. *Analiza statystyczna w psychologii i pedagogice*. PWN, Warszawa, pp. 434–435.

NAJDER K. *Schematy poznawcze*. 1997. [In:] *Psychologia i poznanie*. Red. M. Materska, T. Tyszka, PWN, Warszawa, p. 39.

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REVITALIZATION OF URBAN COURTYARDS IN WROCŁAW (SOUTHWESTERN POLAND)

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K e y w o r d s: revitalization, concept of development, green area, housing block, urban greenery.

A b s t r a c t

Urbanization processes in Poland usually occur at the expense of green areas. Therefore it seems important to restore biologically active areas in urban courtyards, especially in old and neglected neighborhoods. The revitalization proposal in this paper aims to create a more resident-friendly space in Wrocław. The concept of green areas and small architecture is intended to meet the needs of peoples of different ages and different needs of leisure, taking into account exercise and more passive activities, such as reading outdoors, integration of people, and other pastimes, such as the barbecue.

REWITALIZACJA MIEJSKICH WNĘTRZ PODWÓRZOWYCH NA PRZYKŁADZIE WROCŁAWIA (POLSKA POŁUDNIOWO-ZACHODNIA)

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S ł o w a k l u c z o w e: rewitalizacja, koncepcja zagospodarowania, teren zielony, kwartał zabudowy, zieleń miejska.

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Abstrakt

Procesy miejskie w Polsce zwykle przebiegają kosztem terenów zieleni. Z tego powodu ważne jest odbudowywanie terenów biologicznie czynnych wewnątrz kwartałów zabudowy, zwłaszcza w starych, zaniedbanych dzielnicach miasta. Efektem zaproponowanej koncepcji rewitalizacji we Wrocławiu ma być przestrzeń przyjaźniejsza dla mieszkańców. Dlatego nowa koncepcja terenów zieleni i projektowana mała architektura powinny odpowiadać potrzebom mieszkańców w różnym wieku i o różnych potrzebach wypoczynku. W projekcie przewidziano zarówno miejsca na rozwój kultury fizycznej, jak i bierne spędzenie czasu na świeżym powietrzu z książką, miejsca na integrację mieszkańców wśród terenów zieleni i dla miłośników grillowania.

Introduction

In Polish cities, old neighborhoods with pre-1939 buildings are often in very bad condition. Urgent repairs are required to buildings as well as in their courtyards which constitute a common space for residents (BARTOSZEWICZ 2007, WOŁOSZYN 2010). Regardless of the size, courtyards should be a site for the integration of residents, leisure and contact with other people (CARLOS and BALSAS 2007, MEILING et al. 2007, OZUS et al. 2011). The best solution for deprived courtyards seems to be greenery which can create a comforting, aesthetic and biocoenotic space (DOLAN et al. 2011, LORAM et al. 2008); part of the natural system of the city.

After the Polish accession to the European Union in 2004, Polish cities experienced an intensified urbanization of previous agricultural and environmentally active areas on the outskirts of the cities (COX et al. 2008, GASCHET 2002, MODICA et al. 2002, SWIANIEWICZ and KLIMSKA 2005). In addition, new sealed areas emerged in the city centers (i.e., parking lots near new shopping malls, streets and individual parking spaces), as a result of the improved economic conditions and a rapid increase in the number of cars (RZESZOTARSKA-PAŁKA 2012); the surface area of naturally active land decreased (PRASAD and BADARINATH 2003–2004). Therefore there is a need to restore biologically active areas with a beneficial effect to the local microclimate, biodiversity and soil water holding capacity (CUI and DE FOY 2012, DAVIES et al. 2011, HALPER et al. 2012, LEMONSU et al. 2012, LINDBERG and GRIMMOND 2011). Many Polish cities have already started to revitalize deprived neighborhoods (ZIMNICKI 2005), but it is important to remember that changes in technical infrastructure need to accompanied by the restoration of urban green structures (PRZEWOŹNIAK 2005). In this way, the rebuilt biologically active areas will become part of the local ecological system in the city.

The aim of this study was to identify ways of revitalizing courtyards through modernization, increased functionality and social participation. The detailed objectives were: cognitive objective, consisting in specifying the condi-

tion and functions of building quarters interiors, and practical objective, which was the recommendation regarding the development of the examined interiors.

Materials and Methods

This study included two courtyards and a square located in the central part of the city of Wrocław, in south-western Poland. The courtyards are bounded by four streets (Sienkiewicza, Piastowska, Reya, Walecznych); one section (area A) is split by Krzywa Street (Figure 1). The total surface area is approximately 6.2 hectares.

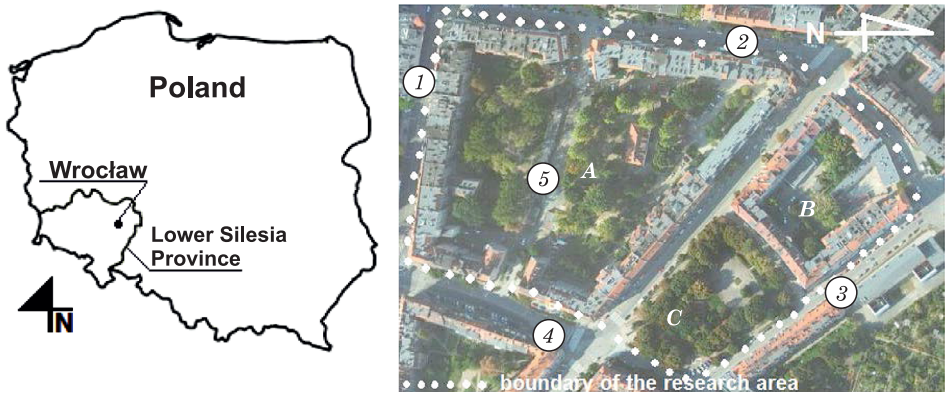

Fig. 1. The location of the research area: *1* – Sienkiewicza Street; *2* – Reya Street; *3* – Walecznych Street; *4* – Piastowska Street; *5* – Krzywa Street; *A*, *B*, *C* – sectors of the research area

The field works were carried out between April and October 2011. The quarters interiors, as well as their nearest surroundings, were observed and their condition was subjectively assessed. All elements of the quarters interiors were considered in the inventory: surfaces, greenery, small architecture objects, construction objects and the nearest surrounding. During the observation, the photographic documentation along with tabular statements were accomplished. In the following stage, the recommendation of the studied area development as the concept prepared both in the descriptive and graphic form, was elaborated.

Basing on results of the Wrocław Social Diagnosis (BŁASZCZYK et al. 2010, SUTRYK et al. 2010), the succeeding assumptions of the concept were adopted: multifunctionality, aesthetic value and participation of the citizens in forming the resident – friendly space for users of different age and needs. During

preparation of the concept, the requirements regarding the location of the construction objects (according to the Regulation of the Minister of Infrastructure dated 12 April 2002 – Concerning the technical conditions to be met by buildings and their location, OJ 2002, No. 75, item. 690), were taken into consideration.

The proposed species of trees and shrubs for planting were in accordance with recommendations for specific sites in cities with a temperate climate (BOJARCZUK and RACHWAŁ 2007, GREINERT 2007). The study were carried out initiative authors.

Results and Discussions

Functional and spatial structure of the research area and the features of buildings

The research area (areas *A, B, C*) is dominated by housing estates, but also includes premises for services (i.e. trade, hairdressers, shoemaker, pub), a kindergarten and a health center. These are located on the ground floors of buildings, while apartments are on the upper floors. There are no buildings with for only residential purposes. There is a square, a green area available to all. To the north of the study area are allotment gardens available only to their owners.

Current status of the area

Area *A* is approximately 4.3 hectares. It is split by a street lined with neglected garages and the premises of a kindergarten. The street and all traffic routes, including pavements, have a gravel surface. In this quarter there is low greenery (lawns), bushes (privet hedge and single, randomly distributed clumps of shrubs or bushes) and trees, mainly *Populus alba, Populus nigra* (which are also the tallest), some of which are overgrown by mistletoe (*Viscum album*). Moreover, there are growing *Acer platanoides*, *Picea abies*, *Abies alba*, *Aesculus hippocastanum*, *Salix x pendulina* 'Wender') and large *Quercus robur* (in the north-western part of the yard). Street furniture includes a few destroyed benches; there is a lack of street lights, litter bins or recreational equipment. Segregated waste containers are placed randomly, while mixed waste containers are standing against the walls of buildings and are exposed, which creates an unsightly view. In this particular courtyard (*A*), there are two separate and fenced areas – one is the kindergarten playground, the other is

a health clinic. The interior of the courtyard is filled with cars, including some parked on lawns, creating an area unfriendly to pedestrians (Figure 2).

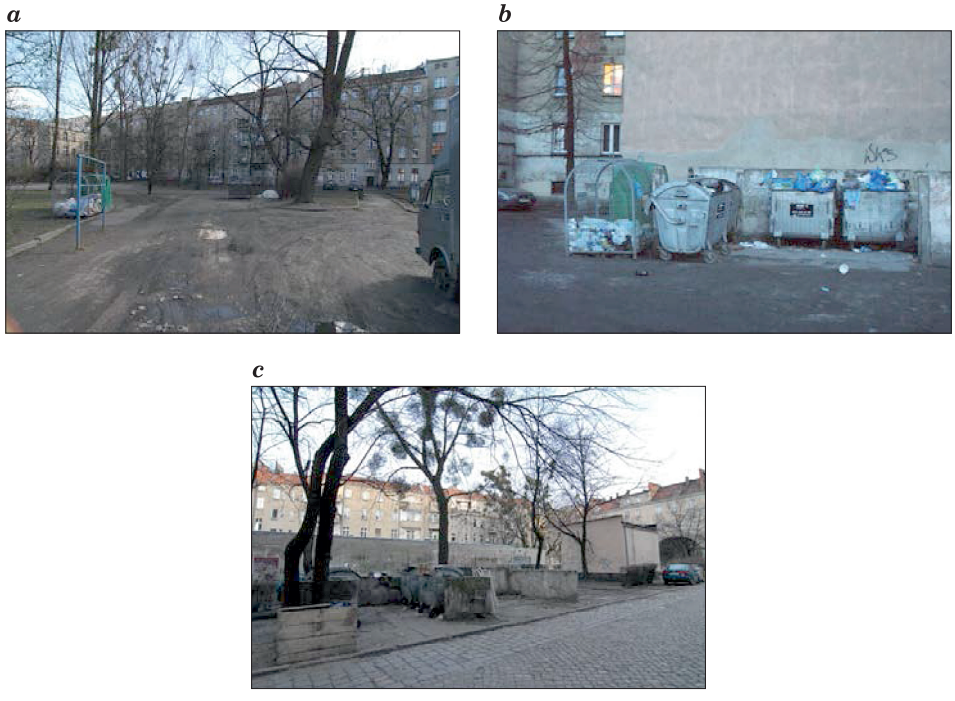

Fig. 2. Courtyards in March 2013: *a* – view from the Krzywa Street to Reya Street; *b* – messy waste management; *c* – one of the two sites for waste containers (phot. A. Zienkiewicz)

Courtyard *B* has an area of approximately 1.1 hectares. Nearly half of the area is occupied by one-storey buildings for services, workshops and warehouses, usually fenced off from the rest of the yard, so that the area available for residents to relax is very small. This courtyard includes deciduous trees (e.g. *Acer saccharinum*, *Acer platanoides*, *Populus nigra*), plants (mainly privet *Ligustrum vulgare* L. hedges and randomly-growing privet) and lawns with a mesh of footpaths. Recreational equipment includes a sandpit, two swings and benches without backrests. In two places there are bins without covers, while cars are parked on the pavement. The yard is neglected, and definitely is not a pleasant place for integration and recreation by residents (Figure 2).

Area *C*. In the case of the square, the main problem is the condition of the infrastructure: damaged pavement sidewalks, dilapidated old benches and garbage cans. There are no street lights which reduces safety after dark. The area is used mostly for car parking. Almost the entire area is covered with grass. Low greenery is supplemented by a flowerbed. Medium height greenery

includes mainly shrubs forming hedges (*Ligustrum vulgare*) and new plantings, for example with *Ligustrum vulgare* L. High greenery are trees of all ages, giving considerable shade (apart from the northwestern part of the square). These are mainly: *Acer platanoides*, *Betula pendula*, *Salix alba* 'Tristis', *Abies alba*, and some 15-year-old *Platanus x hispanica*. Greenery is quite neglected, with many trees that were self-seeded. In some places, due to soil erosion, tree roots are exposed. The lawns have well-trodden „wild paths". The leisure facilities include a badly damaged surface to play chess and cubes for the same purpose.

Recommendations: design concept for the development of separate sectors

Area *A*. Within Area A we propose establishing several sectors. Sector *A–a* is the area around a spreading oak (*Quercus robur)*. In its center is a roundish square, which leads to two paths paved with bright fine gravel. Around the square are two garden swings and two pergolas planted with *Hedera helix*. Additional greenery includes *Berberis thunbergii, Cornus alba, Philadelphus coronarius, Tamarix ramosissima* and *Rosa rugosa* shrubs. South of the oak we propose to plant *Ligustrum vulgare*.

Sector *A–b* is adjacent to the kindergarten in the east. The biggest part of this sector is a playground for older children. It would be equipped with ladders, a slide, swings, sand pit and benches. We propose to maintain the currently existing high greenery. The rest of the area is intended to be green, with uneven sidewalk slabs, and sown with grass. The path is to be lined with benches.

Sector *A–c* comprises lawn with a hoop for basketball. We propose to transform this area into a space for grilling and integration. This is to be achieved with a gazebo, benches and a table. Paths are to be hardened with paving slabs overgrown with grass. In addition, the area will include a toilet for dogs and dog fouling bins (to help maintain cleanliness in other places). High greenery would be supplemented by a flowering tree (e.g. *Magnolia* 'Susan'). We also propose planting high and low shrubs, the same species as in the sector *A–a*.

Sector *A–d* includes a formerly fenced and wooded terrain. We propose a square with benches and a pergola. Greenery, mostly preserved and supplemented with the composition of bushes tolerant to shade and low soil pH (due to the presence of conifers), i.e. *Rhododendron hirsutum*, *Thujopsis dolabrata* 'Nana'. An abandoned and partially destroyed building in this sector would be modernized to become a meeting place for residents.

Sector *A–e* is the largest part of the area. We propose establishing an elliptical square within the sector. It would be surrounded by a pergola, benches and a garden swing. Within the square is place for a small playground for younger children, with a rubber surface and a place to play chess (tables and seats). The main part of the ellipse will be an outdoor gym with steel maintenance-free devices, resistant to weather conditions. Fragile and dangerous old poplars (*Populus* sp.) would be cut down and replaced with deciduous trees with spreading crowns, high-performing in urban environments, e.g. *Platanus x hispanica* and *Liriodendron tulipifera*. In most shaded places, we propose plantings of shade-tolerant plants such as *Vinca minor* or *Hedera helix*. Also this area should include a fenced area for dogs.

Sector *A–f* covers the area of the former garages and part of the land currently belonging to the kindergarten. In this project, the sector would be used as a utility and relaxation space. The main idea is to build an underground garage (one or two level), to improve car parking spaces for residents and others, and eliminate the unsightly garages on the surface. This will allow use of the land for other purposes, such as the creation of a local sports center with a football field, multipurpose sport ground (handball, volleyball and two basketball courts) and a social building with changing rooms, toilets, showers and room for table tennis. This area will not only be for young people but also for other residents. In addition, high greenery (old poplars *Populus* sp.) would be replaced with other species (e.g. *Platanus x hispanica, Liriodendron tulipifera*, *Acer campestre*, *Acer saccharinum*, *Aesculus hippocastanum*, *Tilia cordata)*.

For improved security, area *A* needs to be illuminated. Unsightly waste containers should be placed in specially designed buildings made of brick. Therefore, in several places in Area *A* we have designated locations for the containers for waste and sorted waste. In addition, we propose to announce a competition for residents for murals on the two blank walls on the eastern side of the courtyard (Figure 3).

Area *B* (small courtyard). In the case of Area *B*, it is necessary to demolish the one-storey warehouses and small business offices and hand the area back to the residents. A smaller part of this area may include parking space, while the remaining part should have a green area, a gazebo, barbecue, benches, table and garden swings. It would be isolated from the parking area by new plantings of conifers (e.g. *Thuja occidentalis* - which suppresses noise well and can be easily formed into a dense hedge). Beside them may also be rhododendrons (e.g. *Rhododendron ferrugineum*). They may be complemented by small trees with looser tops, i.e. *Acer campestre* and *Acer saccharinum*. In the rest of the area the existing greenery should be protected, along with changes and supplementation of street furniture: additional benches, tables for playing

a

b

c

Fig. 3. Concept of development of the study area: *a* – area *A, b* – *area* B, *c* – area *C*

chess and for table tennis. It is also necessary to place street lights across the entire area. Containers for mixed waste should be moved into a single and more secluded spot in the western part of the yard, where other containers already stand, into a place sheltered from the wind and rain, accompanied by the segregated waste containers.

In place of the sandbox and swings we plan a playground for children aged 3–14 years as well as benches. One very old poplar (*Populus* sp.) should be cut down and replaced with another deciduous tree (e.g. *Acer saccharinum*). In the most shaded area in the western part of the yard, it is proposed to replace the lawn by ground cover plants (e.g. *Vinca minor*). In the sunny (eastern) part of the yard, we propose a herb garden with mint (e.g. *Mentha* \ *citrata*), oregano (*Origanum vulgare*), basil (*Ocimum basilicum*), tarragon (*Artemisia dracun-*

culus), catnip (*Nepeta cataria*), lavender (e.g. *Lavandula angustifolia*) and wild strawberry (*Fragaria vesca*), for example. Routes for pedestrians should be paved with slanting stone slabs. In place of the current steps we propose a special entrance for the disabled.

Area *C*, is in the south-east immediately adjacent to area *B*, is very neglected. Cleanup work is required. A large part of the square (especially the western side) is very shaded by self-seeded trees with dense crowns. They should be made less dense by pruning branches. The square is entered via an archway, part of the frontage of the houses. It is a key element of the proposed axis of observation to be emphasized by tree pruning. The damaged asphalt surface in the interior of the square should be replaced by cobblestones and pavements, and partly with a surface made of bright fine gravel. In the square there will be a place for a playground area for younger children with a rubber surface and a fountain, whose water jets shoot straight from the stone floor (the place where children like to play). Under the existing trees, chess tables have been introduced. There will also be a shelter for bikes and a site for renting city bikes. The central part of the square, which was formerly a large lawn, will be turned into an open green space. The ground will be covered with irregular slabs of sandstone, with compact cushion clumps in between (e.g. species preferring exposure to sunlight: *Stachys grandiflora*, *Thymus serpyllum* 'Coccineus', *Globularia cordifolia* and those tolerant to shade, such as *Lamium maculatum* 'Beacon silver', *Armeria maritima* 'Dusseldorfer Stolz'*)*. The site will include irregularly arranged garden swings, benches and tables. In addition, we propose removing all privet *(Ligustrum vulgare)* hedges due to their low aesthetic value or the unnecessary division of space. Instead, we propose low hedges, for example, made of boxwood *(Buxus sempervirens)*. Around the square there will be a large number of benches, new trash cans and new street lamps. The square is also to include a space for dogs with bins for dog fouling.

Urbanization processes in Poland tend to occur at the expense of green areas. The result is a loss of biologically active areas, mostly being turned into parking spaces and residential areas (RZESZOTARSKA-PAŁKA 2012). Inventory conducted inside the aforementioned courtyards in Wrocław has shown a progressive process of appropriation of urban green areas, mostly for parking spaces. A major problem is the poor aesthetics of these places caused by messy waste management, poor state of infrastructure and a lack of proper care of vegetation.

Urban development may never be performed in perfect harmony with green areas; it is almost always destructive (GREINERT 2007). Long-term urbanization has many negative effects on the human environment in the city, such as air pollution, noise, the problem of disposal and storage of waste, in

addition to the limited space for recreation (KALBARCZYK and KALBARCZYK 2009, MAKSYMIUK 2005, PRZEWOŹNIAK 2005). But developing urban green spaces may counteract these effects and help maintain the quality of urban life (CHERNOUSENKO et al. 2000, KABISCH and HAASE 2013). The proposed inclusion of greenery in land development, thanks to its diversity and appropriate distribution, has the potential to fulfill most of the functions of urban green areas.

The most important and desirable features of greenery in the human environment include health-related, social and aesthetic functions (RZESZOTARSKA-PAŁKA 2012). Green areas stay in contrast with rigid architecture, produce dynamics in the city landscape, changing their form and color throughout the year, creating spaces of different scale and character. In addition, research indicates that these areas have a positive impact on the restoration of mental health (PESCHARDT and STIGSDOTTER 2013). Due to the role of greenery in the city structure it is necessary to support the development of biologically active areas (RYDIN 2010), even though resources of urban green space in densely built-up cities are limited (WU et al. 2013).

Actions taken at various levels of ecological regeneration of the city should also be synergistically connected (ZIMNICKI 2005); they should involve the widest possible group of community and external investors, and attract tourists. In the presented design for the quarters we allow for the participation of citizens in the creation of their living space (murals, or outdoor herb garden). Revitalization of Polish cities should be the main direction of development in the early 21st century because of the failure of the urban structures, inefficient use of space, increasing operating costs, and negative social and environmental phenomena (PRZEWOŹNIAK 2005). The changes proposed within the aforementioned quarters in Wrocław will improve their functionality, and also create a space visually appealing and resident-friendly for people of all ages and tastes. The city should offer an attractive living environment to residents to stop the escape to houses outside the city and the uncontrolled, wasteful and environmentally harmful growth of suburbia (DĄBROWSKA-MILEWSKA 2010, SERUGA 2013). Research carried out in the small towns of South Africa showed that most people felt that having a public green space (PGS) is important (SHACKLETON and BLAIR 2013). Many people also felt that the involvement of local authorities was insufficient to maintain the PGS and showed a willingness to get involved in making or contributing to the development of PGS. The presented concept in this study also allows for public participation in shaping the city.

Conclusions

The effect of the proposed concept of revitalization in Wrocław will be a space more welcoming for residents, as well as more useful to them and more aesthetic. The planned green space, equipment and street furniture are diverse. They should meet the needs of people of different ages and different needs with regard to types of rest. Therefore, we have included places for the development of physical culture and also a passive way of spending time outdoors, such as reading, meeting other people and barbecuing. Those who like working in the garden may take care of those near buildings or the herb garden. The involvement of citizens in the implementation of the concept of revitalization may have additional social effects – they will treat the places as their own, and so respect them. There is, therefore, a better chance for the revitalized spaces to remain in good condition so that they can serve the new generation and create a bond with the place and social bonds among people.

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References

Bartoszewicz D. 2007. *„Kwartał duński" – próba rewitalizacji warszawskiej Pragi*. Człowiek i Środowisko, 31(3–4): 73–85.

Błaszczyk M., Kłopot S.W., Kozdraś G. 2010. *Problemy społeczne w przestrzeni miasta. Raport z badań socjologicznych nad mieszkańcami miasta*. Oprac. wyk. w ramach projektu „Wrocławska diagnoza problemów społecznych", Wrocław.

Bojarczuk T., Rachwał L. 2007. *Drzewa i krzewy w mieście*. [In:] *Zieleń miast i wsi*. Eds. I. Wojewoda, M.E. Drozdek. PWSZ Press, Sulechów vol. 1, pp. 15–24.

Carlos J., Balsas L. 2007. *City centre revitalization in Portugal: a study of Lisbon and Porto*. Journal of Urban Design, 12(2): 231–259.

Chernousenko G., Yamnova I., Skripnikova M. 2000. *Problems of anthropogenic salinization of urban soils in Moscow*. First International Conference of Soil of Urban. Industrial, Traffic and Mining Areas. Universitat-GH Essen, 3: 939–940.

Cox W., Gordon P., Redfearn C.L. 2008. *Highway penetration of central cities: not a major cause of suburbanization*. Econ Journal Watch, 5(1): 32–45.

Cui Y.Y., De Foy B. 2012. *Seasonal Variations of the Urban Heat Island at the Surface and the Near-Surface and Reductions due to Urban Vegetation in Mexico City*. J. Appl. Meteorol Clim., 51: 855–868.

Davies Z.G., Edmondson J.L., Heinemeyer A., Leake J.R., Gaston K.J. 2011. *Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale*. J. Appl. Ecol., 48: 1125–1134.

Dąbrowska-Milewska G. 2010. *Standardy urbanistyczne dla terenów mieszkaniowych – wybrane zagadnienia*. Architecturae et Artibus, 1: 17–31.

Dolan R.B., Stephens J.D., Moore M.E. 2011. *Living more than just enough for the city: persistence of high-quality vegetation in natural areas in an urban setting*. Diversity, 4: 611–627.

Gaschet F. 2002. *The new intra-urban dynamics: suburbanisation and functional specialisation in French cities*. Papers Reg. Sci., 81: 63–81.

Greinert A. 2007. *Efekty antropopresji urbanistycznej wobec terenów zieleni*. [In:] *Zieleń miast i wsi*. Eds. I. Wojewoda, M.E. Drozdek. PWSZ Press, Sulechów, 73–82.

HALPER E.B., SCOTT C.A., YOOL S.R. 2012. *Correlating vegetation, water use, and surface temperature in a semiarid city: a multiscale analysis of the impacts of irrigation by single-family residence.* Geogr. Anal., 44: 235–257.

KABISCH N., HAASE D. 2013. *Green spaces of European cities revisited for 1990–2006*. Landscape Urban Plan, 110: 113–122.

KALBARCZYK R., KALBARCZYK E. 2009. *Seasonal variability of tropospheric ozone concentration in chosen localities of north-western Poland shaped by meteorological conditions*. Ekólogia (Bratislava), 28(3): 277–290.

LEMONSU A., MASSON V., SHASHUA-BAR L., ERELL E., PEARLMUTTER D. 2012. *Inclusion of vegetation in the Town Energy Balance model for modeling urban green areas.* Geosci, Model Dev, Discuss, 5: 1295–1340.

LINDBERG F., GRIMMOND C.S.B. 2011. *The influence of vegetation and building morphology on shadow patterns and mean radiant temperatures in urban areas: model development and evaluation*. Theor. Appl. Climatol., 105: 311–323.

LORAM A., THOMPSON K., WARREN P.H., GASTON K.J. 2008. *Urban domestic gardens (XII): The richness and composition of the flora in five UK cities*. J. Veg. Sci., 19: 321–330.

MAKSYMIUK G. 2005. *Rozwój terenów rekreacyjnych – wspomaganie czy ograniczenie w przyrodniczej rewitalizacji miast*. Teka Kom. Arch. Urb. Stud. Krajobr. – OL PAN, pp. 149–156.

MEILING P., ROSVALL J., PANAS I. 2007. *Conservation and maintenance of modern urban architecture: the need for long-term maintenance and sustainable management of metropolitan housing areas.* Minerals & Energy, 1–2: 72–82.

MODICA G., VIZZARI M., POLLINO M., FICHERA C.R., ZOCCALI P., DI FAZIO S. 2002. *Spatio-temporal analysis of the urban-rural gradient structure: an application in a Mediterranean mountainous landscape (Serra San Bruno, Italy).* Earth Syst. Dynam., 3: 263–279.

OZUS E., TURK S.S., DOKMECI V. 2011. *Urban Restructuring of Istanbul*. European Planning Studies, 19(2): 331–356.

PESCHARDT K.K., STIGSDOTTER U.-K. 2013. *Associations between park characteristics and perceived restorativeness of small public urban green spaces*. Landscape Urban Plan, 112: 26–39.

PRASAD V.K., BADARINATH K.V.S. 2003–2004. *Changes in vegetation vigor and urban greenness in six different cites of India-analysis from coarse resolution remote sensing datasets.* Journal of Environmental Systems, 30(3): 255–272.

PRZEWOŹNIAK M. 2005. *Teoretyczne aspekty przyrodniczej rewitalizacji miast: ku metodologii zintegrowanej rewitalizacji urbanistyczno-przyrodniczej*. Teka Kom. Arch. Urb. Stud. Krajobr. – OL PAN, 25–34.

RZESZOTARSKA-PAŁKA M. 2012. *Rewitalizacja terenów zieleni osiedlowej szansą dla dwudziestowiecznych blokowisk?* Architektura, 1A(2): 157–164.

RYDIN Y. 2010. *Governing for sustainable urban development*, Earthscan, London. Washington.

SERUGA W. 2013. *The social space of new residential complexes in Berlin*. Architektura, 1A: 145–164.

SHACKLETON CH.M., BLAIR A. 2013. *Perceptions and use of public green space is influenced by its relative abundance in two small towns in South Africa*. Landscape Urban Plan, 113: 104–112.

SUTRYK J., KŁOPOT S.W., BŁASZCZYK M., PLUTA J., TROJANOWSKI P. 2010. *Studia nad strategia rozwoju społecznego miasta Wrocławia.* SCHOLAR, Warszawa.

SWIANIEWICZ P., KLIMSKA U. 2005. *Społeczne i polityczne zróżnicowanie aglomeracji w Polsce – waniliowe centrum, mozaika przedmieść*. Pr. Stud. Geogr. 35: 45–70.

WOŁOSZYN M. 2010. *Ujmowanie – kształtowanie przestrzeni wewnątrz kwartałów zabudowy czynszowej*. Przestrzeń i forma, pp. 195–202.

WU B., YU B., YUE W., SHU S., TAN W., HU C., HUANG Y., WU J., LIU H. 2013. *A voxel-based method for automated identification and morphological parameters estimation of individual street trees from mobile laser scanning data.* Remote Sens, 5: 584–611.

ZIMNICKI G. 2005. *Szczecin – revitalization of waterfronts.* Teka Kom. Arch. Urb. Stud. Krajobr. – OL PAN, pp. 196–205.

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SOCIAL AND ECONOMIC FOUNDATIONS FOR THE GROWTH OF EQUESTRIAN SPORT AND LEISURE HORSE RIDING IN WARMIA AND MAZURY

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K e y w o r d s: stud stations, herds, breeding, equestrian sport, leisure horse riding.

A b s t r a c t

After World War Two, the breeding of horses for reproduction in the Province of Olsztyn grew on what had remained from the East Prussian infrastructure. The first State Stallion Stud was opened (on the initiative of the State Horse Rearing Stations) in Ketrzyn as late as in 1947, and the delay was due to the extensive war damage and the slow process of building of the Polish administration. The catchment area served by that stud covered nearly half of the province. Four years later, in response to the progressing post-war reconstruction, intensive growth of state-owned farms and farmers' cooperatives, another stallion stud was created in Braniewo. The formation of both studs was greatly aided by the State Stallion Stud in Kwidzyn. Horses from the two studs in the Province of Olsztyn were used for work in farming, for transport as well as for recreation and sports horse riding. Some of the horses could also be seen in historical films. However, the technological progress in farming gradually depreciated the role of horses, which led to a decline in horse breeding. After a few decades, it caused the collapse of the State Stallion Studs in Warmia and Mazury.

SPOŁECZNO-EKONOMICZNE UWARUNKOWANIA ROZWOJU SPORTU JEŹDZIECKIEGO I JEŹDZIECTWA REKREACYJNEGO NA WARMII I MAZURACH

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Abstrakt

Hodowla koni zarodowych po drugiej wojnie światowej w województwie olsztyńskim osadzała się na pozostałościach infrastruktury pruskiej. Pierwszą państwową stację ogierów, z uwagi na duże zniszczenia i proces organizacji polskiej administracji, uruchomiono w Kętrzynie z inicjatywy Państwowych Zakładów Chowu Koni dopiero w 1947 r. Obsługiwała ona niemal połowę ówczesnego województwa olsztyńskiego.

Z uwagi na postępujący proces odbudowy, intensywny rozwój państwowych gospodarstw rolnych i spółdzielni produkcyjnych cztery lata później utworzono identyczne przedsiębiorstwo w Braniewie. Wielce pomocna w procesie tworzenia obu zakładów była Państwowa Stacja Ogierów w Kwidzynie. Wierzchowce z olsztyńskich ośrodków hodowlanych oprócz pracy w rolnictwie i transporcie użytkowane były także w rekreacji konnej i sporcie jeździeckim. Twórcy kultury wykorzystywali je także w znanych powszechnie filmach o tematyce historycznej. Jednakże postęp techniczny w rolnictwie sukcesywnie pomniejszał rolę konia, powodując ograniczania w dalszej hodowli. Proces ten na Warmii i Mazurach po kilkudziesięciu latach zakończył się upadkiem państwowych stad ogierów.

Introduction

On 14th March 1945, the Polish Council of Ministers passed an act approving the provisional division of so-called Regained Territories. What followed was the creation of four administrative districts: Opole Silesia, Lower Silesia, West Pomerania and East Prussia, later called the Masuria Administrative District (WOJNOWSKI 1970). Soon afterwards, on 30th March that year, the Government Envoy Jakub Prawin arrived in the heavily ruined and depopulated town of Olsztyn, thus marking the return of the Polish administration to this region, many years after the Partitions of the Polish Kingdom. The formation of administrative structures and councils created the base for the constitution of the Province of Olsztyn, which was proclaimed by the government of the People's Republic of Poland on 20th May 1945 (Journal of Law 1946, No 28, Item 177).

At that time, there were several horse breeding studs in central Poland. For the new Polish province set up in former East Prussia, the turning point was the year 1947, when the State Stallion Stud (PSO) in Kętrzyn was opened (JOSSÉ 1959). The roots of the Kętrzyn Stud can be traced back to East Prussia, formally dissolved in 1947 by Act no 47 of the Allied Council Control Germany (KLAFKOWSKI 1967).

Material and Methods

The principal aim of the article is to present horse breeding traditions, to discuss the circumstances in which State Stallion Studs were created in Warmia and Mazury after World War Two, and to identify the relations between horse breeding and both equestrian sport and leisure horse riding.

The general hypothesis is that these processes were merging with each other. Thus, the following questions were posed:

1. What criteria/conditions justified the decision to create State Stallion Studs in the region?

2. What influence did the breeding of horses for reproduction have on pleasure and sports horse riding?

In order to achieve the following tasks listed above, methods from social sciences (talks, interviews and surveys), historic sciences (indirect, direct and comparative methods) and pedagogy (monographic method, analysis of documents) were employed.

Development of the State Stallion Stud in Kętrzyn

After the stables and other facilities had been raised from the war damage, horse breeding in Kętrzyn was resumed in April 1947, when nine stallions were brought from the stud in Kwidzyn, which had reopened earlier. The animals were almost instantly transferred to four service stations. In the following year, the stud grew to 57 horses which stood in 23 service points. They had been purchased or transferred from other horse stations. Since the early 1950s, the State Stallion Stud (PSO) in Kętrzyn served nearly half of the administrative districts within the Province of Olsztyn. The Ministry of State Agricultural Farms (PGR) appointed the District Board of the State Agricultural Farms in Giżycko to act as a supervising body for this and two other horse breeding stations in the District of Kętrzyn (AAN, no. 436/351). In 1951, the area covered by the Kętrzyn PSO was enlarged by incorporating the Province of Białystok. Moreover, the State Stallion Stud in Kętrzyn was subordinated to another supervising body, such as the Central Board of Horse Breeding (CZHK), which had been distinguished in the administration structure of the State Farms. Out of the districts in the Province of Olsztyn which used to be served by the Kętrzyn PSO, Kętrzyn, Mrągowo, Pisz, Giżycko and Węgorzewo remained in the station's catchment area, while the rest of the province was submitted to an analogous stud created in Braniewo.

The stud in Kętrzyn was composed of thoroughbred Trakehnen/Masuren horses as well as a large number of heavy studs, i.e. the Swedish Dole and the Polish Sokolski breed. The role of the reopened stallion stud in Kętrzyn cannot be neglected. In 1945, there were just 77 horses in all state studs in Poland, compared to as many as 1480 ones in 1938 (STANISZEWSKI 1958). Kętrzyn enjoyed long horse breeding tradition, dating back to former East Prussia, which helped immensely to re-establish the barn. The man who initiated the idea and became the first manager of the post-war stud was Stanisław

Zdanowicz, lieutenant of the 10th Cavalry Regiment in Grajewo (AMK, no D-1408). The staff was recruited among Poles who had been settling in Mazury but, like many other companies and institutions, the PSO in Kętrzyn struggled with the shortage of experts.

The Kętrzyn stud was expected to 'produce' a fast draft type of horse; later, the stud farm also provided a purebred (Masuren) horse for leisure and sports horse riding. Although horse riding had avid lovers among the first horse breeders in post-war Kętrzyn, who associated it with the interwar Republic of Poland, its development was hindered by many obstacles, both in the region of Warmia and Mazury and all over Poland. Horse riding was first taught inasmuch as it was needed for everyday work at the stud farm. Stanisław Zdanowicz, who organized and headed the Kętrzyn PSO, set a good example for the staff, with his manners of a cavalry officer and an outstanding personality. Under his management, it was possible to set up the People;s Sports Club (LZS), which was one of the first sports organizations started in the Province of Olsztyn (WÓJCIK 2010). Soon afterwards, the PSO in Kętrzyn was appointed a new manager, but the horsemanship skills of the staff continued to fourish. The stallions Pregor and Wolbórz were particularly appreciated. However, it took too long before the management realized that leisure and sports horse riding could promote the outcome of the breeding efforts. Table 1 contains a list of horses used in the early development of equestrian sport and leisure horse riding.

Table 1
Horses used for equestrian sport and leisure horse riding in the early years of the PSO in Kętrzyn

Name	Foaled	Parents		Breeder
		sire	mare	
Baszybzuk	1948	Fiołek	Kohorta	PSK* Racot
Barkas	1948	Lehar	Wajdelotka	PSK Liski
Chryzostom	1949	Coriolan	Nawarka	PSK Pępowo
Czaprak	1949	Hunnenkonig	Dunkierka	PSK Pępowo
Drapichrust	1950	Pyrrhus	Drapich	PSK Liski
Paryż	1950	Pyrrhus	Paryżanka	PSK Liski
Wareg	1950	Jamajka	Wełtawa	PSK Liski
Hermest	1951	Marzhase	Himera	PSK Plękity
Pregor	1951	Polarstern	Peseta	PSK Liski
Wolbórz	1951	Marzhase	Wolborka	PSK Liski

* State Horse Station
Source: the authors, based on the Registers of stallions and brood mares in the State Horse Breeding Plants in Poland, published by the Ministry of Agriculture and comprising years 1946–1951 and 1955.

In 1949, following the state-imposed division of Poland into catchment areas, the region of Warmia and Mazury became a mixed catchment area. This is why the horses were mixed breeds, i.e. the Döle horses with the dominant Masuren and other related breeds. Consequently, sires from the Kętrzyn Stud which stood in the service stations, important for the regional horse breeding, belonged to different breeds and types. Soon afterwards, the post-war history of the Kętrzyn Stallion Stud recorded a significant event. On 14th October 1951, members of the LZS Sports Club at the Kętrzyn Stallion Stud Station participated in a friendly horse riding contest between horse breeding farms, organized by horse riders from the State Horse Stable in Liski and held in Bartoszyce (WÓJCIK 2012a). At that time, the State Stallion Stud in Kętrzyn held 141 horses of different breeds and types, including 56 Masuren and related breeds, 1 Thoroughbred and 22 half-bred Anglo-Arabian horses, 39 Döle and related breeds, 19 Belgian, Ardennes and Bretons, as well as 4 Polish Konik ponies (JOSSÉ 1959). In general, the number of stallions which stood in roster in the Kętrzyn farm and at the outside service stations complied with the statutory requirements (Polish Monitor no 93 of 16 August 1955, item 1198) and regulations of the Ministry of Agriculture on the division of catchment areas for the breeding of horses of particular breeds and types. The above regulation imposed the division into catchment areas for particular horse breeds and types, where the Province of Olsztyn was assigned a bidirectional status. In practice, this meant parallel breeding of hot-blooded (suitable for leisure horse riding) and warm-blooded horses. A somewhat worse solution, from the point of sports horse riding, was yet to come. In that time, the Kętrzyn Stallion Stud Station and its staff enjoyed good reputation, which reached far beyond the nearest surroundings. On 27th–28th September 1952, horse riders from Kętrzyn took part in the Polish Horse Riding Competition in Wrocław. In the following year, W. Nosarzewski, an animal husbandry specialist from Kętrzyn, became one of the first licensed horse riding instructors in the region. The knowledge and new qualifications obtained during a horsemanship course in Poznań enabled the most talented breeders and horse riders to qualify for the Polish Horse Riding Championships. Meanwhile, the Central Board of Horse Breeding (CZHK) transformed all horse farms into State Stud Stations. The successful growth of the Kętrzyn PSO attracted the attention of Polish film makers. The first was the film director Alexander Ford, who 'employed' horses from Kętrzyn for his highly successful historic drama *The Teutonic Knights*, made in the late 1950s.

In 1960, the aforementioned regulations were amended, increasing the share of the Polish territories where cold-blooded horses should be bred from 11 to 37.5%. In the bidirectional areas, like Warmia and Mazury, the percentage of the catchment where hot-blooded horses could be reared was decreased

from 38 to 4.3%. This had very negative consequences for the composition of the stud in Kętrzyn and retarded the advance of pleasure and sports horse riding. As a result, warm-blooded stallions grew in number and became much more often selected to join the roster at service stations. The number of saddle horses was distinctly smaller, which had an adverse impact on equestrian sport and leisure horse riding. A memorable moment in the history of the Kętrzyn Stud and the whole region occurred in 1964, when, for the first time – under the auspices of the International Federation for Equestrian Sports (FEI) – the International Official Horse Riding Championships were held in the capital city of Warmia and Mazury (WÓJCIK 2010). Soon afterwards, preparations started for a parade commemorating the millennium of the Polish State (in 1966), one in a series of propaganda events organized by the government and the communist party. The new management of the State Stallion Stud in Kętrzyn delegated the grooms, who had just returned with stallions from service stations, to travel to Warsaw and join in the parade rehearsals held in Okęcie. Several dozens of horse groom and breeders from Kętrzyn took part in the actual parade of the Polish cavalry in Warsaw. For many, it was a special honor to be there. The parade attracted attention to the horses from the Kętrzyn stud. For example, the film director Jerzy Hoffman invited horse breeders from Kętrzyn, with their best saddle horses, to take part in the making of his film based on the third part of the Trilogy by Henryk Sienkiewicz, titled *Pan Wołodyjowski*. For the horse breeders from Kętrzyn, it was another mark of honor to see horses from the Kętrzyn Stallion Stud in that extremely popular Polish film. It also contributed to the prestige they had already earned.

At that time, the whole region of Warmia and Mazury and its capital city Olsztyn were renowned for thriving equestrian sports, whose highlight was the annual International Official Horse Championships, held at the hippodrome in Olsztyn-Kortowo. A few years before the first competition, students had started summer camps called 'Holiday in a saddle', which enjoyed much popularity. Every summer, groups of twenty people joined in a horse-riding holiday at any time (WÓJCIK 2012b). However, the late 1960s witnessed a sudden downfall in the equestrian sport development. Equestrian competitions in Kętrzyn were held only sporadically, for example to celebrate state holidays. They were then organized by members of the People's Sports Club (LZS) in Liski, which the Provincial Committee for Physical Culture considered to be the leading club in the region. The LZS in Liski was helped by the authorities of the District of Kętrzyn in the organization of horse-riding contests and shows. Many were international events, with participants from the Baltic republics of the Soviet Union and even from West Berlin (ASKL 1973). In 1981, the International Official International Jumping Show Competition was transferred from Olsztyn to Sopot. In the same year, a new director

of the PSO in Kętrzyn was appointed. The post was taken by Andrzej Różyczki, an animal husbandry specialist, who had been involved in horse breeding for a long time. During his management, in the mid-1980s, an attempt was made to revive the sporting traditions, but it proved impossible to attain an equally high level as in the previous years. With Mr Rożyczki as the manager, the PSO in Kętrzyn survived through the turbulent years of the state transformation of Poland. But eventually, in 2003, the Stallion Stud in Kętrzyn was incorporated in the Stud Station in Łąck.

Setting up and development of the State Stallion Stud in Braniewo

The horse breeding traditions in Braniewo (the Trakehnen horse) also date back to the times of East Prussia (JASZCZUR-NOWICKI 1998, KAMZAŁOW 2002). Horses were bred in Braniewo until the outbreak of World War Two, but the stud of breeding horses in Braniewo had ceased to exist before the war was brought to end. The revival of economic life in and around Braniewo struggled with severe problems. Two reasons were responsible: the peripheral location of the town and a much larger extent of war damage than elsewhere. As a result, settlers arrived in deserted villages at a very slow rate, which matched an equally slow economic growth of this part of Warmia (ŁUSZCZEWSKA 1973). These circumstances largely explain why the first attempt to resume horse breeding in Braniewo was not made until January 1947. In that time, the PZChK (the State Horse Rearing Farms) assumed the possession of what had remained from the former German horse farm in Braniewo (PERZYNA 1966). In fact, quite many buildings and facilities of the pre-war farm had survived, but they were in bad repair, having been destroyed or damaged during and after the war. Compared to the stables in Kętrzyn, the horse farm in Braniewo had suffered much higher loss due to the war damage and post-war plunder. Nevertheless, some of the stables in Braniewo were used for several months by the PZChK to temporarily keep horses imported from Finland. At that time, it was impossible to reopen the horse farm because of the laborious and time-consuming process of reconstruction. For this reason, the PZChK accepted the suggestion put forth by the municipal authorities and leased the former horse farm buildings and amenities to the District Board of Communal Cooperatives, which managed the property for nearly four years. Meanwhile, the repairs continued and the facilities were gradually refurbished. At the same time, the new stud was being formed. This enabled the State Farms to regain the possession of the whole property. The act had been preceded by an evaluation performed by a specially appointed commission, which had visited the buildings and checked the entire infrastructure less than six months before the official opening of the stables. The commission had agreed that „the opening of

the State Stallion Stud Station (PSO) in Braniewo is necessary for the horse breeding run by the State Farms and by farmers' cooperatives" (APO, no 2471/489). The commission's approval meant that in early 1951, after a twelve-year interval caused by the war followed by post-war reconstruction, the horse breeding practice in Braniewo was resumed (PERZYNA 1966). Before that, the authorities had accepted the transfer of several stallions owned by the Kwidzyn Stud and kept at a service point located at the state farm in Elżbiecin to the PSO in Braniewo. The Braniewo Stallion Stud Station did not neglect the local community. In the summer of 1951, children of some of the employees were trained and sent to Warsaw to participate in the First Polish Youth Sports Contest. In October the same year, in collaboration with the District Physical Culture Committee, the Braniewo PSO held an official horse riding contest, the first of such events in the Province of Olsztyn (APO, no 444/22). For obvious reasons, the horsemanship was on a very low level, but this is how the Polish tradition of sports horse riding in Warmia and Mazury was born. The hippodrome at the Stallion Stud Station in Braniewo was turned into a venue for a number of horse shows as well as recreational and sports events in the years to come. In 1952 horse riders from Braniewo joined representatives of the Kętrzyn Station in the Polish Horse Riding Competition in Wrocław. But the greatest sports achievement for the Braniewo staff in the 1950s was becoming qualified for the first post-war Polish Horse Riding Championship, which took place in 1953, on the State Horse Racing Track in Sopot. At that time, the best horses kept in Braniewo were Baronet and Monopol.

Table 2
Horses used for equestrian sport and leisure horse riding in the early years of the PSO in Braniewo

Name	Foaled	Parents		Breeder
		sire	mare	
Narwik	1941	Łebwłeb	Cudna	Potocki/Łańcut
Klejnot	1941	Hyazintu	Konigsdalme	PSK* Racot
Wrzos	1946	NN**	NN	NN
Baronet	1948	Celsius	Królewianka	PSK Liski
Balador	1948	Midas	Irma	PSK Pępowo
Monopol	1949	Dukat	Madzia	Józef Ruchlik
Grab	1950	Tamerlan	Grań	PSK Liski
Gratjano	1951	Polverturm	Gapa	PSK Plękity
Fach	1952	Lehar	Harosza	PSK Kroplewo
Cejlon	NN	NN	NN	NN

* State Horse Station
** Not known
Source: the authors, based on the Registers of stallions and brood mares in the State Horse Breeding Plants in Poland, published by the Ministry of Agriculture and comprising years 1946–1951 and 1955.

It should be underlined that the main task of the Braniewo PSO was to supply horse stables in Mazury with sires. Another goal was to affect, via service stations located across Warmia and Mazury, the horse breeding carried out in field by the State Farms, cooperatives and private farmers. Equestrian sport and leisure horse riding was therefore seen as a way to promote the breeding stud. Having little land to grow crops, the station bought fields from other farms. Oat was rationed and obtained from the State Cereal Crops Consortium, while straw and hay were purchased from the Communal Farmers' Cooperatives. Once the PSO in Braniewo had been organized and started, it quickly expanded its economic power and impact on the field horse breeding. In 1953, another wing of the second stable (destroyed during the war) was re-built, providing 23 more stalls. At the beginning of each year, so-called service sires supervised by grooms were located at service stations. The Barniewo PSO served a catchment area taken over from the PSO Kwidzyn and composed of the districts of Olsztyn, Ostróda, Morąg, Nidzica and Susz, as well as six districts which used to be served by the PSO in Kętrzyn, such as Bartoszyce, Lidzbark, Biskupiec, Szczytno, Działdowo and Nowe Miasto Lubawskie) (PERZYNA 1966). In total, 103 stallions joined in the roster, including 19 elite stallions kept in the farms in Liski, Rzeczna, Plękity and Kroplewo. The stallions included 54 purebred Masuren horses. In the early 1950s, the director of the Braniewo PSO delegated Mr Niedbalski, an animal husbandry specialist, to the first post-war course for horse-riding instructors. In the years to come, the new qualifications obtained by the staff contributed to the promotion of equestrian sport and leisure horse riding in the region. However, the inspections carried out by the CZHK officers showed severe shortages of the horse breeding staff (AAN, no 436/351). That did not prevent the Braniewo PSO from growing. The most severe problems during the early post-war years were an inadequate number of expert horse breeders and shortage of complete uniforms for the staff. Despite that, the Braniewo PSO had notable achievements in the region. The horse breeding practice was thriving. The station held 139 horses, composed of the following stallions: 74 Masurian breed and related, 4 Thoroughbred and 8 half-bred Anglo-Arabian, 27 Döle and related, 24 Fjords and 2 Konik Polski ponies (JOSSÉ 1959). The presence of hot- and cold-blooded stallions corresponded to the statutory requirements. Warmia and Mazury belonged to the regions with a bi-directional horse-breeding strategy, which met the expectations of farmers and agreed with the planned national economy growth. However, the steadily increasing number of warm-blooded stallions limited the development of equestrian sport and leisure horse riding. It was increasingly more difficult to provide visiting horse riders with a suitable number of saddle horses (WÓJCIK 2012b). Apart from reproduction, the cold-blooded stallions from Braniewo,

like the ones from Kętrzyn, were also used in film making and participated in the aforementioned millennium parade in 1969. These two aspects proved especially memorable in the history of Braniewo. In 1960, as mentioned before, the Ministry for Agriculture amended the regulation on horse breeding catchment areas. As a result, the districts of Działdowo, Nidzica and Nowe Miasto Lubawskie were assigned to the group of regions with the unidirectional breeding of the hot-blooded horse, while the districts of Braniewo, Pasłęk, Lidzbark and Biskupiec were superimposed a unidirectional breeding strategy for the warm-blooded horse. The remaining districts were to continue, for a transient period of five years, the bidirectional horse breeding (PERZYNA 1966). The PSO in Braniewo was obliged to adjust to the regulations and withdrew noble sires from the service points in these parts of its catchment area where they were no longer permitted. The diminished area served by hot-blooded horses caused a proportional decrease in their number in the stud. This in turn had dramatic consequences for the development of horsemanship. Despite these difficulties, the Braniewo PSO was an outstanding horse riding center in Poland, although the Polish Horse Riding Association expressed some disillusionment with the lack of sporting achievements. In 1969, a horse riding show was held on the Press Day in the football pitch in Orneta. It was one of the last in a series of such events. Because of his age, the former representative of the Polish national team, Mr Perzyna, participated only as an organizer and a judge. The State Stallion Stud in Braniewo was represented by just two riders. In later years, the Barniewo PSO staff only sporadically joined horse riding events. This aroused widespread dissatisfaction and the quarterly *Koń Polski* commented: „We have built several beautiful centres, while there are such horse breeding stations as the State Stallion Studs in Braniewo, Kętrzyn and Klikowa, or the Horse Farm in Walewice and many others were literally nothing is done to promote horse riding" (WÓJCIK 2010). Horse riding as a sport could not be revived in Braniewo, but stallions from this stud were often distinguished and given awards at auctions and shows in Poland. In the 1970s, the Braniewo PSO was a leader in horse breeding in Poland, winning the first place among Polish stallion studs five times. The Braniewo staff was honored for their achievements, being granted the permanent possession of the Challenge Cup founded by the Minister for Agriculture. However, the technological progress meant that horses were steadily replaced by machines and horse breeding was in less demand. The draft horse was less needed. From the economic point of view, it was becoming unjustifiable to maintain two studs in the province. The Braniewo stud and its staff were going through difficult times. To make things worse, the experienced manager of the Braniewo PSO and a great horse lover, E. Perzyna, became seriously ill. A new manager, Wojciech Ganowicz, was appointed in March 1992, but it was

impossible to revert the unfavourble situation. On the last day of May 1997, the PSO in Braniewo was dissolved. Despite having very rich traditions, well-furnished amenities and a shorter history than the twin PSO in Kętrzyn, it was the first one to be closed down.

Summary

The high level of horse breeding in East Prussia had a strong influence on the decision to resume the breeding process when World War Two was over. The setting up of two stallion studs was easier owing to the remaining German infrastructure and a few Trakehnen horses left in former East Prussia (e.g. Hunnenkönig, Königsdaume, Märzhase). When the State Stallion Studs had been created, each year sires from these studs were sent to service stations, which enabled the breeders to maintain the continuity of breeding lines. The growing horse breeding output supplied the Polish agriculture with working horses. It also produced horses for leisure horse riding (friendly competitions, 'holidays in a saddle') and then equestrian sport. The horses from Warmia and Mazury were also used by the film industry. Being able to choose good riding horses (e.g. Pregor, Wolbórz) was a condition to achieve a good level in horse riding. The progress in this area was also stimulated by the International Official Horse Riding Championships, known in the inter-war Poland and resumed in Olsztyn in 1964. For several years afterwards, the championships were held under the auspices of the International Federation for Equestrian Sports (FEI). However, the further growth of pleasure horse riding and equestrian sports was hindered by the imposed division into catchment areas, which resulted in a diminished population of hot-blooded horses and a growing number of cold-blooded (heavy) horses, suitable for agriculture and transport. It was therefore difficult to develop horse riding for pleasure and almost impossible to maintain a high level of equestrian sports. In the later years, working horses from the studs in Warmia and Mazury were gradually replaced by machines, as a result of which both stud stations were closed down.

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References

AAN, no 436/351. *Funkcjonowanie państwowych stadnin koni, plan, sprawozdania, protokoły lustracji*. Instrukcje i zarządzenia. Centralny Zarząd Hodowli Koni. Archiwum Akt Nowych, Warszawa, sygn. dok.: 436/351.

AMK, no D-1408. Archiwum Muzeum im. W. Kętrzyńskiego, Kętrzyn, sygn. dok.: D-1408.

APO, no 2471/489. *Korespondencja i sprawozdania w sprawie chowu koni. Protokół w sprawie organizacji PSO w Braniewie z dnia 26 lipca 1950 roku*. Archiwum Państwowe, Olsztyn, sygn. dok.: 2471/489.

APO, no 444/22. *Sprawozdanie opisowe z wykonanego planu Prezydium Wojewódzkiego Komitetu Kultury Fizycznej za IV kwartał 1951 roku*. Sprawozdania z działalności. Plany Pracy 1950–1956. Archiwum Państwowe, Olsztyn, sygn. dok.: 444/22.

ASKL 1973. *Sprawozdanie z działalności Sekcji LZS Liski za rok 1972*. Teczka *Korespondencja LZS Liski-1973*. Archiwum Stadniny Koni, Liski.

Jaszczur-Nowicki J. 1998. *Działalność sportowych ośrodków jeździeckich regionu elbląskiego w półwieczu 1945–1995*. [In:] *Z najnowszej historii kultury fizycznej w Polsce*. Red. Woltmann B. Wyd. AWF Poznań, pp. 158–167.

Jossé W. 1959. *Koń Mazurski*. Informator Inst. Zootechniki, Kraków.

Kamzolov B. W. 2002. *Istoriâ trakenenskoj lošadi*. Kavalier Pabliszers IOOO, Mińsk.

Klafkowski A. 1967. *Likwidacja państwa pruskiego. Ustawa nr 46 Sojuszniczej Rady Kontroli nad Niemcami*. PWN, Warszawa.

Łuszczewska A. 1973. *Braniewo. Z dziejów miasta i powiatu*. Wyd. Pojezierze, Olsztyn.

Perzyna E. 1966. *Państwowe Stado Ogierów w Braniewie i jego działalność hodowlana* (praca magisterska), WSR Olsztyn.

Staniszewski J. 1958. *Państwowe Stada Ogierów*. Prz. Hodowl., 10: 22–24.

Wojnowski E. 1970. *Warmia i Mazury w latach 1945–1947*. Wyd. Pojezierze, Olsztyn.

Wójcik Z. 2010. *Sport jeździecki na Warmii i Mazurach w latach 1945–1975*. Wyd. Erzet, Olsztyn.

Wójcik Z. 2012a. *Od rekreacji do treningu. Rozwój jeździectwa w Zrzeszeniu Sportowym „Ogniwo" na Warmii i Mazurach*. Rocz. Nauk. Wyższej Szkoły Wychowania Fizycznego i Turystyki w Białymstoku, 8: 103–110.

Wójcik Z. 2012b. *Turystyka i rekreacja konna*. Szkice Humanistyczne, 12(2): 187–196.

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LONG-TERM HYDROCHEMICAL CHANGES IN A LAKE AFTER THE APPLICATION OF SEVERAL PROTECTION MEASURES IN THE CATCHMENT

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K e y w o r d s: lake, eutrophication, protection techniques, water quality.

A b s t r a c t

A study was conducted on Wulpińskie Lake (706.7 ha, 54.6 m), located in north-eastern Poland. In the middle of the twentieth century, the lake began to be subjected to accelerated eutrophication due to excessive pressure from recreation and an inflow of sewage and pollution from leaky septic tanks and putrefactive reservoirs. The protective actions begun in the basin in 1996 resulted in a 77% reduction in phosphorus load and 28% reduction in nitrogen load. In 2008, mineral phosphorus and TP concentrations averaged 0.1 mg L^{-1} and 0.16 mg L^{-1}, respectively, and the TN concentration was 0.84 mg L^{-1}. In addition, chloride and calcium concentrations declined and electrical conductivity subsequently decreased.

DŁUGOTERMINOWE ZMIANY HYDROCHEMICZNE W JEZIORZE PO ZASTOSOWANIU ZABIEGÓW OCHRONNYCH ZLEWNI

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S ł o w a k l u c z o w e: jezioro, eutrofizacja, techniki ochrony, jakość wody.

A b s t r a k t

Badania przeprowadzono na Jeziorze Wulpińskim (706,7 ha, 54,6 m), zlokalizowanym w północno-wschodniej Polsce. Jezioro to od lat 50. XX w. zaczęło podlegać przyspieszonej eutrofizacji z powodu nadmiernej presji turystycznej i rekreacyjnej oraz dopływu ścieków i zanieczyszczeń z nieszczelnych szamb i zbiorników gnilnych. W 1996 r. rozpoczęto działania ochronne w zlewni.

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Ładunek fosforu wprowadzany do jeziora zredukowano o 77%, a ładunek azotu o 28%. Spowodowało to bardzo wyraźną i trwałą poprawę jakości wody. W 2008 r. średnia koncentracja fosforu mineralnego wynosiła: 0,1 mg $P \cdot L^{-1}$, a fosforu ogólnego 0,16 mg $P \cdot L^{-1}$, natomiast azotu ogólnego oscylowała wokół 0,84 mg $N \cdot L^{-1}$. Zmniejszało się ponadto stężenie chlorków i wapnia oraz wartości przewodności elektrolitycznej.

Introduction

Lakes with high inflow of minerals and organic compounds from catchments have an elevated risk for eutrophication (JORGENSEN 2001, CARPENTER 2008; FRATERRIGO and DOWNING 2008, ISTVÁNOVICS 2009). The pace of this process can be influenced by many factors, such as the morphometry of the basin and the geological and hydrological systems and features of the catchment (MALMAEUS and HÅKANSON 2004). Under natural conditions, this process will be slow and prolonged. However, human civilization has made a significant contribution to the degradation of water and eutrophication acceleration. Lakes adjacent to urban and agricultural areas, in particular, are usually eutrophicated due to receiving municipal sewage and industrial wastewaters (WANG et al. 2012) and nutrients from leaky septic tanks and agriculture (LI et al. 2007).

Accelerated eutrophication has prompted a search for effective remediation methods, involving the protection of endangered lake basins and reservoirs and the recultivation of those that have already been degraded (JEPPESEN et al. 2007, CASTILLO 2010, FRIESE et al. 2010). COOKE et al (2005) and KLAPPER (2003) provide many solutions for eliminating or reducing external sources of nutrients (protection of lakes) and the technical and chemical methods carried out on the lakes (lakes recultivation). However, many years of experience have shown that the most important and fundamental role in the improvement of the aquatic environment are the protective methods carried out in catchment (FRISK and BILALETDIN 2001, DUNALSKA 2003, GAWROŃSKA and LOSSOW 2003, REYNOLDS 2003). These activities are arduous, lengthy and not very spectacular, but a reduction in the external load from the catchment can help to prevent the use of expensive recultivation, and improve the efficiency of agriculture and industry by eliminating the leakage of essential nutrients as well as other chemicals and materials.

The first and most important protective method is to cut off the flow of sewage into the lake and redirect its flow beyond the catchment area. In addition, leaky septic tanks and other uncontrolled discharges of pollutants should be identified and eliminated. If lakes are surrounded by agricultural areas, it may be necessary to change the land use practices in the catchment and reduce the amount of arable land in favor of grassland.

Wulpińskie Lake (north-eastern Poland, Olsztyn Lake District) is an example of a water body in which the protective treatments have caused improvements in water quality and other environmental conditions. This lake eutrophicated in the middle of the twentieth century due to excessive nutrient inflow which, in turn, was a result of an increase in wastewater entering the lake due to intensified recreation in the area and the subsequent effect on water quality, including leaks from septic tanks and putrefactive reservoirs.

In 1996, protection actions were started in the basin. In the first stage, the sewerage system was expanded and the localities and recreational centers around the lake were connected to the sewage system. Wastewater was redirected beyond the catchment of the lake. Through this method, the scattered sources of nutrients were eliminated. The next step was to eliminate the discharge of pre-treated wastewater to Wulpińskie Lake. That was done by redirecting the pre-treated wastewaters to the sewage system of Olsztyn, the capital of the region.

Until 1996, before the protective measures in the catchment of Wulpińskie Lake, the lake was affected by 1.6 tons $\cdot$ a^{-1} of phosphorus and > 13 tons a^{-1} of nitrogen, i.e. 0.24 g m^{-2} a^{-1} of P and 1.99 g m^{-2} a^{-1} of N. As a result, Wulpińskie Lake had high concentrations of P and N, which is characteristic for eutrophic water bodies (HAVENS et al 2001).

This study demonstrated that after reducing external nutrient loading to the lake, essential (apparently long-term) improvements in water quality were achieved.

Material and methods

Wulpińskie Lake (53°42.4' N, 20°22.1' E) is situated at a height of 106.04 m. The area of the water body is 706.7 ha and its maximum depth is 54.6 m (Table 1) (CHOIŃSKI 2008). The lake has two basins: eastern – Tomaszowska and western – Barwińska, which have different morphometric features. The basins are inter-connected by a narrow isthmus with a width of 60 m and a depth of 3.8 m. The western basin is a deep, elongated gutter. In this part of the lake bottom there are four distinct hollows. The eastern basin has a wheel-like shape and seven islands. The largest of these are Herta, Mewa and Urbanki. There are a few small inflows to the lake and Giłwa River which flows into the western bay from the SE and flows out in NW. The catchment area of the lake is 82.8 km^2 and the immediate catchment is 7.0 km^2. Areas bordering the reservoir are mainly barren land (62.4%), forests (16.7%), buildings (10.4%) and arable land (5.7%).

Table 1

Basic morphometric data of Wulpińskie Lake

Morphometric parameter	Value
Surface area	706.7 ha
Maximum depth	54.6 m
Average depth	10.9 m
Relative depth	0.0205
Depth index	0.19
Water volume	76990300 m^3
Maximum length	8321 m
Maximum width	2330 m
Elongation	3.6
Average width	849 m
Length of shoreline	24250 m
Shoreline development	3.4

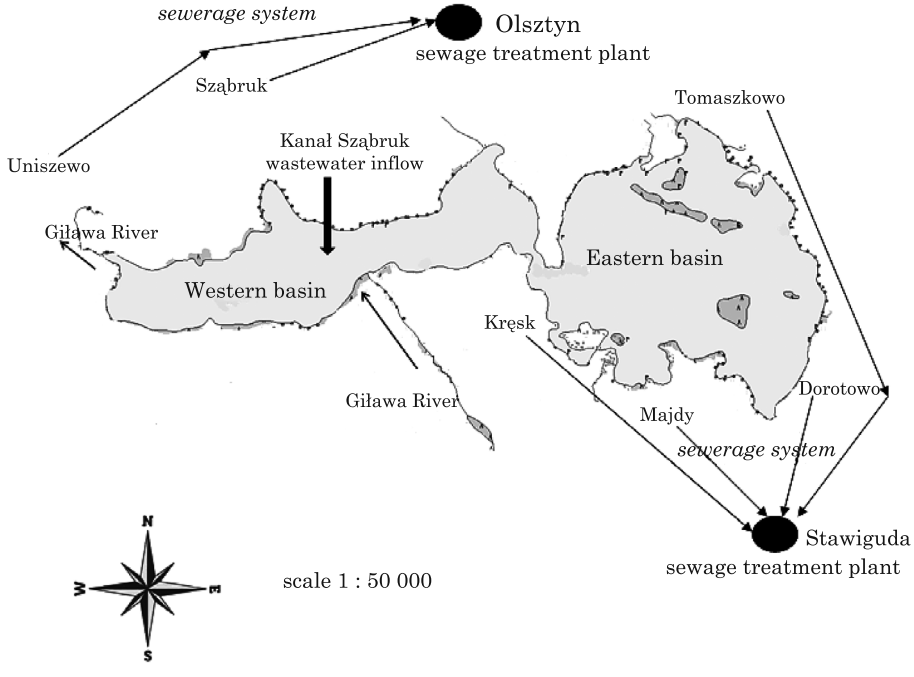

Fig. 1. Research area

Until 2002, Wulpińskie Lake received pre-treated municipal wastewater from the towns of Unieszewo (26.0 m^3 d^{-1}) and Sząbruk (28.0 m^3 d^{-1}). Sewage flowed into the western basin via a stream called Kanał Sząbruk. In order to protect the lake, in 2002, a 20-km collector was built and wastewaters were redirected to sewage treatment plants in Olsztyn.

The lake is surrounded by the towns of Tomaszkowo (population – 584), Dorotowo (population – 391), Majdy (population – 125) and Kręsk (population – 26) (Figure 1). In the catchment of the eastern basin there are also 18 recreational complexes, four holiday resorts and two camp sites. Towns adjacent to the lake and recreation areas were not connected to a sewage system. However, the loading of these sources was eliminated between 1996–1998, when the lake was encircled by a sewerage network and the buildings around the lake were connected to it. Later on, sewage was discharged into a modernized sewage treatment plant in Stawiguda, outside the catchment area of Lake Wulpińskiego (Figure 1).

Water samples for chemical analyses were collected at two stations located at the deepest point of two basins of Wulpińskie Lake. Station 1 was located in the eastern basin (20 m) and station 2 in the western basin (54 m). Samples were taken from a depth of 1 m below the surface and 1 m above the bottom. A chemical analysis was conducted according to the guidelines given in Standard Methods (1999). Electrical conductivity was measured with a WTW MultiLine F/SET – 3, mineral phosphorus was determined with ammonium molybdate and ascorbic acid by a MACHEREY-NAGEL NANOCOLOR UV/VIS spectrophotometer, total phosphorus was determined after digestion with sulfuric acid and potassium persulfate with ammonium molybdate and ascorbic acid by a MACHEREY-NAGEL NANOCOLOR UV/VIS spectrophotometer, ammonium nitrogen was determined by Merck SQ 118 spectrophotometer, total nitrogen was determined by HACH TOC-TN IL 550 carbon and nitrogen analyzer, and calcium, magnesium and chloride were determined by DIONEX DC ICS 5000 ion chromatography

A one-way ANOVA, $p=0.05$, post-hoc Tukey was used for statistical analyses using Statistica 9.0. The alternative hypothesis tested was based on statistically significant differences of mean concentrations of P and N compounds, Ca, Cl and the values of conductivity between the control year (1992) and the experimental years (1999, 2008), i.e. after application of protection techniques in the catchment.

Results

The results showed that the use of protection techniques did not cause any significant changes in P concentrations in the surface layer of Wulpińskie Lake (Table 2). Before and after the protective actions, inorganic P concentrations varied in surface water from <0.05 to 0.108 mg L^{-1} and TP from 0.020 to 0.180 mg L^{-1}. The average values fluctuated around 0.045 mg L^{-1} (inorganic P) and around 0.076 mg L^{-1} (TP) (Figure 2, Figure 3). However, bottom water P concentrations were different before and after measures (Table 2); before the protection measures inorganic P concentrations averaged 0.238 mg L^{-1} and total P 0.384 mg L^{-1} (Figure 2, Figure 3) while five years after the end of protection measures, in 2008, the mineral P concentration was 0.106 mg L^{-1} and TP was 0.157 mg L^{-1}.

Table 2
Results of one – way ANOVA analyses (with Tukey HSD) for investigated variables in Wulpińskie Lake water

Variable	*F* value	*p* value	Years which differed significantly from 1984 (before the application of protection techniques in the catchment)
$P_{min.}$ surface	0.931894	0.401273	–
$P_{min.}$ bottom	4.101017	0.023115	1992, 2008
TP surface	0.227555	0.797389	–
TP bottom	4.816231	0.012724	1992, 2008
$N_{min.}$ surface	0.839057	0.438766	–
$N_{min.}$ bottom	4.540644	0.015985	1992, 2008
TN surface	21.43367	0.000000	1992, 1999, 2008
TN bottom	13.52575	0.000025	1992, 1999, 2008
Chlorides surface	1652.200	0.000000	1992, 1999, 2008
Chlorides bottom	1076.976	0.000000	1992, 1999, 2008
Calcium surface	11.58936	0.000087	1992, 1999, 2008
Calcium bottom	43.71172	0.000000	1992, 1999, 2008
Conductivity surface	95.2324	0.000000	1992, 1999, 2008
Conductivity bottom	176.9345	0.000000	1992, 1999, 2008

Along with P, no changes in inorganic N concentrations in the surface water layers (on average 0.056 mg L^{-1}) were found (Figure 4, Table 2), but deep water concentrations decreased from 0.560 mg $\cdot$ l^{-1} to 0.165 mg L^{-1} (Figure 4). Correspondingly, before the protective measures in the surface water,

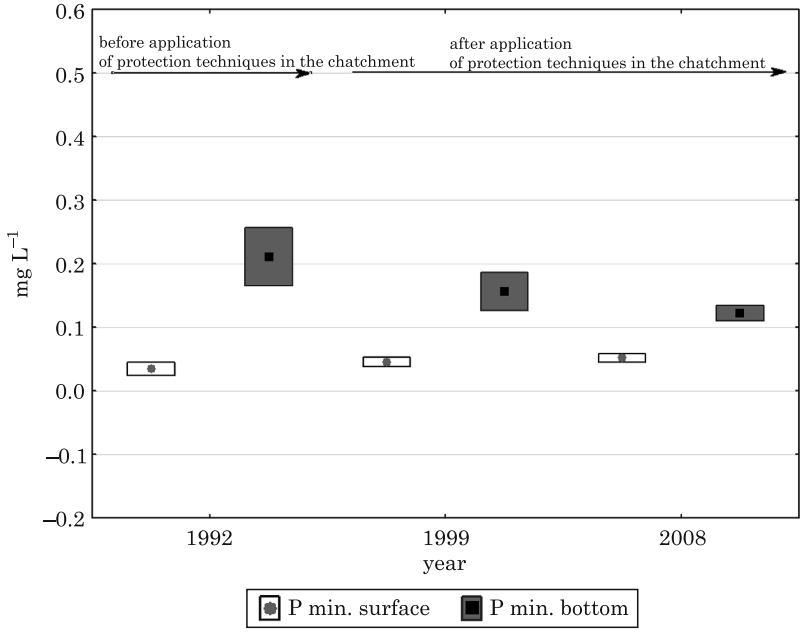

Fig. 2. Mean annual concentrations of phosphate – phosphorus (± SEM and SD) in the water of Wulpińskie Lake

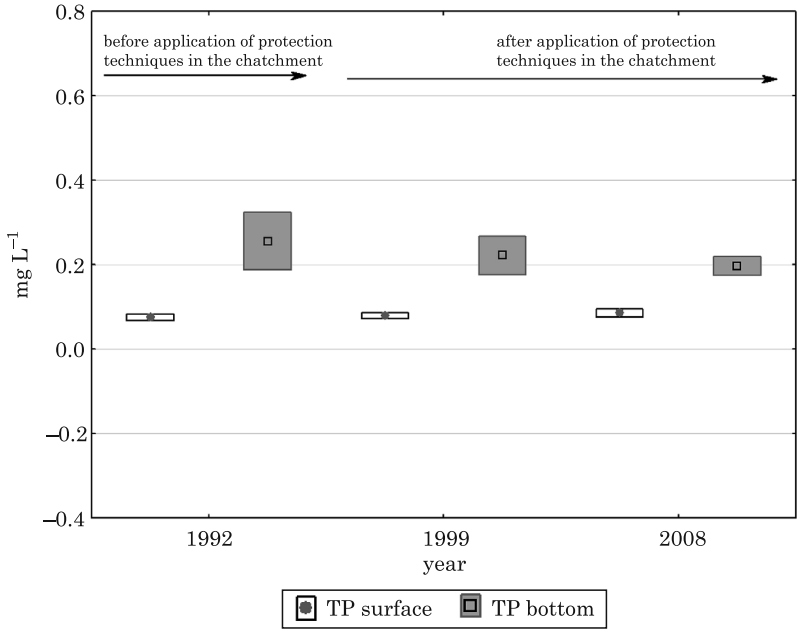

Fig. 3. Mean annual values of total phosphorus content (± SEM and SD) in the water of Wulpińskie Lake

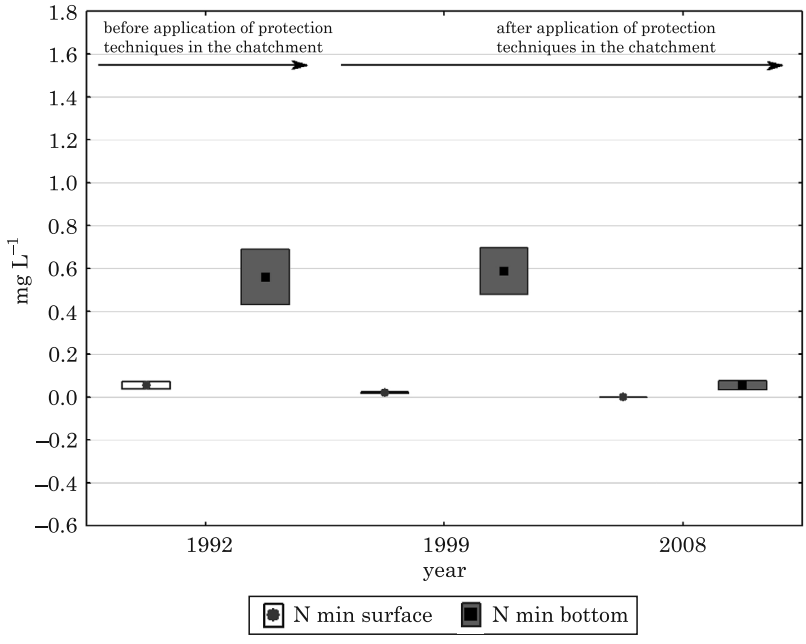

Fig. 4. Mean annual values of mineral nitrogen content (± SEM and SD) in the water of Wulpińskie Lake

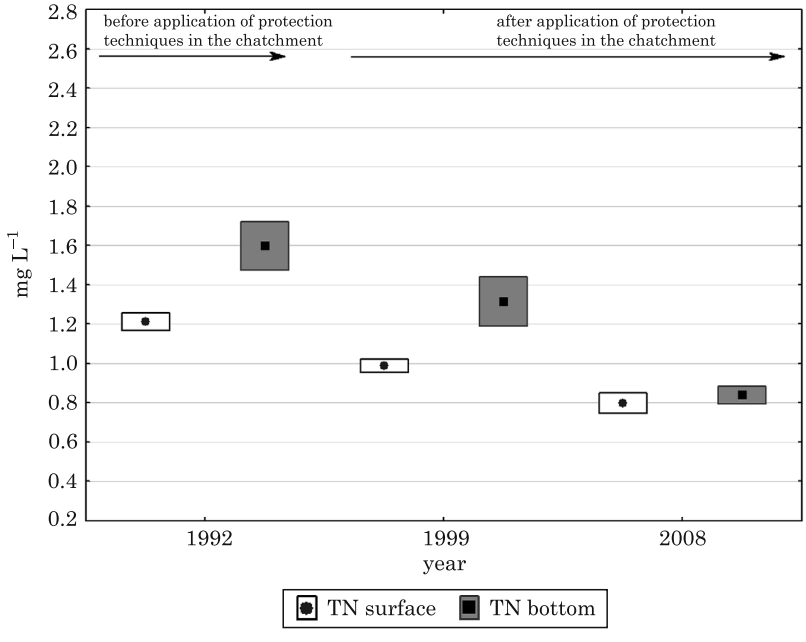

Fig. 5. Mean annual values of total nitrogen content (± SEM and SD) in the water of Wulpińskie Lake

the mean concentration of TN was 1.21 mg L^{-1} and above the bottom 1.60 mg L^{-1}, respectively, while after the end of the measures the concentrations were significantly lower, i.e. 0.80 mg L^{-1} and 0.84 mg L^{-1} (Figure 5).

The results revealed a clear change in chloride concentration as well (Table 2); before the protection measures the average concentration was 33.8 mg L^{-1} (Figure 6), and after it was 16.8 mg L^{-1}. Five years after the end of the measures, a further reduction was found – the concentrations varied between 14.5 mg L^{-1} to 14.3 mg L^{-1} (Figure 6). Clear differences in calcium concentrations were also found (Figure 7). In parallel with the above results, significant differences in electrical conductivity were found (Table 2). Before the protection measures, the mean value on the surface was 284 μS L^{-1} and above the bottom it was 315 μS L^{-1}, respectively. In 2008, the respective values were 201 μS L^{-1} and 210 μS L^{-1} (Figure 8).

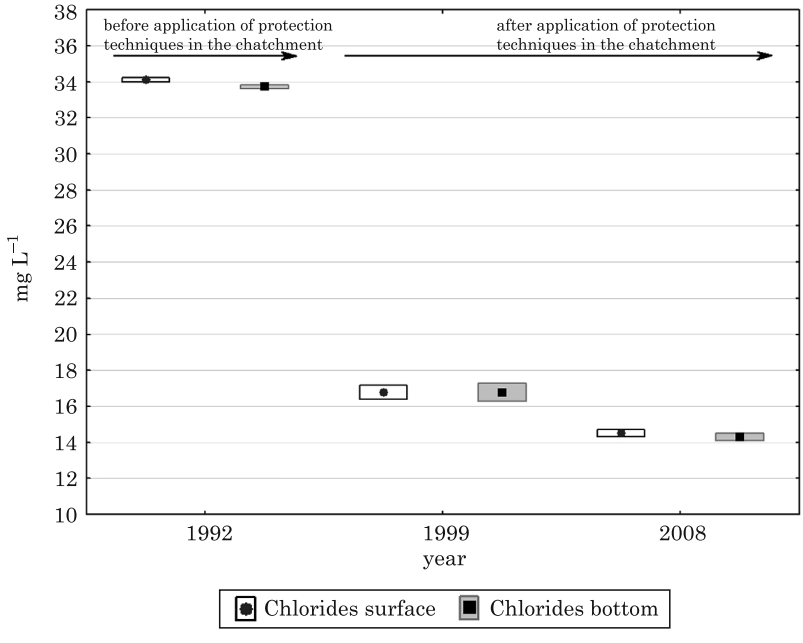

Fig. 6. Mean annual values of chloride content (± SEM and SD) in the water of Wulpińskie Lake

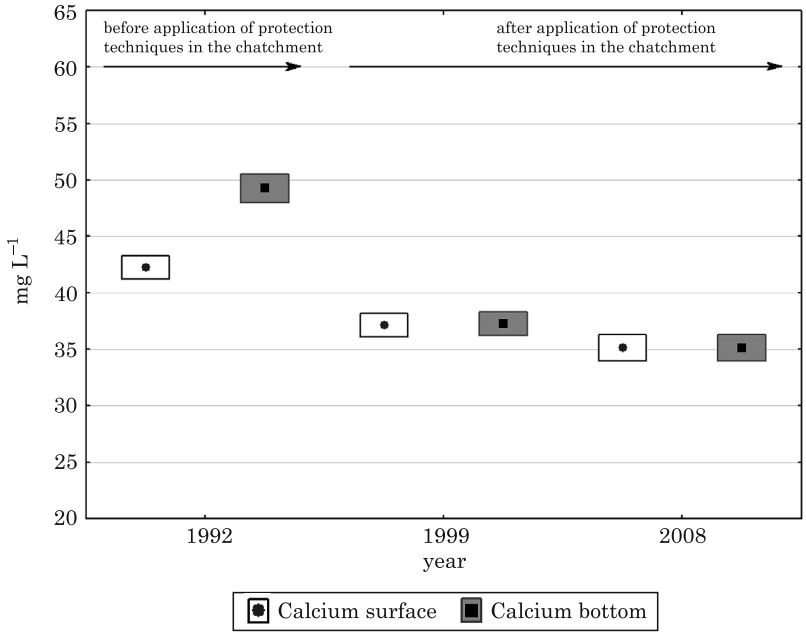

Fig. 7. Mean annual values of calcium content (± SEM and SD) in the water of Wulpińskie Lake

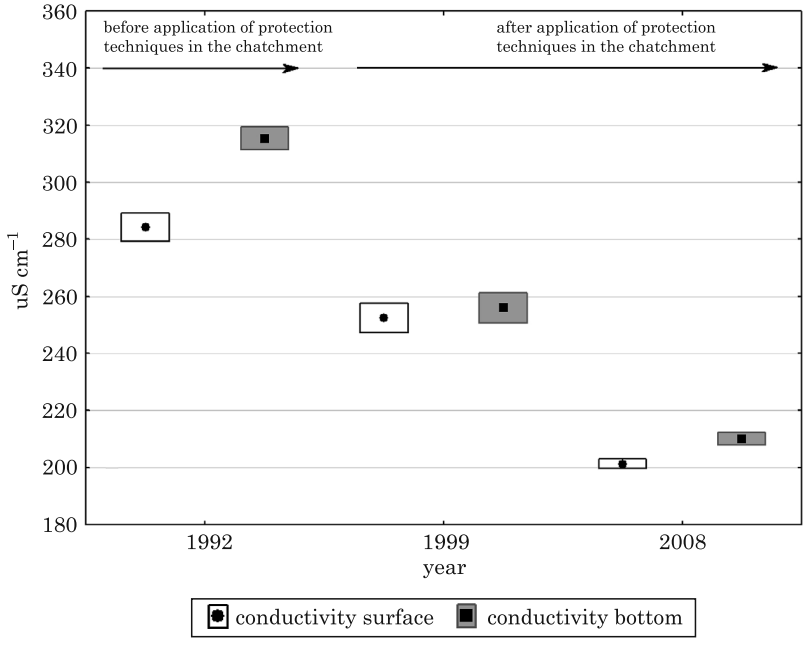

Fig. 8. Mean annual values of water conductivity (± SEM and SD) of Wulpińskie Lake

Discussion

According to KUBIAK and TÓRZ (2005) and GROCHOWSKA and TANDYRAK (2007), the quantity of nutrients in an aquatic ecosystem depends not only on their external load, but also on long-term accumulation to sediments. SCHINDLER and FEE (1974) have stated that lake sediments act as nutrient „trap" until their sorption capacity is depleted. In lakes with high trophic state and oxygen depletion in the near-bottom zone, sediments may act as a significant P source and become the cause of secondary pollution (HICKEY and GIBBS 2009, LIM and CHAI 2011). The substances stored in sediments may have a harmful impact on lake water for a long time. The wastewater inflow to Wulpińskie Lake and the bottom water oxygen depletion may be conducive to the removal of P to the bottom sediments. The anoxic conditions may also limit the nitrification of ammonia, which was produced in the decomposition of organic matter.

In moderately eutrophic lakes, P and N cycles are regulated largely by phytoplankton and during its maximum development, inorganic P concentration may decrease below to the detection limit of standard analytical methods (GOLTERMAN 1975). The results showed that despite the external load, P was lowered by 77% and N by 28%, in the surface water layers there was no clear change in total phosphorus or total nitrogen concentrations relative to the time-period before the treatments. The decrease in TP was caused mainly by the decrease in inorganic P concentration. Micro-organisms play a key role in the transformation of N compounds; their activity depends on many factors, and ammonification, for example, can take place under both aerobic and anaerobic conditions across wide pH and temperature ranges (DUNALSKA et al. 2012). The intensity of the process ultimately depends on the activity of microbes. According CERCO (1989) and HÖHENER and GÄCHTER (1994), the release of ammonium-N from lake sediments is correlated with temperature. As already stated, NH_4-N concentrations in Wulpińskie Lake were very high before the protection measures (up to 1.5 mg L^{-1}). Improving the oxygen conditions in deeper waters resulted in NH_4-N oxidation to NO_3-N and a rapid decrease in NH_4-N concentration.

Non-contaminated Polish surface water typically has up to 15 mg L^{-1} of chlorides (PASCHALSKI and OLSZEWSKI 1959), which is « 50% of the level found in Wulpińskie Lake prior to 1992. However, in 2008 Cl concentrations were only c.a. 13 mg L^{-1} (Figure 6). Respectively, calcium concentrations usually vary in Polish lakes between 25–75 mg L^{-1} (KOLADA et al 2005), and we found very similar concentrations in Wulpińskie Lake as well. KOWALSKI (1997) suggested that Ca concentrations in surface waters are influenced by processes occurring in the presence of organic pollutants introduced with sewage. In the

surface layer, there was a distinct minimum of calcium during the summer stagnation, which coincided with the highest concentrations of chlorophyll *a* and the lowest water transparency. This relationship seems to be associated with the biological decalcification of water during high photosynthesis and the absence of free carbon dioxide (HÅKANSON et al 2005). The resulting calcium carbonate falls to deeper layers of the lake, causing an increase in metal ions at the bottom. After cutting off the external load, calcium concentrations decreased substantially (Figure 7). In good agreement with Ca and Cl results and the results of MARSZELEWSKI (2005), electrical conductivity values decreased significantly after the protection measures in Wulpińskie Lake (Figure 8), which strongly suggests essential improvements in water quality.

Conclusions

The results showed that a radical reduction in external loading resulted in a decrease in nutrient (P, N, Cl and Ca) concentrations in lake water. At the same time, the results indicate that nutrients were released from the bottom sediments of the lake. Along with the above, electrical conductivity decreased substantially relative to the prior water protection measures.

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References

BENNET E.M., CARPENTER S.R., CARACO N.F. 2001. *Human impact on erodible phosphorus and eutrophication: A global perspective*. Bioscience, 51: 227–232.

CARPENTER S.R. 2008. *Phosphorus control is critical to mitigating eutrophication*. Proceedings of the National Academy of Science, 105: 11039–11040.

CASTILLO M.M. 2010. *Land use and topography as predictors of nutrient levels in a tropical catchment*. Limnologica, 40: 322–329.

CERCO C.F. 1989. *Measured and modelled effects of temperature, dissolved oxygen and nutrient concentration on sediment – water nutrient – exchange*. Hydrobiology, 174: 185–194.

CHOIŃSKI A. 2008. *Limnologia fizyczna Polski*. Wyd. UAM Poznań, s. 547.

DUNALSKA J. 2003. *Impact of limited water flow in a pipeline on the thermal and oxygen conditions in a lake restored by hypolimnetic withdrawal method*. Polish Journal of Environmental Studies, 12(4): 409–415.

DUNALSKA J.A., GÓRNIAK D., JAWORSKA B., GAISER E.E. 2012. *Effect of temperature on organic matter transformation in a different ambient nutrient availability*. Ecological Engineering, 49: 27–34.

FRATERRIGO J.M., DOWNING J.A. 2008. *The influence of land use on lake nutrients varies with watershed transport capacity*. Ecosystems DOI: 10, 1007/s10021-008-9176-6.

FRIESE K., SCHMIDT G., CARCALHO DE LENA J., NALINI JR H.A., ZACHMANN D.W. 2010. *Anthropogenic influence on the degradation of an urban lake – The Pampulha reservoir in Belo Horizonte, Minas Gerais*, Brazil. Limnologica, 40: 114–125.

GAWROŃSKA H., LOSSOW K. 2003. *Possibilities of a saprotrophic lake recultivation exemplified by Lake Długie in Olsztyn*. Polish Journal of Environmental Studies, 12(3): 301–307.

GOLTERMAN H.L. 1975. *Physiological limnology*. Elsevier Scientific Publishing Company, Amsterdam – Oxford – New York.

GROCHOWSKA J., TANDYRAK R. 2007. *Nitrogen and phosphorus compounds in Lake Pluszne*. Archives of Environmental Protection, 33: 1, 59–66.

HÅKANSON L., BLENCKNER T., BRYHNA, C., HELLSTRÖM S.S. 2005. *The influence of calcium on the chlorophyll – phosphorus relationship and lake Secchi depths*. Hydrobiologia, 537: 111–123.

HAVENS K.E., FUKUSHIMA T., XIE P., IWAKUMA T. M., JAMES R.T., TAKAMURA N., HANAZATO T., YAMAMOTO T. 2001. *Nutrient dynamics and the eutrophication of shallow lakes Kasumigaura (Japan)*, Danghu (PR China) and Okeechabe (USA). Environmental Pollution, 111(2): 263–272.

HICKEY CH.W., GIBBS M.W. 2009. *Lake sedimental phosphorus release management – Decision support and risk assessment framwork*. New Zeland Journal of Marine and Freshwater Research, 43: 819–856.

HÖHENER P., GÄCHTER R. 1994. *Nitrogen cycling across the sediment – water interface in an eutrophic, artificially oxygenated lake*. Aquatic Sciences, 6(2): 115–132.

ISTVÁNOVICS V. 2009. *Eutrophication of lakes and reservoirs*. Encyclopedia of Inland Waters, pp. 157–165.

JEPPESEN E., SØNDERGAARD M., MEERHOFF M., LAURIDSEN T.L., JENSEN J.P. 2007. *Shallow lake restoration by nutrient loading reduction – some recent findings and challenges ahead*. Hydrobiologia, 584: 239–252.

JORGENSEN S.E. 2001. *Water quality. The impact of eutrophication*. Lake and Reservoir Management, 3: 15–18.

KOLADA A., SOSZKA H., CYDZIK D. GOŁUB M. 2005. Abiotic typology of Polish lakes. Limnologica, 35: 145–150.

KOWALSKI T. 1997. *Wpływ zanieczyszczeń organicznych na skład wód*. Ochrona Środowiska, 2(65): 33–36.

KUBIAK J., TÓRZ A. 2005. *Eutrofizacja. Podstawowe problemy ochrony wód jeziornych na Pomorzu Zachodnim*. Słupskie Prace Biologiczne, 2: 17-36.

LI Y., WANG CH., YANG L., LI Y. 2007. *Influence of seepage face obliquity on discharge of groundwater and its pollutant into lake from a typical unconfined aquifer*. Journal of Hydrodynamics, 19(6): 756–761.

LIM B., KI B., CHAI J. 2011. *Evaluation of nutrient release from sediments of artificial lake*. Journal of Environmental Engineering, 137(5): 347–354.

MALMAEUS J.M., HÅKANSON L. 2004. Development of a lake eutrophication model. Ecological Modelling, 171: 35–63.

MARSZELEWSKI W. 2005. *Zmiany warunków abiotycznych w jeziorach Polski północno-wschodniej*. Wydawnictwo UMK, s. 350.

OLSZEWSKI P., PASCHALSKI J. 1959. *Wstępna charakterystyka limnologiczna niektórych jezior Pojezierza Mazurskiego*. Zeszyty Naukowe WSR Olsztyn, 4: 1–10.

REYNOLDS C.S. 2003. *The development of perceptions of aquatic eutrophication and its control*. Ecohydrology and Hydrobiology, 3(20): 149–163.

SCHINDLER D.W., FEE E.J. 1974. *Experimental lakes area: whole – lake experiments and eutrophication*. Journal of the Fisheries Research Board of Canada, 31(5): 937–953.

Standard methods for examination water and wastewater. 1999. American Public Health Association. AWWA, WPCF, Washington DC.

StatSoft Inc. 2010. STATISTICA (data analysis software system), version 9.1. www.statsoft.com.

WANG J., ZHANG K., LIANG B. 2012. *Tracing urban sewage pollution in Chaohu lake (China) using linear alkylbenzenes (LABs) as molecular marker*. Science of the Total Environment, 414: 356–363.

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KNOWLEDGE AND OPINIONS OF STUDENTS ON ADDITIVES USED IN FOOD PRODUCTION

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K e y w o r d s: food additives, students, opinion.

A b s t r a c t

The objective of the study was to analyse the knowledge and opinions of students on additives used in food production. The studies were conducted in 2010 with a survey methodology using a questionnaire among 215 students from the University of Warmia and Mazury with a varied socio-demographic profile. The statistical analysis of empirical material included the analysis of frequency distribution of the recorded responses and the evaluation of the significance of the impact of the socio-demographic features on the investigated phenomena. chi-square test of Statistica 9.0 software (StatSoft Inc., USA) was applied to compare the data.

It was demonstrated that the majority of respondents paid attention to the presence of additives in food products. By analyzing the results of students opinions on additives, it was shown that the highest proportion of respondents indicated that the use of additives was rather necessary. The knowledge of the purpose of adding preservatives, aromatizing compounds and stabilizers to food was predominantly correct among students. It was observed that the knowledge of antioxidants was smaller. Among a substantial proportion of the respondents, there were some fears on the use of additives. The existing fears may indicate a need for a wider informative approach towards consumers.

WIEDZA I OPINIE STUDENTÓW NA TEMAT SUBSTANCJI DODATKOWYCH STOSOWANYCH W PRODUKCJI ŻYWNOŚCI

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Abstrakt

Celem pracy była analiza wiedzy i opinii studentów w odniesieniu do substancji dodatkowych stosowanych w produkcji żywności. Badania przeprowadzono w 2010 r., metodą wywiadu z użyciem kwestionariusza ankiety wśród 215 studentów Uniwersytetu Warmińsko-Mazurskiego o zróżnicowanej charakterystyce socjo-demograficznej. W analizie statystycznej materiału empirycznego zastosowano analizę rozkładu częstości uzyskanych odpowiedzi oraz ocenę istotności wpływu cech socjo-demograficznych respondentów na badane zjawiska. Do analizy danych zastosowano test chi-kwadrat programu Statistica 9.0 (StatSoft Inc., USA).

Wykazano, iż większość respondentów zwracała uwagę na obecność substancji dodatkowych w produktach żywnościowych. W wynikach dotyczących opinii studentów na temat konieczności stosowania substancji dodatkowych wykazano, że największy odsetek respondentów stwierdził, iż stosowanie substancji dodatkowych jest raczej konieczne. Wiedza dotycząca celu stosowania substancji konserwujących, aromatyzujących oraz stabilizujących w żywności wśród większości studentów była poprawna. Zauważono natomiast mniejszą wiedzę z zakresu stosowania substancji przeciwutleniających. Wykazano istnienie obaw dotyczących stosowania substancji dodatkowych wśród znacznej liczby respondentów.

Obawy te mogą świadczyć o konieczności szerszego informowania konsumentów na ten temat.

Introduction

Although food additives, without which it is difficult to imagine food production, are not nutrients, they are components of a product and impact its properties. The necessity for their addition is determined by technological, health and economical factors. In each country, the laws on food and nutrition specify which substances may be added to food, for specified purposes and in specified amounts (GERTIG 2008). In Poland, the list of additives that may be traded and used in food are detailed in the Commission Regulation (UE) No 1129/2011 and (UE) No 1130/2011 of 12 November 2011 (Dz.Urz. UE L 295) according to their technological functions, detailed conditions of their storage and their maximum permissible limits.

Studies aimed at identifying the permissible additives include numerous aspects, such as a determination of their impact on human health, histopathological, embryotoxic and carcinogenic lesions as well as safe and toxic genetic doses (GERTIG 2008).

The use of additives is a controversial issue and it thus provokes predominantly negative emotions. Nowadays, consumers are searching for healthy products that are attractive in their colour, tastiness and durability with the lowest number of additives possible (RUTKOWSKI 2006). In the last five decades, the use of additives has been found to be an essential element of technological processes, especially for additives which impact durability and the health properties of food products (RUTKOWSKI 2006).

The optimal durability of food is ensured by using substances with preserving and antioxidative properties. Preservatives (E200-E299) are used to inhibit or prevent unfavourable microbiological (growth of bacteria, moulds, fungi),

chemical (non-enzymatic browning) and biochemical (inactivation of metabolites, some enzymes and substances essential for microbial growth) changes. No preservative has the same effect on all microorganisms (ROGOZIŃSKA, WICHROWSKA 2011). Benzoic acid has been known for years and used as a preservative. It shows its preservation properties in an acid environment, predominantly towards fungi. It is mainly used to preserve effervescent non-alcoholic beverages as well as fruit and vegetable preserves. The disadvantages of benzoic acid are that it reduces taste, causes turgidity of protein-containing solutions, irritates the epithelium and acidifies the body (GERTIG 2008).

Antioxidants constitute a group of substances which extend the durability of products, yet with a different mechanism than for preservatives (GERTIG 2004). The action of these substances refers to two groups of phenomena: biological oxidation (with air oxygen) of non-lipid substances with enzymes and chemical lipid oxidation which is commonly called "rancidity" (ROGOZIŃSKA, POBIEREŻNY 2008). Antioxidants reduce the speed of oxidative reactions of food nutrients, thereby preventing the degradation of free radicals into volatile odour substances or the activation of polyphenol oxidase enzymes which generate a greyish pigment, i.e. melanin (ZIELIŃSKI, KOZŁOWSKA 2008). Of the natural antioxidants, special attention should be paid to tocopherols and organic acids that prevent enzymatic browning and simultaneously create the conditions that are unfavourable for microorganisms, such as bacteria and moulds. Antioxidants that are most beneficial to food products due to their synergic action are labelled with the symbols E300-E321 (ROGOZIŃSKA, WICHROWSKA 2011).

Food products are also supplemented with deficient compounds which are thought to eliminate disease conditions and vitamin deficiencies or deficiencies in other nutrients. The objective of food supplementation is, apart from increasing its nutritional value, to restore its natural value that has been lost during technological processing. In Poland, L-ascorbic acid is added to powdered milk, effervescent fruit beverages and vegetable preserves; retinol or β-carotene and cholecalcipherol – to margarines; and calcium carbonate and iron(III) sulphate – to flour. Vitamin B is added to flour, cereal products, fruit juices and some beverages (GERTIG 2008). TARKO et al. (2012) describe several plant products which are used in food production as sources of polyphenols with high antioxidant potential.

Technological processes often require using different additives in order to make a production process run smoothly and correctly as well as to make it economically efficient. Such additives include stabilizers, emulsifiers, surface covering substances and thickeners. These are chemical substances with varied properties whose application must be justified by the conditions and method of manufacturing a given food product (GERTIG 2008).

Despite strict human health requirements, additives considered to be safe have been discovered to be harmful after many years of usage and have been removed from the list of permitted compounds. For instance, for many colorants and synthetic sweeteners, it has been found that they induce neoplastic lesions or are teratogenic. Many additives, despite being authorized for the use in food, may cause skin allergic reactions or food allergies in sensitive individuals. It is thus important to thoroughly investigate the composition of a given product, especially if it is bought for the first time (GERTIG 2008, ZIELIŃSKA, CZERWIONKA-SZAFLARSKA 2008).

According to studies carried out in 2000 on a group of 100 persons, nearly 75% of the respondents declared that information featured on food packages was important (OZIMEK 2005) while the studies conducted in 2004 on a group of 1,250 consumers demonstrated that information on the lack of preservatives, taste enhancers and colorants was a factor influencing purchase decisions (GUTKOWSKA, OZIMEK 2005). SOON-MI et al. (2011) indicated that consumer education on food additives should be more widespread.

The objective of the study was to analyse the knowledge and opinions of students on additives used in food production.

Materials and Methods

The study was carried out in 2010 on a group of 215 students (148 women and 67 men) from the University of Warmia and Mazury in Olsztyn. The respondents represented four faculties: The Faculty of Social Sciences (24.7%), The Faculty of Technical Sciences (29.8%), The Faculty of Food Science (23.3%) and The Faculty of Theology (22.3%). The study was of a survey type and a questionnaire was used as a research tool. The questions in the questionnaire related to the interest of the respondents in the additives in food products, knowledge of the functional properties of selected additives and opinions on the necessity to use additives in food production. The results of the studies are presented as the frequency distribution of the recorded responses and they were statistically analysed with chi-square test of Statistica 9.0 software (StatSoft Inc., Tulsa, USA) in order to determine the significance of the impact of gender and faculty of study on the investigated phenomena. The relations were assumed significant at $p \leq 0.05$.

Results and Discussion

The studies demonstrated that the most common answer to the question on the frequency of attention paid to the content of additives in purchased food products was "sometimes", which was indicated by 31.6% of the respondents (Table 1). This response was more often given by women than by men, yet the difference between these groups was not statistically significant (34.5% vs. 25.4%, $p = 0.45$). The option "rarely" was most often selected by students from the Faculty of Food Science (16.0%). The studies by KOŚCIOŁEK et al. (2012) showed that 64% of students from postsecondary schools "sometimes" paid attention to additives in food products. Similar results were reported in the studies by KREJPCIO et al. (2011) in which this response was selected by 50% of students from the Faculty of Architectural Engineering and Environmental Engineering. DZIUBANEK and ZUŻAŁEK (2008) recorded that 30% of students from the Poznań University of Technology and 50% of students from the University of Natural Sciences "sometimes" paid attention to the content of additives in food products. TARNAVÖLGYI and MOLNÁR (2004) demonstrated that the content of additives in food did not have any impact or had only a moderate impact on the selection of food by consumers.

Table 1

The frequency of paying attention to the presence of additives in purchased food products

Criterion		Respondents [%]					p
		frequency					
		always	often	sometimes	rarely	never	
Gender	total	6.5	22.3	31.6	23.3	16.3	0.45
	women	6.1	23.0	34.5	23.0	13.4	
	men	7.5	20.9	25.4	23.9	22.3	
Faculty	Technical sciences	9.3	18.8	25.0	28.1	18.8	0.56
	Social sciences	9.4	18.9	30.2	26.4	15.1	
	Food science	2.0	30.0	40.0	16.0	12.0	
	Theology	4.2	22.9	33.3	20.8	18.8	

p – statistically significant at $p \leq 0.05$

By analyzing the results on the opinions of the students on the necessity to supplement food products with additives, it may be pointed out that the highest proportions of both women (33.8%) and men (35.8%) were of the opinion that the use of these substances was rather necessary (Table 2). Considering the faculty of the respondents, the highest proportion of the students who believed that it was definitely needed or rather necessary to use

food additives came from the Faculty of Food Science (52.0%) while the lowest was observed for the Faculty of Theology (20.8%). The responses given by the respondents, both in relation to gender and the faculty, did not differ statistically ($p = 0.93$ and $p = 0.21$, respectively). KREJPCIO et al. (2011) demonstrated that 65% of students represented the view that the use of additives in food was necessary. KOŚCIOŁEK et al. (2012) found that 34% of respondents thought that food could be produced without additives whereas 24% of respondents believed that it was impossible.

Table 2

Opinion on the necessity of the use of additives in purchased food products

Criterion		Respondents [%]					p
		opinion					
		definitely needed	rather necessary	no opinion	rather unnecessary	definitely not necessary	
Gender	total	4.7	34.4	23.7	27.9	9.3	0.93
	women	4.1	33.8	24.3	29.1	8.8	
	men	6.0	35.8	22.4	25.4	10.4	
Faculty	Technical sciences	4.7	34.4	23.4	26.6	10.9	0.21
	Social sciences	7.6	35.9	17.0	28.3	11.2	
	Food science	6.0	46.0	24.0	22.0	2.0	
	Theology	0.0	20.8	31.3	35.4	12.5	

p – statistically significant at $p \leq 0.05$

The results of the conducted studies demonstrated that 55.4% of the respondents expressed some fears related to the use of additives in food (Table 3). A slightly higher proportion of women (57.4%) than men (50.7%) expressed such fears, although the difference in the distribution of responses was not statistically significant between these groups ($p = 0.13$). The highest proportions of persons who selected this response were recorded among the students of the Faculty of Food Science (62.0%) and the Faculty of Theology (62.5%). Among the respondents from the Faculty of Theology, the proportion of students not showing any fear of additives was lowest (14.6%). OZIMEK et al. (2004) and KREJPCIO et al. (2011) also demonstrated that consumers expressed some fears in relation to the use of food additives. Similar results were recorded in Korea by SOON-MI et al. (2011) who found that consumers were very concerned about the amount of preservatives, artificial colorants and sweeteners in food. Over 2/3 of the respondents felt that information on food additives was insufficient.

Table 3

Concerns with the application of additives in foods products

Criterion		Respondents [%] concerns					p
		definitely I have concerns	rather I have concerns	I have no opinion	rather I do not have concerns	definitely I do not have concerns	
Gender	total	15.4	40.0	17.2	23.3	4.1	0.13
	women	15.5	41.9	18.9	21.6	2.1	
	men	14.9	35.8	13.4	26.9	9.0	
Faculty	Technical sciences	10.9	31.3	20.3	29.7	7.8	0.32
	Social sciences	17.0	41.5	15.1	22.6	3.8	
	Food science	14.0	48.0	10.0	26.0	2.0	
	Theology	20.8	41.7	22.9	12.5	2.1	

p – statistically significant at $p \leq 0.05$

In the present study, the knowledge of the students on the purpose of using antioxidants, preservatives, aromatizing substances and stabilizers was verified by providing several answers with a possibility to select only one correct response.

The analysis of the results demonstrated that 34.9% of the respondents selected the correct answer regarding the purpose of using antioxidants, with women displaying higher knowledge than men (36.5% vs. 31.4%) and students from the Faculty of Food Science (56.0%) than from the other faculties (18.8–37.7%; Table 4).

Table 4

Indications of correct answers on the application of antioxidants, stabilizers, preservatives and flavourings

Criterion		Respondents [%]			
		antioxidants	stabilizers	preservatives	flavourings
Gender	total	34.9	47.9	66.0	86.0
	women	36.5	47.3	68.9	93.9
	men	31.4	49.3	59.7	68.7
Faculty	Technical sciences	28.1	42.2	53.1	73.4
	Social Sciences	37.7	32.1	79.2	92.5
	Food Science	56.0	66.0	74.0	90.0
	Theology	18.8	54.2	60.4	91.7

Nearly half of the respondents (47.9%) expressed an awareness of the purpose of using stabilizers (Table 4). A slightly higher percentage of the men than of the women indicated "maintaining the physical properties of food products" as the purpose of adding stabilizers (49.3% vs. 47.3%). The highest proportion of the correct answers was recorded among the students from the Faculty of Food Science (66.0%). Among the respondents representing the other faculties, the rate of correct responses ranged from 32.1% (the Faculty of Social Sciences) to 54.2% (the Faculty of Theology).

The knowledge of the purpose of using preservatives and aromatizing substances in food was demonstrated by over a half of the respondents (66.0% and 86.0%, respectively). The students from the Faculty of Social Sciences, Faculty of Food Science and Faculty of Theology showed higher knowledge than the students from the Faculty of Technical Sciences (Table 4). The percentage of women demonstrating this knowledge was higher compared to the men. The studies by KREJPCIO et al. (2011) also demonstrated that the students from the Faculty of Food Sciences had higher knowledge of the purpose of using preservatives than the students from the Faculty of Architectural Engineering and Environmental Engineering.

Conclusions

1. The conducted studies indicate that the respondents were predominantly concerned with the content of additives in food products, which may result from their interest in this issue.

2. The knowledge of the purpose of using preservatives, aromatizing substances and stabilizers was correct for the majority of respondents while a lower knowledge of the objective of using antioxidants may result from the fact that this information is less popularized by the media. This study shows that the knowledge of additives depends to a minor degree on the type of faculty of study. Nevertheless, the students from the Faculty of Food Science had a higher knowledge of this subject.

3. The significant proportion of respondents who expressed a fear of using additives may reflect the need for wider information dissemination among consumers on the use of additives in food production.

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References

DZIUBANEK G., ZUŻAŁEK J. 2008. *Świadomość ryzyka zdrowotnego wynikającego z konsumpcji artykułów spożywczych zawierających chemiczne dodatki do żywności w populacji studentów Wydziału Zdrowia Publicznego w Bytomiu*. Ann. Acad. Med. Siles, 62(3–4): 56–65.

GERTING H., DUDA G. 2004. *Żywność a zdrowie i prawo*. Wyd. Lekarskie PZWL, Warszawa, pp. 196–207.

GERTING H. 2008. *Dodatki do żywności*. [In:] *Żywienie człowieka. Podstawy nauki o żywieniu*. Red. J. Gawęcki, L. Hryniewiecki. Wyd. PWN, Warszawa, pp. 373–383.

GUTOWSKA K., OZIMEK J. 2005. *Wybrane aspekty zachowań konsumentów na rynku żywności – kryteria zróżnicowania*. Wyd. SGGW, Warszawa.

KOSCIOŁEK A., HARTMAN M., SPIOŁEK K., KANIA J., PAWŁOWSKA-GÓRAL K. 2012. *Ocena stanu wiedzy uczniów szkół policealnych na temat dodatków do żywności*. Bromat. Chem. Toksykol., XLV(3): 1055–1059.

KREJPCIO Z., SULIBORSKA J., HYŻYK A., DYBA S., SKWAREK K. 2011. *Ocena poziomu wiedzy na temat dodatków do żywności oraz ich spożycia w wybranych grupach studentów*. Bromat. Chem. Toksykol., XLIV(3): 404–408.

OZIMEK I. 2005. *Bezpieczeństwo żywności w aspekcie ochrony konsumenta w Polsce*. Wyd. SGGW, Warszawa.

OZIMEK I., GUTOWSKA K., ŻAKOWSKA-BIEMAS S. 2004. *Postrzeganie przez konsumentów zagrożeń związanych z żywnością*. Żywność. Nauka. Technologia. Jakość, 4(41): 100–111.

ROGOZIŃSKA I., POBIEREŻNY J. 2008. *Przeciwutleniacze stosowane w technologii żywności*. Inż. Ap. Chem., 47(3): 13–15.

ROGOZIŃSKA I., WICHROWSKA D. 2011. *Najpopularniejsze dodatki utrwalające stosowane w nowoczesnej technologii żywności*. Inż. Ap. Chem., 50(2): 19–21.

Rozporządzenie Komisji (UE) nr 1129/2011 oraz (UE) nr 1130/2011 z dnia 12 listopada 2011 r. w sprawie dozwolonych substancji dodatkowych. Dz. Urz.UE L 295.

RUTKOWSKI A. 2006. *Dodatki funkcjonalne do żywności. Geneza i perspektywy*. Przem. Spoż., 60(5): 2–8.

SOON-MI S., SUN H., YOUNHJA L., GUI-IM MOON, MIN-SHIK K., JU-HEE P. 2011. *Consumers' knowledge and safety perceptions of food additives: Evaluation on the effectiveness of transmitting information on preservatives*. Food Control, 22: 1054–1060.

TARKO T., DUDA-CHODAK A., WAJDA D. 2012. *Wzbogacanie żywności w związki polifenolowe*. Przem. Spoż., 66(10): 16–19.

TARRNAVÖLGYI G., MOLNÁR E. 2004. *Attitudes toward food additives in Hungarian consumers – preliminary results*. Acta Agriculturae Slovenica, supl. 1: 113–120.

ZIELIŃSKA J., CZERWIONKA-SZAFLARSKA M. 2008. *Nadwrażliwość na substancje dodatkowe do żywności – niedoceniany problem w praktyce pediatrycznej*. Przegl. Pediatr., 38: 307–312.

ZIELIŃSKI H., KOZŁOWSKA H. 2008. *Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions*. J. Agric. Food Chem., 48(6): 16.

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HONEY AS A SOURCE OF BIOACTIVE COMPOUNDS

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K e y w o r d s: phenolic compounds, flavonoids, metals, honey.

A b s t r a c t

The total phenolic content and the content of flavonoids and metals – K, Ca, Mg, Zn, Fe, Mn and Cu, were determined in honey of different botanical origin supplied mostly by domestic producers, in particular from north-eastern Poland. The daily intake of the analyzed compounds supplied with honey was determined for Poland on a per capita basis.

Phenolic compound levels in the analyzed honey ranged from 86 to 1141 mg kg^{-1}, and the highest concentrations were noted in buckwheat honey, followed by honeydew and heather honey. The majority of the analyzed honeys were characterized by low total flavonoid levels, and the highest flavonoid concentrations were noted in buckwheat honey at 27.8 mg kg^{-1} on average. The average flavonoid content of the analyzed samples was determined at 10.5 mg kg^{-1}. Summer multifloral honey and linden honey were most abundant in metals, and linden honey was characterized by the highest concentrations of K.

The results of this study and honey consumption statistics indicate that honey, in particular light-colored botanical varieties, is a poor dietary source of phenolic compounds and flavonoids. Honey is also deficient in metals. It is a source of approximately 0.02% of the recommended daily allowance (RDA) for calcium, 0.01% RDA for magnesium and 0.03% AIs of potassium.

MIÓD JAKO ŹRÓDŁO ZWIĄZKÓW BIOAKTYWNYCH

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S ł o w a k l u c z o w e: związki fenolowe, flawonoidy, metale, miód.

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Abstrakt

Określono poziomy stężeń związków fenolowych ogółem i flawonoidów oraz metali: K, Ca, Mg, Zn, Fe, Mn i Cu w botanicznych odmianach miodu pochodzącego w większości z pasiek krajowych, przede wszystkim z regionu północno-wschodniej Polski. Przedstawiono szacunkowe dzienne pobranie tych składników z porcją miodu spożywaną przez statystycznego mieszkańca Polski.

Poziomy związków fenolowych w badanych miodach były zróżnicowane i wynosiły od 86 do 1141 mg kg^{-1}, najwyższe oznaczono w miodach gryczanych, nieco niższe w spadziowych i wrzosowych. Większość miodów charakteryzowała się niskimi poziomami flawonoidów ogółem, najwięcej zawierały ich miody gryczane, średnio 27,8 mg kg^{-1}. Z kolei średnia zawartość flawonoidów w badanych miodach wyniosła 10,5 mg kg^{-1}. Najbogatszym źródłem metali okazały się miody letnie: wielokwiatowy letni oraz lipowy, z najwyższym udziałem K.

Zestawiając uzyskane wyniki z danymi dotyczącymi spożycia miodu stwierdzono, że miód, a szczególnie jego jasne odmiany botaniczne, wnoszą do dziennej diety niewielką ilość związków fenolowych oraz flawonoidów. Miody są również ubogim źródłem metali. Pobranie Ca z miodem stanowiło około 0,02% RDA, Mg około 0,01% RDA oraz K około 0,03% AIs.

Introduction

The therapeutic properties of honey have been valued for many centuries. The health benefits offered by honey can be attributed to the specific chemical composition of different honey types. Natural honey is a rich source of natural antioxidants which effectively minimize the risk of coronary heart disease, immune system disorders and cancer (Linus Pauling Institute). Honey also contains bioactive phenolic compounds, enzymes and minerals. The group of non-enzymatic antioxidants present in honey includes phenolic acids, flavonoids (flavanones and flavanols), carotenoids and organic acids. The antioxidant properties of honey are attributed mainly to the presence of phenolic compounds. Dark-colored varieties are believed to be have the most potent antioxidant properties, although research results are not always conclusive (LACHMAN et al. 2010, WILCZYŃSKA 2010, ESCUREDO et al. 2013). The total phenolic content of honey differs significantly across varieties. It was determined in the range of 17.6 to 189.5 mg per 100 g in nine types of Polish honey (WILCZYŃSKA 2010) and 59.9 to 121.4 mg per 100 g in heather and buckwheat honey (JASICKA-MISIAK et al. 2012).

The predominant flavonoids in European varieties of honey are pinocembrin, pinobanksin, chrysin, hesperetin, galangin, myricetin, kaempferol and quercetin. In Spanish honey, the presence of around 18 flavonoids was determined with total concentrations of 500 to 2000 μg 100 g^{-1} (ANKLAM 1998). Polish buckwheat honey is a rich source of myricetin and quercetin. The flavonoid profiles of honeys of different botanical origin vary considerably between studies, and there is scant information about the total flavonoid content of particular varieties (JASICKA-MISIAK et al. 2012). Selected polyphenols can be used as specific markers with characteristic UV spectra (such as

hesperetin, a marker of citrus honey), and they facilitate quick identification of monofloral honey varieties (TOMÁS-BARBERÁN et al. 2001).

Phenolic acids that can be potentially used as markers for identifying the botanical origin of honey include p-coumaric, hydroxybenzoic, ellagic, syringic, ferulic, gallic and abscisic acid (AMIOT et al. 1989, BOGDANOV et al. 2004). Polish honey is also a rich source of those compounds. Buckwheat honey contains mainly p-hydroxybenzoic, ferulic, p-coumaric and vanillic acid, whereas heather honey is a potent source of abscisic, ellagic, rosmarinic and p-coumaric acid (BIESAGA, PYRZYŃSKA 2009, JASICKA-MISIAK et al. 2012, WILCZYŃSKA 2012).

The authenticity and health benefits of different honey types is determined based on their polyphenol profiles and mineral composition. Trace elements have been long used as indicators of the geographic and botanical origin of honey, and honey is a reliable environmental marker (CAROLI et al. 1999, WIECZOREK et al. 2006, ATANASSOVA et al. 2009). BOGDANOV et al. (2007) analyzed trace elements of anthropogenic and natural origin in honey. The elements of anthropogenic origin are mainly Pb, Cd and Zn. The presence of Cu, Cr and Ni could also be attributed to environmental pollution, whereas Fe and Mn occur naturally in the soil.

The average mineral content of floral honey is 0.2% (max. 0.5%). The most abundant trace element is potassium. Honey varieties may differ in their content of Mg, Ca, Al, Fe, Mn, Zn, B, Cu, Co, Cr, Ni, Cd and P (NOZAL NALDA et al. 2005, WIECZOREK et al. 2006). The correlations between the content of trace elements and types of honey were determined by NOZAL NALDA et al. (2005).

The authenticity of different honey types is ascertained by infrared spectroscopy and fluorescence spectroscopy (ETZOLD, LICHTENBERG-KRAAG 2007). It should be noted, however, that the time-consuming palynological analysis continues to be the reference method for identifying polyfloral honey types. Its results point to considerable pollen diversity across spring and summer varieties of honey harvested from the same region in different years, which explains the significant variations in bee products and the mineral content of honey (ATANASSOVA et al. 2009).

European suppliers have to document the botanical and geographic origin of their products to register traditional and regional honey in the EU protection system. For the consumers, certificates of authenticity testify to the product's high quality (desirable sensory characteristics and health benefits) which, in turn, contributes to higher sales. In Poland, consumers buy 65% of honey directly from apiaries, which testifies to the product's authenticity (*Pszczelarstwo*... 2012).

The objective of this study was to determine the total phenolic content, flavonoid content, metal concentrations (K, Ca, Mg, Zn, Fe, Mn and Cu) and

differences in the concentrations of the analyzed chemical compounds in honey of different botanical origin. Also, the daily intake of the analyzed bioactive compounds supplied with honey was determined for Poland on a per capita basis.

Materials and Methods

Honey samples

Honey of different botanical origin was supplied directly by Polish apiaries. The majority of samples were obtained from the Region of Warmia and Mazury, including the Department of Apiology at the University of Warmia and Mazury in Olsztyn (samples 1–5, 7 and 8). Information about the supplied honey varieties was provided by the apiaries. Manuka honey was purchased online, and honeys produced in and outside the EU were purchased in a supermarket. The purchases were made in 2011–2012 (Table 1), and the acquired samples were dark-stored at the temperature of 10°C. Total phenolic concentrations and flavonoid concentrations were determined in 23 products, metal levels were identified in four botanical varieties, including two spring (acacia and polyfloral) and two summer (linden and polyfloral) varieties.

Determination of total phenolic content

Honey was dissolved in distilled water to produce a solution with the concentration of 0.1 g/ml. The solution was filtered, 2 ml of the filtrate was transferred to 50 ml flasks and combined with 8 ml of distilled water, 2.5 ml of the Folin-Ciocalteau reagent and 7.5 ml of 20% Na_2CO_3. The mixture was supplemented with distilled water and stirred. After 1 hour, absorbance was measured in the Varian Cary 50 spectrophotometer at $\lambda = 765$ nm. The honey solution was replaced with distilled water in the reference sample. The total phenolic content was expressed as the equivalent of gallic acid in mg per kg of honey (LACHMAN et al. 2010).

Determination of total flavonoid content

The total flavonoid content of honey was determined colorimetrically with aluminum trichloride (analytically pure $AlCl_3$, Fluka) according to the method proposed by ÖZKÖK et al. (2010) with own modifications. 3 g of honey was dissolved in 10 ml of 80% water methanol solution and the mixture was

Table 1
Total phenolic and flavonoid content of the analyzed honey samples expressed as gallic acid and quercetin equivalents

Sample	Botanical variety	Origin	Harvest date	Color*	Phenolic compounds [mg kg^{-1}]	Flavonoids [mg kg^{-1}]
1	linden	Mazury	summer 2012	yellow	409 ± 24	15.1 ± 3.2
2	buckwheat	Mazury	summer 2012	dark brown	1141 ± 45	32.3 ± 4.1
3	honeydew	Mazury	summer 2012	brown	737 ± 14	11.5 ± 2.0
4	heather	Mazury	summer /fall 2012	amber, brown	517 ± 18	3.4 ± 1.3
5	buckwheat	Mazury	summer 2012	dark brown	1104 ± 42	23.4 ± 3.5
6	bean	Lublin	summer 2012	white, pale yellow	181 ± 29	3.2 ± 1.2
7	mixed (multifloral, rapeseed)	Mazury	spring 2012	white, pale yellow	175 ± 9	2.8 ± 0.9
8	willow	Mazury	spring 2012	white, pale yellow	281 ± 11	9.6 ± 2.1
9	linden	Mazury	summer 2012	amber, yellow	309 ± 25	8.4 ± 3.2
10	linden	Mazury	summer 2012	amber, yellow	252 ± 12	4.3 ± 2.6
11	multifloral	Mazury	spring 2011	yellow	217 ± 10	1.8 ± 0.8
12	honeydew	Mazury	summer 2012	brown	588 ± 43	21.8 ± 3.1
13	multifloral	Mazury	spring 2012	pale yellow	176 ± 13	2.0 ± 0.7
14	multifloral	Podlasie	summer 2012	yellow	307 ± 24	5.8 ± 1.1
15	manuka	New Zealand**	2012***	amber, orange	634 ± 39	22.3 ± 3.2
16	multifloral	Lublin	summer 2012***	yellow	255 ± 10	4.7 ± 1.8
17	linden	Mazury	summer 2012	yellow	296 ± 7	7.5 ± 2.1
18	mixed	EU and non-EU**	2012***	pale yellow	179 ± 13	3.3 ± 0.5
19	multifloral	Mazury	summer 2012	amber	292 ± 12	14.4 ± 2.9
20	acacia	Mazury	spring 2012	cream, pale yellow	86 ± 7	1.1 ± 0.5
21	mixed (linden, multifloral)	Mazury	summer 2012	yellow	167 ± 10	8.5 ± 1.7
22	linden	Mazury	summer 2012	yellow	259 ± 30	9.4 ± 1.5
23	mixed (buckwheat, linden)	Mazury	summer 2012	brown, medium-dark	878 ± 22	25.6 ± 4.1

* visual evaluation, **foreign honey, ***date of purchase

filtered. 1 ml of the filtrate was transferred to a centrifuge tube, it was combined with 3 ml of 99.8% methanol, 0.2 ml of 10% water solution of aluminum trichloride and 0.2 ml of 1M potassium acetate and supplemented with 5.6 ml of distilled water. The mixture was stirred and left to stand for 45 minutes at room temperature. Absorbance was measured in the Varian Cary

50 spectrophotometer at $\lambda = 415$ nm in two replications for each sample. The reference (blind sample) for every honey sample was prepared by replacing 0.2 ml of 10% aluminum trichloride solution with distilled water. The total flavonoid content was expressed as the equivalent of quercetin which was used to plot the calibration curve (MALWADE 2013).

Metal concentrations

Metal concentrations – K, Ca, Mg, Zn, Fe, Mn and Cu – in honey samples were determined by flame atomic absorption spectroscopy (FAAS) according to the method proposed by WIECZOREK et al. (2006).

Statistical analysis

The results were processed statistically in the GraphPad Prism v.4.01 software (GraphPad Software, San Diego, California, USA). Significant differences between the analyzed honey types were verified by the unpaired t-test with Welch correction and the Kruskal-Wallis test.

Results and Discussion

Total phenolic content

The total content of phenolic compounds and flavonoids in the analyzed honeys is presented in Table 1. Phenolic concentrations varied significantly in the range of 86 to 1141 mg kg^{-1}. The lowest average phenolic content was determined in acacia honey. Buckwheat honey was the richest source of phenolic compounds whose content was several to more than ten times higher (acacia honey) in comparison with other honey types. Similar phenolic compound concentrations in 7 buckwheat honey varieties were noted by JASICKA-MISIAK et al. (2012) in the range of 983 to 1214 mg kg^{-1}. The relatively leveled phenolic content of buckwheat honey could be an indicator of phenolic compound concentrations in mixed honey. Brown-colored buckwheat and linden honey (sample 23) was characterized by high phenolic content, which points to a small share of linden honey in the product. JASICKA-MISIAK et al. (2012) observed somewhat higher phenolic compound concentrations (599 to 762 mg kg^{-1}) in 14 varieties of heather honey in comparison with heather honey harvested in the region of Mazury (Table 1).

The botanical variety declared by suppliers was difficult to confront with the actual pollen content of honey. A palynological analysis revealed significant differences in the composition of the evaluated honey types, which explains the variations in their phenolic content (ATANASSOVA et al. 2009). In general, brown-colored honey had a higher phenolic content than lighter varieties which were white to pale yellow in color.

In comparison with domestic honey, manuka honey was characterized by higher phenolic content which was similar to that of honeydew honey but nearly twice lower than that of buckwheat honey. Honeys produced in and outside of the EU, including bean honey, spring multifloral honey and Polish mixed honey, were characterized by low levels of phenolic compounds.

Flavonoids

The total flavonoid content of the analyzed honey types was determined in the range of 1.1 to 32.3 mg kg^{-1} with an average of 10.5 mg kg^{-1}. In Polish honey, the highest flavonoid concentrations were reported in buckwheat honey, followed by buckwheat and linden honey and honeydew honey (Table 1). Similar flavonoid levels were reported in manuka honey from New Zealand (22.3 mg kg^{-1}). A comparison of our results with other authors' findings indicates that the highest flavonoid concentrations in Polish products are similar to the average values reported in foreign honey varieties. Minimum flavonoid concentrations were similar regardless of geographic origin. Honey produced in Burkina Faso was characterized by a higher average flavonoid content at 25.7 mg kg^{-1} (in the range of 1.7 to 83.5 mg kg^{-1}) (MEDA et al. 2005), and the average flavonoid concentrations in Turkish honeydew honey were determined at 22.8 mg kg^{-1} (in the range of 4.8 to 54.8 mg kg^{-1}) (ÖZKÖK et al. 2010). Average flavonoid levels were also higher in Spanish honey of botanical origin (ESCUREDO et al. 2013).

Metals

The average mineral concentrations in the analyzed honey samples are presented in Table 2. The levels of different minerals were compared by the Kruskal-Wallis test to reveal varietal differences. Similarly to other samples of European honey (YILMAZ, YAVUZ 1999, LATORRE et al. 1999, ATANASSOVA et al. 2009), the predominant element was potassium. The highest concentrations of potassium were noted in summer multifloral and linden honey, whereas spring multifloral honey was least abundant in this mineral.

Table 2

Metal concentrations in honey. Concentrations are given in mg kg^{-1}, *p*-values refer to the Kruskal-Wallis test

		K	Ca	Mg	Mn	Zn	Fe	Cu
Spring multifloral	Mean	233	58.4	11.6	0.37	2.26	1.9	0.04
	SD	94	7.8	3.1	0.25	1.4	0.7	0.03
Acacia	Mean	383	54.1	13.2	0.41	1.65	3.6	0.06
	SD	150	27.6	6.0	0.30	0.59	1.3	0.07
Linden	Mean	742	86.6	14.3	0.39	2.63	3.1	0.06
	SD	340	14.3	6.0	0.34	1.6	0.9	0.03
Summer multifloral	Mean	782	68.7	24.0	1.25	6.20	4.0	0.04
	SD	305	4.6	8.5	0.76	1.5	1.7	0.02
	p	0.007	0.024	0.125	0.187	0.052	0.050	0.695

The second most prevalent element in the tested honey varieties was calcium. Calcium concentrations were similar to those reported by YILMAZ and YAVUZ (1999) and ATANASSOVA et al. (2009). The highest Ca levels were noted in linden honey. Significant differences in Ca concentrations ($p < 0.05$) were determined between linden and spring multifloral honey, linden and summer multifloral honey, and spring multifloral and summer multifloral honey. Calcium concentrations varied over a relatively narrow range of values.

Magnesium concentrations in spring multifloral, acacia and linden honey were characterized by very low variation, and similar results were reported in a study of Bulgarian honey (ATANASSOVA et al. 2009). The average Mg concentrations reached 24.0 mg kg^{-1} only in summer multifloral honey.

Summer multifloral honey was characterized by significantly higher Zn concentrations in comparison with the remaining botanical varieties. Fe levels were relatively similar, but significant differences were observed between varieties. Zn and Fe concentrations determined in this study were somewhat higher than those noted by BOGDANOV et al. (2007) and MATUSEVICIUS et al. (2010), but Zn levels were more than ten-fold lower than in multiflower and linden honey analyzed by PRZYBYŁOWSKI and WILCZYŃSKA (2001).

The tested honey samples were characterized by similar manganese and copper levels (Table 1). The average Mn content of the evaluated samples was nearly identical to that of Swiss acacia honey and similar to that of multifloral varieties (Bogdanov et al. 2007). Honey of botanical origin produced in north-eastern Poland had a low Cu content which corresponded to minimum Cu concentrations reported by BOGDANOV et al. (2007) and MATUSEVICIUS et al. (2010).

Dietary intake of total phenolic compounds, flavonoids and metals (K, Ca and Mg) from honey

The estimated daily intake of selected bioactive ingredients consumed with one serving of honey in Poland and Greece is compared in Table 3. The presented data indicates that even dark-colored honey is a poor source of phenolic compounds in the daily diet (2 to 8 mg). In comparison with honey, berries are a much more abundant source of phenolic compounds. Even a small serving of berries whose phenolic content is equivalent to that of 16 g of strawberries (Institute of Agricultural and Food Economics – National Research Institute) supplies 76 to 126 mg of total phenolic compounds (BOJARSKA et al. 2006). The most popular fruit juice varieties – orange, apple and black currant – are also characterized by a high phenolic content which was determined at 27, 16 and 50 mg per 100 ml, respectively (MICHALAK-MAJEWSKA et al. 2009).

Table 3
Daily intake of phenolic compounds, flavonoids and metals (K, Ca, Mg) from consumed honey

Honey consumption [g/person/day]		Average intake from honey [mg/person/day]						
		phenolic compounds			flavonoids, average $n=22$	K	Ca	Mg
		polish honey $n=22$	dark-colored honey $n=6$	light-colored honey $n=16$				
Poland (2011):	1.67*	0.68	1.38	0.40	0.017	0.9	0.1	0.03
	2.33**	0.96	1.93	0.56	0.023	1.2	0.2	0.04
Greece	9.58***	3.92	7.93	2.30	0.096	5.1	0.6	0.15

* estimated based on annual per capita honey consumption in Poland in 2011 (0.61 kg/person/year), ** estimated based on per capita honey consumption in Poland in 2011, adjusted for exports and imports (0.85 kg/person/year), *** in terms of the highest honey consumption in the EU – Greece (3.5 kg/person/year).

Honey is a poor dietary source of flavonoids (Table 3). In the treatment of vascular diseases, cancer and neurodegenerative diseases (Parkinson's disease, Alzheimer's disease), the recommended daily flavonoid intake should exceed 13 mg (Linus Pauling Institute). Regardless of daily honey consumption, the estimated daily flavonoid intake does not exceed 0.02 mg in Poland and 0.1 mg in Greece. Plants are the richest source of flavonoids in the diet, and even regular and increased consumption of honey will not deliver similar flavonoid intake levels. Dark-colored fruit is abundant in anthocyanidins, and high concentrations of flavones (apigenin) and flavonols (isorhamnetin) are found in parsley, but the main sources of dietary flavonoids are tea, citrus fruit, berries, apples and vegetables (celery, lettuce) (USDA Database. 2011).

The intake of K, Ca and Mg from an average daily serving of honey is presented in Table 3. For adult consumers, the RDA for calcium is 1000-1300 mg, and the RDA for magnesium – 310–420 mg. Therefore, the daily intake of the above minerals from honey accounts for 0.02% RDA for calcium and 0.01% RDA for magnesium (Dietary Reference Intakes). Honey is also deficient in potassium whose intake with a daily serving of honey accounts for 0.03% RDA for K (Adequate Intakes, AIs).

Conclusions

1. Polish dark-colored honey (buckwheat honey and honeydew honey) has a much higher total phenolic and flavonoid content than honey of other botanical varieties and mixed honey.

2. Polish honey, in particular summer varieties, is most abundant in K, Ca and Mg.

3. The dietary intake of total phenolic compounds, flavonoids and metals from an average and increased (to the European maximum) daily serving of honey is low.

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References

Amiot M.J., Aubert S., Gonnet M., Tacchini M. 1989. *Phenolic composition of honeys: preliminary study on identification and group quantification*. Apidologie, 20: 115–125.

Anklam E. 1998. *A review of the analytical methods to determine the geographical and botanical origin of honey*. Food Chem., 63(4): 549–562.

Atanassova J.R., Yurukova L.D., Lazarova M.A. 2009. *Palynological, physical, and chemical data on honey from the Kazanlak region (Central Bulgaria)*. Phytol. Balcan., 15(1): 107–114.

Biesaga M., Pyrzyńska K. 2009. *Liquid chromatography/tandem mass spectrometry studies of the phenolic compounds in honey*. J. Chromatogr. A., 1216: 6620–6626.

Bogdanov S., Haldimann M., Luginbühl W., Gallmann P. 2007. *Minerals in honey: environmental, geographical and botanical aspects*. J. Apic. Res. Bee World, 46(4): 269–275.

Bogdanov S., Ruoff K., Persano Oddo L. 2004. *Physico-chemical methods for the characterization of uniflorals honey: a review*. Apidologie, 35: 4–17.

Bojarska J.E., Czaplicki S., Zarecka K., Zadernowski R. 2006. *Związki fenolowe owoców wybranych odmian truskawki*. Żywność. Nauka. Technologia. Jakość., 2(47): 20–27.

Caroli S., Forte G., Iamiceli A.L., Galoppi B., 1999. *Determination of essential and potentially toxic trace elements in honey by inductively coupled plasma-based techniques*. Talanta, 50(2): 327–336.

Dietary Reference Intakes. DRI Tables, http://fnic.nal.usda.gov/dietary-guidance.

Escuredo O., Míguez M., Fernández-González M., Seijo M.C. 2013. *Nutritional value and antioxidant activity of honeys produced in a European Atlantic area*. Food Chem., 138: 851–856.

Etzold E., Lichtenberg-Kraag B. 2008. *Determination of the botanical origin of honey by Fourier-transformed infrared spectroscopy: an approach for routine analysis*. Eur. Food. Res. Technol., 227: 579–586.

IERiGŻ-PIB, 2007. *Rynek owoców i warzyw. Stan i perspektywy*. Analizy Rynkowe, 2007 czerwiec, pp. 24–39.

Jasicka-Misiak I., Paliwoda A., Dereń M., Kafarski P. 2012. *Phenolic compounds and abscisic acid as potential markers for the floral origin of two Polish unifloral honeys*. Food Chem., 131: 1149–1156.

Lachman J., Orsák M., Hejtmánková A., Kovářová E. 2010. *Evaluation of antioxidant activity and total phenolics of selected Czech honeys.* LWT – Food Sci. Techn., 43: 52–58.

Latorre M.J., Peña r., pita C., Botana A., García S., Herrero C. 1999. Chemometric classification *of honey according to their type. II. Metal content data*. Food Chem., 66: 263–268.

Linus Pauling Institute. Micronutrient Research for Optimum Health. Flavonoids, http://lpi.oregonstate.edu/infocenter/phytochemicals/flavonoids/.

Malwade C.R., Qu H., Rong B-G., Christensen L. P. 2013. *Purification of artemisinin from quercetin by anti-solvent crystallization.* Front. Chem. Sci. Eng., 7(1): 72–78.

Matusevicius P., Staniskiene B., Budreckiene R. 2010. *Metals and organochlorine compounds in Lithuanian honey*. Pol. J. Food. Nutr. Sci., 60(2): 159–163.

Meda A., Lamien C.E., Romito M., Millogo J., Nacoulma O.G. 2005. *Determination of the total phenolic, flavonoid and prolinę contents in Burkina Fasan honey, as well as their radical scavenging activity*. Food Chem., 91: 571–577.

Michalak-Majewska M., Żukiewicz-Sobczak W., Kalbarczyk J. 2009. *Ocena składu i właściwości soków owocowych preferowanych przez konsumentów*. Bromat. Chem. Toksykol., XLII(3): 836–841.

Nozal Nalda M.J., Yague J.L.B., Calva J.C.D., Gomez M.T.M. 2005. *Classifying honeys from the Soria Province of Spain via multivariate analysis*. Anal. Bioanal. Chem., 382(2): 311–319.

Özkök A., D'arcy B., Sorkun K. 2010. *Total phenolic acid and total flavonoid content of turkish pine honeydew honey*. J. Api Product & Apimedical Sci., 2(2): 65–71.

Przybyłowski P., Wilczyńska A. 2001. *Honey as an environmental marker*. Food Chem.,74: 289–291.

Pszczelarstwo i rynek miodu. 2012. http://www.minrol.gov.pl/pol/Ministerstwo/Biuro-Prasowe/Informacje-Prasowe/Pszczelarstwo-i-rynek-miodu.

Tomás-Barberán F.A, Martos I., Ferreres F., Radovic B.S., Anklam E. 2001. *HPLC flavonoid profiles as markers for the botanical origin of European unifloral honeys*. J. Sci. Food Agric., 81(5): 485–496.

USDA Database for the Flavonoid Content of Selected Foods – Release 3, 2011. http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/Flav/Flav3-1.pdf.

Wieczorek J., Wieczorek Z., Mozolewski W. 2006. *Can bee honey serve as an environmental marker?* Pol. J. Environ. Stud., 15(2A): 203–207.

Wilczyńska A. 2010. *Phenolic content and antioxidant activity of different types of polish honey – a short report*. Pol. J. Food Nutr. Sci., 60(4): 309–313.

Wilczyńska A. 2012. *Oznaczanie zawartości flawonoidów i fenolokwasów w odmianowych miodach pszczelich*. Bromat. Chem. Toksykol., XLV(3): 892–896.

Yilmaz H., Yavuz Ö. 1999. *Content of some trace metals in honey from south-eastern Anatolia*. Food Chem., 65: 475–476.