Rocz. Nauk. Zoot., 44, 1 (2017) 107–119

INFLUENCE OF DIETARY TURMERIC SUPPLEMENTATION ON PERFORMANCE AND MEAT QUALITY OF BROILER CHICKENS*

Monika Łukasiewicz[1], Katarzyna Mucha[2], Kamila Puppel[3], Beata Kuczyńska[3], Arkadiusz Matuszewski[1]

[1]Warsaw University of Life Sciences, Faculty of Animal Science, Department of Animal Breeding and Production, Poultry Breeding Division, Ciszewskiego 8, 02-786 Warszawa, Poland
[2]Scientific Circle „Aves", Ciszewskiego 8, 02-786 Warszawa, Poland
[3]Warsaw University of Life Sciences, Faculty of Animal Science, Department of Animal Breeding and Production, Cattle Breeding Division, Ciszewskiego 8, 02-786 Warszawa, Poland

Celem badań było określenie wpływu dodatku 0,75% kurkumy w paszy na wyniki produkcyjne, analizy rzeźnej, jakość mięsa oraz profil kwasów tłuszczowych kurcząt brojlerów Ross 308. Mięśnie piersiowe i nóg pobrano do analiz 24h po uboju od 12 kurcząt (6 ♂ i 6 ♀) z każdej grupy. Dodatek kurkumy do mieszanek dla kurcząt brojlerów nie wpłynął ujemnie na wyniki produkcyjne i jakość mięsa. Ptaki charakteryzowały się niższą śmiertelnością (P≤0,05) w porównaniu do grupy kontrolnej. U kurcząt, u których stosowano dodatek kurkumy w paszy zaobserwowano zmniejszenie udziału kwasów z grupy SFA w mięśniach nóg (P≤0,01) i mięśniach piersiowych (P≤0,05) oraz wzrost udziału MUFA w mięśniach piersiowych (P≤0,05).

Słowa kluczowe: kurczęta brojlery, kurkuma, wydajność rzeźna, jakość mięsa

Poultry meat market is one of the most rapidly growing sectors of meat industry. Constantly increasing demand for poultry meat is fueled mostly by its high nutritional and dietetic values. Expanding output and rising consumer awareness induce producers to pursue meat quality-enhancing solutions. (Augustyńska-Prejsnar & Sokołowicz, 2014). Apart from genotype, sex, age and housing system, feeding belongs to the main factors influencing meat quality. Dietary supplementation of herbs, in addition to improving feed taste and flavor which contributes to a better feed efficiency, has a beneficial effect on birds' health and performance, and on sensory attributes attractive for consumers (Radkowska, 2013). Among herbs used for this purpose, an increasing interest is focused on turmeric *(Curcuma longa* L.*)*.

Currently turmeric, used in Europe as a spice and yellow dye in industry, is also known for its multidirectional medicinal properties. Thus, dietary turmeric supplementation in animals can play a significant role in strengthening their

* This study was funded from statutory activity.

immune system and boosting performance.

Turmeric is a very valuable plant. It is a good energy source in the diet (390 kcal/100 g). It contains carbohydrates (69.9%), mostly starch, protein (8.5%) and fat (8.9%) (including omega-3 fatty acids) (Przybylska, 2015). Turmeric supplies also macroelements (ca. 4%) to the body, like phosphorus, potassium, iron, sodium or calcium. It is a source of vitamins: ascorbic acid (50 mg/100 g), niacin (4.8 mg/100 g), riboflavin (0.9 mg/100 g) and thiamine (0.09 mg/100 g) (Lal, 2012). Other important components include essential oils (2–7%), like turmerone, germacrene, zingiberene, elmenon, curlone or pellanderene, which are responsible for the characteristic earthy aroma of turmeric (Ohshiro & Kuroyanagi, 1990; Esatbeyoglu et al., 2012; Terlikowska et al., 2014). However, these are curcuminoids (2–5%), biologically active compounds belonging to polyphenols, responsible for yellow-orange colour and probably for pungent flavor, that are the most valuable turmeric components. They include curcumin, demethoxycurcumin, bismethoxycurcumin and recently identified cyclocurcumin (Lim et al., 2011).

Literature data indicate that the dietary turmeric supplementation to broiler chickens improves their health and reduces mortality (Mondal et al., 2015), decreases serum cholesterol level (Hussein, 2013) and abdominal fat content (Mondal et al., 2015). Turmeric also stimulates bile acid synthesis in the liver, which improves digestion and absorption of lipids. It was evidenced that turmeric increased general performance of birds (Mondal et al., 2015), their body weight (Al-Sultan, 2003) and feed conversion ratio (Naderi et al., 2014), and improved fatty acid profile in intramuscular fat (Daneshyar et al., 2011). Studies of Radwan et al. (2008) indicated that dietary turmetic supplemented to in laying hens increased egg production, and egg weight and yolk content.

The aim of the present studies was to determine the effect of dietary turmeric supplementation on performance and meat quality of Ross 308 broiler chickens.

Material and methods

The studies were carried out in the experimental farm of the Warsaw University of Life Sciences, Agricultural Experimental Station Wilanów-Obory.

The studies were conducted on 100 Ross 308 broiler chickens reared till 42 days of age. At the beginning of the experiment, chickens were randomly assigned to 2 groups (with 5 repetitions each): control group (50 chicks) and treatment group (turmeric-treated, 50 chicks). The groups differed in dietary supplementation of 0.75% ground turmeric (Kamis) in the treatment group. Feed was available *ad libitum*. A three-phase feeding program was used (starter, grower and finisher diets) (Tab. 1).

Table 1. Ingredient composition and nutritional value of the diets

Component (%)	Starter	Grower	Finisher
Corn	10,00	11,40	10,00
Wheat	53,00	55,00	60,80
Soybean meal	30,60	27,40	21,60
Ground limestone	1,19	1,20	0,97
Sodium bicarbonate	0,20	0,14	0,16
NaCl	0,24	0,28	0,26
Dicalcium phosphate	1,18	0,78	0,64
Soybean oil	2,10	2,40	4,40
Methionine 84% calcium salt	0,48	0,42	0,28
Lysine	0,36	0,34	0,28
Threonine	0,14	0,13	0,10
Premix[1] 0.5%	0,50	0,50	0,50
Nutritional value			
ME [kcal]	2990	3047	3217
Crude fat	3,67	4,00	5,92
Crude protein	21,99	20,78	18,51
Crude fiber	3,60	2,55	2,41
Crude ash	5,83	5,35	4,67
Lysine	1,38	1,28	0,97
Methionine + cystine	1,08	1,01	0,76
Available phosphorus	0,45	0,38	0,35

Individual body weight, feed intake and mortality of chickens were recorded at 1, 14, 35 and 42 days of rearing. On day 42, 12 chicks (6 cocks and 6 hens) of approximately average body weight for each sex in a given group were chosen for slaughter. The chosen birds were starved for 12 hours with constant access to water and then they were delivered to a slaughterhouse. Carcasses were chilled in dry air at 4°C for 12 hours. In total, 24 chilled carcasses (12 from control group and 12 from treatment group) were weighed and dissected according to the method described by Ziołecki and Doruchowski (1989). Dressing percentage and percentage yield of breast muscle, leg muscle and giblets (gizzard, liver and heart) in a carcass were calculated.

Meat analysis was carried out on breast and leg muscles collected during dissection. Meat samples were prepared and analyzed for: basal chemical composition with conventional methods: protein content by Kjeldahl method (according to Polish Standard PN – 75/A-04018), fat content by Soxhlet method (according to AOAC, 2005), pH_{24} was measured using a pH-meter CP-411 with a glass-calomel electrode (Elmetron, Zabrze), water holding capacity (WHC) was determined by a filter paper method (according to Grau and Hamm, 1956), cooking loss was assayed according to Iwańska and Jacórzyński (1973) and shear force in breast muscles was measured using an apparatus ZWICK type 1120 with Warner-Bratzler blade. Meat colour parameters L*, a*, b* were assayed using colourimeter CR – 410 (Minolta). In addition, fatty acid profile was determined in meat samples (breast and leg muscles) using gas chromatography on a Hewlett Packard 6890 Series GC System with FID detector, equipped with a capillary column BPX 70, length 50 m x 0.25 mm x 0.25 mm film (SGE Inc. Austin). Helium was used as a carrier gas.

Statistical analysis of the obtained results was performed using IBM SPSS 21 Statistics software package and significance of differences was determined by one-way analysis of variance.

Results

The experimental results are presented in Tab. 2–10. No significant changes in body weight of hens were observed between treatment and control group but body weight of cocks fed tumeric-supplemented diet was statistically significantly ($P \leq 0.05$) reduced. The obtained results indicated no significant differences in carcass weight of birds. No statistically significant tendency in feed conversion ratio (FCR) was also evidenced. Dressing percentage (Tab. 3, 4) in chickens receiving 0.75% turmeric-supplemented diet remained statistically significant unchanged, as well. There were also no changes in percentage yield of breast and leg muscles in the carcass. In the treatment group, both in cocks and hens, a higher percentage of gizzard, liver and heart was noted compared with the control group (Tab. 3 and 4), but it was not confirmed by statistical analysis. Breast muscles, unlike leg muscles, contained less fat which is a genetically determined trait (Tab. 5, 6). The experiment showed a tendency towards reduction of fat content both in breast and leg muscles in turmeric-treated group but these differences did not reach statistical significance. Further, the addition of turmeric increased water holding capacity of breast muscles and reduced cooking loss which could result in better meat juiciness and protect producers from economic losses, however, these values also were not confirmed by statistical analysis. Based on the obtained results (Tab. 7, 8), it can be concluded that dietary turmeric did not statistically significantly influence ($P \geq 0.05$) colour parameters L*, a*, b*. Analysis of data on fatty acid profile in intramuscular fat (Tab. 9, 10) showed that these were monounsaturated fatty acids (MUFA) that were the largest fraction in breast muscles of tumeric-treated chickens. In addition, MUFA content in fat of breast muscles was significantly higher ($P \leq 0.05$) in chicken receiving turmeric-supplemented diet compared with the control group. In contrast, PUFA prevailed in leg muscles compared with the control group where saturated fatty acids (SFA) dominated. Turmeric supplement reduced SFA level in fat of breast ($P \leq 0.05$) and leg ($P \leq 0.01$) muscles. Dietary turmeric supplementation to chickens elevated *n-3* and *n-6* PUFA percentage content in leg muscles and *n-3* PUFA in breast muscles ($P \leq 0.01$).

Table 2. Performance of broiler chickens

Group	Body weight on day 42 (g)		Carcass weight (g)		FCR (%)	Mortality (%)
	females	males	females	males		
Turmeric	2529	2905[b]	1810	2100	1,59	5,12[b]
Control	2533	3028[a]	1842	2194	1,69	6,45[a]
SE	0,92	1,25	0,91	0,99	1,25	1,27

[a, b] – values in rows differ significantly at $P \leq 0.05$; [A, B] – values differ significantly at $P \leq 0.01$.
FCR – feed conversion ratio.

Table 3. Results of slaughter analysis for females (%)

Group	Dressing percentage	Pectoral muscles	Leg muscles	Gizzard	Liver	Heart	Total giblets	Abdominal fat
Turmeric	71,56	21,15	13,55	1,15	1,56	0,45	3,16	0,32
Control	72,62	22,34	13,94	0,98	1,52	0,36	2,86	0,54
SE	0,95	0,69	0,38	0,14	0,08	0,09	1,20	0,08

Table 4. Results of slaughter analysis for males (%)

Group	Dressing percentage	Pectoral muscles	Leg muscles	Gizzard	Liver	Heart	Total giblets	Abdominal fat
Turmeric	72,33	23,02	14,60	0,96	1,51	0,46	2,93	0,43
Control	72,46	22,21	14,08	0,81	1,43	0,38	2,63	0,41
SE	0,94	0,74	0,32	0,05	0,09	0,09	0,02	0,02

Table 5. Chemical composition and parameters of the pectoral muscles from males and females

Group	Fat (%)	Protein (%)	Water (%)	Collagen (%)	pH_{24}	Shear force (N)	Cooking loss (%)	WHC (cm^2)
Turmeric	1,04	23,06	74,28	0,88	5,62	62,90	15,19	4,59
Control	1,16	22,97	74,32	0,95	5,68	56,38	17,81	4,92
SE	0,19	0,18	0,37	0,17	0,45	5,52	1,19	1,25

Table 6. Chemical composition and parameters of the leg muscles from males and females

Group	Fat (%)	Protein (%)	Water (%)	Collagen (%)	pH_{24}	WHC (cm^2)
Turmeric	4,81	20,24	73,44	1,14	6,03	3,84
Control	5,06	20,04	73,17	1,15	6,02	3,01
SE	0,58	0,25	0,47	0,11	0,10	1,06

Table 7. The colour of the pectoral muscles from males and females

Group	L*	a*	b*
Turmeric	50,41	4,66	5,94
Control	51,12	4,01	5,31
SE	1,05	0,48	0,57

a *- represents the colours from green (-a) to red (+a).
b *- represents the colours from blue (-b) to yellow (+b).
L* - L* (lightness) axis is perpendicular to the hue plane and intersects it at the point where a* and b* axes meet. L* values extend from 0 (black) to 100 (white). All the grey hues are in between.

Table 8. The colour of the leg muscles from males and females

Group	L*	a*	b*
Turmeric	53,65	8,64	8,48
Control	53,96	8,28	8,01
SE	1,26	0,77	0,49

a *- represents the colours from green (-a) to red (+a).
b *- represents the colours from blue (-b) to yellow (+b).
L* - L* (lightness) axis is perpendicular to the hue plane and intersects it at the point where a* and b* axes meet. L* values extend from 0 (black) to 100 (white). All the grey hues are in between.

Table 9. Fatty acid profile of fat in the pectoral muscles, g/100 g

Group	SFA	MUFA	PUFA	PUFA n-3	PUFA n-6	PUFA/SFA
Turmeric	34,94^b	39,33^a	25,73	2,07^A	23,66	0,74
Control	38,25^a	35,61^b	26,14	1,22^B	24,92	0,68
SE	1,32	1,39	1,27	0,12	1,16	0,03

$^{a, b}$ – values in rows differ significantly at P≤0.05; $^{A, B}$ – values differ significantly at P≤0.01.

Table 10. Fatty acid profile of fat in the leg muscles, g/100 g

Group	SFA	MUFA	PUFA	PUFA n-3	PUFA n-6	PUFA/SFA
Turmeric	28,29^{B}	35,43	36,37	1,63	34,74	1,29
Control	34,87^{A}	33,00	32,13	1,16	30,97	0,92
SE	2,04	3,10	5,69	0,33	5,40	0,17

$^{a, b}$ – values in rows differ significantly at P≤0.05; $^{A, B}$ – values differ significantly at P≤0.01.

Discussion

Performance and slaughter analysis of broiler chickens

One of the main priorities in poultry science and practice is the search for alternative dietary supplements optimizing chicken health and improving quality of chicken products. Herbs and many spices containing biologically active substances have been used in medicine since antiquity. A ban on the use of antibiotics as growth promoters issued by the European Commission contributed to an increased interest of producers in the use of herbs and herbal extracts, including turmeric, as dietary supplements.

Tab. 2 illustrates data on performance of broiler chickens. No significant differences in body weight of hens were observed between the treatment and control group which confirms the reports of Namagirilakshmi (2005) and Mehala & Moorthy (2008). Statistically significant (P≤0.05) reduction of body weight after dietary turmeric treatment was noted only in cocks. However, most authors (Al-Sultan, 2003; Hussein, 2013; Raghdad & Al-Jaleel, 2012; Mondal et al., 2015) claimed that dietary turmeric treatment significantly influenced weight gain in chickens. It can be supposed (though it was not investigated) that the present experimental results were obtained because of differences in curcumoid contents in commercial turmeric preparations and different developmental stage of plants during harvest.

Feed conversion ratio (FCR) is a significant factor contributing to costs of live poultry production (Murawska & Bochno, 2006). In the present experiment, a tendency towards FCR reduction was observed but it was not confirmed by statistical analysis, although in practice it may affect economic profit. Similar effect of turmeric was observed by Al-Sultan (2003), Nouzarian et al. (2011), Hussain (2013) and Naderi et al. (2014). In the turmeric-treated group, mortality was decreased as demonstrated by reduced percentage of dead birds (P≤0.05). Perhaps the presence of antibacterial components was decisive in this case. These results suggest that antibacterial turmeric components can modulate digestive tract microflora, thereby improving feed digestibility and chicken health.

Profitability of poultry farming essentially depends on dressing percentage and percentage yield of the most valuable carcass components, i.e. breast and leg muscles. Slaughter analysis of carcasses (tab. 3, 4) did not show statistically significant changes in dressing percentage of chickens fed the diet containing 0.75% turmeric. No differences were also observed in percentage content of breast and leg muscles in the carcass. Hens, in spite of a slightly worse dressing percentage (71.56 %) compared with cocks (72.33%) were characterized by low content of abdominal fat (0.32%) which probably resulted from the ability of turmeric to activate lipolysis and suppress lipogenesis (Lone et al., 2016).

It is worth noting that both cocks and hens were usually characterized by a higher percentage content of the gizzard, liver and heart compared with the control group (Tab. 3, 4). However, the results on the elevated giblet percentage content were not confirmed by statistical analysis although they are in line with reports of other authors: Al-Sultan (2013) and Hussein (2013), who observed a slight ($P \geq 0.05$) increase in the liver weight, and Mondal et al. (2015) who noted a rise in heart weight in chicken consuming 0.5% and 1% turmeric-supplemented diet. Tastiness and characteristic aroma of turmeric-supplemented feed might increase birds' appetite which most probably contributed to a greater use and development of the gizzard.

Physicochemical properties of broiler chicken breast and leg muscles

Breast muscles of chickens, in opposite to leg muscles, contain significantly less fat which is a genetically determined trait (Tab. 5, 6). It should be underlined that fat has a positive effect on taste, juiciness and tenderness of meat (Aberle et al., 2001). Lower fat content observed in breast muscles worsens its sensory attributes but increases dietetic value. Poultry meat, compared to meat of large slaughter animals, is highly valued as an excellent source of complete protein (Smolińska et al., 2009). Turmeric addition increased its content in muscles (though without statistical significance), thus improving dietetic value of meat. It could result from the stimulating effect of turmeric on the digestive system of poultry and better utilization of nutrients from feed (Hernandez et al., 2004). Similar results indicating an increased percentage content of protein after dietary turmeric treatment were obtained by Hussein (2013). According to Niewiarowicz (1993) if fat content increases, protein content declines or dry mass of muscles rises. Such tendency was observed also in the present experiment.

Collagen is considered to be an incomplete protein, reducing meat digestibility and worsening its nutritional value (Kołczak, 2008). Chicken leg muscles are characterized by higher collagen content than breast muscles, however, turmeric additive to the diet reduced collagen content in both groups, thus improving meat tenderness. Also, breast muscle pH value reduction in the turmeric-supplemented group contributed to improvement of meat quality because according to Jakubowska et al. (2004) it enhanced meat taste and flavor. Reduced meat acidity is most often connected with lower water holding capacity (WHC) during cooking and greater loss of meat juice (Fanatico et al., 2007). In the present experiment, dietary turmeric did not influence the basic chemical composition of breast and leg muscles. However, turmeric supplementation produced an increasing tendency in shear force, which imitates chewing and is an important feature from consumer's perspective because its increased value indicates a longer contact with meat and an opportunity to fully appreciate its taste.

The colour of fresh meat is an important parameter influencing consumer purchasing decisions first evaluated by consumers. The desired colour of meat products is one of major quality traits (Żywica et al., 2011). Based on the obtained results (Tab. 7, 8) it can be seen that turmeric supplement did not significantly affect ($P \geq 0.05$) parameters of colour L*, a*, b*.

Turmeric is known of its colouring properties, however, dietary turmeric treatment only slightly elevated b* component. This increase was not noticeable enough either in breast or in leg muscles to impair meat quality. No dietary turmeric-induced changes in carcass colour were observed also by Wattanachant et al. (2011). According to Grabowski (2012) concentration of myoglobin which is decisive for meat colour, increases with muscle use which is confirmed by higher values of colour parameters for leg muscles compared with breast muscles of chickens.

Fatty acid profile in intramuscular fat

Percentage contents and ratios of different groups of fatty acids influence health value of meat. The current guidelines based on clinical studies (Massaro et al., 2008) recommend higher consumption of polyunsaturated (PUFA) and monounsaturated (MUFA) fatty acids as indicators of health-promoting properties of food products. High content of PUFA in poultry meat and fat increases its health benefits over pork or beef. It was demonstrated (López-Ferrer et al., 2001) that daily PUFA intake of 0.3–1.0 g protects humans from coronary heart disease. Further, they show therapeutic and prophylactic efficacy in arthritis, and breast and spleen cancer. However, according to Wood et al. (1995) too high content of unsaturated fatty acids can impair meat organoleptic traits. On the other hand, too high level of saturated fatty acids (SFA) in human diet, according to Wolańska & Kłosiewicz-Latoszek (2012), adversely affects serum cholesterol level. Currently, health problems in people often result from excessive consumption of fat and its unfavorable composition.

Analysis of fatty acid profile in intramuscular fat of dietary turmeric-treated chickens (Tab. 9, 10) indicated that MUFA were the largest fraction in breast muscles. It was also observed that MUFA percentage content in breast muscle fat significantly increased ($P \leq 0.05$) in chicken fed turmeric-supplemented diet vs. control group. In contrast, in leg muscles PUFA dominated compared with the control group, in which SFA percentage content was the highest. Turmeric addition reduced SFA level in breast ($P \leq 0.05$) and leg ($P \leq 0.01$) muscle fat which is desirable for prevention of cardiovascular diseases. In this context, dietary turmeric supplementation proved to have a beneficial effect. The obtained results are in line with studies by Daneshyar et al. (2011) indicating that turmeric supplement in the chicken diet significantly reduced SFA percentage content in fat. Based on the obtained results it can be seen that leg muscle fat is characterized by a lower SFA content compared with breast muscles, which probably resulted from decreased *de novo* synthesis in these muscles.

The contents of fatty acids in fat depends most of all on poultry species but it can also be influenced by diet composition. Saturated fatty acids (mostly palmitic and stearic) and monounsaturated fatty acids (mostly oleic and vaccenic) can be synthesized in the liver but polyunsaturated fatty acids, like linolenic (*n-3*) and linoleic (*n-6*) acid, indispensable for proper functioning of the body, have to be supplied with the diet (Hargis & Van Elswyk, 1993; Pikul, 1996; Łukasiewicz et al., 2011). Turmeric supplement to chicken diet increased *n-3* and *n-6* PUFA percentage content in leg muscles and *n-3* PUFA content in breast muscles ($P \leq 0.01$).

According to World Health Organization (WHO) recommended daily intake of different types of fats, PUFA/SFA ratio was estimated at 1:1. In the present studies, dietary turmeric supplementation in chicken resulted in a more beneficial value of this ratio in breast muscles (compared with the control group) but slightly worsened PUFA/SFA ratio in leg muscles (differences were not confirmed by statistical analysis).

Summary and conclusions

1. Dietary turmeric supplementation in broiler chickens did not adversely affect production performance and meat quality.
2. The obtained results suggest better health status in chickens which was reflected by reduced mortality after dietary turmeric treatment.
3. The studies showed that turmeric inclusion in chicken diet can have beneficial effects, especially on percentage contents of different groups of fatty acids (SFA reduction in breast and leg muscles and MUFA increase in breast muscles), and on sensory attributes and nutritional value.
4. Further studies should focus on investigating the active substance and purity of plant extract by using different commercially available turmeric preparations as a dietary additive.

References

Aberle E.D., Forrest J.C., Gerrard D.E., Mills E.W., Hendrick H.B., Judge M., Merkel R.A. (2001). Principles of Meat Science, 4th ed. Kendal/Hunt Publishing Co., Dubuque, IA.

Al-Sultan S.I. (2003). The effect of *Curcuma longa* (turmeric) on overall performance of broiler chickens. Inter. J. Poultry Sci., 2 (5): 351–353.

AOAC (2005). Official methods of analysis of AOAC International. Gaithersburg, Md.: AOAC International, 2005, USA.

Augustyńska-Prejsnar A., Sokołowicz Z. (2014). Czynniki kształtujące jakość sensoryczną mięsa kurcząt brojlerów. Wiad. Zoot., 2: 108–116.

Daneshyar M., Alizadeh Ghandkanlo M., Sabzi Bayghra F., Farhangpajhoh F., Aghaei M. (2011). Effects of dietary turmeric supplementation on plasma lipoproteins, meat quality and fatty acid composition in broilers. South Afr. J. Anim. Sci., 41 (4): 420–428.

Esatbeyoglu T., Huebbe P., Ernst I.M., Chin D., Wagner A.E., Rimbach G. (2012). Curcumin – from molecule to biological function. Angew. Chem. Int. Ed. Engl., 51: 5308–5332.

Fanatico A.C., Pilla i P.B., Emmert J.L., Owens C.M. (2007). Meat quality of slow- and fast- growing chicken genotypes fed low-nutrient or standard diets and raised indoors or without outdoor accesss. Poultry Sci., 86 (10): 2245–2255

Grabowski T. (2012). Wpływ czynników przyżyciowych na jakość mięsa drobiowego. Cz. I Pol. Drob., 8: 40–41.

Grau R., Hamm R. (1956). Die Bestimmung der Wasserbindung des Fleisches mittels der Press- methode. Fleischwirtsch., 8: 733–734.

Hargis P.S., Van Elswyk M. (1993). Manipulating the fatty acid composition of poultry meat and eggs for the health conscious consumer. World's Poultry Sci. J., 49: 251–264.

Hernandez F., Madrid J., Garcia V., Orengo J., Megias M.D. (2004). Influence of two plant extracts on broiler performance, digestibility and digestive organ size. Poultry Sci., 83: 169–174.

Hussein S.N. (2013). Effect of turmeric (*Curcuma longa*) powder on growth performance, carcass traits, meat quality, and serum biochemical parameters in broilers. J. Adva. Biom. & Pathobiol. Res., 3 (2): 25–32.

Jakubowska M., Gardzielewska J., Kortz J., Karamucki T., Buryta B., Rybarczyk A., Otolińska A., Natalczyk-Szymkowska W. (2004). Kształtowanie się wybranych cech fizykochemicznych mięśni piersiowych w zależności od wartości pH mierzonego 15 minut po uboju kurcząt brojlerów, Acta Sci. Pol. Technol. Aliment., 3 (10): 139–144.

Kołczak T. (2008). Jakość wołowiny. Żywność. Nauka. Technologia. Jakość, 1 (56): 5–22.

Lal J. (2012). Turmeric, curcumin and our life: a review. Bulletin of Environment, Pharmacology and Life Sciences, 1 (7): 11–17.

Lim S., Park H., Ghafoor K., Hwang S.Y., Park J. (2011). Quality and antioxidant properties of bread containing turmeric (*Curcuma longa* L.) cultivated in South Korea. Food Chemistry, 124: 1577–1582.

López-Ferrer S., Baucells M.D., Barroeta A.C., Grashorn M.A. (2001). N-3 enrichment of chicken meat. 1. Use of very long-chain fatty acids in chicken diets and their influence on meat quality: fish oil. Poultry Sci., 80 (6): 741–752.

Łukasiewicz M., Michalczuk M., Głogowski R., Balcerak M., Popczyk B. (2011). Carcass efficiency and fatty acid content of farmed pheasants (*Phasianus colchicus*) meat. Anim. Sci., 49: 199–203.

Massaro M., Scoditt i E., Carluccio M.A., De Caterina R. (2008). Basic mechanisms behind the effects of n-3 fatty acids on cardiovascular disease. Prostagl. Leukotr. & Ess. Fatty Acids, 79 (3–5): 109–115.

Mehala C., Moorthy M. (2008). Production performance of broilers fed with *Aloe vera* and *Curcuma longa* (turmeric). Intern. J. Poultry Sci., 7 (9): 852–856.

Mondal M.A., Yeasmin T., Karim R., Nurealam Siddiqui M., Raihanun-Nabi S.M., Sayed M.A., Siddiky M.N.A. (2015). Effect of dietary supplementation of turmeric (*Curcuma longa*) powder on the growth performance and carcass traits of broiler chicks. SAARC J. Agri., 13 (1): 188–199.

Murawska D., Bochno R. (2006). Porównanie kogutów typu nieśnego z kurczętami brojlerami pod względem masy ciała, zużycia paszy i kosztów produkcji żywca rzeźnego. Acta Sci. Pol., Zoot., 5 (1): 59–70.

Naderi M., Akbari M.R., Asadi-Khoshoei E., Khaksar K., Khjali F. (2014). Effects of dietary inclusion of turmeric (*Curcuma longa*) and cinnamon (*Cinnamomum verum*) powders on performance, organs relative weight and some immune system parameters in broiler chickens. Poultry Sci. J., 2 (2): 153–163.

Namagirilakshm i S. (2005). Turmeric (*Curcuma longa*) as nutraceutical to improve broiler performance. M.V.Sc., thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai.

Niewiarowicz A. (1993). Niejadalne produkty z uboju drobiu. Technologia mięsa drobiowego. Praca zbiorowa pod red. T. Grabowskiego, Warszawa.

Nouzarian R., Tabeidian S.A., Toghyani M., Ghalamkari G., Toghyani M. (2011). Effect of turmeric powder on performance, carcass traits, humoral immune response, and serum metabolites in broiler chickens. J. Anim. Feed Sci., 20: 389–400.

Oshiro M., Kuriyanagi M. (1990). Structures of sesquiterpenes from *Curcuma longa*. Phytochemistry, 29 (7): 2201–2206.

Pikul J. (1996). Lipidy mięsa drobiu. Gosp. Mięsna, 48 (7): 8–34.

Przybylska S. (2015). Kurkumina – prozdrowotny barwnik kurkumy. Probl. Hig. Epidemiol., 96 (2): 414–420.

Radkowska I. (2013). Wykorzystanie ziół i fitogenicznych dodatków paszowych w żywieniu zwierząt gospodarskich. Wiad. Zoot., 4: 117–124.

Radwan N., Hassan R.A., Qota E.M., Fayek H.M. (2008). Effect of natural antioxidant on oxidative stability of eggs and productive and reproductive performance of laying hens. Int. J. Poultry Sci., 7: 134–150.

Raghdad A., Al-Jaleel A. (2012). Use of turmeric (*Curcuma longa*) on the performance and some physiological traits on the broiler diets. The Iraqi J. Vet. Med., 36 (1): 51–57.

Smolińska T., Korzeniowska M., Żechałko-Czajkowska A. (2009). Wartość odżywcza białka mięsa drobiowego. W: Przetwórstwo mięsa drobiu – podstawy biologiczne i technologiczne, Smolińska T. i Kopeć W. (red.) UWP.

Terlikowska K., Witkowska A., Terlikowski S. (2014). Kurkumina w chemoprewencji raka piersi. Post. Hig. Med. Dośw., 68: 571–578.

Wattanachant Ch., Wattanasit S., Itharat A. (2011). Crude turmeric extract

(*Curcuma longa* Linn.) supplementation in broiler diets on sensory evaluation of meat. Khon-Kaen Agricult. J., 62: 237–249.

Wolańska D., Kłosiewicz-Latoszek L. (2012). Struktura spożycia kwasów tłuszczowych a profil lipidowy u osób z nadwagą i otyłością. Rocz. Państw. Zakł. Hig., 63 (2) 155–162.

Wood J.D., Enser M., Nute G.R. (1995). New feeding regimes to improve meat quality. Conf. Proc. “International developments in process efficiency and quality in the meat industry”, Dublin Castle, Ireland.

Ziołecki J., Doruchowski W. (1989). Metody oceny wartości rzeźnej drobiu. COBRD, Poznań, ss. 1–22.

Żywica R., Charzyńska D.G., Banach J.K. (2011). Wpływ procesu oszałamiania elektrycznego kurcząt za pomocą urządzenia własnej konstrukcji na barwę mięsa. Żywność. Nauka. Technologia. Jakość, 1 (74): 52–67.

MONIKA ŁUKASIEWICZ, KATARZYNA MUCHA, KAMILA PUPPEL,
BEATA KUCZYŃSKA, ARKADIUSZ MATUSZEWSKI

Influence of dietary turmeric supplementation on performance and meat quality of broiler chickens

SUMMARY

The aim of the study was to determine the effect of dietary supplementation of 0.75% turmeric on performance, slaughter analysis, meat quality and fatty acid profile in fast-growing Ross 308 chickens. The pectoral and leg muscles were collected for analysis 24 hours after the slaughter of 12 chickens (6 ♂ and 6 ♀) of each group. Based on the survey, there was no impairment in performance and quality of the meat after dietary supplementation with turmeric. Birds were characterized by lower mortality ($P \leq 0.05$) compared to the control group. Chickens supplemented with turmeric showed a decrease in the share of SFA in leg muscles ($P \leq 0.01$) and pectoral muscles ($P \leq 0.05$) and an increase in the share of MUFA in pectoral muscles ($P \leq 0.05$).

Key words: broiler chickens, turmeric, dressing percentage, meat quality