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Original Article

The Effect of a Balanced Diet Containing Yellow Lupin (Lupinus Luteus L.) on Carcass and Meat Quality of Broiler Ducks

Author(s)

Biesek J[I] https://orcid.org/0000-0003-3050-8617
Kuźniacka J[I] https://orcid.org/0000-0002-0464-0326

[I] Department of Animal Breeding, Faculty of Animal Breeding and Biology, UTP - University of Science and Technology in Bydgoszcz, Mazowiecka 28, 85-084 Bydgoszcz, Poland.

Mail Address

Corresponding author e-mail address
Jakub Biesek
Department of Animal Breeding, Faculty of Animal Breeding and Biology, UTP - University of Science and Technology in Bydgoszcz, Mazowiecka 28, 85-084 Bydgoszcz, Poland.
Phone: (+48) 608-509-997
Email: jakub.biesek@utp.edu.pl

Keywords

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ABSTRACT

The aim of this study was to compare the final productivity parameters, carcass and meat quality in ducks fed with yellow lupin (*Lupinus luteus*) as a protein source instead of soybean meal. 200 Cherry Valley ducks were divided into two equal groups. Control (1) was fed with soybean meal, experimental (2) was fed with yellow lupin. Productivity parameters were calculated. After 8 weeks of rearing, 10 ducks from each group were slaughtered. The pH of breast muscles was measured 15 minutes and 24 hours post-mortem. Carcasses were dissected and each carcass part was weighed. After dissection, breast and leg muscles were analysed for selected parameters of meat quality (water holding capacity, and colour). Additionally, drip loss in breasts was analysed. The body weight of ducks, as well as FI and FCR between groups was compared ($p<0.05$). There were no differences ($p>0.05$) between groups in post-slaughter parameters, but the weight of offal was higher ($p<0.05$) in group 1 than in group 2. There were no differences in the weight of carcass muscles and fatness between the two groups ($p>0.05$). Lightness (L*) and yellowness (b*) of breast muscles were higher ($p<0.05$) in group 2 than in group 1. The water-holding capacity of leg muscles was higher ($p<0.05$) in group 1 than in group 2. Yellow lupin in duck feed as a high-protein component did not deteriorate most meat traits, or the physicochemical parameters of their muscles. It can be proposed as a partial alternative to soybean meal.

INTRODUCTION

The worldwide production of duck meat relies on crossbred hybrids. In Poland these are mainly foreign hybrids – French Pekin duck (Grimaud Fréres Sélection), English Pekin duck (Cherry Valley), and crossbreeds of French Muscovy ducks. There are also Polish crossbreeds of Pekin ducks. An increased interest of consumers in duck meat has been observed in many countries. Duck meat is characterized by a darker red colour and higher content of fat compared to chicken or turkey meat. The high nutritional value of duck meat results from the beneficial composition of fatty acids, lipids in muscles, and fat storage (Biesiada-Drzazga *et al.,* 2011; Kokoszyński *et al.,* 2015; Smith *et al.,* 2015).

Meat characteristics, quality of carcass, and parameters of duck meat depend on a number of factors, including origin (genotype), age and sex of birds, management system and diet (Mazanowski *et al.*, 2003; Wołoszyn *et al.,* 2011a, 2011b; Rahman *et al.,* 2014; Smith *et al.,* 2015). Meat traits also depend on how the birds are fed during the rearing period and handled before and during slaughter, and the duration and conditions of meat storage (Ali *et al.,* 2008; Nurkhoeriyati *et al.,* 2012; Zdanowska-Sąsiadek *et al.,* 2013; Naveen *et al.,* 2016). Diet is one of the crucial factors influencing the quality of carcass and meat. The proportion of nutrients in the feed, necessary for proper growth and development, especially proteins, must be at an optimal level (Kuźniacka *et al.,* 2014; Świątkiewicz *et al.,* 2017).

Polish regulations prohibiting the distribution of feed originating from genetically modified plants prompted many researchers to investigate sources of protein alternative to soybean, e.g. legumes (lupin species, pea, field bean), that can be grown on different types of soil.

In the past, lupin seeds characterized by high content of antinutrients, like alkaloids or non-starch polysaccharides, and its level depends on the cultivars and conditions where it is growing. (Hejdysz *et al.,* 2016). It could affect with a negative growth performance, but nowadays the new cultivars of lupins are characterized by lower alkaloid content (Rutkowski *et al.*, 2017). As Hejdysz *et al.,* (2018) reported, the main problem was that many countries don't grow soybean, because of environmental conditions. Yellow lupin seeds have a potential. There is similar content of protein and its utilization is the same as that of soybean. In the other study, ducks were fed with lupin-rich feed (Kuźniacka *et al.,* 2020). Authors concluded that the use of yellow lupin seeds with addition of rapeseed meal provided the best results in ducks comparing to the ducks fed with soybean meal. In this research, authors also reported that yellow lupin, cv. Mister in ground form had over 42% of crude protein in dry matter, no starch was found, as well as the total alkaloids content was very low (0.00085 g/kg in dry matter). Jamroz & Kubizna (2007; 2008) concluded that 5 to 15% of lupin seeds could be proposed in waterfowl diets. Biesek *et al.,* (2020) also suggested that the use of yellow lupin-rich feed in the waterfowl (geese) diets could be proposed as an alternative for soybean meal.

The aim of our study was to compare the quality of carcass and meat from ducks receiving a balanced feed containing 38% yellow lupin (*Lupinus luteus* L.) as a source of protein alternative to commonly used soybean meal.

MATERIALS AND METHODS

According to the directive no. 2010/63/EU, the agreement of Local Ethics Committee was not required.

Animals and diets

One-day-old Cherry Valley SM3 Medium broiler ducks (males and females) were kept in pens on litter in two groups, 100 birds each. The sex breakdown was not included because sexual dimorphism does not differentiate in slaughter ducks. The control group (1) received balanced feed containing soybean meal (SBM). The experimental group (2) received balanced feed containing yellow lupin *var.* Mister (ground form). Ducks were raised in production conditions on a small-scale farm. In the duck house there were 4 pens, where 50 birds were kept in each. (2 pens = 100 birds = 1 group). Each duck was marked by padlock stamp, so each bird was treated as the experimental unit. The experiment was of implementation nature. The experimental tests were provided earlier in the experimental station (Kuźniacka *et al.*, 2020). This part was practical test, which improved that small-scale production of broiler ducks could be done with the use of yellow lupin seeds as an alternative source of plant protein for commonly used soybean meal. The main assumption of the project was cooperation with small producers, where they expressed their willingness to provide production buildings without much interference in order to create conditions prevailing as in experimental (sterile) stations. The feed provided to both groups contained 55% of concentrate and 45% of wheat in the whole rearing period. The composition of feed and concentrates is presented in Table 1. Total crude protein content was declared at 19.50% and metabolic energy of around 11.95 MJ in kg of feed for both groups. Birds received feed and water *ad libitum* and were reared for 8 weeks.

Table 1 – Composition of feed for ducks.

Composition of feed, %	1[1)]	2[2)]
Concentrate	55	55
Wheat	45	45
Composition of concentrate, %	1[1)]	2[2)]
SBM 44%	65	-
Yellow lupin *var.* Mister	-	68.98
Potato protein	-	3
Brewer's yeast	-	3
Triticale in concentrate	23.04	12
Soybean oil	5.2	5.4
Premix 1%	2	2
Fodder chalk	2	2
Monocalcium phosphate	1.52	1.74
NaHCO3	0.84	0.8
Fodder salt	0.18	0.12
L-lysine	-	0.32
DL - methionine	0.2	0.4
L-threonine	0.02	0.24

[1)]control group - fed with feed based on soybean meal (SBM 44%);
[2)]experimental group - fed with feed based on yellow lupin.

Productivity parameters

Productivity parameters were calculated for the whole flock (100 birds per group that was 50 birds in each of 2 pens). Ducks and feed were weighted. On this basis the mean parameters of initial and final body weight (BW), body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) per kg of body weight gain were calculated. After 8 weeks of rearing, 20 birds (10 from each group), of body weight close to the mean for the whole flock, were slaughtered. From each group 5 females and 5 males were selected for carcass and meat quality analysis. Plucked and gutted carcasses were analysed in a laboratory for qualitative parameters.

Meat quality

Carcass traits and meat quality analyses were done for 20 birds (10 from each group), which were selected for slaughter like a representative bird for research (each bird had a padlock stamp). The pH value of breast muscles was measured 15 minutes post-mortem (pH_{15}). The carcasses were refrigerated at 2°C for 24 hours and pH was measured again (pH_{24}) using a CX-701 El-metron pH meter with a knife electrode. Duck carcasses were weighed on RADWAG scales with accuracy to the nearest 0.01 g and then dissected using the method described by Ziołecki & Doruchowski (1989). The following parts were separated: breast muscles, leg muscles, skin with subcutaneous fat from the whole carcass, including breast and leg parts, abdominal fat, offal (liver, heart, stomach), wings with skin, neck with skin, and carcass remains (body and leg bones). Each carcass part was weighed. The colour of breast and leg muscles was assessed using a colorimeter (Konica Minolta, model CR400, Japan). The apparatus was calibrated using the white calibration plate no. 21033065 and the $D_{65}Y_{86.1}x_{0.3188}y_{0.3362\ \text{scale}}$. The colour was graded according to the CIE system (International Commission on Illumination) for L* (lightness), a* (redness), and b* (yellowness) (CIE, 1986). To analyse drip loss, breast muscles were weighed post-mortem (M1) and after 24-hour storage at 2°C (M2) (Honikel, 1987). Breast and leg muscles were also analysed for water holding capacity using a modified method proposed by Grau and Hamm (1952). For that purpose, pooled samples (about 0.300 g) of disintegrated muscles were wrapped in Whatman grade 1 filter paper and kept under 2 kg pressure for 5 minutes. The water holding capacity of meat was calculated based on the difference in weight before and after the test.

Statistical analysis

Numerical data were analysed using statistical software Statistica 10.0 PL (2011) by calculating means and their standard deviations (±SD) using one-way analysis of variance (ANOVA). The standard error of measurement (SEM) was also calculated. The significance of differences was verified by the post-hoc Sheffe test. The level of significance was at $p<0.05$. The individual bird (marked by padlock stamp) was the experimental unit for all the analysed traits of carcass and meat quality. This work focused on quality analyses. Information about the productivity parameters are additional part. It was not typical nutrition experiment, but poultry product quality research.

RESULTS

Productivity parameters

Production results of whole flock kept in the experiment (100 birds per group) have been calculated. In the group fed with feed based on soybean meal (1), the initial body weight was 52.89 g, and in the experimental group 53.45 g. The final body weight (3117.90 g) was shown to be 37.7 g higher in experimental group (2) than in the group of ducks fed with feed based on soybean meal (3080.20 g). Daily weight gain (BWG) was also higher in group 2 (54.06 g/day) by 0.68 g than in group 1 (54.72 g/day). Lower feed intake (FI) and feed conversion ratio (FCR) were demonstrated in group 1 (9.07 kg, 2.94 kg per kg gain, respectively) than in group 2 (9.26 kg, 2.97 kg per kg gain, respectively). Differences were at 0.19 kg (FI) and 0.03 kg per kg gain (FCR) between groups (table 2). These slight differences were not statistically significant ($p>0.05$).

Meat quality

Considering carcass elements, the analysis showed that the weight of offal was significantly lower ($p=0.038$) in ducks from group 1 compared to group 2 (Table 3). Other post-slaughter parameters of ducks did not differ significantly ($p>0.05$) between groups 1 and 2. There were no differences ($p>0.05$) in the weight and proportion of muscles and subcutaneous and abdominal fat in duck carcasses (Table 4). Physicochemical analysis of breast muscles revealed that duck breast muscles from group 2 were darker (higher value of L*) (p=0.011) and yellower (b*) (p=0.001) (Table 5). Leg muscles from group 1 were characterised by significantly greater (p=0.020) water holding capacity compared to group 2 (Table 6).

Table 2 – Productivity parameters of all of ducks (means) after 8-week rearing period.*

Group n = 100 per group	1 x ±SD	2 x ±SD	SEM	P-value
IBW (g)	52.89 ±5.54	53.45 ±4.94	0.34	0.105
FBW (g)	3080.20 ±7.82	3117.90 ±10.20	0.25	0.610
BWG (g/day)	54.06 ±0.62	54.72 ±0.24	0.24	0.084
FI (kg)	9.07 ±0.85	9.26 ±0.82	0.17	0.594
FCR (kg/kg gain)	2.94 ±0.09	2.97 ±0.09	0.02	0.589

*no statistically significantly differences were found

n– number of ducks in each group; IBW – initial body weight (g) FBW – final body weight (g); BWG – body weight gain (g/day) FI – feed intake (kg); FCR – feed conversion ratio (kg/kg gain);

[1)] control group - fed with feed based on soybean meal; [2)] experimental group - fed with feed based on yellow lupin;

x – means; ±SD – standard deviation; SEM – standard error of measurement; comparisons between groups 1 and 2 on a one-way analysis of variance (ANOVA). Mean values represented by two pens per group (1 group = 50 birds / 2 pens).

Table 3 – Post-slaughter parameters of 8-week-old ducks (means; ±SD; SEM).

Group n = 10 per group		1 x ±SD	2 x ±SD	SEM	*p*-value
Pre-slaughter body weight (g)		3088.00 ±64.60	3116.00 ±85.66	16.82	0.420
Weight of carcass (g)		2151.18 ±40.95	2199.62 ±80.88	15.01	0.108
Dressing percentage (%)		69.68 ±1.78	70.59 ±1.53	0.37	0.239
Weight and proportion in carcass	Neck with skin (g)	268.97 ±26.52	262.45 ±33.98	6.68	0.638
	Neck with skin (%)	12.50 ±1.21	11.93 ±1.54	0.31	0.370
	Wings (g)	290.13 ±26.12	294.55 ±37.21	7.01	0.762
	Wings (%)	13.49 ±1.21	13.40 ±1.72	0.32	0.898
Weight of offal (g)		145.38[b] ±24.96	166.24[a] ±15.67	5.13	0.038
Carcass remains (g)		538.9 ±56.29	544.38 ±66.77	13.46	0.845

[a, b] …. – means in columns marked with different letters differ significantly between groups, p-value <0.05 ; n – number of ducks chosen to the carcass and meat analyses in each group; [1)] control group - fed with feed based on soybean meal; [2)] experimental group - fed with feed based on yellow lupin; x – means; SD – standard deviation; SEM – standard error of measurement; comparisons between groups 1 and 2 on a one-way analysis of variance (ANOVA). Mean values represented by 10 birds per group (1 group = 5 birds / 2 pens).

Table 4 – Content of muscles and skin with fat in 8-week-old ducks (means; ±SD; SEM).*

Group n = 10 per group		1 x ±SD	2 x ±SD	SEM	*p*-value
Weight and proportion in carcass	breast muscles (g)	350.01 ±36.50	354.94 ±54.98	10.17	0.816
	Breast muscles (%)	16.27 ±1.67	16.14 ±2.49	0.46	0.892
	Legs muscles (g)	246.52 ±53.54	270.49 ±25.73	9.55	0.218
	Leg muscles (%)	11.46 ±2.48	12.30 ±1.06	0.43	0.342
	Total muscles (g)[#]	596.53 ±79.46	625.43 ±73.65	17.00	0.410
	Total muscles (%)[#]	27.73 ±3.68	28.44 ±3.24	0.76	0.656
	Skin with subcutaneous fat (g)	537.00 ±88.36	541.06 ±62.53	16.67	0.907
	Skin with subcutaneous fat (%)	24.95 ±3.98	24.59 ±2.57	0.73	0.811
	Abdominal fat (g)	25.44 ±12.57	31.44 ±14.16	2.99	0.330
	Abdominal fat (%)	1.18 ±0.57	1.42 ±0.60	0.13	0.373

*no significant differences; n – number of ducks chosen to the carcass and meat analyses in each group; [1)] control group - fed with feed based on soybean meal; [2)] experimental group - fed with feed based on yellow lupin; [#]total muscles = breast muscles + leg muscles; x – means; ±SD – standard deviation; SEM – standard error of the mean; comparisons between groups 1 and 2 on a one-way analysis of variance (ANOVA). Mean values represented by 10 birds per group (1 group = 5 birds / 2 pens).

Table 5 – Physicochemical parameters of breast muscles from 8-week-old ducks (means; ±SD; SEM).

Group n = 10 per group		1 x ±SD	2 x ±SD	SEM	*p*-value
pH_{15}		5.96 ±0.34	5.94 ±0.18	0.06	0.838
pH_{24}		5.97 ±0.17	5.88 ±0.13	0.03	0.219
Colour	L*	40.79[b] ±2.65	43.64[a] ±1.77	0.59	0.011
	a*	11.25 ±1.47	11.39 ±2.16	0.40	0.864
	b*	1.13[b] ±0.96	3.02[a] ±1.16	0.32	0.001
WHC (%)		36.03 ±5.14	36.98 ±4.32	1.04	0.659
Drip loss (%)		1.18 ±0.60	1.29 ±0.72	0.15	0.711

[a, b] …. – means in columns marked with different letters differ significantly between groups, *p*-value <0.05; n – number of ducks chosen to the carcass and meat analyses in each group; [1)] control group - fed with feed based on soybean meal; [2)] experimental group - fed with feed based on yellow lupin; WHC – water-holding capacity; x – means; SD – standard deviation; SEM – standard error of the mean; comparisons between groups 1 and 2 on a one-way analysis of variance (ANOVA). Mean values represented by 10 birds per group (1 group = 5 birds / 2 pens).

Table 6 – Physicochemical parameters of leg muscles from 8-week-old ducks (means; ±SD; SEM).

Group n = 10 per group		1 x ±SD	2 x ±SD	SEM	*p*-value
Colour	L*	37.39 ±3.24	40.22 ±4.06	0.86	0.101
	a*	10.10 ±3.31	10.79 ±3.21	0.71	0.641
	b*	1.21 ±1.62	1.10 ±0.37	0.37	0.895
WHC (%)		37.63[b] ±6.08	46.91[a] ±9.78	2.07	0.020

[a, b] …. – means in columns marked with different letters differ significantly between groups, *p*-value <0.05; n – number of ducks chosen to the carcass and meat analyses in each group; [1)] control group - fed with feed based on soybean meal; [2)] experimental group - fed with feed based on yellow lupin; x – means; SD – standard deviation; WHC – water-holding capacity; SEM – standard error of the mean; comparisons between groups 1 and 2 on a one-way analysis of variance (ANOVA). Mean values represented by 10 birds per group (1 group = 5 birds / 2 pens).

DISSCUSION

Various authors (Volek & Marounek, 2009; Zduńczyk *et al.*, 2016; Zwoliński *et al.*, 2017) have reported that lupins are a good source of protein, having a positive impact on productivity parameters in turkeys and rabbits. According to Smulikowska & Rutkowski (2018) feed for waterfowl should contain 17.05% of crude protein and 12.3 MJ of metabolic energy per kg. Karasiński *et al.,* (1988) provided ducks with feed containing different varieties of narrow-leaved lupin *Lupinus angustifolius* (bitter vs sweet; 30%), and reported, unlike in our study, lower pre-slaughter body weight (at week 8) in ducks on a lupin-based diet. Similar experiments conducted by Olver (1997; 1998) revealed lower productivity of ducks fed with bitter lupin, which was attributed to the higher level of alkaloids in these plants. Similar results to those obtained in our experiment were reported by Mihok (1997), who used 13 to 20% of lupin in feed rations for Cherry Valley ducks and found no significantly lower pre-slaughter body weight in 7-week-old birds.

In a similar experiment carried out by Rutkowski *et al.,* (2004) the body weight of Pekin ducks reared for 8 weeks and fed with a concentrate containing legumes grown in Poland was 311 g higher compared to ducks on a diet containing soybean meal. The cited authors also concluded that the feed conversion ratio (FCR) was slightly lower in the group of ducks receiving a concentrate with legumes compared to the group on a conventional diet (FCR=3.45 vs FCR=3.61). However, these FCR values were higher than in our experiment (2.94 to 2.97).

In other studies, Adamski *et al.,* (2011) and Kowalczyk *et al.,* (2012) analysed the carcass composition and meat characteristics of Pekin ducks receiving feed with maize distiller's dried grains with solubles (DGGS) as a source of protein in proportions of 15, 25 and 30% per feed ration. Unlike in our study, Kowalczyk *et al.,* (2012) reported that different diets influenced the weight of gutted carcass from 8-week-old ducks, which was highest (2333 g) in birds fed with 25% DGGS, and lowest in birds fed with 30% DGGS (2034 g). Nevertheless, like our experiment, these researchers found no effect of different diets on the dressing percentage and proportion of breast and leg muscles in the carcass. Their experiment revealed a lower proportion of breast muscles and a higher proportion of leg muscles compared to our study. As in our experiment, the above-mentioned researchers found no significant effect of different levels of DGGS as a source of protein in duck feed rations on the proportion of skin with subcutaneous fat, which was much higher than in Cherry Valley ducks.

We also found no effect of different diets on the pH of meat, water holding capacity, and drip loss from breast muscles. Similar conclusions were reached by Adamski *et al.,* (2011), who reported that different diets (different levels of DGGS per feed ration) had no significant influence on pH15 and pH24 of breast muscles from 7-week-old Pekin ducks, but values of pH for breast muscles in their experiment were lower than in our study. Moreover, Adamski *et al.,* (2011) found no significant differences (p>0.05) between nutritional groups in terms of water-holding capacity, as well as lightness (L*), redness (a*) and yellowness (b*) of breast muscles. Of note is that the values of all parameters of breast muscle colour in the cited experiment were generally higher than in our study. Different diets (yellow lupin vs soybean meal) had no influence (p>0.05) on the colour of duck breast muscles in a study by Witak *et al.,* (2006). A significantly higher lightness (L*) and higher yellowness (b*) of the breast muscles may indicate a higher intramuscular fat content in the breast muscles (Zhao *et al.*, 2017).

The addition of 38% yellow lupin to duck feed as a component rich in protein did not deteriorate most meat traits in birds, or the physicochemical parameters of their muscles. In conclusion, yellow lupin can be used as a partial protein source in feed rations to replace soybean meal in duck diet. These results showed that the use of alternative protein sources for soybean meal could help for small-scale producers of poultry rearing, with own crop resources. Other practical tests should be provided. It could be a sign for the producers, especially from traditional family farms, that we have a wider choice to do the production which obtain the good quality of poultry meat.

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