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SLAUGHTER VALUE AND MEAT QUALITY OF BROILER CHICKENS FED WITH RATIONS CONTAINING A DIFFERENT SHARE OF PEA SEED MEAL

Alina Janocha, Anna Milczarek✉, Kamil Łaski, Justyna Głuchowska

Institute of Animal Science and Fisheries, Siedlce University of Natural Sciences and Humanities
B. Prusa 14, 08-110 Siedlce, **Poland**

ABSTRACT

Background. The study aimed to evaluate the effect of feed rations with a different share of pea seed meal on the slaughter value, physicochemical and organoleptic characteristics of breast muscles in broiler chickens.
Material and methods. A growth experiment was carried out involving 120 Ross 308 broiler chickens allocated randomly to three feeding groups each consisting of 40 birds of both sexes. Each group was divided into five subgroups each consisting of eight chickens. Until the 21^{st} day of life the birds were fed *ad libitum* with loose starter rations, and from day 22 to day 35 with grower rations based on corn, post-extraction soybean meal, soy oil and mineral and vitamin additives. In starter and grower rations in experimental groups (II and III) post-extraction soybean meal was replaced with pea seed meal in the amount of 10% and 20% (II) and 15% and 25% (III). On day 35 the chickens were slaughtered, and their meat was analysed. Samples of breast muscles were collected in order to determine their dietary value and physical and sensory characteristics.
Results. Pea seed meal in feed rations for experimental chickens had no influence on the body weight and dressing percentage, but it increased their muscularity and decreased the fattening grade in comparison to chickens fed with rations in which the only protein feed was post-extraction soybean meal. The breast muscles of chickens receiving feed rations containing pea (group II and III, respectively) contained significantly ($P \leq 0.05$) less crude fat – about 30% and 27% less. Pea added to feed rations significantly ($P \leq 0.05$) increased (by about 19% and 27%) the share of linoleic acid $C_{18:3n-3}$ in the lipids of the breast muscle. The lowest ($P \leq 0.05$) content of saturated fatty acids (23.43%) and at the same time the highest ($P \leq 0.05$) content of unsaturated fatty acids (76.42%) was noted in the breast muscles of chickens receiving feed rations containing 15/25% of pea seed meal. More hypocholesterolemic acids (DFA) and less hypercholesterolemic acids (OFA) were found in the muscles of chickens from groups II and III ($P \leq 0.05$). After 24 hours of cooling the carcasses, it was demonstrated that the pH in the muscles of chickens fed with rations containing pea was significantly ($P \leq 0.05$) higher than in chickens from the control group. Irrespective of the share of pea in the diet, the muscles of these birds were of a significantly lighter colour (51.37 and 52.45 vs 44.18). In addition, muscles of birds from groups II and III were characterised by less ($P \leq 0.05$) redness (a^*) and yellowness (b^*). The values of psychometric colour saturation (C^*) lower by 29% and 48% were identified in the muscles of chickens from groups II and III in comparison to the muscles of birds fed with corn and soy rations. The breast muscles of chickens fed with rations containing a smaller share of pea were characterised by the highest ($P \leq 0.05$) water holding capacity (WHC) in comparison to others. The muscles of chickens from group III scored the highest for all flavour traits, but a statistically significant difference was noted only for tenderness.
Conclusion. Considering the slaughter value and quality of the breast muscles of chickens, the results provide a basis for recommending pea seed meal as a partial substitute for post-extraction soybean meal in feed rations for broilers. An improvement in muscularity and fattening grade was noted in comparison to carcasses of birds receiving corn and soy rations. In addition, the breast muscles of chickens fed rations with

✉anna.milczarek@uph.edu.pl, https://orcid.org/0000-0002-2714-3533, phone +48 25 643 1377

peas contained less intramuscular fat with a more favourable, healthy fatty acids profile (significantly more $C_{18:3n-3}$, PUFA and DFA). In terms of the physical properties of muscles no deterioration in their quality was noted depending on the feed. Also, the results of sensory evaluation provide a basis for recommending peas as a component of broiler feed rations.

Keywords: pea seeds, broiler chickens, breast muscle, chemical composition, physical properties, taste value

INTRODUCTION

In recent years poultry farming has been one of the fastest developing branches of animal production. According to Augustyńska-Prejsnar and Sokołowicz (2014), the main drive for developing broiler chicken production is the growing demand for poultry meat, which is mainly due to its high nutritional value and favourable price ratio in comparison to other types of meat. Thanks to its dietary value, culinary applications and properties (physical, chemical, sensory), poultry meat is more valuable than the meat of other species of farm animals. Such a high value of poultry meat is a result of a relatively higher content of protein and lower content of fat, and thus energy (Kunachowicz et al., 2017; Martinez et al., 2011; Poulta et al., 2010).

Other studies (Banaszkiewicz et al., 2018; Milczarek and Osek, 2019; Milczarek et al., 2020; Zonenberg i Drażbo, 2018) demonstrated that the quality of bird meat is modified due to the choice of feed's raw materials in diets based on domestic cereal products and imported post-extraction soybean meal. Dependence on imports of the main protein material, that is, post-extraction soybean meal, poses a problem for the domestic feed industry and a threat to the stability and economic efficiency of poultry production in Poland. On an annual basis, about 2–2.2 million tonnes of post-extraction soybean meal must be imported for the production of industrial feed in which 65% of the total production is poultry feed (Urban, 2015). A significant share of the feed on the worldwide market is constituted by GMO varieties from South American countries and the USA (Davison and Ammann, 2017). In this context, alternative sources of feed protein of plant origin are sought (Biesek et al., 2020; Hejdysz et al., 2017; Milczarek and Osek, 2019; Niwińska et al., 2019). Developing the cultivation of legumes, including peas, could contribute to improving the self-sufficiency of European agriculture in the area of protein feeds (Laudadio et al., 2011; Osek et al., 2013; Palander et al., 2006). The cultivation of legumes and their share in feed production depends on a number of factors. One of them is the price of post-extraction soybean meal and other oil plants. Another is agricultural policy of the specific country and, in turn, payments for the production of crops increasing the profitability of legumes. A significant element determining their suitability as feed is the nutritional value following from the content of both nutrients and anti-nutrients. The main anti-nutrients in pea seeds are inhibitor trypsin and chymotrypsin as well as tannins (Osek et al., 2013). The seeds of legumes, at the level of both plant species and variety, have a diverse chemical composition, so it is necessary to carry out studies aimed at determining the efficiency of their use in feed rations for various species and production groups of poultry (Laudadio and Tufarelli, 2011; Laudadio et al., 2012; Milczarek et al., 2019; Moschini et al., 2005; Osek et al., 2013; Usayran et al., 2014). Pea seeds are characterised by a lower content of total protein and the highest level of metabolic energy among the seeds of legumes (Czerwiński et al., 2010; Laudadio and Tufarelli, 2010; Osek et al., 2013). As regards efficient animal nutrition, a big advantage of pea seeds is their relatively low content of anti-nutrients, thanks to which peas can be used to a larger extent than other species of legumes (Milczarek and Osek, 2016; Nalle et al., 2010).

Therefore, studies were commenced to evaluate the effect of feed rations with a different share of pea seed meal on the slaughter value, physicochemical and organoleptic characteristics of muscles in broiler chickens.

MATERIAL AND METHODS

A growth experiment was carried out involving 120 Ross 308 broiler chickens allocated randomly to three groups (I, II, III) each consisting of 40 birds of both sexes (1:1). Each group was divided into five subgroups of eight chickens each. The chickens were reared in metabolic cages for 35 days. For the first five days the temperature in the poultry house was 31°C and was then gradually decreased as recommended by the supplier. Until the 21st day of life the birds were fed starter rations, and from day 22 to 35 – grower rations. All feed rations were based on post-extraction soybean meal, soybean oil and mineral and vitamin additives. In starter/grower diets of chickens from experimental groups (II and III) post-extraction soybean meal was replaced with pea seed meal in the amount of 10/20% (II) and 15/25% (III). The nutritional value of rations was calculated according to nutritional recommendations and indicated in Table 1.

On the 35th day of the birds' life, 10 birds (five ♀ and five ♂) with a body weight representative of a specific group and sex were selected from each group and slaughtered (Journal of Laws, 2020). Plucked and

Table 1. Composition, %, and nutritive value of 1 kg rations of broiler chickens

Item	Starter – Groups			Grower – Groups		
	I	II	III	I	II	III
Maize meal	47.70	41.00	37.70	53.70	40.20	36.80
Soybean meal	44.00	40.70	39.00	38.00	31.50	29.90
Pea seed meal	–	10.00	15.00	–	20.00	25.00
Soybean oil	5.00	5.00	5.00	5.00	5.00	5.00
DL-methionine 99%	0.21	0.23	0.23	0.21	0.24	0.24
L-lysine	–	–	–	0.08	–	–
Limestone	0.67	0.65	0.65	0.74	0.81	0.81
Salt	0.12	0.12	0.12	0.15	0.15	0.15
Calcium-sodiumphosphate	1.80	1.80	1.80	1.62	1.60	1.60
Mineral-vitamin premix*	0.50	0.50	0.50	0.50	0.50	0.50
Nutritive value of 1 kg diets						
Metabolizable energy, MJ	12.93	12.89	12.86	13.16	13.10	13.09
Crude protein, g	225.9	225.4	225.0	203.8	203.3	203.5
Crude fibre, g	26.4	29.7	31.3	34.1	39.2	39.9
Crude fat, g	6.98	6.87	6.82	7.10	6.88	6.82
Lysine, g	13.6	14.0	14.2	12.0	12.3	12.5
Methionine, g	5.8	5.9	5.9	5.3	5.4	5.3
Total Ca, g	9.8	9.8	9.9	9.3	9.4	9.5
Available P, g	4.5	4.6	4.6	4.1	4.1	4.2
Na, g	1.6	1.6	1.6	1.7	1.7	1.7

*Mineral-vitamin premix starter in starter rations and grower in grower rations.

gutted carcasses were analysed in a laboratory for qualitative parameters. The reaction (pH_{15}) of their breast muscles (m. *pectoralis maior*) was measured 15 minutes after the slaughter. Next, the carcasses were cooled over 24 hours at a temperature of 4°C and afterwards the reaction (pH_{24}) of the muscles was measured again. In order to calculate the dressing percentage, the weight of cooled carcasses was determined and they were subject to simplified dissection analysis using a procedure described by Ziołecki and Doruchowski (1989). During dissection samples of breast muscles were taken for evaluating their physicochemical and organoleptic characteristics.

The dry matter, total ash, crude protein and crude fat contents were described by the AOAC (1990) according to their method number: dry matter (930.15), total ash (942.05), crude protein (990.03), crude fat (991.36). The energy value of meat was calculated on the basis of the content and physical equivalents of calorific values of protein (5.65 kcal/g) and fat (9.45 kcal/g). The share of respective fatty acids in the lipid fraction of meat was estimated by gas chromatography in a GCMS-QP210 Ultra chromatograph (Shimadzu, Kyoto, Japan).

The concentration of hydrogen ions (pH_{15} and pH_{24}) in *pectoralis maior* muscles was measured using a Testo 205 pH-meter with a dagger electrode (Sparta, NJ, USA).

Water absorption expressed as water holding capacity (WHC) was determined by Grau and Hamm's filter-paper press method described by Jurczak (2005) based on the surface of meat juice on the filter-paper. The colour of breast muscles was determined using a Minolta Chroma Metters CR 300 (Konica Minolta Osaka, Japan) instrument according to the L^*, a^*, b^* system (CIE, 2007). Also applied were two illuminant/observer combinations, i.e., illuminant C (average day light) and standard observer 2° as well as illuminant D65 (day light) and standard observer 10°, recommended for measurements of meat colour (Honikel, 1998). In the used measuring system L^* denotes psychometric colour saturation being a spatial vector. On the other hand, a^* and b^* are trichromatic coordinates, where a^* as a positive value corresponds to red, and as a negative value – green; in turn, positive b^* corresponds to yellow, and negative b^* – blue. The colour parameters a^* and b^* were applied to calculate chroma (*C*) and hue (*H*) with formulas used by Milczarek and Osek (2019).

The right breast muscle was used for evaluating the organoleptic characteristics on a five-point scale. The muscles were cooked in a 0.8% NaCl solution (1:2 meat to water ratio) up to a temperature of 80°C in a geometric centre of the sample. The sensory evaluation was carried out by a group of eight trained people. The samples of muscles were evaluated in terms of palatability, flavour, juiciness and tenderness. The preparation of samples and the criterion of the above-described evaluation was based on the recommendations of Baryłko-Pikielna and Matuszewska (2009).

The results were elaborated by statistical methods using one-way analysis of variance. The significance of differences between mean values was verified using Duncan's test at the significance level $\alpha \le 0.05$. The results were elaborated using Statistica PL 13.1 software (StatSoft Inc., 2019).

RESULTS

Peas added to feed rations for experimental chickens had no significant influence on their body weight prior to slaughter, the weight of carcass after cooling and the dressing percentage (Table 2).

A significantly higher ($P \le 0.05$) total muscle share was characteristic of the carcasses of broiler chickens fed rations with a lower share of pea (group III) compared to other birds. Pea seeds added to feed rations (groups II and III) significantly ($P \le 0.05$) decreased the fattening grade of the birds' carcasses, which is demonstrated by the content of abdominal fat (0.81 and 0.88 vs. 0.99%) and skin adipose tissue (9.06 and 9.07 vs. 9.61%) compared to the carcasses of control birds.

The applied chicken feeding scheme did not modify ($P > 0.05$) the content of dry matter, crude ash or total protein, but had an effect ($P \le 0.05$) on the level of crude fat in the breast muscle (Table 3).

Significantly less crude fat (by about 30% and 27%) was noted in the breast muscles of chickens fed with rations containing peas (respectively groups II and III) compared to the muscles of birds receiving feed rations with post-extraction soybean meal as the only source of protein.

Table 2. Slaughter analysis of broiler chickens

Specification	Groups			SEM	*p*-value
	I	II	III		
Body weight before slaughter, g	1 917	1 996	1 971	35.771	0.654
Cold carcasses weight, g	1 505	1 571	1 527	30.692	0.688
Dressing percentage, %	78.49	78.71	77.49	0.364	0.352
Share in cold carcasses, %					
Muscles total	46.44^{b}	48.27^{a}	46.87^{b}	0.419	≤0.05
breast	27.14	28.13	27.46	0.251	0.269
thigh	11.32^{ab}	12.21^{a}	10.40^{b}	0.201	≤0.05
drumstick	7.98	7.89	7.85	0.092	0.848
Abdominal fat	0.99^{a}	0.81^{b}	0.88^{b}	0.041	≤0.05
Skin with subcutaneous fat	9.61^{a}	9.06^{b}	9.07^{b}	0.206	≤0.05

Means in rows followed by different letters are significantly different at $P \leq 0.05$
SEM – standard error of the mean.

Table 3. Basic nutrients, g/100 g, and energy value, kcal/100 g of muscles

Specification	Groups			SEM	*p*-value
	I	II	III		
Dry matter	25.47	25.29	25.41	0.178	0.131
Crude ash	1.14	1.14	1.17	0.006	0.064
Crude protein	22.96	22.31	22.68	0.198	0.145
Crude fat	1.27^{a}	0.89^{b}	0.93^{b}	0.063	≤0.05
Energy value	142	134	137	0.530	0.354

Means in rows followed by different letters are significantly different at $P \leq 0.05$.
SEM – standard error of the mean.

Considering the dietary values of meat, careful attention is paid not only to the amount of intramuscular fat but primarily to the fatty acids profile of the lipid fraction. From the data in Table 4 it follows that the type of feed rations used had a significant effect on the level of both saturated and unsaturated fatty acids in the breast muscle.

As regards lipids building the muscles of chickens from groups II and III, a decrease (by 1.21 and 1.72 pp) was observed in the share of palmitic acid $C_{16:0}$ and an increased share of stearic acid $C_{18:0}$ compared to the muscles of birds from the control group ($P \leq 0.05$). Peas added to feed rations (II and III) for chickens significantly ($P \leq 0.05$) increased (by about 19 and 27%) the share of linoleic acid $C_{18:3n-3}$ classified as unsaturated essential fatty acids) in the lipid fraction of meat. The lowest ($P \leq 0.05$) content of saturated fatty acids (23.43%) and at the same time the highest ($P \leq 0.05$) content of unsaturated fatty acids (76.42%) was noted in the breast muscles of chickens receiving feed rations containing 15/25% of pea seed meal. More hypocholesterolemic acids (DFA) and less hypercholesterolemic acids (OFA) were found in the muscles of chickens fed with rations containing peas (II and III) compared to the muscles of birds from the control group ($P \leq 0.05$).

The type of feed rations used had no statistically significant ($P > 0.05$) effect on the reaction of breast muscles measured 15 minutes after slaughter (Table 5).

After 24 hours of cooling the carcasses, it was discovered that the acidity in the muscles of chickens fed with rations containing pea was significantly ($P \leq 0.05$) lower than in chickens from the control group.

Peas added to broiler chicken feed rations significantly differentiated the colour parameters of breast

Table 4. Fatty acids profile of breast muscles, % total fatty acids

Fatty acids	Groups			SEM	p-value
	I	II	III		
$C_{14:0}$	0.07^{b}	0.10^{a}	0.10^{a}	0.004	≤0.05
$C_{16:0}$	18.68^{a}	17.47^{b}	16.96^{b}	0.240	≤0.05
$C_{16:1}$	1.09	0.87	1.16	0.057	0.076
$C_{17:0}$	0.13	0.13	0.15	0.005	0.278
$C_{17:1}$	0.05	0.05	0.05	0.003	0.762
$C_{18:0}$	5.14^{c}	6.92^{a}	6.19^{b}	0.208	≤0.05
$C_{18:1}$	30.76	31.62	31.96	0.501	0.637
$C_{18:2}$	41.82	39.59	40.23	0.577	0.284
$C_{18:3}$	1.5^{b}	1.81^{a}	1.97^{a}	0.057	≤0.05
$C_{20:0}$	0.01	0.02	0.02	0.002	0.534
$C_{20:1}$	0.05	0.07	0.09	0.007	0.129
$C_{20:2}$	0.04^{b}	0.10^{a}	0.10^{a}	0.008	≤0.05
$C_{20:3}$	0.05	0.05	0.06	0.003	0.298
$C_{20:4}$	0.41^{c}	1.00^{a}	0.77^{b}	0.072	≤0.05
$C_{22:0}$	0.02^{b}	0.08^{a}	0.02^{b}	0.008	≤0.05
Others	0.09	0.12	0.15	0.010	0.057
Saturated (SFA)	24.07^{ab}	24.72^{a}	23.43^{b}	0.219	≤0.05
Unsaturated (UFA)	75.84^{ab}	75.16^{b}	76.42^{a}	0.218	≤0.05
Monounsaturated (MUFA)	31.96	32.61	33.27	0.530	0.637
Polyunsaturated (PUFA)	43.88	42.55	43.15	0.529	0.626
DFA (UFA + $C_{18:0}$)	80.99^{b}	82.08^{ab}	82.61^{a}	0.229	≤0.05
OFA ($C_{14:0}$ + $C_{16:0}$)	18.75^{a}	17.57^{b}	17.05^{b}	0.239	≤0.05

Means in rows followed by different letters are significantly different at $P \leq 0.05$.
SEM – standard error of the mean.

muscles. Irrespective of the content of peas in a diet, the muscles of birds from groups II and III were characterised by a significantly lighter (51.37 and 52.45) colour compared to the muscles of chickens fed with corn and soy feed rations (44.18). In addition, the muscles of birds receiving experimental feed rations (groups II and III) were characterised by less ($P \leq 0.05$) redness (a*) and yellowness (b*). The variation in colour constituents a* and b* modified muscle colour saturation ($P \leq 0.05$) and hue ($P > 0.05$). Values of psychometric colour saturation (C*) 29% and 48% lower were identified in the muscles of chickens from groups II and III in comparison to the muscles of birds fed with corn and soy rations.

The breast muscles of chickens from group II, fed with rations containing a smaller share of pea, were characterised by the highest ($P \leq 0.05$) water holding capacity (WHC) in comparison to the muscles of other birds.

Pea seed meal added to feed rations had a significant ($P \leq 0.05$) effect on meat tenderness only (Fig. 1).

The highest score (4.58 pts) for tenderness was obtained by birds receiving feed rations with the highest

Table 5. Physical parameters of breast muscles

Specification	Group			SEM	*p*-value
	I	II	III		
pH_{15}	6.21	6.29	6.28	0.028	0.330
pH_{24}	5.78^{b}	5.97^{a}	5.94^{a}	0.034	≤0.05
L^*	44.18^{B}	51.37^{a}	52.45^{a}	1.030	≤0.05
a^*	4.33^{a}	3.60^{ab}	2.05^{b}	0.258	≤0.05
b^*	3.36^{a}	1.42^{b}	2.01^{ab}	0.300	≤0.05
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	5.48^{a}	3.87^{b}	2.88^{b}	0.262	≤0.05
$H = \log(b^*/a^*)$	0.66	0.38	0.77	0.074	0.284
WHC, %	11.31^{b}	15.40^{a}	13.00^{ab}	0.586	≤0.05

Means in rows followed by different letters are significantly different at $P \leq 0.05$.
SEM – standard error of the mean.
L^* – lightness, a^* – redness, b^* – yellowness, C – chroma, H – hue.
WHC – water holding capacity.

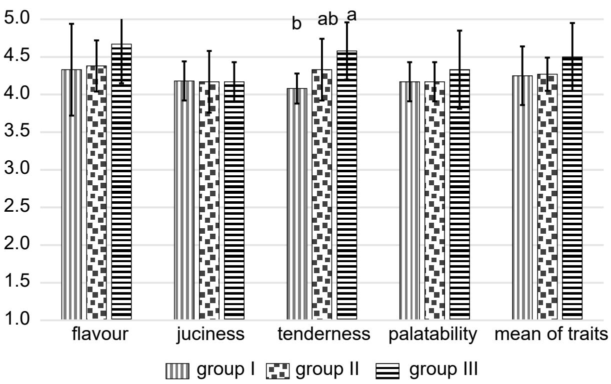

Fig. 1. Results of gustatory value of breast muscles, points

share of pea seeds. The muscles of these chickens scored best for all flavour traits (smell, juiciness and palatability).

DISCUSSION

The dressing percentage of birds fed with rations containing pea seed meal, irrespective of its share in the rations at respective rearing stages, corresponded to the findings of Osek et al. (2013) and Dotas et al. (2014). Dotas et al. (2014) showed that the dressing percentage was similar for broiler chickens fed with corn and soy rations containing peas at 160 g/kg (starter), 240 g/kg (grower) and 480 g/kg (finisher). Despite a similar dressing percentage of chickens fed pea-containing diets, Osek et al. (2013) did not observe any significant effect of peas on the fattening grade and muscularity of the birds' carcasses. Also, Laudadio et al. (2012) did not demonstrate a decrease in the dressing percentage, muscularity and fattening grade of broiler chickens when pea seeds were introduced into feed rations.

Many authors (Połtowicz and Doktor, 2012; Zdanowska-Sąsiadek et al., 2013) claim that the quality of meat is significantly affected by five basic traits, including: sensory attributes (colour, taste) and texture of meat (juiciness, tenderness), hygienic and toxicological indicators (pH of the carcass), physicochemical parameters (content of protein, carbohydrates and fat) and technological traits (content of connective tissue). Studies carried out by Nowak and Trziszka (2010) indicate that the dietary value of meat is very often the reason behind consumer choices and is mainly determined by the amount of fat in the birds' muscles, which should not exceed 2.5%, as a higher content of fat is unacceptable to customers.

Although the applied starter / grower rations were iso-protein and iso-energetic, the supplementation of pea seeds significantly ($P \leq 0.05$) contributed to decreasing the content of crude fat in muscles compared to the group of birds fed with corn and soy rations. A similar content of fat in the breast muscles after supplementing chicken feed rations with peas was observed by Osek et al. (2013). Furthermore, Milczarek and Osek (2017) also found similar amounts of intramuscular fat (and other essential components) in the evaluated muscles of birds fed with rations containing the seeds of legumes compared to birds from the control group.

Considering the dietary values of meat, careful attention is paid not only to the amount of intramuscular fat but primarily to the fatty acids profile of the lipid fraction, which according to Banaszkiewicz et al. (2018) depends on the chickens' diet. Fébel et al. (2008) reported that the physiological capabilities of poultry could help enrich the tissues of broilers with polyunsaturated fatty acids (PUFA), since, in contrast to mammals, their fat metabolism is different.

In our own studies the highest ($P \leq 0.05$) level of neutral and hypocholesterolemic acids was found in the muscles of chickens fed with rations containing pea seeds (II and III) compared to birds receiving corn and soy rations. An increased share of DFA was a result of a considerably higher (compared to the control group) share of stearic and linolenic acid in the lipid profile of the meat of birds receiving feed mixtures containing peas. The high level of these acids in the muscles is related to the lipid profile of pea seeds (Khrisanapant et al., 2019; Rybiński et al., 2013). The results are corroborated by the reports of Laudadio and Tufarelli (2010). The authors, using pea seed meal as a source of protein in feed rations for slaughter chickens, showed its positive effect on the fatty acids profile as they noted an increased content of n-3 PUFAs in white muscles compared to soy-containing diets. Also, Milczarek and Osek (2017), having supplemented broiler chicken feed rations with faba bean, noted an increased share of linoleic acid $C_{18:3n-3}$ and significant favourable changes in the amount of SFA and UFA as well as DFA and OFA in breast muscles. Kiczorowska et al. (2016) showed that the substitution of micronized pea for post-extraction soybean meal contributed to a significant reduction in the content of SFA and increase of MUFA in the lipid fraction of breast muscles.

The value of pH, that is, the level of muscle tissue acidity is one of the most common criteria used in the evaluation of poultry meat quality. The level of acidity is an indicator of intensive glycolytic transformations taking place in the muscle accounting for differences in meat quality, its technological suitability and firmness (Zdanowska-Sąsiadek et al., 2013). Our own studies revealed that the type of feed rations used had no effect on pH_{15} of breast muscles but caused a significant difference in pH_{24}. Many authors (Le Bihan-Duval et al., 2008; Osek et al., 2010; Raach-Moujahed and Haddad, 2013) confirm the relationship between the technological quality of meat and the rate of decrease in the final pH. Namely, when the pH falls rapidly, a PSE (pale, soft, exudative) defect can occur in meat. In turn, high post-mortem pH means that the meat is DFD (dark, firm, dry), which is also not desirable in terms of technological suitability. The optimum pH_{24} of broilers should oscillate around 5.6–6.1 (Berri et al., 2005; Pietrzak et al., 2013), which corresponds to the results obtained for breast muscles. Osek et al. (2013) did not note any significant effect of peas in the feed ration of muscle acidity both 15 minutes and 24 hours after slaughter. Similarly, Milczarek and Osek (2017; 2019), having introduced different seeds of legumes into the diet of birds, did not find any effect on the pH reaction of muscles.

The water holding capacity of meat is one of the most important indicators of the technological suitability of meat for processing. It can have a positive effect on the juiciness, shelf life, colour and texture of the meat. The water holding capacity of meat is the lowest at the isoelectric point of muscle proteins (pH from 5.1 to 5.3). The further the pH from the isoelectric point, the higher the water holding capacity of muscle proteins is, which leads to increased thermal drip and drip loss. In turn, larger meat juice drip in the packaging increases microbiological contamination since bacteria can grow better in such an environment than on the surface. The larger the drip, the larger the susceptibility of meat to dry out (Orkusz, 2015). Our own studies corroborated the results of Milczarek and Osek (2017; 2019) pointing to the lack of influence of various protein feeds on the water holding capacity of breast muscles.

Colour is an important attribute taken into account by consumers when buying meat, and an important element of evaluating meat dishes during their consumption. Magdelaine et al. (2008) report that meat of a darker colour resulting from an increased share of oxidised myoglobin is less desired by consumers. Zdanowska-Sąsiadek et al. (2013) indicate a relationship between meat colour and acidity – the higher the pH, the darker the meat and vice versa. Extremely high pH leads to DFD and low to PSE meat defect. The breast muscles of chickens fed with rations containing peas (irrespective of its share) were characterised by a significantly lighter colour *L** and less redness (*a**) and yellowness (*b**) compared to muscles of chickens fed with rations containing corn and soy. In turn, Laudadio et al. (2012) showed that the muscles of birds fed pea-containing diets had slightly lower *L** and *b** values compared to the muscles of chickens fed with wheat and soy. On the other hand, Milczarek and Osek (2019) did not find any significant effect of different protein feeds on *L**, *a** and *H* parameters of meat colour.

Poultry meat available on the market should be of an adequate quality and is perceived by consumers as a collection of many subjective attributes, the most important of them being: colour, tenderness, palatability and nutritional value (Nowak and Trziszka, 2010; Tougan et al., 2013). In addition, Nowak and Trziszka (2010) emphasize that for a consumer buying meat its palatability and nutritional value are equally important.

Their results were corroborated by those obtained by Osek et al. (2013) showing a positive effect of rations containing the seeds of legumes, including peas, on the sensory attributes and especially the tenderness and juiciness of breast muscles. In turn, Zonenberg and Drażbo (2018) gave a lower evaluation of the flavour of the breast muscles of chickens fed with rations containing post-extraction soybean meal, respectively by 19% lower for palatability, by 17% for juiciness, by 11% for smell and by 10% for tenderness. Similarly, in the studies of Osek et al. (2010) a lower evaluation was given for the breast muscles of chickens fed with cereal and soy rations. In turn, Milczarek and Osek (2019) showed no significant effect of different protein feeds on the sensory attributes of muscles.

CONCLUSION

Considering the slaughter value and quality of the breast muscles of chickens, the results provide a basis for recommending pea seed meal as a partial substitute for post-extraction soybean meal in feed rations for broilers. An improvement in the slaughter value of chicken carcasses, manifested in increased muscularity and decreased fattening grade, was noted in comparison to carcasses of birds receiving corn and soy rations. In addition, the breast muscles of chickens fed rations with peas contained less intramuscular fat with a more favourable, healthy fatty acids profile (significantly more $C_{18:3n-3}$, PUFA and DFA). In terms of the physical properties of muscles, no deterioration in their quality was noted depending on the feed variant. Also, the results of sensory evaluation provide a basis for recommending peas as a component of broiler feed rations.

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