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Dietary supplementation with sea buckthorn meal alone and in combination with bilberry leaves: assessment of growth performance, health status and intestinal microflora in broiler chickens

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ABSTRACT

This experiment aimed to investigate the effect of sea buckthorn meal alone and in combination with bilberry leaves on growth performance, health status and intestinal microflora in broiler chickens. A total of 90 healthy 1-day-old Cobb 500 broilers were randomly divided into 3 treatment groups and housed in digestibility cages under controlled environmental conditions. The dietary treatments included a basal diet (T0), a basal diet +1% sea buckthorn meal (T1) and a basal diet + 1% sea buckthorn meal and bilberry leaves (T2). The results showed that experimental diets did not influenced the growth performance. At 42 d, T2 had the highest serum iron level among the three groups. Compared to T0, T1 and T2 significantly reduced *Enterobacteriaceae, E.coli* and staphylococci in the cecal and intestinal contents and improved the lactobacilli populations number. The most effective way to reduce the number of harmful bacteria in the cecal content was through the diet that contained sea buckthorn meal alone. In conclusion, adding sea buckthorn meal in the diet of broiler chickens can be an effective solution to promote a healthy gut microflora. This aligns with the current strategy of reducing agro-industrial food waste by repurposing it in other industries.

Keywords: sea buckthorn meal, bilberry leaves, performance, health status, intestinal microflora.

INTRODUCTION

An increase in industrialization and globalization, along with population growth, has led to a significant rise in agricultural and industrial activities worldwide (Aruna et al., 2017). This increase has also resulted in the generation of substantial amounts of agro-industrial food waste from domestic and commercial farms, as well as food processing industries (Sadh et al., 2018). Several studies have demonstrated that the waste generated from fruit processing is rich in bioactive compounds with a high antioxidant capacity (Hrelia et al., 2023; Sha et al., 2023). The international scientific community is currently exploring the characterization of fruit by-products for their potential use in the development of functional feeds and foods (Trigo et al., 2020). However, using agro-industrial waste as functional feed materials can be a promising approach to reduce feed costs while maintaining the nutritional qualities of the feed (Alhotan, 2021; de Oliveira et al., 2021).

Sea buckthorn (*Hipophea rhamnoides*) is a deciduous shrub or tree of the genus *Hippophae* in the family *Elaeagnaceae* which has been extensively studied because of its active components. Sea buckthorn berries contains nearly 200 nutritional and bioactive compounds and is known as a "natural vitamin treasure house" and a "source of nutrition and health care" (Wang et al., 2021). Fruits and leaves of sea buckthorn are considered to be good source of large number of bioactive substances such as vitamins, trace elements, amino acids, β-carotene, zeaxanthin, lycopene, flavonoids, folic acid, fatty acid, tannic acid etc (Alam and Sana 2015; Panaite et al. 2016). These compounds have biological and therapeutic activities such as antioxidant, anti-stress and immunomodulatory properties (Paweł et al 2014; Kalia et al. 2018). Sea bukthorn has long been used in animal nutrition as an additive to feed mixtures for its favourable effects on animal health. Ancient Greeks used leaves and twigs of sea buckthorn for feeding animals, with a positive effect on the weight gain (Suryakumar and Gupta 2011). In previous animal experiments, dietary supplementation of sea buckthorn has been shown to improve the growth performance of broilers and pigs (Liu et al. 2008; Chen et al. 2011). Suryakumar and Gupta (2011) showed a positive effect on the quality of farm animal products. Ma et al. (2015) reported a significant enhancement in broilers performance after supplementation of flavonoids of *H. rhamnoides* fruits in broilers diet. The polyphenolic compounds present in fruit mealcould exert positive effects in the modulation of gastrointestinal microbial activity, histomorphology, and functionality of the gut (Chamorro et al., 2017, 2019; Kumanda et al., 2019) in broiler chickens.

Bilberry (*Vaccinium myrtillus L.*) is a low-growing shrub native to northern Europe. Bilberry fruits, along with other forest fruits like blackberries, raspberries, strawberries, mulberries, and black chokeberries,

are known for their antioxidant, anti-inflammatory, antimicrobial, and antidiabetic properties (Chehri et al., 2022) due to their phytochemical content, which includes anthocyanins, vitamins, and minerals. However, recent studies have shown that bilberry leaves contain significantly higher levels of phenolic compounds than the berries (Ştefănescu et al., 2020), making them a promising source of bioactive natural products for the development of food supplements, nutraceuticals, or functional food. In fact, a study on broiler chickens (Saracila et al., 2023) found that bilberry leaves can help lower cholesterol levels and have antimicrobial effects without affecting performance.

Sea buckthorn meal and bilberry leaves are often discarded or used for unproductive purposes like landfills, despite their potential as a source of dietary fiber and antioxidants in poultry nutrition. Incorporating these by-products into poultry diets could create value-added market opportunities for fruit processors, reduce ecological burdens, and provide a suitable alternative to antibiotics (Erinle et al., 2022). Recent research has shown that combining different plants or by-products can have even more pronounced effects than when used alone (Pezzani et al., 2019).This study is the first to investigate the effects of combining sea buckthorn meal and bilberry leaves in the diets of broiler chickens. The aim was to evaluate the growth performance, health status, and intestinal microflora of broiler chickens fed diets containing sea buckthorn meal alone or in combination with bilberry leaves.

MATERIALS AND METHODS

Experiment design and diets

This investigation was done under the approval of Ethical Commission of National Research and Development Institute for Biology and Animal Nutrition (no. 4775/02.08.2019).

Sea buckthorn meal used in this study was supplied by a local producer (E-Prod SRL, Teleorman, Romania) and bilberry leaves were purchased from pharmacies. The samples were purchased dried, grounded and packed.

This study employed a total of 90 healthy 1-day old Cobb 500 broilers selected and randomly divided into 3 treatment groups (30 chicks/group). The chickens were housed in digestibility cages under controlled environmental conditions and monitored by a Viper Touch computer. The three dietary treatments (Table 1) included a basal diet (T0), a basal diet +1% sea buckthorn meal (T1) and a basal diet + 1% sea buckthorn meal and bilberry leaves (T2). The experiment lasted for 42 days (1-42d). The basal diet was formulated to meet the recommendations (NRC, 1994; Management guide of Cobb 500). Table 1 lists the contents and theoretical composition of the experimental diets. The light regimen was 23h light and 1h darkness, feed and water were administered *ad libitum*.

Sea buckthorn meal was previously characterized by Saracila et al. (2020). The study revealed that it contains significant amounts of crude protein (12.43%), crude fiber (16.11%), and crude fat (13.29%). Additionally, it has high concentrations of lutein and zeaxanthin (91.80μg/g) and vitamin E (143.16 μg/g). This makes it an excellent source of antioxidants, with a high total antioxidant capacity of 99.84 mM ascorbic acid equivalents.

The previous study by Saracila et al. (2023) characterized the bilberry leaves. The analysis showed that the leaves had 91.67% dry matter, 5.91% crude protein, 1.57% ether extractives, 32.67% crude fiber, 3.05% Ash, high total polyphenolic content (35.9 mg GAE/g) and high antioxidant capacity (647.88 mM Trolox).

Table 1. Ingredients and diet composition (%)

Ingredient	Starter (0-14 d)			Grower (15-28 d)			Finisher (29-42 d)		
	T0	T1	T2	T0	T1	T2	T0	T1	T2
Corn	32.73	31.73	31.73	36.47	35.47	35.47	40.45	39.45	39.45
Wheat	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Corn gluten	2.00	2.00	2.00	4.00	4.00	4.00	6.00	6.00	6.00
Soybean meal	36.17	36.17	36.17	30.20	30.20	30.2	23.95	23.95	23.95
Sea buckthorn pomace		1.00			1.00			1.00	
Mixture of sea buckthorn meal and bilberry leaves	-	-	1.00	-	-	1.00	-	-	1.00
Sunflower oil	3.85	3.85	3.85	4.31	4.31	4.31	4.72	4.72	4.72
Monocalcium phosphate	1.68	1.68	1.68	1.52	1.52	1.52	1.43	1.43	1.43
Calcium carbonate	1.50	1.50	1.5	1.38	1.38	1.38	1.31	1.31	1.31
Salt	0.39	0.39	0.39	0.38	0.38	0.38	0.33	0.33	0.33
Methionine	0.33	0.33	0.33	0.25	0.25	0.25	0.21	0.21	0.21
Lysine	0.3	0.30	0.3	0.29	0.29	0.29	0.36	0.36	0.36
Choline	-	-	-	0.15	0.15	0.15	0.19	0.19	0.19
Monocalcium phosphate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin-mineral premix	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TOTAL	100	100	100	100	100	100	100	100	100
Calculated									
ME, kcal/kg	3039.79			3128.99			3217.72		
Crude protein, %	23.00			21.50			20.00		
Ether extractives, %	5.48			6.01			6.49		
Crude fibre, %	3.77			3.57			3.36		
Calcium, %	0.96			0.87			0.81		
Phosphorus, %	0.77			0.70			0.65		

Available phosphorus, %	0.48	0.43	0.41
Lysine, %	1.44	1.29	1.19
Methionine, %	0.69	0.61	0.57
Tryptophan, %	0.25	0.22	0.19

T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

Growth performance

Body weight (BW) and feed consumed (FC) were monitored throughout the experiment's 1 to 42 d duration, and weekly calculations of body weight gain (BWG), average daily feed intake (ADFI) and feed conversion ratio (FCR) were made for each group.

Sample collection

At 42 days, six broilers from each group were randomly selected and blood was drawn from the wing vein. The blood was centrifuged and the serum was separated and stored at -20°C. Subsequently the selected broilers were slaughtered by cervical dislocation. Samples of caecal and intestinal contents of 6 broilers for each treatment were collected in sterile plastic tubes, and kept at −20°C until the microbiological tests were done.

Blood parameters

Serum glucose, cholesterol, triglycerides, creatinine, urea, phosphorus, calcium, magnesium, iron, total protein, total bilirubin, alanine aminotransferase, aspartate aminotransferase, and gamma GT were assessed using commercial kits according to the protocol of the manufacturer instructions.

Intestinal microflora analysis

To ascertain the numbers of Enterobacteriaceae, Escherichia coli (E. coli), Staphylococci, and Lactobacilli, the techniques outlined by (Criste et al., 2017; Saracila et al., 2020) were utilized. A colony counter (Scan 300, Interscience, France) was accustomed to tally the colonies. Logarithms base 10 of colony-forming units per gram of cecal and intestinal contents (CFU/g) were used to express the microbial counts.

Statistical analysis

Data were analysed by one-way analysis of variance (ANOVA) using Addinsoft statistical software version 2022.3.1 (Addinsoft, 2023). Tukey's multiple comparison test was used to analyse the differences between means of groups. $P<0.05$ was used as the criterion for determining significant

differences. Graphics were then visualized using GraphPad software v. 9.03 (San Diego, CA, USA).

RESULTS AND DISCUSSION

Growth Performance

The effects of tested compound feeds on the growth performance of broiler chickens are presented in Table 2.

Table 2. Effect of inclusion of dietary sea buckthorn pomace alone and in combination with bilberry leaves in broiler feed on growth performance

Parameter	Days of age	T0	T1	T2	SEM	P-value
Body weight (g)	1	39.27	39.24	39.23	0.182	0.999
	14	427.7	430.27	427.38	6.728	0.555
	35	2065.63	2060.28	2096.96	3.654	0.794
	42	2605.83	2613.16	2617.50	1.254	0.990
Average daily feed intake (g/day)	1-42	95.37	87.86	96.40	2.334	0.404
Body weight gain (g/broiler/day)	1-42	61.11	58.62	60.72	1.597	0.373
Feed conversion ratio (g feed/g gain)	1-42	1.56	1.50	1.59	0.027	0.092

T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

It is observed that none of the tested compound feeds had a significant influence on the production parameters. The results of the present study are supported by literature research. For example, in heat stress Saracila et al., (2020) showed no significantly differences on performance between group fed basal diet and group fed 1% sea buckthorn meal. Broilers challenging oxidative stress (addition of oxidized soybean oil in diet) and fed 0.1%, 0.2% and 0.4% of sea buckthorn meal extract did not have any changes in the performance parameters (Feng et al., 2023). Stef et al. (2012) indicated that chicken diet supplementation with 2% buckthorn fruit meal did not improve the production data of birds. On the contrary, Seregin et al., (2021) reported an increase with 1% of daily weight gain of broilers fed diet supplemented with 0.6% sea buckthorn meal compared to the control group. Moreover, a significant reduction effect of dietary 3% flax oil and 3% dried sea buckthorn meal on feed intake and feed conversion ratio of Ross 308 broilers was reported by Orczewska-Dudek et al., (2018).

The impact of dietary sea buckthorn meal alone and in combination with bilberry leaves on broilers' serum biochemical parameters was demonstrated by the data in Table 3.

Table 3. Effect of inclusion of dietary sea buckthorn meal alone and in combination with bilberry leaves in broiler chicken diet on serum biochemical parameters

Item	T0	T1	T2	SEM	p-value
Glucose, mg/dL	214.98	234.09	227.28	5.662	0.084
Cholesterol, mg/dL	151.36	149.43	144.49	2.850	0.245
Triglycerides, mg/dL	41.76	54.75	67.30	6.284	0.370
Creatinine, mg/dL	0.11	0.11	0.11	0.005	0.972
Urea, mg/dL	2.99	2.72	2.60	0.209	0.421
Phosphorus, mg/dL	4.90	4.91	4.93	0.298	0.994
Calcium, mg/dL	8.47	8.43	8.18	0.190	0.531
Magnesium, mg/dL	2.40	2.44	2.55	0.065	0.261
Iron, µg/dL	88.73^{b}	88.69^{b}	96.73^{a}	1.564	0.003
Total protein, g/dL	2.44	2.46	2.55	0.093	0.706
Total bilirubin, mg/dL	0.11	0.07	0.06	0.015	0.058
ALT, U/L	8.93	8.85	8.68	0.45	0.923
AST, U/L	402.84	353.70	386.94	20.97	0.270
Gamma GT, U/L	31.24	30.34	25.64	3.305	0.456

$^{a–b}$ Means within a column with no common superscript differ ($p<0.05$). T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

Blood and intestinal parameters are important indicators that respond to the physiological state of the animal. In terms of the biochemical analysis (Table 3), it can be seen that the level of iron in the blood increased in group T2 (basal diet with 1% sea buckthorn meal and bilberry leaves) compared to groups T0 (basal diet) and T1 (basal diet with 1% sea buckthorn pomace). Iron (Fe) is an essential trace mineral for all living organisms, playing important roles in oxygen and electron transport as well as in DNA synthesis (Lin et al., 2020). However, administration of sea buckthorn meal and the mixture with bilberry leaves in the diet of chickens did not significantly affect the other biochemical parameters. No studies were found investigating the effect of mixture of sea buckthorn meal and bilberry leaves. When supplementing alone, sea buckthorn extracts (0.5, 1.0, and 1.5 g/kg) diets reduced the levels of serum total cholesterol, triglyceride, and low-density lipoprotein cholesterol, compared to the control in laying ducks (Yao et al., 2023). Contrary, Orczewska-Dudek et al., (2018) showed a reduction of triglyceride, cholesterol and glucose content in plasma from the chickens receiving sea buckthorn meal in the diet (dietary 3% flax oil and 3% dried sea buckthorn pomace). When supplemented alone, bilberry leaves decreased

serum glucose in rats (Sidorova et al., 2018) and cholesterol level in broiler chickens (Saracila et al., 2023).

Table 4. Effect of inclusion of dietary sea buckthorn meal alone and in combination with bilberry leaves in broiler chicken diet on cecal microflora

Item	T0	T1	T2	SEM	P-value
Enterobacteriaceae	11.41[a]	11.37[c]	11.39[b]	0.003	<0.0001
E. coli	10.20[a]	10.09[c]	10.15[b]	0.005	<0.0001
Staphylococci	8.87[a]	8.79[c]	8.85[b]	0.003	<0.0001
Lactobacilli	11.46[b]	11.60[a]	11.61[a]	0.014	<0.0001

[a–c] Means within a column with no common superscript differ ($p<0.05$). T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

Microbiological analyzes of the cecal contents (Table 4) showed that chickens from groups T1 and T2 had a lower number of *Enterobacteriaceae*, *E.coli* and staphylococci compared to group T0. The effect of sea buckthorn meal and its mixture with bilberry leaves in this study on patogenic bacteria could be due to the polyphenolic content and antioxidant activity. Compared to control group (T0), the intestinal tract of broilers after dietary addition of sea buckthorn meal (T1) and a mixture of bilberry leaves and sea buckthorn meal (T2) was enriched with Lactobacilli which play an important role in maintaining the health (Teixeira et al., 2021; Liu et al., 2023). It seems that supplementing the diet with a mixture of sea buckthorn meal and bilberry leaves did not significantly influence the number of lactobacilli in the cecal content compared to the single administration of sea buckthorn pomace.

Table 5. Effect of inclusion of dietary sea buckthorn meal alone and in combination with bilberry leaves in broiler chicken diet on intestinal microflora

Item	T0	T1	T2	SEM	P-value
Enterobacteriaceae	7.41[a]	7.39[b]	7.38[c]	0.002	<0.0001
E. coli	6.21[a]	6.07[c]	6.12[b]	0.004	<0.0001
Staphylococci	7.15[a]	5.94[b]	5.94[b]	0.004	<0.0001
Lactobacilli	7.15[b]	7.18[a]	7.17[a]	0.003	<0.0001

[a–c] Means within a column with no common superscript differ ($p<0.05$). T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

The data on the effect of the inclusion of sea buckthorn meal and the mixture of sea buckthorn meal and bilberry leaves on the intestinal microbiota are shown in table 5. It is observed that the supplementation of diets intended for chickens had a significant effect on pathogenic bacteria. The number of colony-forming units of *Enterobacteriaceae*, *E. coli* and staphylococci was

significantly lower in the intestinal contents of chickens that included in diets the addition of sea buckthorn meal and a mixture of sea buckthorn meal and bilberry leaves compared to those fed with the basal diet. A significant increase in the number of lactobacilli in the intestinal contents of the chickens from the groups that included in the diet the addition of sea buckthorn meal and the mixture between sea buckthorn meal and bilberry leaves was noted compared to those fed with the control diet.

Many in vitro studies were demonstrated the strong antimicrobial activity of sea buckthorn against *Escherichia coli*, *Staphylococcus aureus* (Yue et al., 2017; Sandulachi et al., 2022; Liu et al., 2023), but there is a paucity in vivo studies. Sea buckthorn phenolic compounds represent the main group of bioactive substances that are responsible to the overall antimicrobial activity of sea buckthorn (Chaman et al., 2011; Michel et al., 2012). These compounds suppress gram-negative bacteria (Khan et al., 2010) and reduce gram-positive bacteria (Kumar and Sagar, 2007). Antimicrobial activities of sea buckthorn fruits (PuupponenPimia et al., 2001), seeds (Chauhan et al., 2007) and leaves (Upadhyay et al., 2010) have been reported. Kaushal et al. (2011) noted that the seed oil showed antimicrobial activity against *E. coli*. The oil was found to be more effective for the rest of the bacteria tested, except for *E. coli*, on which the seed oil showed twice the inhibitory effect of the leaf oil (Yue et al. 2017).

The effect of sea buckthorn on beneficial bacteria was taken under investigation. In an in vitro study simulated gut model, Attri and Goel, (2018) demonstrated that sea buckthorn juice has a stimulatory effect on the beneficial microbial population of Lactobacilli, Bacteroides/Prevotella, and Bifidobacteria. Additionally, the ascending colon had higher levels of resveratrol, rutin, and chlorogenic acid, while quercetin, ferulic, and caffeic acid levels were higher in the descending colon due to the biotransformation of polyphenols in the latter part of the colon. In other study, Yuan et al., (2018) found that sea buckthorn protein can increase the population of beneficial bacteria such as *Bifidobacterium*, *Lactobacillus*, and *Bacteroides*. The biologically active components in sea buckthorn pomace, particularly polyphenols, prevent harmful bacteria from adhering to the gut microbiota and boosting the growth of friendly bacteria.

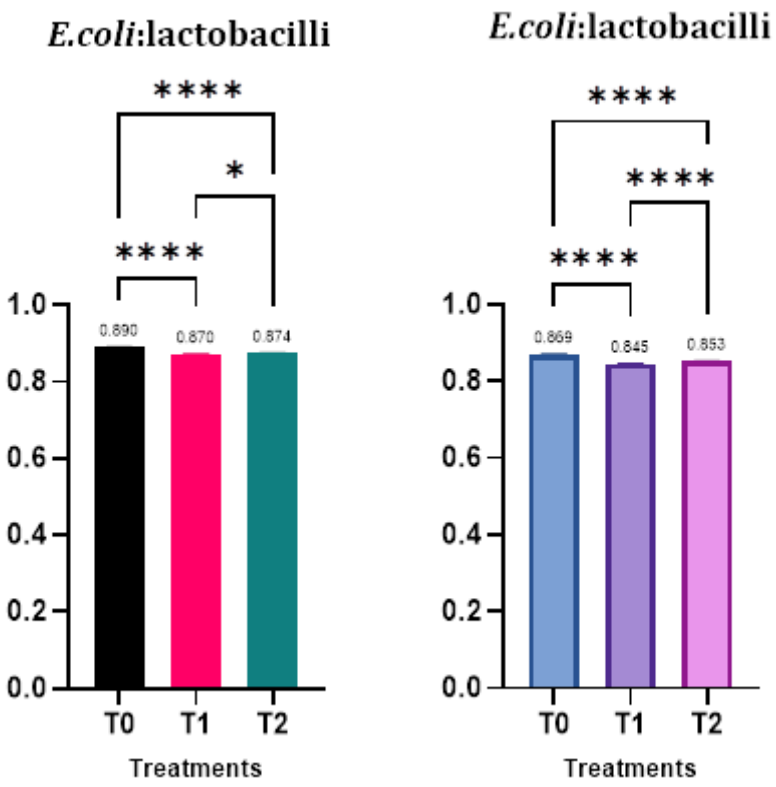


Figure 1. The effect of inclusion of dietary sea buckthorn meal alone and in combination with bilberry leaves in broiler chicken diet on the *E. coli*: lactobacilli ratio in the cecal (a) and intestinal (b) content

T0- control group; T1- experimental group fed diet supplemented with 1% sea buckthorn meal; T2- experimental group fed diet supplemented with 1% mixture of sea buckthorn meal and bilberry leaves.

Figure 1 shows the effect of dietary sea buckthorn meal alone and in combination with bilberry leaves on the ratio between *E. coli* and lactobacilli in the cecal (a) and intestinal (b) content. It can be seen that both in the cecal and in the intestinal content, the *E. coli*:lactobacilli ratio was significantly lower in the tested experimental groups compared to the T0 group. It can be stated that both the addition of sea buckthorn meal and the mixture between it and bilberry leaves positively affected the balance of the intestinal microflora. Comparing the two experimental diets, T1 and T2, it can be seen that the lowest ratio was found in group T1, which indicates that the nutritional solution that included sea buckthorn meal alone was more effective than the one together with bilberry leaves. A growing body of research supports the important role of polyphenolic plant-derived products

in animal gut health (Kumar Singh et al., 2019; Wang and Zheng 2022; Bešlo et al. 2023). However, there is a paucity of literature on the in vivo effects of sea buckthorn meal and its mixture with bilberry leaves on the gut microbial composition in broiler chickens.

CONCLUSION

The addition of sea buckthorn meal to the diet alone or in combination with bilberry leaves reduced the harmful bacterial populations and promoted growth of beneficial gut bacteria in the cecal and intestinal contents. Dietary supplementation with sea buckthorn meal alone was the most effective in reducing the number of harmful bacteria in the cecal content. In conclusion, using sea buckthorn meal in broiler feeding can reduce ecological burden of food waste disposal and promote healthy gut microflora. Future perspectives focus on the interaction of dietary phytochemicals with other nutrients such as minerals, vitamins, and essential fatty acids and their effects on digestion, gut nutrient bioavailability, and health maintenance of monogastric animal using in vivo studies.

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REFERENCES

Addinsoft, 2023. XLSTAT statistical and data analysis solution. New York, USA. https://www.xlstat.com/en.

Alam, Z., Sana, U., 2015. Sea buckthorn seed oil protects against the oxidative stress produced by thermally oxidized lipids. Food Chem 186:6e12.

Alhotan, R.A., 2021. Commercial poultry feed formulation: Current status, challenges, and future expectations. World's Poultry Science Journal, 77(2): 279-299.

Aruna, T.E., Aworh O.C., Raji A.O., Olagunju A.I., 2017. Protein enrichment of yam peels by fermentation with Saccharomyces cerevisiae (BY4743), Ann. Agric. Sci., 62:33-37.

Attri, S., Goel, G., 2018. Influence of Polyphenol Rich Sea buckthorn Berries Juice on Release of Polyphenols and Colonic Microbiota on Exposure to Simulated Human Digestion Model; Elsevier Ltd.: Amsterdam, The Netherlands, volume 111, ISBN 9117922453.

Bešlo, D., Golubić, N., Rastija, V., Agić, D., Karnaš, M., Šubarić, D., Lučić, B., 2023. Antioxidant Activity, Metabolism, and Bioavailability of Polyphenols in the Diet of Animals. Antioxidants, 12, 1141.

Chaman, S., Syed, N.I., Danish, Z., & Khan, F.Z., 2011. Phytochemical analysis, antioxidant and antibacterial effects of sea buckthorn berries. Pakistan Journal of Pharmaceutical Sciences, 24(3).

Chamorro, S., Romero, C., Brenes, A., Sánchez-Patán, F., Bartolomé, B., Viveros, A., Arija, I., 2019. Impact of a sustained consumption of grape extract on digestion, gut microbial metabolism and intestinal barrier in broiler chickens. Food Funct., 10:1444–1454. doi: 10.1039/c8fo02465k.

Chamorro, S., Viveros, A., Rebolé, A., Arija, I., Romero, C., Alvarez, I., Rey, A., Brenes, A., 2017. Addition of exogenous enzymes to diets containing grape pomace: effects on intestinal utilization of catechins and antioxidant status of chickens. Food Res Int. 96:226–234.

Chauhan, A.S., Negi, P.S., Ramteke, R.S., 2007. Antioxidant and antibacterial activities of aqueous extract of seabuckthorn (*Hippophae rhamnoides*) seeds. Fitoterapia 78: 590-592.

Chehri, A., Yarani, R., Yousefi, Z., Shakouri, S.K., Ostadrahimi, A., Mobasseri, M., Araj-Khodaei, M., 2022. Phytochemical and pharmacological anti-diabetic properties of bilberries (Vaccinium myrtillus), recommendations for future studies. Primary care diabetes, 16(1): 27-33.

Chen, X., Zhao, W., Liu, H.N. Su, J., Wang, P.Z., Zhang, Z.H., Li, Y., 2011. Effect of sea buckthotn leaves on growth performance and calcium metabolism in Arbor Acres broilers. J. Northwest. Agric. Univ. 42:19-24.

Criste, R.D., Panaite, T.D., Tabuc, C., Saracila, M., Soica, C., Olteanu, M., 2017. Effect of oregano and rosehip supplements on broiler (14-35 days) performance, carcass and internal organs development and gut health. AgroLife Scientific Journal, 6:75-83.

De Oliveira, C.O., Roll, A.A.P., Medeiros Gonçalves, F.M., Lopes, D.C.N., Xavier, E. G., 2021. Olive pomace for the feeding of commercial poultry: effects on performance, meat and eggs quality, haematological parameters, microbiota and immunity. World's Poultry Science Journal, 77(2):363-376.

Erinle, T.J., Adewole, D.I., 2022. Fruit pomaces—their nutrient and bioactive components, effects on growth and health of poultry species, and possible optimization techniques. Animal nutrition, 9:357-377.

Feng Zhipeng, Luyu Li, Liu Mengjian, Zhang Xiao, Li Xuanyue, Lu Yan, Chen Yong., 2023. Effects of Sea Buckthorn Pomace Extract on Growth Performance, Antioxidant Capacity and Immune Function of Yellow-Feathered Broilers under Oxidative Stress. Chinese Journal of Animal Nutrition. 35(10): 6374-6386.

Hrelia, S., Angeloni, C., Barbalace, M.C., 2023. Agri-Food Wastes as Natural Source of Bioactive Antioxidants. Antioxidants 12, 351.

Kalia, S., Bharti, V.K., Giri, A., Kumar, B., Arora, A., Balaje, S.S., 2018. Hippophae rhamnoides as novel phytogenic feed additive for broiler chickens at high altitude cold desert. Sci Rep. 8(1):5954.

Kaushal, M., Sharma, P.C., 2011. Nutritional and antimicrobial property of seabuckthorn (*Hippophae sp*.) seed oil. J Sci Indust Res. 70:1033-1036.

Khan, B.A., Akhtar, N., Mahmood, T. 2010. A comprehensive review of a magic plant Hippophae rhamnoides. Pharmacogn J 16: 58-61.

Kumanda, C., Mlambo, V., Mnisi, C., 2019. From landfills to the dinner table: red grape pomace waste as a nutraceutical for broiler chickens. Sustainability, 11:1931.

Kumar, S., Sagar, A., 2007. Microbial associates of *Hippophae rhamnoides* (Sea buckthorn). Plant Pathol J 6:299-305.

Kumar Singh, A., Cabral, C., Kumar, R., Ganguly, R., Kumar Rana, H., Gupta, A., Rosaria Lauro, M., Carbone, C., Reis, F., Pandey, A.K., 2019. Beneficial effects of dietary polyphenols on gut microbiota and strategies to improve delivery efficiency. Nutrients. 11(9):2216.

Lin, X., Gou, Z., Wang, Y., Li, L., Fan, Q., Ding, F., Zheng, C., Jiang, S., 2020. Effects of dietary iron level on growth performance, immune organ indices and meat quality in chinese yellow broilers. Animals (Basel). 10(4):670.

Liu, M., Zhou, J., Li, Y., Ding, Y., Lian, J., Dong, Q., Qu, Q., Lv, W., Guo, S., 2023. Effects of dietary polyherbal mixtures on growth performance, antioxidant capacity, immune function and jejunal health of yellow-feathered broilers. Poult. Sci., 102.

Liu, X., Lv, M., Maimaitiyiming, R., Chen, K., Tuerhong, N., Yang, J., Aihaiti, A. Wang, L., 2023. Development of fermented sea buckthorn (Hippophae rhamnoides L.) juice and investigation of its antioxidant and antimicrobial activity. Front. Nutr. 10:1120748.

Liu, C.W., Li, Y., Zuo J.G., Jin, S.M., Shi, Y.L., 2008. Effect of extract of sea buckthorn on growth and fat metabolism in weanling pigs. Feed industry 29: 6-8.

Ma, J.S., Chang, W.H., Liu, G.H., Zhang, S., Zheng, A.J., Li, Y., Xie, Q., Liu, Z.Y. and Cai, H.Y., 2015. Effects of flavones of sea buckthorn fruits on growth performance, carcass quality, fat deposition and lipometabolism for broilers. Poultry Science 11:2641-2649.

Michel, T., Destandau, E., Le Floch, G., Lucchesi, M.E., Elfakir, C., 2012. Antimicrobial, antioxidant and phytochemical investigations of sea buckthorn (Hippophaë rhamnoides L.) leaf, stem, root and seed. Food chemistry, 131(3):754-760.

Orczewska-Dudek, S., Pietras, M., Nowak, J., 2018. The effect of amaranth seeds, sea buckthorn pomace and black chokeberry pomace in feed

mixtures for broiler chickens on productive performance, carcass characteristics and selected indicators of meat quality. Annals of Animal Science, 18(2), 501.

Panaite, T.D., Criste, R.D., Ropota, M., Criste, V., Vasile, G., Olteanu, M., Mitoi, M., Socoliuc, R., Vlaicu, P.A., 2016 Determination of the feeding value of food industry by-products. Scientific Papers-Animal Science Series: Lucrări Ştiinţifice - Seria Zootehnie, 66.

Paweł, G., Elga, S., Aleksander, S., Dalija, S., 2014. Sea buckthorn (*Hippophae rhamnoides L.)* leaves as valuable source of lipophilic antioxidants: the effect of harvest time, sex, drying and extraction methods. Ind Crop Prod 60:1e7.

Pezzani, R., Salehi, B., Vitalini, S., Iriti, M., Zuñiga, F.A., Sharifi-Rad, J., Martorell, M., Martins, N., 2019. Synergistic Effects of Plant Derivatives and Conventional Chemotherapeutic Agents: An Update on the Cancer Perspective. Medicina (Kaunas), 55(4):110.

Puupponen-Pimia, R., Nohynek, L., Meier, C., Kahkonen, M., Heinonen, M., Hopia, A., 2001. Antimicrobial properties of phenolic compounds from berries. J Appl Microbiol 90: 494-507.

Sadh, P.K., Duhan S., Duhan J.S., 2018. Agro-industrial wastes and their utilization using solid state fermentation: a review, Bioresour. Bioprocess., 5, p. 1.

Sandulachi, E., Macari, A., Cojocari, D., Balan, G., Popa, S., Turculeț, N., Sturza, R., 2022. Antimicrobial properties of sea buckthorn grown in the Republic of Moldova. Journal of Engineering Sciences, (1), 164-175.

Saracila, M., Untea, A.E., Varzaru, I., Panaite, T.D., Vlaicu, P.A., 2023. Comparative effects on using bilberry leaves in broiler diet reared under thermoneutral conditions vs. heat stress on performance, health status and gut microbiota. Life (Basel). 14(1):39.

Saracila, M., Panaite, T.D., Untea, A., Vărzaru, I., Drăgotoiu, D., & Criste, R.D., 2020. Use of the dietary sea buckthorn meal as phytoaditive in heat-stressed broiler. Scientific Papers: Series D, Animal Science-The International Session of Scientific Communications of the Faculty of Animal Science, 63(1).

Saracila, M., Panaite, T.D., Tabuc, C., Soica, C., Untea, A., Varzaru, I., Criste, R.D., 2020. Maintaining intestinal microflora bal-ance in heat-stressed broilers using dietary creeping wood sorrel (Oxalis corniculata) powder and chromium (chromium picolinate). Spanish journal of agricultural research 2020, 18, e0612-e0612.

Seregin, I.G. et al., 2021. Improving the quality of broiler meat when using sea buckthorn meal in feed. IOP Conf. Ser.: Earth Environ. Sci. 935 012042.

Sha, S.P., Modak, D., Sarkar, S., Roy, S.K., Sah, S.P., Ghatani, K., Bhattacharjee, S., 2023. Fruit waste: a current perspective for the sustainable production

of pharmacological, nutraceutical, and bioactive resources. Front Microbiol. 14:1260071.

Sidorova, Y.S., Shipelin, V.A., Mazo, V.K., Zorin, S.N., Petrov, N.A., Kochetkova, A.A., 2018. Comparative studies of antidiabetic activity of bilberry leaf extract in Wistar rats with STZ-induced diabetes and Zucker diabetic fatty rats. International Food Research Journal, 25(3).

Stef, D.S., Stef, L., Mot, D., Pop, C., Hegedus, M.G., 2012. The effect of medicinal plants on broilers immunological profile and productive performance. J. Food Agri., 10: 434–437.

Ştefănescu, B.-E., Călinoiu, L.F., Ranga, F., Fetea, F., Mocan, A., Vodnar, D.C., Crişan, G., 2020. Chemical Composition and Biological Activities of the Nord-West Romanian Wild Bilberry (Vaccinium myrtillus L.) and Lingonberry (Vaccinium vitis-idaea L.) Leaves. Antioxidants, 9, 495.

Suryakumar, G., Gupta, A., 2011. Medicinal and therapeutic potential of sea buckthorn (Hippophae rhamnoides L.). Ethnopharmacol. 138:268–278.

Teixeira, C.G., Fusieger, A., Milião, G.L., Martins, E., Drider, D., Nero, L.A., de Carvalho, A.F. 2021. Weissella: an emerging bacterium with promising health benefits. Probiotics Antimicrob. Proteins. 13:915–925.

Trigo, J.P., Alexandre, E.M.C., Saraiva, J.A., Pintado, M.E., 2020. High value-added compounds from fruit and vegetable by-products—Characterization, bioactivities, and application in the development of novel food products. Crit. Rev. Food Sci. Nutr. 60, 1388–1416.

Upadhyay, N.K., Kumar, M.S.Y., Gupta, A., 2010. Antioxidant, cytoprotective and antibacterial effects of Sea buckthorn (Hippophae rhamnoides L.) leaves. Food Chem Toxicol 48: 3443-3448.

Wang, K., Xu, Z., Liao, X., 2021. Bioactive compounds, health benefits and functional food products of sea buckthorn: a review. Crit Rev Food Sci Nutr. 2021:1–22.

Wang, X., Qi, Y., Zheng, H., 2022. Dietary Polyphenol, Gut Microbiota, and Health Benefits. Antioxidants (Basel). 11(6):1212.

Yao, B.N., Liao, F.Y., Yang, J.Y., Liu, A., Wang, J., Zhu, B.G., Feng, G., Yang, S.L., 2023. Effect of sea buckthorn extract on production performance, serum biochemical indexes, egg quality, and cholesterol deposition of laying ducks. Front Vet Sci. 10:1127117.

Yuan, H., Shi, F., Meng, L., Wang, W., 2018. Effect of sea buckthorn protein on the intestinal microbial community in streptozotocin-induced diabetic mice. Int. J. Biol. Macromol. 107:1168–1174.

Yue, X.F., Shang, X., Zhang, Z.J., Zhang, Y.N., 2017. Phytochemical composition and antibacterial activity of the essential oils from different parts of sea buckthorn (Hippophae rhamnoides L.). Journal of Food and Drug Analysis 25: 327-332.