Slovak J. Anim. Sci., 41, 2008 (4): 173 - 178

EFFECT OF VARIED PROTEIN AND ENERGY CONTENTS IN MIXTURE ON MEAT QUALITY OF BROILER CHICKEN

J. BARTECZKO*, O. LASEK

Cracow Agricultural University, Poland

ABSTRACT

The quality of broiler chicken meat depends on genetic factors (genetic line, sex), age at slaughter and environmental conditions, especially feeding (Zlender et al., 1995). The components of concentrate mixtures do not provide the appropriate concentration of energy for fast-growing broilers. The use of full-fat oilseed meal, ground maize or fat supplemented forage helps in solving this problem (Barteczko et al., 2003). However, the use of full-fat oilseed meals can adversely affect the quality traits of broiler meat. The aim of this study was to determine the effect of different protein level and origin (plant or animal), as well as an addition of vegetable oil to wheat-based mixtures on sensory quality of broiler chicken meat, particularly texture, smell, tenderness, juiciness, flavor intensity, pH and color. Besides chemical composition like dry matter, crude protein, crude fat and ash, a content of cholesterol in muscles was determined. Furthermore, body mass gain, food intake and feed conversion ratio were recorded. The research was carried out on ninety six broiler chickens of Ross 308 line at the age of 14-49 days. Broilers were divided into 8 groups of 12 fowls each and fed ad libitum a wheat diet with 19% and 23% protein contents and also 2% and 4% of oil added. The results of the study show that the mixtures supplemented with plant and animal proteins positive influenced body mass gain in comparison to mixtures with plant protein only. The higher protein content diet (23%) increased the total cholesterol content in the muscle in comparison to the lower protein content diet (19%). Soybean oil added at an amount of 2% or 4 % increased feed intake, as well as improved sensory quality of breast muscle, particularly smell, flavor intensity and tenderness.

Key words: feeding, broiler chickens, protein, fat, meat quality

INTRODUCTION

Meat and meat products are important source of high-value animal protein in human diets. Meat fat comprises of mostly monounsaturated and saturated fatty acids, with oleic (C18:1), palmitic (C16:0) and stearic acid (C18:0) being the most ubiquitous, however meat is a considerable source of cholesterol in diet. Consumers prefer lean meat with reduced content of fat. Appropriate manipulation with broiler chicken diet could modify fatty acid profile in meat and increase its nutritional value (Valsta et al., 2005). Świerczewska et al. (2000) assume that the quality of meat and mainly fatty acid profile both in breast and leg muscles mostly depend on components contained in mixture. Previous studies demonstrate that ingredients of diet can influence human cholesterol balance (Barteczko et al., 2004; Scheeder, 2004; Valsta et al., 2005; Zanini et al., 2006). Saturated fatty acids especially with medium length chain (lauric C12:0, myristic C14:0, palmitic C16:0) have a hypercholesterolemia effect. Oppositely, polyunsaturated fatty acids, like linoleic acid (C18:2) and linolenic acid (C18:3), reduced cholesterol content (Hańczakowski, 2001; Noble, 2001). According to Valsta et al. (2005) poultry and pork meat comprises of more polyunsaturated fatty acids (about 10-15% of the total fatty acids) in comparison with beef and lamb meat.

Correspondence: E-mail: rzbartec@cyf-kr.edu.plk

*Scientific paper formerly presented at the 8th International Conference on Risk Factors of Food Chain, Kraków, Poland, September 17, 2008

ISSN 1335-3686

The aim of the study was to determine the effect of different levels of protein and fat in diet mixtures on performance, chemical composition and physicochemical and sensory quality of broiler chicken breast meat.

MATERIALS AND METHOD

The experiment was carried out on ninety six broiler chickens of Ross 308 line at the age of 2 - 7 weeks. Broilers were divided into 8 groups of 12 birds each and were fed ad libitum balance diet of two protein levels (19 and 23%), as well as two fat levels (2 and 4% of soybean oil added). Differential protein contents in mixtures (about 19 and 23%) were obtained adding different proportions of soybean meal and fish meal **(Table 1)**. Diverse levels of fat (2 and 4%) were achieved by soybean oil supplementation. At 49 days of age fowls were slaughtered. Breast muscles were isolated by the dissection from the carcasses and weighed; meat samples were taken for chemical analysis. As a part of physicochemical analyses, meat color was evaluated using chromometer CR-310 Minolta in color system L*, a*, b*. A pH value of meat was measured using P.H. Star CPU with stab electrode calibrated on the set of buffers with pH 4, 6, 7, 0.

The chemical composition (basic nutrients, amino acids, energy) of diets was determined according to standard method (AOAC, 2000). Fatty acid profile was measured using chromatography apparatus VARIAN 3400 CX, cholesterol content was determined by colorimetric method. The sensory analysis of meat samples was carried out following roasting at 170 ºC and cooling to an internal temperature of 78 ºC. The sensory evaluation of the meat (structure, smell, brittleness, juiciness and flavor) was performed by 5- personel (Baryłko-Pikielna, 1975) on the basis of a 5-grade scale scoring system. The sensory analysis was carried out on meat samples from broiler chickens fed diet mixtures contained 19% of protein (plant and animal origin) and supplemented with soybean oil at 0, 2 and 4%.

Data were evaluated statistically by the one-way analysis of variance using Statistica 7.1 software (2005). Differences between treatment means were tested using Duncan's multiple range test.

Table 1: Ingredients and nutrient composition of experimental diets, %

Item	Group							
	I	II	III	IV	V	VI	VII	VIII
Maize	40	40	40	40	40	40	40	40
Wheat	31	19	28	16	25	13	25,5	13,5
Soybean meal	18	30	19	31	20	32	27,5	39,5
Fish meal	8	8	8	8	8	8	0	0
Soybean oil	0	0	2	2	4	4	4	4
Limestone	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Monocalcium phosphate	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Premix DKA	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NaCl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dry matter	87.67	87.87	87.54	87.82	87.77	87.62	87.54	87.83
Crude ash	4.87	5.42	4.88	5.43	4.90	5.42	2.86	3.40
Organic matter	82.80	82.45	82.66	82.39	82.87	82.20	84.68	84.43
Crude protein	18.94	22.98	19.04	22.94	19.04	23.01	19.01	22.96
Crude fat	4.09	3.99	5.97	6.01	7.22	7.35	6.52	6.59
Crude fibre	3.23	3.62	3.22	3.62	3.20	3.64	3.70	4.15
Nitrogen free extract	56.64	51.79	54.43	49.82	53.11	48.20	55.45	50.73
Methionine	0.58	0.66	0.58	0.66	0.58	0.66	0.58	0.66
Cystine	0.30	0.34	0.30	0.34	0.30	0.34	0.30	0.34
Lysine	0.28	0.32	0.28	0.32	0.28	0.32	0.28	0.32
AME_N								
- kcal/kg	2833	2722	2942	2832	3052	2941	3048	2938
- MJ/kg	11.85	11.39	12.31	11.84	12.76	12.30	12.75	12.29
kcal EM_N/ % crude protein	149.56	118.46	154.52	123.43	160.26	127.81	160.34	127.94

AME_N- matabolizable energy corrected to nitrogen balance

Table 2: Body weight gain, feed intake and feed, protein and energy conversion ratios in broiler chickens

Item	Group							
	I	II	III	IV	V	VI	VII	VIII
Body mass [g]								
- initial	388	405	389	407	393	397	409	417
- final	2108^{a}	2235^{ab}	2117^{a}	2262^{ab}	2203^{ab}	2307^{b}	2213^{ab}	2237^{ab}
Body weight gain [g]								
- total	1720^{a}	1830^{ab}	1728^{a}	1855^{ab}	1810^{ab}	1910^{b}	1804^{ab}	1820^{ab}
- daily	49.1^{a}	52.3^{ab}	49.43^{a}	53.13^{ab}	51.73^{ab}	54.6^{b}	51.7^{ab}	52.0^{ab}
Feed intake [g/item]								
- total	3007.5^{a}	3461.7^{b}	3269.2^{a}	3370.8^{b}	3336.7^{b}	3489.8^{b}	3678.8^{c}	3566.6^{b}
- daily	85.9^{a}	98.9^{b}	93.4^{a}	96.3^{c}	95.3^{b}	99.7^{b}	105.1^{c}	101.9^{b}
Conversion								
- feed [kg/kg]	1.74^{a}	1.88^{a}	1.89^{a}	1.81^{a}	1.86^{a}	1.82^{a}	2.03^{b}	1.95^{b}
- crude protein [g/kg]	330.6^{a}	432.4^{c}	359.1^{a}	416.3^{c}	353.4^{a}	418.6^{c}	385.7^{b}	448.5^{c}
- AME_N [kcal/kg]	4929	5118	5561	5125	5676	5353	6188	5729

a, b- values in rows with different letters differ significantly at P<0.05

RESULTS

According to the experimental methods, the influence of two different levels of protein and fat in mixtures on performance, chemical composition and physicochemical and sensory quality of breast meat was determined. The highest body weight gain was obtained in broiler chickens from 6th group (1910 g) fed a diet with 23% of protein (comprised of 19.2% plant protein and 3.8% animal protein), as well as with 4% soybean oil addition (Table 2). Mixtures containing 4% of soybean oil addition caused higher body weight gain in comparison with 2% of soybean oil addition (P<0.05). Broiler chickens fed mixtures with higher protein content (23%) obtained higher body weight gain in comparison with broilers fed a diet with 19% content of protein. No statistical differences in daily body weight gain were observed between broiler chickens fed diet mixtures with soybean meal (an only source of protein without fish meal contribution; 7 and 8 group) and broilers fed a diet with both soybean meal and fish meal (P>0.05). The higher proportion of soybean oil in a diet caused increase in feed intake by broilers. The highest feed conversion ratio (2.03 kg per 1 kg body weight gain) was obtained in 7th group but the lowest in 1st group, where broiler chickens fed a diet without soybean oil addition.

Chemical composition of breast muscles depended on type of the diet. It was observed that application of nutrient factors has a considerable influence on the content of ash, crude protein, crude fat and cholesterol in breast meat (Table 3). Content of crude fat in breast meat depended on level of soybean oil addition. The lower fat content in meat (1.15 and 1.13%) was in broiler fed mixtures without soybean oil (1st and 2nd group). Soybean oil addition at 2% (3rd and 4th group) increased crude fat content in breast meat up to 1.16% and 1.17% respectively. On the other hand, 4% soybean oil addition increased fat content in meat up to 1.19% and 1.32% resp. Higher total cholesterol content was observed in breast meat in broiler chickens fed diets with higher content of crude protein (23%) in comparison to the diet with 19% crude protein proportion. Fatty acid profile of breast meat lipids (tab. 3) did not depend on soybean oil addition but on the amount of particular fat fraction.

The lowest pH value (measured 1 hour after slaughter) was observed in broiler breast muscles from 7th (5.85) and 2nd (5.86) groups. However the highest pH value (6.29) was found in broilers from 5th group fed a mixture containing 19% of crude protein and 4% of soybean oil addition (P<0.05). A value of pH measured 24 hours after slaughter did not differ between groups (Table 4). Breast muscles were varied with regard to brightness of meat color (L*). The bright color of meat (measured 24 hours after slaughter) was observed in broiler chickens from 3rd group (57.68) and dark color was observed in broilers from 6th group (55.06). The best sensory quality (structure, smell, brittleness, juiciness, flavor) was found in breast muscles of broiler chickens fed a diet with 2% of soybean oil addition and 19% content of crude protein (3rd group). Using a 5- grade scale scoring system the lowest sensory quality was recorded in meat of broiler chickens fed a mixture without soybean oil (3.71). There were found significant differences in smell intensity between 1st and 3rd as well as 5th groups (P<0.05) and also in flavor intensity between 1st and 3rd groups (Table 5).

Table 3: Weight, chemical composition, cholesterol content and fatty acid profile of breast meat in broiler chickens

Item	Group							
	I	II	III	IV	V	VI	VII	VIII
Weight of brest muscle	445.23^{ab}	429.12^{a}	458.18^{ab}	477.65^{ab}	450.62^{ab}	481.33^{b}	441.65^{ab}	443.41^{ab}
Components of breast meat								
Dry matter, %	26.81	26.95	26.99	26.88	26.92	26.96	26.83	26.83
Crude ash, %	1.24	1.27	1.32	1.32	1.38	1.29	1.22	1.20
Crude protein, %	23.35	23.74	24.08	24.20	24.30	24.21	23.96	23.82
Crude fat, %	1.15	1.13	1.17	1.16	1.18	1.20	1.29	1.32
Total cholesterol, mg/dl	83.15	90.57	86.85	88.90	83.62	89.90	85.42	91.33
C14:0	0.71	0.63	0.62	0.62	0.74	0.70	0.71	0.72
C16:0	24.82	22.66	23.12	24.45	24.74	22.84	24.16	23.84
C16:1	4.52	3.64	2.60	4.44	2.57	2.20	2.57	1.94
C18:0	9.99	9.63	11.25	9.16	11.40	11.86	11.72	13.06
C18:1	42.03	38.04	36.67	39.71	38.13	35.78	37.72	34.56
C18:2	12.81	18.71	17.86	16.81	14.42	18.44	17.22	18.26
C18:3	0.52	1.52	0.96	1.31	1.54	3.57	1.35	2.46
C20:1	0.55	0.41	0.45	0.52	0.57	0.53	0.45	0.46
C20:2	0.51	0.52	0.59	0.34	0.63	0.46	0.41	0.47
C20:3	0.40	0.47	0.60	0.38	0.57	0.37	0.28	0.33
C20:4	2.18	3.05	3.74	1.89	3.43	2.24	2.73	2.97
SFA	35.52	32.91	34.99	34.22	36.88	35.40	36.58	37.61
UFA	63.50	66.36	63.82	65.02	61.86	63.76	62.69	61.45
MUFA	47.09	42.09	39.72	44.66	41.27	38.51	40.74	36.96
PUFA	16.41	24.27	24.10	20.36	20.59	25.26	21.95	24.49

SFA- saturated fatty acid; UFA- unsaturated fatty acid; MUFA- monounsaturated fatty acid; PUFA- polyunsaturated fatty acid
a, b- values in rows with different letters differ significantly at P<0.05

Table 4: Color and pH values of broiler chicken breast muscle

Item	Group							
	I	II	III	IV	V	VI	VII	VIII
Measured immediately after slaughter								
pH	5.90^{a}	5.86^{a}	5.98^{ab}	5.93^{ab}	6.29^{b}	6.10^{ab}	5.85^{a}	6.00^{ab}
L	57.33	58.14	57.98	56.20	57.27	55.69	57.12	57.71
a	9.83^{a}	9.65^{a}	9.44^{a}	10.30^{b}	9.16^{a}	10.29^{b}	10.11^{b}	9.73^{a}
b	5.41^{c}	5.55^{c}	5.38^{c}	3.83^{a}	4.79^{b}	3.68^{a}	6.36^{d}	4.88^{b}
Measured 24 hours after slaughter								
pH	5.76	5.74	5.79	5.77	5.83	5.76	5.76	5.67
L	57.26	57.00	57.68	56.87	57.15	55.06	56.30	56.97
a	10.67^{a}	10.68^{a}	10.82^{a}	11.71^{b}	10.47^{a}	11.56^{b}	11.24^{a}	10.75^{a}
b	9.23^{c}	9.32^{c}	9.70^{d}	7.87^{a}	9.00^{c}	7.25^{a}	9.82^{d}	8.05^{b}

L- brightness coefficient; a and b – color coefficients
a, b- values in rows with different letters differ significantly at P<0.05

Table 5: Sensory quality of broiler chicken breast muscle (5- grade scale scoring system)

Item	Group		
	I	III	V
Structure	4.0[b]	3.6[a]	3.7[ab]
Smell intensity	3.2[a]	3.6[b]	3.6[b]
Smell desirability	3.8	4.1	3.8
Tenderness	3.8	3.6	3.9
Juiciness	4.0[b]	3.7[ab]	3.6[a]
Flavor intensity	3.4[a]	3.8[b]	3.6[ab]
Flavor - desirability	3.8	4.0	4. 0
Average	3.71	3.77	3.74

a,b- values in rows with different letters differ significantly at $P<0.05$

DISCUSSION

The origin of proteins does not influence body weight gain and final body mass of broiler chickens (Osek et al. 2004; Pawlak et al. 2005), what was corroborated in our study. A number of investigations proved that regardless of diet components, broiler chickens reached final body mass from 2.0 to 2.2 kg after 42 days of feeding with feed conversion ratio under 2 kg fodders (per 1 kg body weight gain) (Rutkowski et al. 2000; Świerczewska et al. 2000; Osek et al. 2001; Pawlak et al. 2005). The results of present study show, that higher daily body weight gain was obtained when broiler fed diet with higher crude protein content was used, what is in agreement with reports of Świerczewska et al. (2000) and Bregendahl et al. (2002). Conditions of correct growth, proper feed protein and energy conversion ratio, as well as high nutrient digestibility and nitrogen retention is appropriate proportion of energy to protein and energy to amino acids (Bregendahl et al. 2002; Barteczko 2003; Barteczko and Augustyn, 2006). Basing on our results, feed intake increased with higher supplementation of soybean oil, which probably improved the tastiness of the diet to broiler chickens (Barteczko and Kamiński, 1992). The best feed conversion ratio was obtained in broilers fed oil-enriched mixtures. Usage of soybean oil improved feed intake and favorable influenced body weight gain and also sensory quality of meat (Adamski and Gornowicz 1993; Osek et al. 2001). These authors applied 5% soybean oil addition and, at the same time, increased energy concentration in mixture what caused lower feed conversion ratio (1.77 kg per 1 kg body weight gain).

Chemical composition of breast meat depended on type of the diet. The results of present investigation show that fat contribution to breast muscle was dependent on soybean oil addition level, what agrees with the observations of Osek et al. (2002). In industrialized countries a high meat intake contributes to a higher, than recommended, total and saturated fat and cholesterol intake (Valsta et al. 2005; Zanini et al. 2006). In the present study the breast meat comprised of 1.15% crude fat. Similar results were obtained by Świerczewska et al. (2000) and Pawlak et al. (2005). Crude protein and its amino acid content, as well as unsaturated fatty acid profile in fat could influence a cholesterol balance (Hanczakowski et al. 2001). Our results indicate that higher protein ratio in mixture reduces cholesterol content in breast meat. According to Mikołajczak et al. (2001) and Świerczewska et al. (2000) content of total cholesterol in breast muscle was lower than in present study.

The influence of soybean oil addition to mixtures on fatty acids profile in breast meat was not proved in our study. Diet comprised of plant oil (cereals) also modified fatty acids profile (Barteczko and Kamiński 1992; Barteczko and Borowiec 2000). According to Jamroz (1997) body lipid ratio was influenced by genetic factors and depended on poultry species but not on the type of feeding. However, Osek et al. (2001, 2002, 2004) claimed that type of fat addition to mixture is a factor influencing a proportion of lipid fraction of meat and abdominal fat.

According to Połtowicz (2000), a pH value may influence some physicochemical meat quality, like color. It is generally known, that proper pH value should be in the range between 5.9 and 6.2 (Niewiarowicz, 1997). Proper pH measured immediately after slaughter gained in most groups, on the other hand, pH measured 24 hours after slaughter were lower for all groups similarly to results obtained by Gardzielewska et al. (2005). A higher pH of breast muscles immediately after slaughter is a result of higher content of glycogen which induced higher resistance of broilers against slaughter stress (Połtowicz 2000).

The results of many studies confirmed that proportion of fat and oil seeds in mixtures for broilers influences sensory attractiveness of broiler chickens meat (Połtowicz 2000; Osek et al. 2001; Barteczko et al. 2003) and content of aromatic compounds, which are flavor and smell precursors, become active during thermal processing (Karlik et al. 1997). In present study, soybean oil addition to the diet improved smell and flavor of breast meat in comparison with the meat of broiler chicken fed a mixture without soybean oil. According to Jaśkiewicz (2004), sensory quality of breast meat of broilers fed a diet supplemented with soybean meal and soybean oil was higher (4.5) in comparison to our result (3.77), however Osek et al. (2004) obtained similar outcome in sensory quality.

REFERENCES

ADAMSKI, K. – GRONOWICZ, E. 1993. Wpływ dodatku tłuszczów do paszy na wskaźniki przyżyciowe i poubojowe kurcząt brojlerów. In: *Zesz. Nauk. Przeg. Hod.*, PTZ : Warszawa, 8, p. 194-200.

AOAC. 2000. Official Methods of Analysis.17th ed. Association of Official Analytical Chemists, Washington DC.

BARTECZKO, J. – KAMIŃSKI, J. 1992. Zastosowanie tłuszczów pochodzenia roślinnego zwierzęcego w żywieniu drobiu. Biul. Reg. ZDR AR Kraków 301, p. 25- 41.

BARTECZKO, J. – BOROWIEC, F. 2000. Wpływ poziomu wielonienasyconych kwasów tłuszczowych w mieszankach paszowych na efektywność odchowu kurcząt brojlerów. Rocz. In: *Nauk. Zoot*., vol. 6, 2000, p. 318-322.

BARTECZKO, J. 2003. Badania nad metabolizmem energii u kurcząt brojlerów. Zesz. Nauk. AR w Krakowie. Rozprawy, p. 288.

BARTECZKO, J. – BOROWIEC, F. – WĘGLARZ, A. 2003. Chemical composition and sensory traits of meat of broiler chickens fed probiotic supplemented diets. In: *Ann. Anim. Sci*., vol. 2, 2003, p.169-173.

BARTECZKO, J. – BOROWIEC, F. – MIGDAŁ, W. 2004. Wpływ mieszanek z dodatkiem nasion lnu odmian opal, omega i linola na skład chemiczny i cechy sensoryczne mięsa kurcząt brojlerów. In: *Rocz. Nauk. Zoot*., vol. 20, 2004, p. 165-168.

BARTECZKO, J. – AUGUSTYN, R. 2006. Effect of protein and amino acid to energy ratio in wheat– and maize–based diets on performance, nitrogen retention and fatness in broiler chickens. In: *Pol. J. Nat. Sci*., vol. 3, 2006, p. 389–395.

BARYŁKO-PIKIELNA, N. 1975. Zarys analizy sensorycznej żywności. WNT : Warszawa.

BREGENDAHL, K. – SELL, J. L. – ZIMMERMAN, D. R. 2002. Effect of low-protein diets on growth performance and body composition of broiler chicks. In: *Poult. Sci*., vol. 81, 2002, p. 1156-1167.

GARDZIELEWSKA, J. – JAKUBOWSKA, M. – TARASEWICZ, Z. – SZCZERBIŃSKA, D. – LIGOCKI, M. 2005. Meat quality of broiler quail fed on feed with different protein content. In: *Electronic J. of Polish Agric. Universities*, vol. 8 (1), 2005, p.13-21.

HAŃCZAKOWSKI, P. 2001. Wpływ nasyconych i jednonienasyconych kwasów tłuszczowych na zawartość cholesterolu w organizmie zwierząt. IZ. In: *Post. Nauk. Rol*., vol. 6, 2001, p. 41- 47.

JAMROZ, D. 1997 Wpływ żywienia na jakość produktów drobiarskich. VIII Sympozjum drobiarskie, WPSA, Polanica Zdrój. Wrocław, p. 12-16.

JAŚKIEWICZ, T. 2004. Wpływ udziału przetworzonych nasion lnianki w mieszankach paszowych na skład i cechy sensoryczne mięśnia piersiowego kurcząt brojlerów. In: *Rocz. Nauk. Zoot*., vol. 20, 2004, p. 189-192.

KARLIK, G. – PETRIČEVIĆ, A. – IVETIĆ, D. – VUKADINAWIĆ, B. 1997.Meat quality of chicken by dietary FAT. Poultry Meat Quality. Proc. XIII Europ. Symp. Quality Poultry Meat, Poznań, p. 216-222.

MIKOŁAJCZAK, J. – ROJSZCZAK, I. – GRABOWICZ, M. – PIŁAT, J. 2001. Wpływ probiotyków Lactiferm L-5 na efekty produkcyjne, wydajność rzeźną i jakość produktu poubojowego kurcząt brojleró1). Ann. of Warsaw Agric. University. Anim. Sci. p. 509-513.

NIEWIAROWICZ, A. 1997. Meet anomalie in broilers. In: *Poultry Int*., vol.17, 1997, p. 50.

NOBLE, R.C. 2001. Modification the fatty acid profile of poultry meat for the health conscious consumer. 13th Eur. Symp. Poult. Nutr., Blankenberge- Belgium. p. 17-24.

OSEK, M. – JANOCHA, A. – KLOCEK, B. – WASIŁOWSKI, Z. 2001. Wpływ mieszanek zawierających różne tłuszcze na wskaźniki produkcyjne i jakość mięsa kurcząt rzexnych. In: *Rośliny Oleiste*, vol. 1, 2001, p. 153-163.

OSEK, M. – JANOCHA, A. – WASIŁOWSKI, Z. 2002. Wskaźniki odchowu, wartość rzeźnai jakość mięsa kurcząt brojlerów żywionych mieszankami bez białka zwierzęcego zawierającymi nasiona roślin oleistych. In: *Rośliny Oleiste*, vol. 12, 2002, p. 515-529.

OSEK, M. – JANOCHA, A. – KLOCEK, B. – WASIŁOWSKI, Z. – MILCZAREK, A. 2004. Wpływ rodzaju białka na jakość tuszek i mięsa drobiowego. In: *Rocz. Nauk. Zoot*., vol. 20, 2004, p. 229-234.

POŁTOWICZ, K. 2000 Wpływ początkowego poziomu pH mięśni piersiowych na wybrane wskaźniki jakości mięsa kurcząt brojlerów należących do trzech genotypów. In: *Rocz. Nauk. Zoot*., vol. 8, 2000, p. 161-165.

PAWLAK, A. – GORNOWICZ, E. – DZIADEK, K. 2005. Wpływ rodzaju białka w mieszankach paszowych na wskaźniki użytkowości i jakości mięsa kurcząt brojlerów. In: *Rocz. Nauk. Zoot*. vol. 32, 2005, p. 115-123.

RUTKOWSKI, A. – FRĄTCZAK, M. – WIĄZ, M. 2000. Zastosowanie preparatów enzymatycznych Avizyme 1 w dietach kukurydziano-rzepakowych i kukurydziano sojowych pozbawionych białka zwierzęcego w żywieniu kurcząt rzeźnych. Materiały Konferencyjne, Komisja Żywieniowa. KNZ PAN, Rogów, 36.

SCHEEDER, M.R.L. 2004. The fatty acid composition of meat: manipulation and relevance for human nutrition. Proceedings of the British Society of Animal Nutrition. Pig and poultry meat quality- genetic and non-genetic factors. International Conference Krakow- Poland. 14-17.

StatSoft, Inc 2005. Statistica (data analysis software system), Version 7.1 www.statsoft.com

ŚWIERCZEWSKA, E. – NIEMIEC, J. – MROCZEK, J. – SIENNICKA, A. – GRZYBOWSKA, A. – GROCHALSKA, D., 2000. Wpływ żywienia kurcząt mieszankami różniącymi się zawartością białka na wyniki produkcyjne, skład tkankowy i skład chemiczny mięsa. In: *Zesz. Nauk. PTZ, Chów i Hodowla Drobiu*, vol. 49, 2000, p. 365-375.

VALSTA, L.M. – TAPANAINEN, H. – MÄNNISTÖ, S. 2005. Meat fats in nutrition. In: *Meat Sci*., vol. 70, 2005, p. 525-530.

ZANINI, S. F. – COLNAGO, G. L. – BASTOS, M. R. – PESSOTTI, B. M. S. – CASAGRANDE, F. P. – LIMA, V. R. 2006. Oxidative stability and total lipids on thigh and breast meat of broilers fed diets with two fat sources and supplemented with conjugated linoleic acid. In: *LWT*, vol. 39, 2006, p. 717-723.

ZELENKA, J. – KOMPRDA, T. – FAJMONOVA, E. 2001. Physiologically important fatty acids in meat of restrictively fattened chickens. 13th Eur. Symp. Poult. Nutr., Blankenberge- Belgium. p. 43-44.

ZLENDER, B. – HOLCMANT, A. – RAJAR, A. – GASPERLIN, L. – STEVANOVIC, M. 1995. Meat quality of different provenances of chickens. XII Europ. Symp. Quality Poult. Meat., WPSA, Zaragoza- Spain, p. 135-144.

Author's addresses: Jan Barteczko; Department of animal nutrition, Cracow Agricultural University, Al. Mickiewicza 24/24, 30-059 Krakow, Poland, Olga Lasek; Department of animal nutrition, Agricultural University, 31-120 Kraków, Al. Mickiewicza 21