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Efficiency of peas in broiler chicken feeding

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SUMMARY

The study aimed to evaluate how feed rations containing different shares of pea seed meal (Tarchalska variety) affect the rearing performance, carcass composition, and physicochemical and sensory characteristics of the muscles of broiler chickens. The experiment was conducted on 120 broiler chickens randomly allocated to three groups (C, EI, and EII) of 40 birds each. The birds received starter diets up to 21 days of age and then grower diets from days 22 to 35. In the starter and grower diets for groups EI and EII, soybean meal was replaced with 10% and 20% (EI) and 15% and 25% (EII) pea seed meal, respectively. Pea added to chicken feed diets was shown to have no effect on the birds' body weight (P > 0,05), but chickens fed diets with a smaller share of this component had lower feed conversion by more than 3% (P ≤ 0,05). The diet was not shown to affect the dressing percentage, muscularity or fatness of the chickens. The muscles of chickens from groups EI and EII contained significantly less (by about 21% and 6%) crude fat. Lower AI and TI indices (P ≤ 0,05) and a higher ratio of hypocholesterolaemic to hypercholesterolaemic acids (P ≤ 0,05) indicate that pea added to diets for broiler chickens improves the fatty acid profile of the muscles. Irrespective of the content of peas in the diet, the birds' muscles had a significantly (P ≤ 0,05) lighter colour and lower red and yellow saturation, hue, and chroma. The muscles of birds from groups EI and EII received higher scores (P > 0,05) for sensory features. The results suggest that partial replacement of soybean meal with pea seed meal can be recommended in the diet of broiler chickens, as it improved rearing performance, carcass composition and the nutritional characteristics of the muscles.

KEY WORDS: broiler chicken, nutrition, pea seeds, performance results, carcass value

INTRODUCTION

Broiler chicken feeding relies on domestic grains and imported soybean meal. The dependency

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on imported soybean meal –the main source of protein – poses a threat to the stability and economic efficiency of poultry production (Jerzak, 2015; Urban, 2015; Statistical Yearbook of Agriculture, 2020). A good way to improve the self-sufficiency of European agriculture in protein-based feeds is to develop the cultivation of legumes, including peas (Laudadio et al., 2012; Osek et al., 2013; Księżak and Bojarszczuk, 2014). The cultivation of legumes and their use in feed production is determined by multiple factors, including soybean meal prices, agricultural policy, e.g. subsidies for growing legumes, and their nutritional value (Osek et al., 2013; Jerzak, 2014; Jerzak, 2015; Milczarek et al., 2016; Sharma et al., 2021). Due to variation in the chemical composition of legume seeds, it is advisable to examine their suitability for feeding various species and age groups of poultry (Moschini et al., 2005; Laudadio et al., 2012; Milczarek and Osek, 2019; Księżak et al., 2014; Proskina et al., 2021). Among all legume seeds, peas have the lowest content of crude protein, the highest level of metabolic energy, and the lowest content of antinutrients, so they can be widely used in diets for poultry (Cowieson et al., 2003; Laudadio and Tufarelli, 2011; Osek et al., 2013; Księżak and Bojarszczuk, 2014). However, research results (Czerwiński et al., 2010; Laudadio and Tufarelli, 2010; Nalle et al., 2010; Proskina et al., 2021; Sharma et al., 2021) do not provide a clear answer regarding the efficiency of including pea seed meal in diets for broiler chickens.

Therefore, a study was conducted to evaluate the effect of diets with different shares of pea seed meal on the rearing performance, carcass composition, and meat quality of broiler chickens.

MATERIAL AND METHODS

First, the chemical composition of peas of the Tarchalska variety was evaluated. The pea seeds were purchased from a seed distribution company.

A growth experiment was carried out involving 120 Ross 308 broiler chickens allocated randomly to three groups (C, EI, and EII), each consisting of 40 birds of both sexes (50%:50%). Each group was divided into 5 subgroups of 8 chickens each. The chickens were reared for 35 days. The birds were fed starter diets up to 21 days of age and grower diets from days 22 to 35. All feed rations were based on extracted soybean meal, soybean oil, and feed additives. In the starter/grower diets of chickens from the experimental groups (EI and EII), soybean meal was replaced with pea seed meal in the amount of 10/20% (EI) and 15/25% (EII). The nutritional value of the diets was calculated according to nutritional recommendations (Table 1).

Table 1

Composition and nutritive value of experimental diets

	Starter period			Grower period		
	Group					
	C	EI	EII	C	EI	EII
Components, g/kg						
Maize meal	477,0	410,0	377,0	537,0	402,0	368,0
Extracted soybean meal	440,0	407,0	390,0	380,0	315,0	299,0
Pea seed meal	-	100,0	150,0	-	200,0	250,0
Soybean oil	50,0	50,0	50,0	50,0	50,0	50,0
Feed additives	33,0	33,0	33,0	33,0	33,0	33,0
Calculated nutritive value per kg of diets:						
Metabolizable energy, MJ	12,93	12,89	12,86	13,16	13,10	13,09
Crude protein, %	22,59	22,54	22,50	20,38	20,33	20,35
Crude fibre, %	2,64	2,97	3,13	3,41	3,92	3,99
Lysine, %	1,36	1,40	1,42	12,0	1,23	1,25
Methionine, %	0,58	0,59	0,59	0,53	0,54	0,53
Total calcium, %	0,98	0,98	0,99	0,93	0,94	0,95
Available phosphorus, %	0,45	0,46	0,46	0,41	0,41	0,42
Sodium, %	0,16	0,16	0,16	0,17	0,17	0,17
Analysed nutrients per kg of diets:						
Dry matter, %	89,48	90,49	89,68	89,82	90,85	90,06
Crude ash, %	6,32	6,43	6,36	5,86	6,11	6,13
Crude protein, %	23,15	22,64	22,93	20,68	20,61	20,33
Crude fat, %	7,10	7,5	7,54	7,92	7,21	7,13
Crude fibre, %	2,68	2,99	3,24	2,95	3,57	3,79

At the age of 35 days, 10 birds (5 ♀ and 5 ♂) from each group with a body weight representative of their group and sex were selected and slaughtered. After 15 min the reaction (pH_{15}) of the thigh muscles was measured. Then the carcasses were cooled over 24 h at 0-4°C, and the reaction of the muscles was measured again (pH_{24}). To calculate the dressing percentage, the cooled carcasses were weighed, and simplified dissection analysis was performed according to Ziołecki and Doruchowski (1989). During dissection, samples of the leg muscles were taken for determination of their physicochemical and organoleptic characteristics.

The chemical analyses of the pea seeds, diets, and muscles were performed according to AOAC methods (1990): content of dry matter (930,15), crude ash (942,05), crude protein (990,03), crude fat (991,36) and (only in pea seeds and diets) crude fibre (978,10).

The fatty acid profile in the muscles was determined by gas chromatography (Folch et al., 1957). Fatty acid analysis was performed by gas chromatography (GC) using a gas chromatograph (GCMS-QP210 Ultra, Shimadzu, Kyoto, Japan) with a capillary column and flame-ionization detection and helium as the carrier gas. The initial oven temperature was 140°C for 1 min, then increased by 20°C/min to 200°C and held for 20 min, and further increased by 5°C/min to 220°C and held for 25 min. The injector was heated to 250°C and the detector to 270°C. FAME standards (Supelco 37 Component FAME Mix) were used to identify the fatty acids present in the samples. Based on the percentage (% of the total) of fatty acids, the atherogenic (AI) and thrombogenic (TI) indexes were calculated, as well as the ratio of hypocholesterolaemic to hypercholesterolaemic fatty acids (h/H) according to Ulbricht and Southgate (1991) and Santos-Silva et al. (2002):

$$AI = \frac{C12{:}0 + 4 \times C14{:}0 + C16{:}0}{\Sigma MUFA + \Sigma(n{-}6) + \Sigma(n{-}3)}$$

$$TI = \frac{C14{:}0 + C16{:}0 + C18{:}0}{0.5 \times \Sigma MUFA + 0.5 \times \Sigma(n{-}6) + 3 \times \Sigma(n{-}3) + \Sigma(n{-}3)/\Sigma(n{-}6)}$$

$$HH = \frac{C18{:}1n{-}9 + C18{:}2n{-}6 + C20{:}4n{-}6 + C18{:}3n{-}3 + C20{:}5n{-}3 + C22{:}5n{-}3 + C22{:}6n{-}3}{C14{:}0 + C16{:}0}$$

The concentration of hydrogen ions (pH_{15} and pH_{24}) in the *iliotibialis* muscles was measured using a Testo 205 pH-meter with a dagger electrode. Water loss, expressed as water holding capacity (WHC), was determined by Grau and Hamm's filter paper press method as described by Jurczak (2005), based on the area of meat juice on the filter paper. The colour of the *iliotibialis* muscles was determined using a Minolta Chroma Meter (CR 300) instrument according to the L*, a*, b* system. In this system L* denotes lightness, while a* and b* are trichromatic coordinates. A positive value of a* corresponds to red and a negative value to green, while a positive value of b* corresponds to yellow and a negative value to blue. The colour parameters a* and b* were used to calculate chroma (C) and hue (H) using formulas given by Milczarek and Osek (2019).

The right thigh muscle was used to evaluate 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 the geometric centre of the sample. The sensory evaluation was carried out by a panel of eight trained people. The muscle samples were evaluated in terms of palatability, flavour, juiciness and tenderness. Sample preparation and evaluation criteria were based on the recommendations of Baryłko-Pikielna and Matuszewska (2014).

Statistical analysis of the results was performed using one-way analysis of variance (ANOVA). The significance of differences between means was verified using Duncan's test at the significance level of $\alpha \leq 0,05$. The results were processed using STATISTICA PL 13.1 software (StatSoft Inc. 2019).

RESULTS AND DISCUSSION

The pea seeds contained 18,69% crude protein, 1,41% crude fat and 6,93% crude fibre. Peas added to the diets of the experimental chickens had no significant influence on their body weight, but altered their feed conversion rates (Table 2).

Table 2

Broiler performance and carcass composition

	Group			SEM	P-value
	C	EI	EII		
Body weight of chickens, g					
Day 21	689	714	715	5,599	0,099
Day 35	1925	1997	1936	16,757	0,166
Feed conversion ratio, kg					
1–21 days of age	$1,73^{a}$	$1,61^{b}$	$1,68^{b}$	0,017	≤0,05
22–35 days of age	$1,61^{a}$	$1,52^{b}$	$1,62^{a}$	0,018	≤0,05
1–35 days of age	$1,64^{a}$	$1,58^{b}$	$1,63^{a}$	0,013	≤0,05
Dressing percentage, %	78,49	78,71	77,49	0,364	0,352
Share in cold carcass, %					
- breast muscles	27,14	28,13	27,46	0,251	0,269
- leg muscles	19,30	20,10	19,69	0,274	0,234
- abdominal fat	0,99	0,81	0,90	0,041	0,188
- skin with subcutaneous fat	9,08	9,16	9,03	0,206	0,967
Share in body weight, %					
- heart	0,48	0,46	0,48	0,009	0,592
- liver	1,86	2,04	2,08	0,048	0,142
- stomach	$1,36^{b}$	$1,58^{ab}$	$1,70^{a}$	0,056	≤0,05

a, b – means in rows followed by different letters are significantly different at $P \leq 0,05$

In the starter period, chickens fed diets containing pea seed meal (groups EI and EII) showed significantly lower ($P \leq 0,05$) feed conversion rates (FCR), whereas in the grower period the lowest FCR was recorded for birds receiving diets with a 20% share of peas ($P \leq 0,05$). Overall for the rearing period, feed conversion was more efficient (more than 3% lower) for birds from group EI compared with birds from groups C and EII ($P \leq 0,05$).

McNeill et al. (2004), after introducing 10% peas to the diet of chickens, obtained the same average body weight for the experimental chickens as for the controls; however, increasing the share of peas to 20% significantly reduced body weight, but also reduced feed conversion per unit of weight gain. Sharma et al. (2021) showed that birds fed a diet containing 50% pea had lower feed intake and lower body weight gain, but a similar FCR to those fed a wheat-based diet. In contrast, Osek et al. (2013) demonstrated a significant increase in the final body weight of chickens receiving (starter/grower) feed with a (15,5/22,5%) share of peas, with a similar feed conversion rate. Diets containing peas had no influence on the weight gain or FCR of broiler chickens according to Moschini et al. (2005), Diaz et al. (2006), and Laudadio and Tufarelli (2011).

Peas included in diets for chickens had no effect ($P > 0,05$) on their dressing percentage, muscularity or fatness (Table 2). Birds receiving diets with a higher share of peas had a significantly ($P \leq 0,05$) higher share of stomach in their body weight.

The results of our study correspond to those of Nalle et al. (2010), Laudadio et al. (2012), Osek et al. (2013) and Dotas et al. (2014), who found no correspondence between peas added to diets for chickens and their carcass composition. Nalle et al. (2010) found that the inclusion of 15% and 20% peas in diets for broiler chickens from days 1 to 7 and from days 8 to 35 of age, respectively, had no significant influence on dressing percentage. Similarly, Dotas et al. (2014) showed that the dressing percentage was not affected by the use of 16% (starter), 24% (grower) and 48% (finisher) peas in maize and soy diets for broiler chickens. Osek et al. (2013) noted a similar dressing percentage and no significant effect on the fatness or muscularity of carcasses after including 15,5/22,5% peas in starter/grower diets for chickens.

The chicken feeding scheme did not modify ($P > 0,05$) the content of dry matter, crude ash or total protein in the leg muscles, but affected ($P \leq 0,05$) the content of crude fat (Table 3).

Table 3

Basic essential nutrients in leg muscles

Nutrient	Group			SEM	P-value
	C	EI	EII		
Dry matter, %	25,09	24,34	25,38	0,251	0,302
Crude ash, %	1,05	1,06	1,06	0,006	0,299
Crude protein, %	19,14	19,46	19,64	0,135	0,323
Crude fat, %	4,83^{a}	3,81^{b}	4,55^{b}	0,180	≤0,05

a, b – means in rows followed by different letters are significantly different at $P \leq 0,05$

Significantly less crude fat – by about 21% and 6% – was noted in the leg muscles of chickens fed diets containing peas (groups EI and EII, respectively) compared to the muscles of birds receiving feed with soybean meal as the only source of protein.

Meluzzi et al. (2009) included faba beans in the diet of broiler chickens and noted a significant decrease in the content of crude fat in the birds' leg muscles. In contrast, Milczarek et al. (2016) found no correspondence between legumes in broiler chicken diets and the content of essential nutrients in the leg muscles.

In terms of human nutrition, it is not the content of intramuscular fat but the fatty acid profile of the lipid fraction that plays the most important role (Jarosz et al., 2020). The diet used in our study had a significant influence on the content of both saturated (SFA) and unsaturated (UFA) fatty acids in the chickens' leg muscles (Table 4).

The lipid profile of the muscles of chickens from groups EI and EII had lower (by 25,7% and 16,7%) content of palmitic acid $C_{16:0}$ ($P \leq 0,05$) and a higher (by about 15%) proportion of linolenic acid $C_{18:3\ n\text{-}3}$ ($P \leq 0,05$) in comparison to the muscles of birds from the control group. A significantly lower ($P \leq 0,05$) share of saturated fatty acids and at the same time a larger share ($P \leq 0,05$) of unsaturated acids were recorded in the leg muscles of birds receiving diets containing pea seed meal (irrespective of its amount). The muscles of chickens fed diets containing peas showed a significant decrease ($P \leq 0,05$) in AI and TI and an increased ratio of hypocholesterolaemic to hypercholesterolaemic acids ($P \leq 0,05$).

The results corroborate the findings of Laudadio and Tufarelli (2010), who used peas as a source of protein in feed for meat chickens and reported a positive effect on the fatty acid profile. The authors noted increased content of PUFA n-3 acids in the drumstick muscles compared to the muscles of chickens fed soybean. Similarly, Milczarek et al. (2016) found that faba beans added to the diet of broiler chickens increased the share of linoleic acid $C_{18:3\ n\text{-}3}$ and caused beneficial changes in the amount of SFA and UFA in the leg muscles. The values of AI, TI and h/H corroborated the positive effect of faba beans on the nutritional value of meat. In contrast, Laudadio et al. (2012) found no effect of faba beans in feed for broiler chickens on the AI and TI of the leg muscles.

Khrisanapant et al. (2019) claims that the lipid fraction profile of leg muscles is linked to the lipid fraction profile of pea seeds. Numerous researchers (Valavan et al., 2016; Konieczka et al., 2017; Milczarek et al., 2018; Janocha et al., 2021) have demonstrated a correspondence between the diet of chickens and the lipid profile of their meat.

Table 4

Fatty acid profile of leg muscles, % total FA

Fatty acid	Group			SEM	P-value
	C	EI	EII		
$C_{14:0}$	0,09	0,09	0,08	0,002	0,472
$C_{16:0}$	17,20[a]	15,83[b]	16,27[b]	0,189	≤0,05
$C_{16:1}$	1,56[a]	1,16[c]	1,30[b]	0,049	≤0,05
$C_{17:0}$	0,06	0,18	0,17	0,005	0,308
$C_{17:1}$	0,04	0,07	0,05	0,005	0,084
$C_{18:0}$	4,30[b]	4,74[a]	4,29[b]	0,071	≤0,05
$C_{18:1}$	31,83	31,4	30,23	0,305	0,073
$C_{18:2}$	42,19[b]	43,49[ab]	44,71[a]	0,370	≤0,05
$C_{18:3}$	2,09[b]	2,42[a]	2,41[a]	0,057	≤0,05
$C_{20:0}$	0,05	0,03	0,01	0,008	0,285
$C_{20:1}$	0,05[b]	0,09[a]	0,06[b]	0,006	≤0,05
$C_{20:2}$	0,04	0,05	0,04	0,002	0,130
$C_{20:3}$	0,04	0,03	0,03	0,002	0,355
$C_{20:4}$	0,22	0,29	0,24	0,013	0,055
$C_{22:0}$	0,02	0,02	0,01	0,001	0,151
others	0,10	0,07	0,09	0,006	0,052
SFA	21,82[a]	20,88[b]	20,84[b]	0,175	≤0,05
UFA	78,02[b]	79,05[a]	79,07[a]	0,185	≤0,05
MUFA	33,49	32,76	31,64	0,326	0,052
PUFA	44,58[b]	46,29[a]	47,43[a]	0,417	≤0,05
AI	0,23[a]	0,21[b]	0,21[b]	0,003	≤0,05
TI	0,50[a]	0,46[b]	0,46[b]	0,006	≤0,05
h/H	4,41[b]	4,89[a]	4,75[a]	0,065	≤0,05

a, b, c – means in rows followed by different letters are significantly different at $P \leq 0,05$

SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, AI – atherogenicity index, TI - thrombogenicity index, h/H - hypocholesterolaemic/ hypercholesterolaemic ratio

Peas added to the diet significantly ($P \leq 0,05$) increased the pH of the thigh muscles 15 minutes after slaughter (Table 5).

Table 5

Physical properties of thigh muscles

Parameter	Group			SEM	P-value
	C	EI	EII		
pH_{15}	6,15^{b}	6,55^{a}	6,43^{a}	0,042	≤0,05
pH_{24}	6,09	6,15	6,05	0,034	0,484
WHC, %	8,48^{b}	8,07^{b}	11,20^{a}	0,544	≤0,05
Colour					
L*	47,40^{a}	51,61^{b}	50,96^{b}	0,717	≤0,05
a*	6,90^{a}	5,21^{b}	5,09^{b}	0,287	≤0,05
b*	5,08^{a}	0,56^{b}	0,44^{b}	0,469	≤0,05
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	8,57^{a}	5,24^{b}	5,11^{b}	0,381	≤0,05
$H = \log(b^*/a^*)$	0,64^{a}	0,11^{b}	0,09^{b}	0,064	≤0,05

a, b – 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

After 24 hours of carcass cooling no differences were recorded in muscle acidity, which corresponds to the results of Laudadio and Tufarelli (2010) and of Milczarek et al. (2016). The thigh muscles of chickens from group EII, fed diets containing a higher share of peas, had a lower ($P \leq 0,05$) water holding capacity (WHC) than the muscles of other birds. Laudadio and Tufarelli (2010) noted poorer water holding capacity in the drumstick muscles of chickens receiving feed with peas as the only high-protein component. Irrespective of the content of peas in the diets, the muscles of birds from groups EI and EII had a significantly ($P \leq 0,05$) lighter colour and lower red and yellow saturation, hue, and psychometric chroma. Colour is an important attribute taken into account by consumers buying or eating meat (Madgelaine et al., 2008). Meat which has a darker colour due to a higher share of oxidized myoglobin is less appealing to consumers (Zdanowska-Sąsiadek et al., 2013). Broiler meat colour depends on the genotype and age of the birds (Mehaffey et al., 2006), rearing conditions, and feeding regime (Janocha et al., 2020).

No significant effect of peas on the sensory traits of the thigh muscles was observed; however, the muscles of birds from groups EI and EII (Fig. 1) scored higher for flavour, juiciness, tenderness and palatability. These results are corroborated by those obtained by Osek et al. (2013) and Milczarek et. al. (2016), which showed a positive effect of diets containing the seeds of legumes, including peas, on the sensory attributes of muscles.

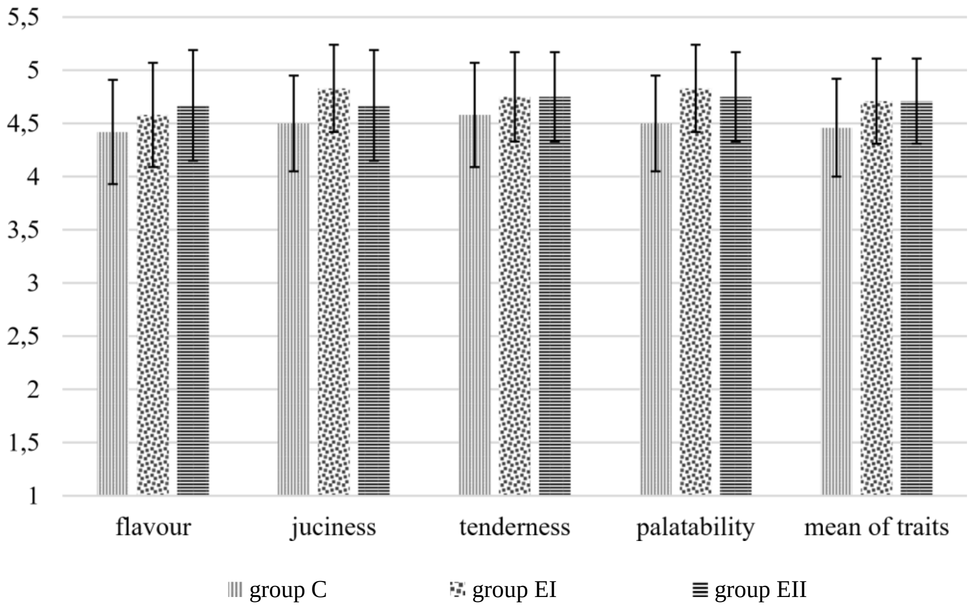

Fig. 1. Sensory evaluation of thigh muscles (points)

CONCLUSION

The results indicate that partial replacement of soybean meal with pea seed meal can be recommended in diets for broiler chickens. To improve the growth performance of broiler chickens, it is recommended to use 10/20% pea meal as a substitute for soybean extraction meal in starter/grower rations, respectively. However, when taking into account the quality (fat content and fatty acid profile) of the leg muscles, it is recommended to use 10/20% or 15/25% pea meal in starter/grower diets, respectively.

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