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Metabolisable energy of dried Sea buckthorn (*Hippophaes rhamnoides*) berries for broiler chickens

Обменна енергия в сушени плодове от облепиха (*Hippophaes rhamnoides*) за пилета бройлери

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ABSTRACT

The aim of the experiment was to assess the content of N-corrected apparent metabolisable energy (AMEn) in dried Sea buckthorn berries (SB) when fed to Ross 308 broiler chickens. Two experimental diets (basal and basal + 12 g/kg dried and milled SB berries) were fed to an equal number of replicated pens (n=8; two birds in each) from 7 to 21d age, following randomisation. The basal diet was formulated to meet breeder's recommendations. The inclusion of dried SB berries at 12 g/kg diet, did not significantly ($P>0.05$) affect broiler chicken growth performance, dietary nutrient availability or AMEn. Using the substitution method, it was found that the AMEn of the dried SB berries was 14.29 MJ/kg DM. Although relatively high in AMEn, the absence of starch in SB berries, suggests SB berries are not a suitable substitute for cereals in poultry diets, but further research on their health benefits as a minor supplement for poultry diets is warranted.

Keywords: sea buckthorn, broiler chicken, metabolisable energy, digestibility

АБСТРАКТ

Целта на експеримента е да се оцени съдържанието на N-коригирана видима обменна енергия (AMEn) в сушени плодове от облепиха (SB), при хранене на пилета бройлери Ross 308. Две експериментални диети (базална и базална + 12 g/kg сушени и смлени SB плодове) бяха приложени с равен брой повторения (n=8; по две птици във всяка клетка) от 7 до 21-годишна възраст, след рандомизиране. Основната диета е формулирана следвайки стандартните изисквания. Включването на сушени плодове SB при 12 g/kg диета не повлия значително ($P>0,05$) върху ефективността на растежа на бройлерите, смилаемостта на хранителни вещества и AMEn. Използвайки метода на заместване, беше установено, че AMEn на изсушените SB плодове е 14,29 MJ/kg DM. Макар и относително високо съдържание на AMEn, отсъствието на скорбяла в плодовете на SB, предполага, че плодовете на SB не са подходящ заместител на зърнените храни в диетите за домашни птици, но са оправдани по-нататъшни изследвания за техните ползи за здравето като незначителна добавка за диети за домашни птици.

Ключови думи: облепиха, бройлери, обменна енергия, хранене

INTRODUCTION

In recent years, the poultry industry has routinely used novel feed ingredients and supplements with potential to improve bird productivity by enhancing the nutritional quality of the feed. Examples of such materials include co-products from the bread industry (Penkov and Chobanova, 2020), fermented feeds (Dairo and Fasuyi, 2007), alternatives to soybean meal (Abdulla et al. 2017; Whiting et al. 2019; Karkelanov et al, 2020), antioxidants (Pirgozliev et al., 2020; Woods et al., 2020), exogenous enzymes (Jimoh et al., 2018), probiotics (Such et al., 2020), prebiotics (Zábranský et al., 2021) and plant extracts (Marć-Pieńkowska et al., 2019).

Sea buckthorn (*Hippophaes rhamnoides*; SB), is a deciduous spiny species widely distributed throughout Asia and Europe, which usually grows in dry areas (Biswas et al., 2010). The berries of SB contain various active components, including vitamins, phenols, terpenes and tannins that have been used in traditional medicine to prevent or treat various diseases, such as inflammation, ulcers and dermatological syndromes (Bal et al., 2011; Mihova, 2019). Different parts of the SB plant also contain nutrients such as protein, fat and vitamins, which makes it a suitable component for poultry diets. So far, the majority of poultry research involving SB studied its impact on growth performance, meat quality, egg production, antioxidant enhancement and bird health (Shaker et al., 2018; Tudor et al., 2019; Panaite et al., 2022); although less attention has been paid to the apparent metabolisable energy (AME) and nutrient availability of SB for poultry. Dietary AME is widely used to describe the available energy in poultry feeds and information on AME of feedstuffs is essential to formulate accurate and balanced poultry diets (Yang et al., 2020). Thus, the aim of this experiment was to study the impact of dried SB berries on dietary AME corrected for N retention (AMEn) and nutrient availability when fed to broiler chickens.

MATERIALS AND METHODS

Diets

Birds were offered one of two diets during the study from 7 to 21d age. The basal diet was formulated to meet breeder's recommendations (Aviagen Ltd., Edinburgh, UK; Table 1). The basal diet was then split into two batches, with one batch used as the control diet (C) and the other diet was the C supplemented with 12 g/kg dried and milled SB berries. The SB berries were collected from the Troyan region of the Balkan Mountains, Bulgaria. Whole berries were air dried and then preserved frozen (-20 °C) for three months before being used in the study. Each diet was supplemented with 5 g/kg titanium dioxide as an indigestible marker.

Animals and experimental design

The study was conducted at the National Institute of Poultry Husbandry and approved by the Harper Adams University Research Ethics Committee, UK.

Forty (40) one-day-old healthy Ross 308 female broilers were purchased from a commercial hatchery. On arrival, the chicks were housed in a communal pen bedded with wood shavings, and fed a wheat-based proprietary starter mash until 7d age. At 7d age, thirty-six birds, excluding small and malformed, were randomly allotted to two groups with eight replicates per group and two birds per replicate. There were no differences in initial live weight (155 g ± 10.3 SDEV) across the treatment groups. Broilers were raised in pens with a solid floor, with *ad libitum* access to feed, fresh water, and controlled environment following breeder's recommendation (Aviagen Ltd., Edinburgh, UK). During the last three days of the study, from 18 to 21d age, the solid floor of each pen was replaced with wire mesh and excreta were collected in trays beneath the floor. Excreta were then oven dried at 60 °C, milled and used for determination of dietary AMEn and total tract nutrient digestibility coefficients.

Analysis of dietary nutrients

Dry matter (DM) in feed, SB sample and excreta was determined by drying in a forced draft oven at 105 °C to a constant weight. Crude protein (6.25 × N) in samples was determined by the combustion method (AOAC 2000; method 990.03) using a LECO FP-528 N (Leco Corp., St. Joseph, MI, USA). Oil (as ether extract) was extracted with diethyl ether by the ether extraction method (AOAC 2000; method 945.16) using a Soxtec system (Foss Ltd., Warrington, UK). The gross energy (GE) value of feed, SB and excreta samples was determined in a bomb calorimeter (model 6200; Parr Instrument Co., Moline, IL, USA), with benzoic acid used as the standard. Total non-starch polysaccharides (NSP) and starch contents in the basal diet and SB sample were determined following the methods of Englyst et al. (1994) and Englyst et al. (2000), respectively. Titanium dioxide in feed and excreta was determined as described by Short et al. (1996).

Table 1. Ingredient composition (g/kg 'as fed') of the basal diet

Ingredient	Composition g/kg
Maize	381.90
Wheat	200.05
Rapeseed meal	50.00
Soya bean meal	290.04
Soya oil	35.00
Lysine	3.00
Methionine	3.00
L Threonine	1.00
Monocalcium phosphate	15.00
Limestone	12.50
Salt	2.00
Sodium bicarbonate	2.50
Vitamin/mineral premix[1]	4.00
Phytase (Quantum Blue 5g)	0.01
	1000
Calculated composition	
ME (MJ/kg)	12.69
Protein (%)	21.11
Lysine (%)	1.39
Methionine + Cystine (%)	0.96
Calcium (%)	0.97
Phosphorus available (%)	0.48

[1] Provided per kg feed: 2160 µg retinol, 75 µg cholecalciferol; 25 mg α-tocopherol, 1.5 mg menadione, 5 mg riboflavin, 8 mg pantotenic acid, 10 µg cyanocobalamin, 1.5 mg pyridoxine, 1.5 mg thiamine, 0.5 mg folic acid, 30 mg niacin, 60 µg biotin, 0.8 mg I, 10 mg Cu, 80 mg Fe, 0.3 mg Se, 80 mg Mn, 80 mg Zn (Target Feeds Ltd., Whitchurch, UK)

Calculations

Total tract dietary DMD coefficient was calculated using the following equation:

$$DMD = \frac{Ti\ Excreta - Ti\ Diet}{Ti\ Excreta}$$

where Ti Excreta and Ti Diet are the concentrations of Ti in the excreta and diet, respectively.

Dietary total tract nutrient digestibility coefficients, i.e. ND and FD, were calculated using the following equation:

$$Nutrien\ digestibility = \frac{(Nutr/Ti)Diet - (Nutr/Ti)Excreta}{(Nutr/Ti)Diet}$$

where (Nutr / Ti) Diet = ratio of the respective nutrient to titanium in diet, and (Nutr / Ti) Excreta = ratio of the respective nutrient to titanium in excreta.

The AMEn value of the experimental diets was determined following the method of Hill and Anderson (1958).

$$AMEn = GE\ Diet - \frac{(GE\ Excreta\ X\ Ti\ Diet)}{Ti\ Excreta} - 34.39\ X\ N\ Retained$$

where AMEn (MJ/kg) = N-corrected apparent metabolisable energy content of the diet; GE Diet and GE Excreta (MJ/kg) = GE of the diet and excreta, respectively; Ti Diet and Ti Excreta (%) = titanium in the diet and excreta, respectively; 34.39 (MJ/kg) = energy value of uric acid; and N Retained (g/kg) is the N retained by the birds per kilogram of diet consumed. The retained N was calculated as

$$N\ Retained = N\ Diet - \frac{N\ Excreta\ X\ Ti\ Diet}{Ti\ Excreta}$$

where N Diet and N Excreta (%) = N contents of the diet and excreta, respectively.

The AMEn in SB berries was determined as follows:

$$AMEn\ (SB) = \frac{AMEn\ of\ SB\ diet - AMEn\ of\ Control\ diet * 0.988}{0.012}$$

where 0.988 is the proportion of Control diet in SB diet and 0.012 is the proportion of SB berries in the SB diet, respectively.

Statistical Analysis

Data were analysed using Genstat (18th edition) statistical software (IACR Rothamstead, Hertfordshire, UK). Comparisons among studied variables were performed by one-way ANOVA. In all instances, differences were reported as significant at $P<0.05$. All data were checked for homogeneity of variances and normality prior to ANOVA.

RESULTS AND DISCUSSION

Compared to the basal diet, the fat content in SB was almost four time higher, 61 vs 233 g/kg, which coincided with approximately 7 MJ/kg higher GE in SB berries (Table 2). The CP content of SB was 180 g/kg, the NSP content was 151 g/kg, however no starch was detected in the SB berry sample. The determined chemical composition of SB agreed with previous reports (Bal et al., 2011; Shaker et al., 2018; Tkacz et al., 2019; Panaite et al., 2022). It is recognised that SB product composition naturally varies, likely due to different climate and soil conditions, cultivars, geographical regions, processing and laboratory analysis techniques.

Table 2. Determined chemical composition of basal diet and dried Sea buckthorn berries

Determined values	Basal diet	Sea Buckthorn
Dry matter (g/kg)	884	903
Gross Energy (MJ/kg)	16.89	23.62
Crude Fat (g/kg)	62	233
Crude Protein (g/kg)	214	180
Starch (g/kg)	381	0
Total non-starch polysaccharides (g/kg)	93	151

All birds were healthy throughout the study period and there were no mortalities. There were no significant differences ($P>0.05$) in growth performance variables (Table 3) and end live weight at 21d age (757 g ± 36.6 SDEV) across the treatment groups. The results in the literature are variable and often contradictive; Zhao et al. (2012) showed that feeding SB flavones deceased daily feed intake of broilers; Ma et al. (2015), reported the opposite, that supplementing SB phenols improve broiler growth performance; Ben-Mahmoud et al. (2014) found lower growth performance when incorporating 50 g/kg SB berries in broiler diets. This is in contrast to the current study where a lower level was fed to avoid reducing bird growth performance, however the levels may be too low to affect the studied variables.

The AMEn and nutrient digestibility values between diets did not differ significantly ($P>0.05$; Table 3), which may be due to the relatively low dietary SB inclusion level. Further applying the substitution technique, it has been found that the SB berries fed in this study contain 14.29 MJ/kg DM AMEn (12.90 MJ/kg, as fed basis). The reported information on metabolisable energy in SB berries is variable. Sharma (2010) found that SB cake contains 12.16 MJ/kg AME when fed to broiler chickens. Using a prediction equation based on chemical composition, Shaker et al. (2018) reported AMEn of 9.9 MJ/kg, although Panaite et al. (2022) reported AME of 12.23 MJ/kg SB meal when fed to laying hens. The observed differences in reported metabolisbale energy values may be due to the use of SB products prepared under different technologies, with different chemical composition. For example, the protein and fat contents of the SB in the reported study were 180 & 233 g/kg, compared to 260 & 45 g/kg (Sharma, 2010), 209 & 171 g/kg (Shaker et al., 2018) and 145 &177 g/kg (Panaite et al., 2022), respectively. Employing different techniques, e.g. prediction equations or bioassays and using different age, types/ strains of birds might also have an impact on the metabolisable energy values. The obtained metabolisable energy and the overall chemical composition of SB is close to those of cereals and oilseed by-products (Biswas et al., 2010). This can be used as a guide for its potential inclusion level in poultry diets. However, starch comprises up to 80% of most cereal grains and is the main source of energy in poultry diets (Azhar et al., 2019). The lack of starch suggests that SB may not be used in great amounts in diets for intensive poultry production.

Table 3. Effect of dietary dried Sea buckthorn berries on feed intake (FI), weight gain (WG), feed conversion efficiency (FCE), total tract dry matter (DMD), fat (FD), nitrogen (ND) digestibility coefficients and apparent metabolisable energy corrected for N retention (AMEn), determined with female Ross 308 broilers between 18 and 21d age

Treatment	FI (g/b)	WG (g/b)	FCE	DMD	FD	ND	AMEn (MJ/kg DM)
Control	880	607	0.690	0.660	0.800	0.643	12.62
Control + 12 g/kg SB	872	596	0.684	0.681	0.810	0.653	12.64
SEM	13.4	11.3	0.0081	0.0188	0.0123	0.0228	0.209
Probabilities	0.677	0.533	0.612	0.467	0.584	0.769	0.984
CV%	4.3	5.3	3.3	7.9	4.3	10.0	4.7

SB: Sea buckthorn, SEM: Pooled standard errors of mean, CV%, coefficient of variation

However, the use of SB berries/ meal may be of interest for backyard producers and small-scale poultry flocks.

CONCLUSIONS

The examined sample of SB contained 903 g/kg dry matter, 23.62 MJ gross energy, 233 g/kg fat, 180 g/kg crude protein, 151 g/kg NSP and 14.29 MJ/kg DM of AMEn. The AMEn of the SB sample in this study approximated that of cereals and oilseed by-products. The inclusion of dried SB berries at 12 g/kg diet, did not significantly affect broiler chicken growth performance. Although relatively high in AMEn, the absence of starch in SB berries, suggests SB berries are not a suitable substitute for cereals in poultry diets, but further research on their health benefits as a minor supplement for poultry diets is warranted.

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