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Effect of partial replacing of wheat by sea buckthorn (*Hippophae rhamnoides* L.) fruit residues in broiler diets on performance and skin pigmentation

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Abstract

Background: Improving poultry products is a constant research topic as the poultry industry aims to provide healthy products to consumers at economic prices and achieve financial profits for breeders. Therefore, recent research has resorted to finding cheap natural sources as alternatives to traditional feed and antibiotics.

Aim: The experiment was conducted to study the effects of sea buckthorn fruit residues meal on broilers' performance and skin pigmentation.

Method: A total of 700 broiler chicks (ROSS 308) were allotted into two groups, and each group comprises 350 birds divided into 10 replicants, 35 birds to each replicant. The experimental group was fed diets where 15% of the wheat was replaced by sea buckthorn residues meal. The control group was fed diets without any color additive. Feed and water were provided *ad-libitum*.

Results: The sea buckthorn fruit residues contained 21% crude protein and metabolisable energy calculated was 9.88 MJ/kg. The live body weight was significantly lower than the experimental group ($p < 0.05$) on days 14 and 28. The feed conversion ratio was significantly poorer in the experimental group compared with the control group on days 35 of age ($p < 0.05$). The mortality was higher in the experimental group than in the control group. The DSM Broiler Fan assessed skin color. The skin of the broilers was significantly more yellowish in the experimental group than the control group (103.08 vs. 102.38 scales). The pigmentation of the skin was higher in males than females.

Conclusion: The use of sea buckthorn residues in poultry feeding negatively affected the overall performance rate. Mightily, its use in diets depends mainly on the price of feed ingredients. Thus, improving the skin color and biological value of broiler meat can determine its usefulness in broiler feed.

Keywords: Sea buckthorn residues, Broilers, Performance, Skin pigmentation.

Introduction

Sea buckthorn (*Hippophae rhamnoides* L.) has been used for several years in different forms, mainly in human nutrition, as a health supplement, due to the content of bioactive substances. It has been examined in recent years as a supplement to animal nutrition (Krejcarová *et al.*, 2015). The reason for this is the assumption that the products of animals fed on Sea buckthorn will be enriched with valuable bioactive substances. Sea buckthorn is a hardy, deciduous shrub bearing small yellow to orange-red berries. It grows widely in Europe, central Asia, and temperate regions of South Asia, India, and China, ranging in altitude of a minimum of 60 m above sea level (ASL) to a maximum of 5,200 m ASL. Sea buckthorn is rich in carotenoids, xanthophylls, phenolics, and flavonoids and has a higher content of essential oils (Yang *et al.*, 2000; Singh *et al.*, 2006). The fruit and leaves are rich in nutrients and bioactive components such as vitamins (Kudritskaya *et al.*, 1989; Zadernowski *et al.*, 2003; Luhua *et al.*, 2004; Ranjith *et al.*, 2006), amino acids (Yushipitsina *et al.*, 1988; Repyakh *et al.*, 1990) lipids (Goncharova and

Glushenkova, 1993; Ul'chenko *et al.*, 1995; Bekker and Giuschenkova, 1997) sugars and acids (Yang, 2009), and flavonoids (Häkkinen *et al.*, 1999). According to certain studies, sea buckthorn contains antioxidants such as Carotene (vitamin A), Ascorbate (vitamin C), Tocopherol (vitamin E), and Glutathione (Geetha *et al.*, 2002a, 2002b; Chawla *et al.*, 2007; Püssa *et al.*, 2007; Dorhoi *et al.*, 2006; Geetha *et al.*, 2009). Sea buckthorn decreases enzyme activity or hormonal status damage caused by immobilization or cold-hypoxia-restraint (Krylova *et al.*, 2000; Saggi and Kumar, 2007). Shao *et al.* (2002) observed that colorants in sea buckthorn fruits are mainly composed of nine carotenoids. High content of carotenoids, xanthophylls, phenolic, and flavonoids in sea buckthorn are present (Yang *et al.*, 2000; Singh *et al.*, 2006). There are two sources of oil in sea buckthorn fruit: the seed contains 10%–15% (w/w) oil, and the pulpy fruit parts surrounding the seed contain 29%–48% oil. Both pulp and seed oils from sea buckthorn vary in vitamin E content depending on whether derived from seed oil (64.4 to 92.7 mg/100 g seed), juice oil (216 mg/100 g berry), or from the pulp

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after juice and seed removal (481 mg/100 g berry). Carotenoids also vary depending upon the source of the oil (Li, 2002).

The seed cake left after oil extraction contained a higher level of crude protein (CP) (27% to 33.2%) and CF (15.0% to 21.9%) reported (Kaushal and Sharma, 2011). According to (Sharma, 2010) the dry matter (DM), CP, ether extract (EE), crude fiber (CF), total ash, nitrogen-free extract, calcium (Ca), phosphorus (P), and metabolizable energy (ME) values of sea buckthorn cake as 90.06%, 26.00%, 4.50%, 14.00%, 2.50%, 53.0%, 0.75%, 1.25% and 12.159 MJ/kg (2,906 kcal/kg), respectively.

The leaves, seeds, and fruit residues of the sea buckthorn have the potential as a feed material for livestock and poultry. There are very little data on the use of sea buckthorn residues in poultry feeding.

This experiment was conducted to determine the effect of a higher proportion of sea buckthorn fruit residues in the broiler diets on their performance and skin color.

Material and Methods

This experiment was conducted at the International Testing of Poultry-Ústřašice, Czech Republic. A total of 700 broiler chicks (Ross 308) was allotted into two groups, and each group was comprised of 350 birds divided into 10 replicants, 35 birds on each replicant. The chicks got housed in an air-conditioned hall on a deep litter of wood shavings. Feed and water were provided *ad-libitum*, and standard management practices of a commercial were applied.

An automatic nipple drinker was used, and tube feeders were filled manually. The chicks were vaccinated against coccidiosis by LIVACOX T[®] applied to the water on day 7 of age.

The lighting program for broilers was as follows: (day 1 to 7: 23 hours of light and 1 hour of darkness; day 8 to 32: 18 hours of light and 6 hours of darkness; day 33 to 35: 23 hours of light and 1 hour of darkness).

The sea buckthorn fruits residue are berries from which the juice and part of oil were extracted by pressing, then dried. Proximate analyses of the sea buckthorn fruits residue were performed: DM, EE, CF, Ash – gravimetric methods; CP – Kjehldahl method; 82 starch and sugars – polarimetry; Ca and P – colorimetric; lysine and methionine – liquid chromatography. The nitrogen-corrected metabolizable energy (MEn) of the sea buckthorn fruits residue was estimated using

the equation provided by the European Federation of Branches of the World's Poultry Association's Subcommittee Energy of Working Group No. 2 Nutrition (Zelenka *et al.*, 1999).

The analytical composition of sea buckthorn fruit residues is shown in Table 1.

The chicks were fed (Table 2) a starter diet (BR1) from day 1 to 14, a grower diet (BR2) from day 15 to 28, and a finisher diet (BR3) from day 29 to 35 of age.

The control group was without color additives supplement in the diets. In the experimental group of broilers, 15% of wheat in the diets got replaced by sea buckthorn fruit residues. 15% of sea buckthorn fruit residues in broiler diets increased contents of CP slightly, lysine and methionine, and slightly reduced content ME in experimental diets. However, the content of CF in the experimental diets with 15% of sea buckthorn fruit residues increased above the generally recommended level (Table 2).

On days 7 and 14 of age, the chicks were weighed without fasting; on day 28 and 35 of age, all chicks were weighed individually after 12-hour fasting. The average weight of broiler chickens was determined in males and females and both sexes together.

Consumption and feed conversion were determined on day 35 of age. The mortality of chicks was recorded daily.

The skin color was determined with eight birds from each box (four males + four females). Skin color was assessed by the Dutch State Mines (DSM) Broiler Fan, expressed in a 1780–7880 scale. The data were subjected to analysis of variance followed by Duncan's range test (analysis of variance).

Ethical approval

This study was approved by the Graduate School of the Czech University of Life Science in Prague, Faculty of Tropical AgriSciences, Department of Animal Sciences and Food Processing. All animal welfare protocols were followed.

Results

Results of the chemical composition of sea buckthorn residue meal in Table 1 showed that the DM was 93.43%, CP was 20.87%, EE was 17.14%, CF was 18.13%, Ash was 2.02%, and metabolic energy (MEn) was 9.883 kJ/kg. The results presented in Table 3 and Figure 1 revealed no significant differences ($p < 0.05$) in live body weights at 1 and 7 and 35 days

Table 1. Chemical composition of sea buckthorn residue meal (%) and MEn (kJ/kg).

DM	93.43	Sugar	3.58
CP	20.87	Lysine	0.785
EE	17.14	Methionine	0.282
CF	18.13	Ca	0.040
Ash	2.02	P	0.321
Starch	1.79	MEn (calculated)	9.883

Table 2. Composition of the diets (%) and calculated analysis.

Ingredients	BR1 starter		BR2 grower		BR3 finisher	
	Control	Exp.	Control	Exp.	Control	Exp.
Wheat (11.6% CP)	40.00	25.00	51.88	36.88	56.45	41.45
Maize	19.46	19.46	10.00	10.00	10.00	10.00
Sea buckthorn meal	-	15.00	-	15.00	-	15.00
Soybean oil meal (46% CP)	32.80	32.80	29.50	29.50	24.60	24.60
Rape oil	4.00	4.00	5.00	5.00	5.80	5.80
Hydrogen carbonate sodium	0.20	0.20	0.20	0.20	0.13	0.13
NaCl	0.25	0.25	0.25	0.25	0.24	0.24
Monocalcium Phosphate	1.00	1.00	0.77	0.77	0.50	0.50
Limestone	1.50	1.50	1.50	1.50	1.40	1.40
L-lysine	0.17	0.17	0.22	0.22	0.20	0.20
DL-methionine	0.06	0.06	0.10	0.10	0.12	0.12
L-threonine	0.06	0.06	0.08	0.08	0.06	0.06
AMV BR1 Plus	0.50	0.50	-	-	-	-
AMV BR2 Plus	-	-	0.50	0.50	-	-
AMV BR3 Plus	-	-	-	-	0.50	0.50
Calculated analysis						
CP%	21.50	22.89	20.52	21.98	18.81	20.20
ME _n MJ/kg	12.39	11.94	12.69	12.24	13.06	12.61
Lysine%	1.27	1.34	1.25	1.33	1.10	1.18
Methionine%	0.60	0.62	0.58	0.60	0.55	0.57
Ca%	0.91	0.90	0.86	0.86	0.77	0.76
P%	0.63	0.66	0.57	0.61	0.50	0.54
Na%	0.18	0.18	0.18	0.18	0.15	0.16
CF%	3.08	5.43	2.98	5.40	2.84	5.21

(AMV BR1, 2, 3 Plus): premix of feed additives (vitamins, trace elements, DL-methionine).

Table 3. Effect of Sea buckthorn on live body weight of broilers (X ± S.D).

Groups	Live body weight (g)				
	1 day	7 days	14 days	28 days	35 days
Control	39.6 ^a ± 2.3	142.6 ^a ± 5.0	434.1 ^a ± 15.2	1,384.3 ^a ± 156.8	1,960.7 ^a ± 213.5
Experimental	39.4 ^a ± 2.8	139.5 ^a ± 4.3	404.5 ^b ± 14.2	1,318.3 ^b ± 167.5	1,958.9 ^a ± 278.3

Mean values within the same column with different superscript letters differ significantly at ($p < 0.05$) level of probability.

of age between the broilers of the control group and the broilers fed on (15%) sea buckthorn fruit residue. On the other hand, the results at 14 and 28 days of age showed a significant ($p < 0.05$) increase in live body weights in the control group compared with the experimental group of broilers.

In the analysis of the results in Table 4 and Figure 2 to evaluate the effect of adding the sea buckthorn fruit residues on sex, it was found that there were no significant differences between males and females of the control group compared with males and females of the experimental group (2,109.0 & 1,812.4 g vs. 2 123.8 & 1 794.0 g), respectively. Furthermore, at the age of 35 days, numerically, the males were heavier, and the females were lighter in the experimental group than their counterparts in the control group.

It was clear from Table 5 and Figure 3 that the results revealed an increase ($p < 0.05$) in the rate of feed consumption in broilers that fed on the sea buckthorn fruit residues compared to broilers of the control group (384 vs. 3,410 g) respectively. The results also indicated a remarkable increase ($p < 0.05$) in the food conversion ratio, where it was higher in the experimental group compared with the control group (1,964.7 vs. 1,739.2 g/kg), respectively.

The natural pigments of sea buckthorn fruit residues were significantly efficient ($p < 0.05$) at increasing skin pigmentation in the experimental group (103.08) compared with the control group (102.38) as presented in Table 6 and Figure 4. In addition, the skin pigmentation of the males and females was significantly higher in the experimental group than in the control group.

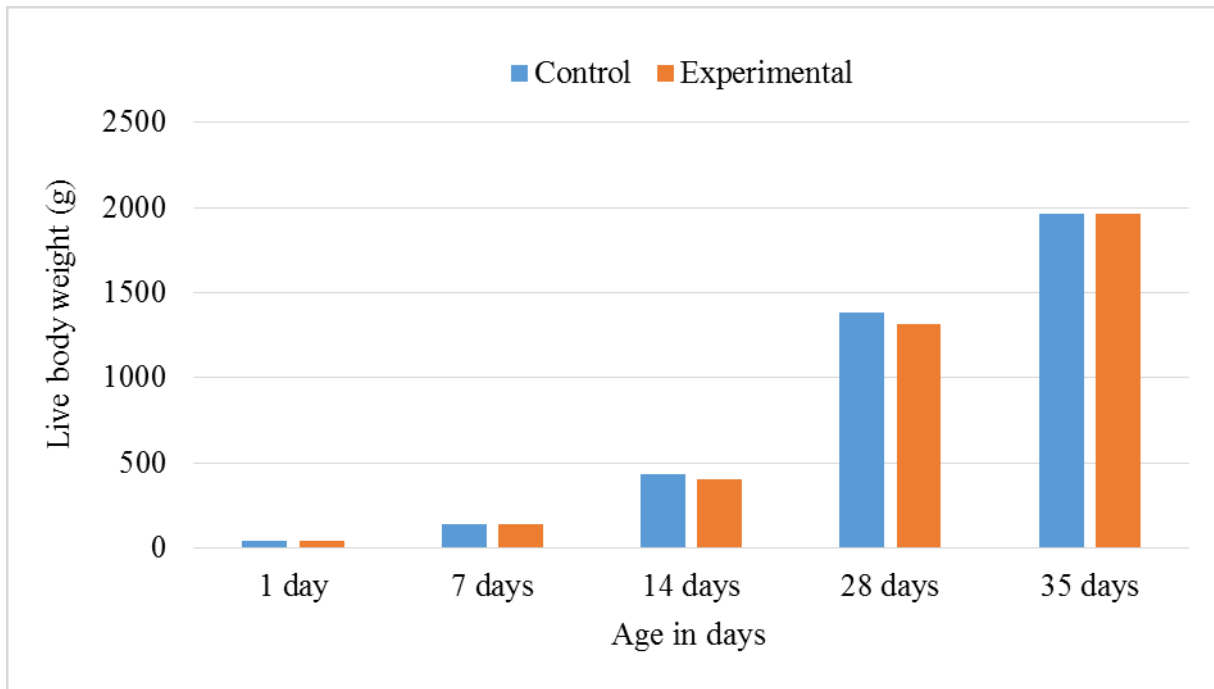


Fig. 1. Effect of Sea buckthorn on live body weight of broilers.

Table 4. Effect of Sea buckthorn on live body weight of broilers (male and female) on 35 days ($X \pm S.D$).

Groups	Sex			
		Male		Female
	<i>n</i>		<i>n</i>	
Control	180	2,109.0 ± 169.0	165	1,812.4 ± 148.6
Experimental	162	2,123.8 ± 220.1	172	1,794.0 ± 221.4

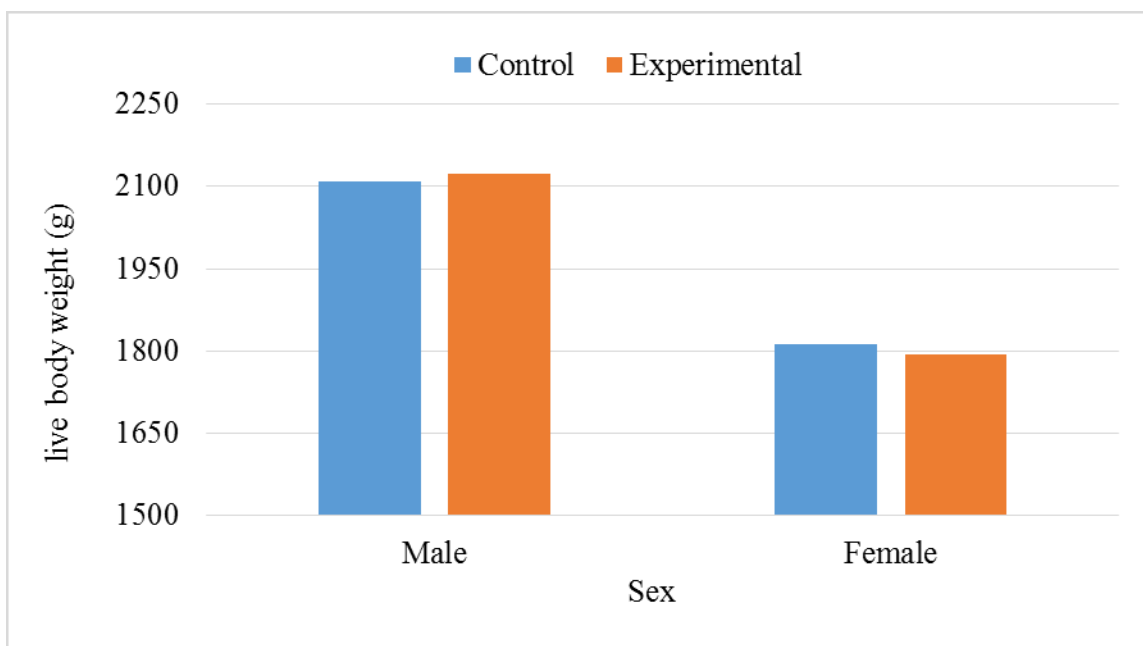


Fig. 2. Effect of Sea buckthorn on live body weight of broilers (male and female) on 35 days.

Table 5. Effect of Sea buckthorn on feed consumption (g/ bird) and feed conversion ratio (g/kg) in broilers on 35 days of age (X ± S.D).

Group	Feed consumption	Feed conversion ratio
Control	3,410 ^a ± 289	1,739.2 ^a ± 62.7
Experimental	3,848 ^b ± 297	1,964.7 ^b ± 73.2

Mean values within the same column with different superscript letters differ significantly at ($p < 0.05$) level of probability.

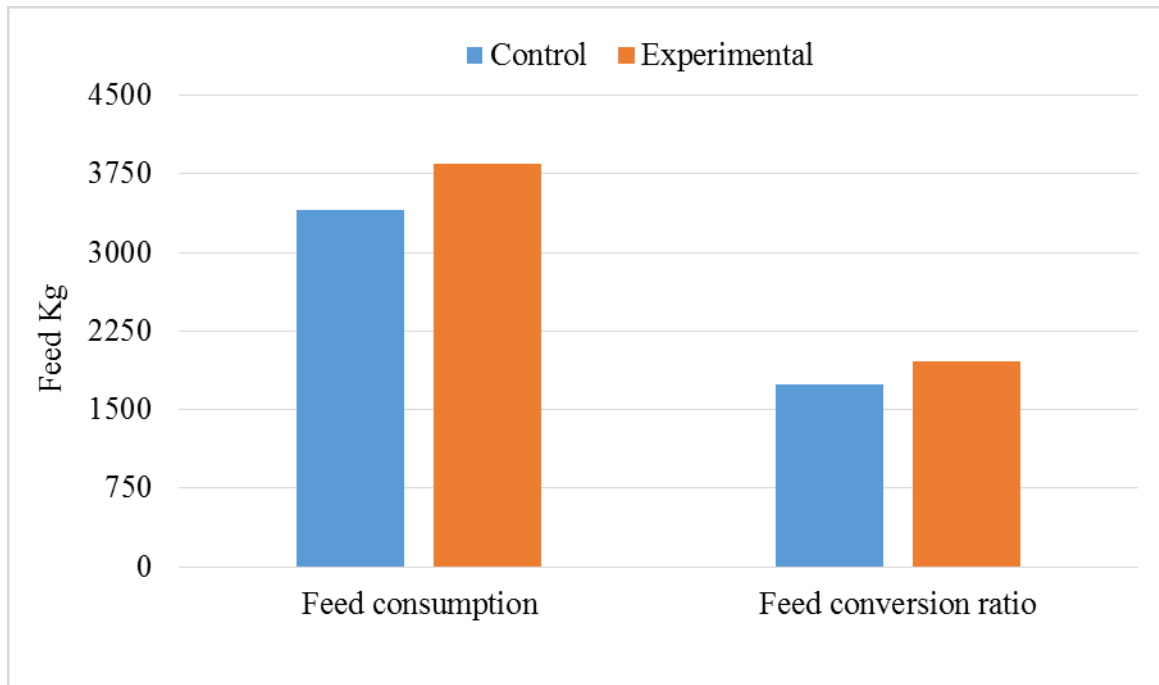


Fig. 3. Effect of Sea buckthorn on feed consumption (g/bird) and feed conversion ratio (g/kg) in broilers on 35 days of age.

Table 6. Effect of Sea buckthorn on skin color determination (X ± S.D).

Group	Male	Sex	
		Female	Male + Female
Control	102.25 ± 0.51 ^a	102.50 ± 0.57 ^a	102.38 ± 0.54 ^a
Experimental	103.25 ± 0.36 ^b	102.92 ± 0.78 ^b	103.08 ± 0.58 ^b

Mean values within the same column with different superscript letters differ significantly at ($p < 0.05$) level of probability.

In Table 7 and Figure 5, the results showed that during the first 2 weeks, there were no cases of death in the birds of the entire experiment. Still, at the beginning of the third week, death cases appeared in the experimental and control groups. Although the number of dead birds in the experimental group was higher, the increased mortality rate was statistically insignificant. At the end of the experiment recorded 5 dead birds in the control

group (1.4%) and 16 dead birds in the experimental group (4.6%).

Discussion

The chemical analysis of the sea buckthorn fruit residue showed lower CP content than reported (Sharma, 2010) – 26%, or (Kaushal and Sharma, 2011) – 27.7%–33% for sea buckthorn oil cake. Also calculated MEN were less compared with

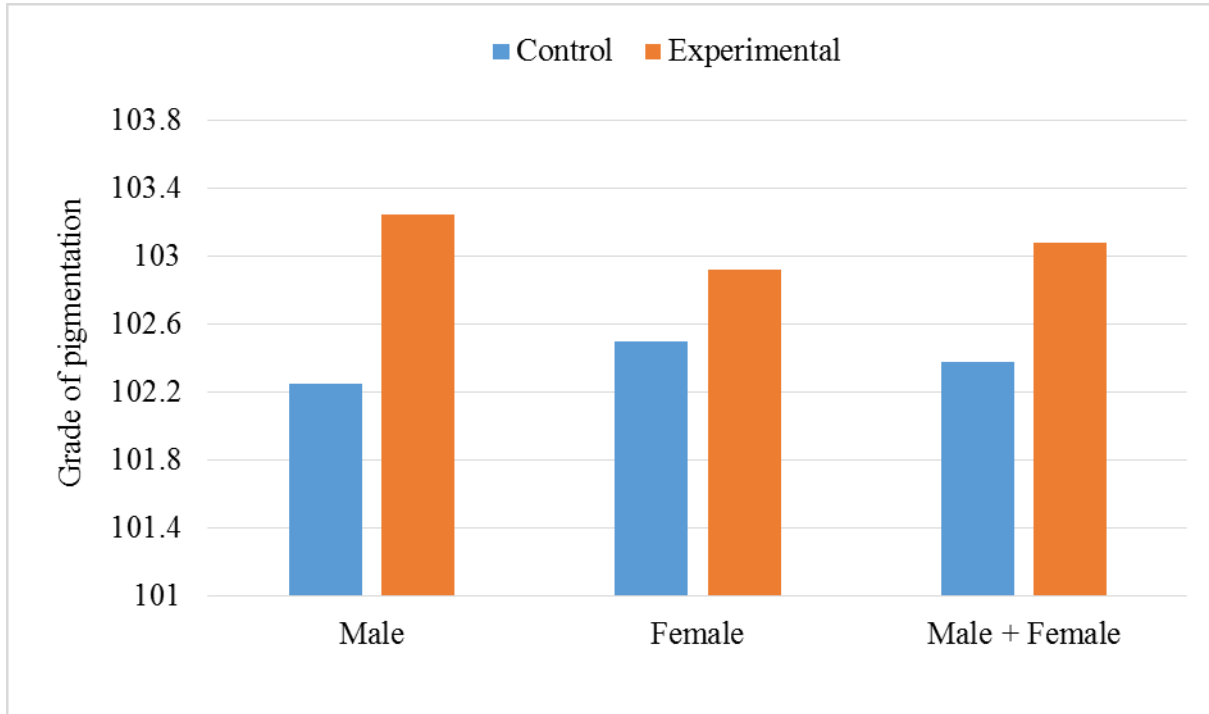


Fig. 4. Effect of Sea buckthorn on skin pigmentation.

Table 7. Effect of Sea buckthorn on mortality rate of broilers.

Group	1–14 days		15–28 days		29–35 days		1–35 days		Cause
	N	%	N	%	N	%	N	%	
Control	0	0	2	0.6	3	0.9	5	1.4	3A, 2B
Experimental	0	0	5	1.4	11	3.1	16	4.6	9A, 7B

The cause of death of chickens were: disease of the musculature system (A) and the syndrome of the sudden death (B).

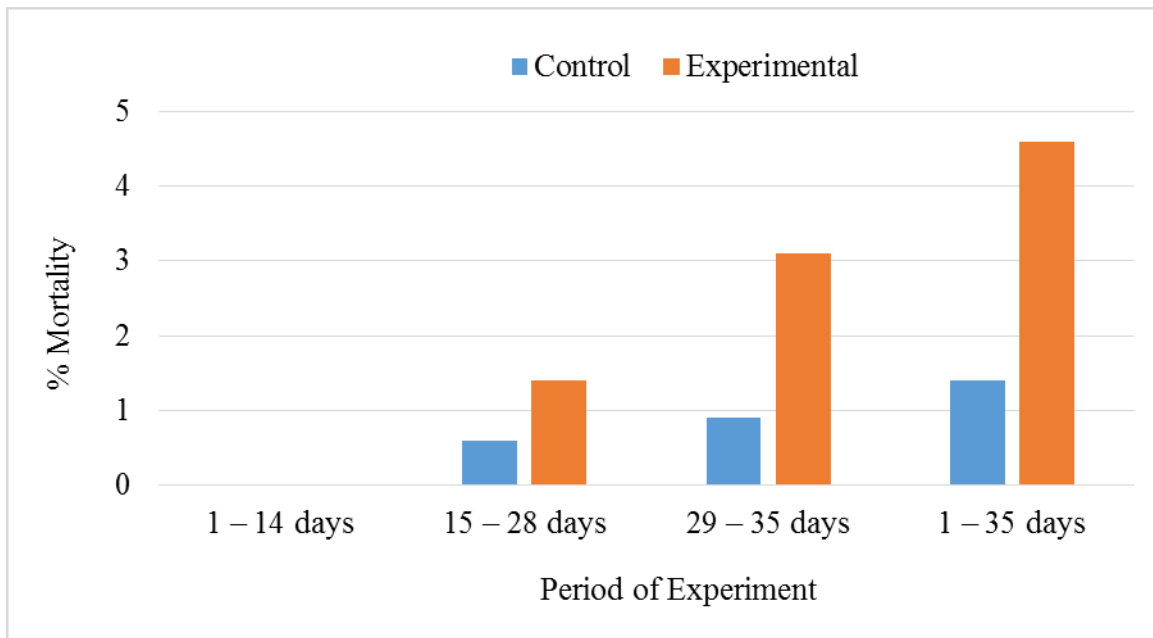


Fig. 5. Effect of Sea buckthorn on mortality rate of broilers.

ME of sea buckthorn oil cake reported (Sharma, 2010): 9,883 kJ/kg versus 2,906 kcal/kg (12,159 kJ/kg). The results of chemical analysis were more in agreement with data reported by Singh (2012) for sea buckthorn fruit residues (CP 18.3%, EE 11.6%, CF 12.7%, lysine 0.84%, but differed in content of methionine (methionine + cysteine 0.06%), Ca 0.19% and P 0.15% (Table 1). The chemical composition of wheat grain is about (DM 85.9%–87.5%, CP 10.4%–13.2%, EE 0.91%–2.26%, CF 1.49%–2.36%, Ash 1.45%–1.85%, ME 15.7–16.4 MJ/kg (Barteczko *et al.*, 2009). Therefore, the sea buckthorn fruit residues are a decent replacement where it is higher in DM, CP, EE, ash, and CF. The results of our study are similar to (Stef *et al.*, 2012) that reported that the addition of dried sea buckthorn berry to feeds of broilers (ROSS 308) did not significantly improve the body weight. In addition, Solcan *et al.* (2011) reported that the broiler chicks who received sea buckthorn oil had a better body weight gain. Likely, higher CF content and lower metabolic energy of sea buckthorn fruit residues in the diets could be the cause of chickens' lower live body weight. Indeed, although the high variability in weight gain of poultry fed on a diet containing 15% of the sea buckthorn fruit residues compared to the control group chickens, it is very important that the final weight of the poultry was similar (1,960.7 vs. 1,958.9 g). In other words, adding sea buckthorn fruit residues had no negative effect on the final body weight of broilers. In contrast, a negative effect was evident on the feed conversion ratio, and this is consistent with what was concluded by Stef *et al.* (2009, 2012), who indicated that the small addition of dried sea buckthorn berries (2%) to chicken diets broiler (ROSS 308) did not significantly improve feed efficiency. Otherwise, according to several articles (Yang and Kallio, 2005; Singh *et al.*, 2006; Seglina, 2007), the fruits of sea buckthorn are rich in fats and fatty acids (omega-6) and (omega-3). In addition, they have beneficial effects on feed conversion ratio, thigh muscle quality, and breast muscle in broilers (Zollitsch *et al.*, 1997; Crespo and Esteve-Garcia, 2001; Azman *et al.*, 2005; Stobdan *et al.*, 2013). In addition, the beneficial effect of the sea buckthorn flavones on poultry has been observed by some researchers, and according to (Li *et al.*, 2008; Zhao *et al.*, 2012), the supplementation of flavones from sea buckthorn to broilers significantly increased their growth, conversion of feeds, meat quality, carcass percentage apparent digestibility of dietary CP and Ca. As mentioned above, it is possible that higher content of CF and lower content of ME in the sea buckthorn fruit residues in the experimental diets (Table 2) could adversely affect the feed conversion ratio in the experimental group broilers. The results also indicated an increase in the rate

of feed consumption in the experimental group. Therefore, the use of buckthorn as a substitute for wheat depends on their prices. as high wheat prices may make the use of buckthorn residues very economically feasible despite the increase in feed consumption that may result from its use. The increase in feed consumption is also a good indicator of poultry palatability of sea buckthorn in the feed. This may open the way for the use of sea buckthorn in feed under heat stress, resulting in lower feed consumption rates in birds. In terms of skin pigmentation, broilers fed on diets containing 15% sea buckthorn residues demonstrated that their skin significant were more yellowish than the control group. This alteration in skin color results from natural yellow pigments of sea buckthorn fruit, where Yang *et al.* (2000) reported that sea buckthorn is rich in carotenoids, xanthophylls, phenolics, and flavonoids. our findings agreed with the previous study (Ben-Mahmoud *et al.*, 2014), where birds fed on diets with 5% of sea buckthorn fruit residue meal. In addition, (Li *et al.*, 2008) mentioned that the broiler diets supplemented with 0.1% and 0.2% flavones of sea buckthorn significantly increased the meat color of breast and thigh muscle. It is probably dependent on the content of oil in the residues of the sea buckthorn after pressing because carotenoids are bound to the oil content in seeds and fruit pulp, as described by Beveridge *et al.* (1999). The mortality rate of broilers was numerically higher in the experimental group compared to the control group (Fig. 2); however, both groups were in an acceptable mortality rate. In the whole period of the study, 5 birds were dead in the control group and 16 birds dead in the experimental group. The cause of death was a disease of the musculature system and the sudden death syndrome through the veterinary examination. So, based on the causes of death of the broilers in the experimental group, it is obvious that the mortality rate was not caused by sea buckthorn fruit residues in the diets.

Conclusion

It was concluded that replacing 15% of wheat with sea buckthorn fruit residues did not negatively affect the broilers' final weight and increased the pigmentation of the broiler's skin. On the other hand, it negatively affected the feed conversion ratio and, to a lesser extent, the mortality rate. Indeed, although it seems evident that replacing 15% of wheat with sea buckthorn fruit residues in broiler feeds caused a deterioration of the feed conversion ratio and thus the economic viability of raising broiler, the possibility of offsetting the high costs of breeding by increasing the biological quality of broilers is a probable matter and needs more research in this regard.

Conflict of interest

The authors declare that there is no conflict of interest.

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