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Beneficial effects of increasing dietary levels of raw lentil seeds on meat fatty acid and plasma metabolic profile in broiler chickens

GEORGETA CIURESCU[1], ANDREEA VASILACHI[2], MARIANA ROPOTÃ[3], MIHAI PALADE[4] and CÃTALIN DRAGOMIR[5]

National Research-Development Institute for Biology and Animal Nutrition Calea Bucuresti no. 1, Balotesoti, 077015, Ilfov, Romania

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ABSTRACT

The aim of the present study was to investigate the effect of diets containing raw lentil seeds (*Lens culinaris* cv. Eston and cv. Anicia) on meat fatty acids profile and blood plasma parameters of broiler chickens. Day old, broiler chicks (1,000; Cobb 500) were randomly allocated to the following 5 treatments, viz. a diet based on corn and SBM as control; 200g/kg of raw lentil seeds cv. Eston (LE); 400 g/kg of LE; 200g/kg of raw lentil seeds cv. Anicia (LA); 400 g/kg of LA. Data were analysed as a 2 × 2 factorial arrangement. The broilers meat fatty acid profile was affected by dietary inclusion of lentil. Accordingly, breast muscle of broilers fed raw lentil seeds had significant higher levels of alfa-linolenic, eicosapentaenoic (EPA), docosapentaenoic and docosahexaenoic (DHA) acids. A significant interaction was observed between level and cultivar for majority of n-3 PUFA profile, except for octadecatetraenoic acid, EPA and DHA. The blood plasma parameters were not influenced by treatments, except for glucose and triglycerides concentration which were lower in the groups fed with lentils. No significant interaction between lentil levels and cultivars was noticed for plasma parameters. Based on the results, we concluded that raw lentil seeds represent an interesting alternative protein source which can improve the quality of broiler meat that can be recommended in healthy, balanced diets to prevent human diseases.

Key words: Broiler, Cultivar, Fatty acids, Lentil, Plasma parameters

Soybean meal (SBM) is the main protein source used in poultry feed, usually known for its high quality. However, SBM comes mostly from genetically modified crops and this situation encourages European Union countries to find ways to reduce the dependence on imported protein feeds, which would increase the security of feed supply. In this regard, seeds legumes can be alternative protein sources replacing transgenic soya beans in animal feedstuffs. In recent years, we have witnessed an increased interest in legumes as a protein source in diets for poultry (Laudadio and Tufarelli 2010, Laudadio *et al.* 2011, Nalle *et al.* 2011, Dotas *et al.* 2014, Smulikowska *et al.* 2014, Zdunczyk *et al.* 2014a,b, Koivunen *et al.* 2016). Lentil (*Lens culinaris*) seeds are produced primarily for human consumption, but they are also available for animal feed industry (S**ö**gut *et al.* 2017, Çabuk *et al*. 2014), especially when they meet quality problems (i.e. frost damage, discoloration, or seed damage) and thus become improper for human use. Lentils have a chemical composition quite similar to other legumes (e.g. peas) and are widely used in pig's nutrition (Bell and Keith 1986, Landero *et al.* 2012, Woyengo *et al*. 2014). Few research on growth performance are reported (Ciurescu *et al*. 2017) on feeding lentil seeds to broiler chickens as an alternative protein source to SBM. Moreover, no experiment has been conducted to assess the effect of lentil seeds on the quality of broiler meat, therefore, there was an opportunity to examine the diet effects (i.e. high lentil inclusion rate, trial duration) on fatty acids (FAs) deposition. As part of a wider study to investigate the potential enhancement of this raw material for broiler chicken diets, the study described here was performed to evaluate the effect of the various dietary levels inclusion of lentil seeds (*Lens culinaris* cv. Eston and cv. Anicia, respectively) on meat quality and blood plasma profile as a guide to optimum production of healthy and safe poultry products.

Present address: [1]Senior Researcher (ciurescu@ibna.ro), [2]Researcher (andryca82@yahoo.com), Animal Nutrition Laboratory; [3,5]Scientific Researcher (m.ropota @yahoo.com), Laboratory of Chemistry and Nutrition Physiology; [4]Scientific Researcher (mihai.palade@ibna.ro), Laboratory of Animal Biology.

MATERIALS AND METHODS

Broiler chickens were treated in accordance with Romanian legislation for handling and protection of animals used for experimental purposes. The study protocol was approved by the Ethical Committee of the National Research Development Institute for Animal Biology and Nutrition, Balotesti, Romania.

Animals and Diets: A total of Cobb 500 broiler chickens

(n=1000), one-day-old (48±0.9 g/chick), obtained from a commercial hatchery were used in a 28-d feeding trial. The chicks were randomly (mixed sex) allocated to five dietary treatments with 4 replicate pens and 50 chicks per pen. The chicks were kept in pens on litter (wood shavings) under similar managerial and hygienic conditions in a shelter with a controlled environment and with constant overhead fluorescent lighting (23L:1D). The temperature was maintained at 33°C on d 1 and then gradually reduced to 26°C by 28 d of age. Vaccinations and a medical program were performed under the supervision of a veterinarian. Two cultivars of spring lentil seeds (cv. Eston, green-seeded and cv. Anicia, green marbled-seeded respectively, locally grown in temperate weather conditions) were included in diets (35 or 41% of SBM was replaced by lentil seeds meal, respectively). The five dietary treatments were formulated as follows: 1) a diet based on corn and SBM as control; 2) 200g/kg of raw lentil seeds cv. Eston (LE); 3) 400g/kg of LE; 4) 200g/kg of raw lentil seeds cv. Anicia (LA); 5) 400 g/kg of LA. Diets were formulated to be isocaloric, isonitrogenous, with similar content of total lysine, total sulfur amino acids (methionine + cysteine; TSAA), calcium and available phosphorous, and to meet or exceed the minimum requirements (22.4% CP and 12.66 ME, MJ/kg) for broiler chickens (Cobb Vantress 2012). The energy value calculations were based on the chemical analyses of the feed ingredients. Feed and water were available *ad lib.* throughout the experimental period. The diets were given in mash form, and water was offered from nipple drinker lines. Body weights was recorded weekly and mortality was recorded when occured. Any bird that died was weighed and the weight was used to adjust the feed conversion ratio (FCR). Feed intake was recorded daily. The FCR was calculated by dividing total feed intake by weight gain of live plus dead birds.

Chemical analysis: Ingredients were analysed before feed formulation (dry matter, crude protein, crude fibre, crude fat, ash and amino acids) using standard procedures according to the methods of the European Commission Regulation (EC) no. 152 (Official Journal of the EU 2009). Amino acids (AA) were separated according to the conditions described by Ciurescu *et al.* (2014). Ingredients were also analyzed for neutral detergent fibre (NDF) and acid detergent fibre (ADF), using an automatic system Foss Tecator (Fibertec 2010 apparatus). Carbohydrate content was estimated as nitrogen-free extract (NFE). All composition data are on a dry-matter basis (MJ kg DM^{-1}).

Sampling, measurements and statistics: To determine FAs profile, samples (30; 6/treatment) of breast muscles were deboned, skin removed, packed into polyethylene bags, sealed, immediately stored in the deep freezer at –20ºC, and than were analyzed for FAs composition as previously described by Ciurescu *et al.* (2016) using as gas chromatograph a Perkin Elmer Clarus 500 GC. The results were expressed for each FAs as % of total fatty acid methyl esters (FAMEs). Blood samples of 40 broiler chickens randomly selected from each dietary treatment (8 chicks/ treatment; 2/replicate) were collected from the wing vein at 28 d of age for biochemical parameter assay. Heparin was used as an anticoagulant. Stored plasma samples were analyzed for glucose, total cholesterol (TC), triglycerides, total protein, albumin, total globulin, creatinine, urea, Ca, P, Mg, Fe, alanine aminotransferase (ALT/GPT), aspartate aminotransferase (AST/GOT), alkaline phosphatase (AP), gamma-glutamyl-transferase (GGT), and lactate dehydrogenase (LDH) as previously described by Ciurescu *et al.* (2014), using an semiautomatic BS-130 Chemistry analyser. Data were analysed using the general liner model procedure in SPSS software (2011) version 20 as a 2 × 2 factorial arrangement with 2 levels of lentil seeds and 2 cultivars. Differences among group means were detected using two way analysis of variance (ANOVA). Tukey's multiple range test was applied to separate means, and the

Table 1. Analysed composition of raw lentil seeds (*Lens culinaris* cv. Eston and Anicia, respectively) (n=3)

Item	Raw Lentil	
	Eston	Anicia
Nutrient, g/kg DM[-1]		
Dry matter	890	903
Gross energy (MJ/kg)	19.45	20.33
Crude protein	292[a]	259[b]
Crude fat	15[b]	32[a]
Crude fibre	54[b]	81[a]
NDF[1]	283	319
ADF[2]	61	72
Ash	33	37
NFE[3]	639	644
Calcium	0.13	0.16
Phosphorous, total	0.48[b]	0.70[a]
Amino acids (g/100g)		
Lysine	1.97	1.79
Methionine	0.19	0.17
Cystine	0.29	0.30
Fatty acids contents[4]		
Myristic (C14:0)	0.93	1.02
Pentadecanoic (C15:0)	0.38	0.35
Pentadecenoic (C15:1)	0.33	0.26
Palmitic (C16:0)	16.75	15.33
Palmitoleic (C16:1)	0.45	0.39
Stearic (C18:0)	2.60	1.81
Oleic (C18:1n-9)	22.19	21.90
Linoleic (C18:2n-6)	41.82[b]	43.87[a]
Alfa-linolenic (C18:3n-3)	13.09	13.54
Heneicosanoic (C21:0)	0.81	0.75
Octadecatetraenoic (C18:4n-3)	0.54	0.67
SFA[5]	21.47	19.26
MUFA[6]	22.97	22.55
Total n-6 PUFA[7]	41.82[b]	43.87[a]
Total n-3 PUFA[8]	13.63	14.21

[a,b]Row values with different superscripts differ (P<0.05). [1]NDF, Neutral detergent fibre; [2]ADF , Acid detergent fibre; [3]NFE, Nitrogen-free extract. [4]Percent of total FAMEs. [5]SFA, saturated fatty acids percent. [6]MUFA, mono-unsaturated fatty acids. [7]Total n-6 PUFA = C18:2n-6. [8]Total n-3 PUFA = sum of C18:3n-3; C18:4n-3.

results were considered significant at P<0.05.

RESULTS AND DISCUSSION

Nutrient composition of lentil seeds: The chemical composition of raw lentils, cv. Eston (green-seeded), and cv. Anicia (green marbled-seeded), used for this study is shown in Table 1. The concentration of raw lentil seeds showed significant (P<0.05) variations among samples for crude protein, crude fat, crude fibre, and phosphorous whereas, DM, gross energy (calculated value), ash, NDF and ADF contents, NFE and calcium were similar in both evaluated lentil cultivars. As with the characteristics of legume, the lentil seeds were high in lysine (6.7–7% of the protein) but low in the sulphur-containing amino acids (methionine and cysteine: 2%), compared to the requirements of broilers in the starter phase. Lentil lipids were predominantly polyunsaturated fatty acid (PUFA, from 55.5 to 58.1% of total FAMEs, depending of cultivar) with low content of saturated fatty acids (SFA, from 19.3 to 21.5%). The lentil (cv. Anicia) had the highest value (P<0.05) for linoleic acid (LA, C18:2n-6), than in cv. Eston. Additionally, the content of alfa-linolenic acid (ALA, C18:3n-3) was higher (P>0.05) in lentil cv. Anicia than in cv. Eston. For this reason, the proportion of total PUFA was also higher in cv. Anicia; more total n-3 PUFA (P>0.05) and n-6 PUFA (P<0.05), as compared to cv. Eston. These values are in accordance with those reported by others (Grela and Günter 1995, Ryan *et al*. 2007). Moreover, Zhang *et al*. (2014), in their study on 20 Canadian lentil cultivars (10 red and 10 green), demonstated that, LA was the dominant FAs ranging from 40.73% to 47.06%, followed by oleic acid (C18:1; 20.11–28.0%), palmitic acid (C16:0;

Table 2. Effects of feeding raw lentil seeds (cv. Eston and cv. Anicia, respectively) on total FAs profile of breast muscle of broiler chickens (28 d)

Fatty acids (% of total FAMEs)	Dietary treatments					SEM[3]	P-value	P-value[4]		
	C	LE2	LE4	LA2	LA4			Level	Cultivar	L× C
Myristic (C14:0)	0.50	0.54	0.56	0.55	0.52	0.07	0.455	0.412	0.960	0.676
Myristoleic (C14:1)	0.12	0.16	0.18	0.15	0.17	0.06	0.211	0.322	0.345	0.513
Pentadecanoic (C15:0)	0.09	0.10	0.12	0.11	0.10	0.04	0.299	0.274	0.749	0.134
Pentadecenoic (C15:1)	0.68^{a}	0.64^{a}	0.38^{b}	0.66^{a}	0.35^{b}	0.03	< 0.001	<0.001	0.855	0.025
Palmitic (C16:0)	21.78^{e}	23.57^{c}	23.29^{b}	23.72^{a}	22.40^{d}	0.16	< 0.001	0.025	0.721	<0.001
Palmitoleic (C16:1)	4.30^{d}	4.98^{c}	5.57^{a}	5.06^{c}	5.31^{b}	0.10	< 0.001	<0.001	0.741	<0.001
Heptadecanoic (C17:0)	0.13	0.10	0.12	0.12	0.14	0.02	0.123	0.098	0.228	0.845
Heptadecenoic (C17:1)	0.25^{a}	0.16^{b}	0.14^{b}	0.13^{b}	0.12^{b}	0.04	< 0.001	0.171	0.123	0.544
Stearic (C18:0)	7.27^{b}	7.25^{b}	6.49^{c}	7.43^{a}	6.60^{c}	0.12	< 0.001	<0.001	0.937	<0.001
Oleic (C18:1n9cis)	29.84^{d}	33.40^{a}	32.22^{b}	30.26^{c}	30.90^{c}	0.38	< 0.001	0.163	<0.001	<0.001
Oleic (C18:1n7cis)	1.96^{d}	2.34^{a}	2.20^{b}	1.98^{c}	1.99^{c}	0.04	< 0.001	0.392	<0.001	<0.001
Linoleic (C18:2n6)	24.05^{a}	18.85^{d}	20.86^{c}	21.05^{c}	22.02^{b}	0.47	< 0.001	<0.001	0.022	<0.001
Arachidic (C20:0)	0.30^{a}	0.20^{c}	0.24^{b}	0.23^{b}	0.30^{a}	0.01	< 0.001	0.002	0.012	0.022
Alfa-linolenic (C18:3n3)	0.78^{e}	1.03^{d}	1.60^{b}	1.31^{c}	1.88^{a}	0.10	< 0.001	<0.001	0.052^{T}	<0.001
Octadecatetraenoic (C18:4n-3)	0.38^{a}	0.13^{b}	0.12^{b}	0.15^{b}	0.11^{b}	0.04	< 0.001	0.990	0.254	0.623
Eicosadienoic (C20:2n-6)	0.09^{d}	0.09^{d}	0.19^{c}	0.41^{a}	0.35^{b}	0.03	< 0.001	0.772	<0.001	<0.001
Eicosatrienoic (C20:3n-6)	0.68^{a}	0.62^{b}	0.48^{c}	0.62^{b}	0.50^{c}	0.02	< 0.001	<0.001	0.802	0.181
Eicosatrienoic (C20:3n-3)	0.88^{a}	0.81^{b}	0.66^{e}	0.72^{d}	0.75^{c}	0.02	< 0.001	0.039	1.000	<0.001
Arachidonic (C20:4n-6)	2.61^{a}	1.93^{c}	1.48^{d}	1.92^{c}	2.09^{b}	0.08	< 0.001	0.243	0.005	<0.001
Eicosapentaenoic (C20:5n-3)	0.07^{c}	0.12^{a,b}	0.13^{ab}	0.10^{b}	0.15^{a}	0.02	< 0.001	0.088^{T}	0.808	0.355
Docosadienoic (C22:2n-6)	0.21^{b}	0.24^{a}	0.20^{b}	0.25^{a}	0.28^{a}	0.01	< 0.001	0.877	0.002	<0.001
Docosatrienoic (C22:3n-6)	0.24^{a}	0.09^{c}	0.02^{e}	0.13^{b}	0.05^{d}	0.02	< 0.001	<0.001	0.099^{T}	0.843
Docosatetraenoic (C22:4n-6)	0.30^{a}	0.14^{bc}	0.12^{c}	0.15^{b}	0.14^{bc}	0.02	< 0.001	0.054^{T}	0.022	0.847
Docosapentaenoic (C22:5n-3)	0.18^{d}	0.23^{c}	0.40^{a}	0.33^{b}	0.42^{a}	0.02	< 0.001	0.411	<0.001	<0.001
Docosahexaenoic (C22:6n-3)	0.17^{c}	0.21^{b}	0.22^{b}	0.27^{a}	0.29^{a}	0.01	< 0.001	0.264	<0.001	0.212
Total n-6 PUFA[1]	28.18^{a}	21.96^{e}	23.35^{d}	24.53^{c}	25.43^{b}	0.54	< 0.001	0.004	0.001	<0.001
Total n-3 PUFA[2]	2.46^{e}	2.53^{d}	3.13^{b}	2.88^{c}	3.60^{a}	0.09	< 0.001	<0.001	0.095^{T}	0.291
n-6 PUFA/ n-3 PUFA	11.46^{a}	8.68^{b}	7.46^{c}	8.52^{b}	7.06^{d}	0.30	< 0.001	<0.001	0.363	0.013

^{a,b,c,d,e}Means in the same row with different superscripts differ significantly (P<0.05). [1]Total n-6 PUFA, sum of C18:2n-6; C20:2n-6; C20:3n-6; C20:4n-6; C22:2n-6; C22:3n-6; C22:4n-6. [2]Total n-3 PUFA, sum of C18:3n-3; C18:4n-3; C20:3n-3; C20:5n-3, C22:5n-3, C22:6n-3. [3]SEM, standard error of means; [4]Data were analysed as a 2 × 2 factorial arrangement, excluding control group. T, tendency to be influenced by the treatment.

12.67–14.82%) and ALA (9.00–13.28%). The differences in FAs contents could be attributed to the type of cultivar, soil characteristics, and growing conditions of the tested lentils. In terms of specific FAs, we were most interested in LA and ALA contents, because both are essential for humans and animals.

Meat FAs profile: The effect of diet on the composition of individual FAs in the breast muscle of the broiler chickens is presented in Table 2. The dietary treatment affected breast meat FAs composition. No research appears to have been reported on the effect of dietary lentil seeds inclusion on FAs profile in broiler chickens meat; therefore, this subject should be considered a new investigation. Across treatments, oleic acid (C18:1, 31.8–35.8%; P<0.001), followed by palmitic acid (C16:0, 21.7–23.7%; P<0.001) and LA (18.9–24.0%; P<0.001) were the main FAs found in the breast muscle of the broilers. All broilers fed raw lentil seeds had higher levels of ALA (P<0.001) in breast muscle. ALA is the precursor of long-chain n-3 PUFA such as eicosapentaenoic acid (EPA, C20:5n-3), docosapentaenoic acid (DPA, C22:5n-3), and docosahexaenoic acid (DHA, C22:6n-3), which are commonly referred to as n-3 or omega-3 FAs. Feeding raw lentil seeds (*Lens culinaris* cv. Eston or cv. Anicia, respectively) in diets for starter and growing broiler resulted in a significant (P<0.001) increase in EPA, DPA and DHA, in comparison with SBM. Similar observations were made when broilers were fed Camelia (*Camelina sativa* L Crantz variety) oil and seeds (Ciurescu *et al*. 2016), fava beans (*Vicia fava* L var. minor) (Laudadio *et al*. 2011), *Camelina sativa* meal (Aziza *et al*. 2010) or oil (Jaskiewicz *et al*. 2014), chia (*Salvia hispanica* L.) seeds (Ayerza *et al*. 2002), full-fat flaxseed (Ajuyah *et al*. 1991, Jia *et al*. 2010) and linseed oil (Loμpez-Ferrer *et al*. 2001) or in turkeys diet fed linseed oil (Jankowski *et al*. 2012). Moreover, this result was associated with a significant (P<0.001) increase in total n-3 PUFA. Additionally, the n-6/ n-3 ratio decreased (P<0.001) in breast muscle of broilers fed raw lentil seeds, compared with the SBM. The higher level of raw lentil seeds has led to a significant (P<0.001) increase of total n-3 PUFA content in the breast muscle; cultivar had a tendence (P=0.095). A significant interaction was observed between level and cultivar for majority of n-3 PUFA profile (P<0.001), except for octadecatetraenoic (C18:4n-3) acid, EPA and DHA. Based on the significant increase in ALA observed in broilers fed raw lentil seeds (cv. Eston and cv. Anicia) in the present study, this legume could replace SBM in diets without affecting meat quality. Furthermore, this study reveals that, the broilers feeding raw lentil seeds in their diets had higher total n-3 PUFA which may have potential benefits to human nutrition.

Blood plasma parameters: The influence of diets on plasma parameters is presented in Table 3. There was no significant (P>0.05) treatment effect on plasma protein and

Table 3. Effects of feeding raw lentil seeds (cv. Eston and cv. Anicia, respectively) on plasma metabolic profile of broiler chickens (28 d)

Parameter	Dietary treatments					SEM[3]	P-value	P-value[3]		
	C	LE2	LE4	LA2	LA4			Level	Cultivar	L × C
Plasma energy profile										
Glucose (mg/dl)	231.83[a]	227.83[ab]	226.93[ab]	225.95[ab]	215.48[b]	5.69	0.021	0.455	0.331	0.759
Cholesterol (mg/dl)	107.10	105.45	95.15	107.23	101.95	5.18	0.153	0.179	0.823	0.116
Triglycerides (mg/dl)	43.73[a]	36.35[ab]	35.26[ab]	27.70[b]	31.88[ab]	3.21	0.035	0.569	0.404	0.590
Plasma protein profile										
Total protein (g/dl)	2.57	2.66	2.51	2.57	2.65	0.06	0.144	0.162	0.200	0.212
Albumin (g/dl)	1.61	1.56	1.58	1.57	1.59	0.05	0.154	0.400	0.336	0.889
Total Bilirubin (mg/dl)	0.42	0.50	0.34	0.41	0.37	0.06	0.180	0.112	0.341	0.152
Creatinine (mg/dl)	0.56	0.57	0.53	0.56	0.53	0.10	0.998	0.724	0.927	0.990
Urea (mg/dl)	4.33	4.84	5.58	4.48	5.13	0.52	0.471	0.241	0.480	0.943
Plasma mineral profile										
Calcium (mg/dl)	10.30	10.46	10.66	9.92	10.49	0.45	0.805	0.419	0.461	0.699
Phosphorus (mg/dl)	6.76	6.28	6.93	6.37	7.09	0.36	0.452	0.094[T]	0.745	0.936
Magnesium (mg/dl)	1.55	1.45	1.43	1.60	1.58	0.13	0.454	0.900	0.173	0.977
Iron (μg/dl)	184.68	162.88	178.40	171.75	190.23	9.17	0.291	0.109	0.313	0.883
Plasma enzyme profile[1]										
ALT/GPT (U/l)	32.65	30.38	27.45	30.70	28.90	2.81	0.227	0.818	0.303	0.895
AST/GOT (U/l)	41.93	42.25	40.20	40.03	39.43	2.68	0.925	0.663	0.622	0.811
AP (U/l)	49.38	51.15	48.51	45.70	49.65	2.73	0.453	0.447	0.316	0.517
GGT (U/l)	18.25	15.65	15.03	16.45	15.58	1.73	0.715	0.598	0.635	0.930
LDH (U/l)	663.68	553.18	594.51	569.53	571.90	83.02	0.354	0.557	0.385	0.560

[a,b,C]Values with different superscripts in a row differ significantly (P<0.05). [1]Alanine aminotransferase (ALT/GPT); Aspartate aminotransferase (AST/GOT); Alkaline phosphatase (AP); Gamma-glutamyl-transferase (GGT); Lactate dehydrogenase (LDH). [2]SEM, standard error of means; [3]Data were analysed as a 2 × 2 factorial arrangement, excluding control group. T, tendency to be influenced by the treatment.

energy profile, except for glucose and triclycerides. The broiler chicken fed raw lentils has significantly lower glucose (P=0.021) and triclycerides (P=0.035) concentration than those fed SBM. Increasing dietary lentils level reduced plasma TC (up to 11%; P>0.05) compared with those chicks fed SBM. These results are in agreement with the observations of Viveros *et al.* (2007) who reported that inclusion of lupin seed in chicken diets causes a reduction of serum cholesterol and glucose. Similar results have been observed in rats fed lentil diets, able to decrease the level of circulating cholesterol and to affect the pathways involved in vascular remodelling and hypertension probably due to their high fibre content (Hanson *et al.* 2014). Also, in human studies it was reported that the consumption of pulse grains, lower serum cholesterol (known as a risk factor for cardio vascular disease) and increase the saturation levels of cholesterol in the bile (Abeysekara *et al.* 2012, Anderson and Major 2002, Bazzano *et al*. 2001). It seems, plasma cholesterol concentration is influenced by the FAs composition of dietary fat with high levels of long chain SFA increasing plasma cholesterol level, compared to high levels of MUFA and PUFA. They also reported that intake of pulses, with their low glycemic index and mineral content, has favourable effects on blood pressure, glycemic regulation and weight management. Plasma ALT/GPT and AST/GOT are parameters for liver damage evaluation and these enzyme diagnosis is frequently used in an evaluation of hepatic function. There is little information regarding plasma enzymes activity, with dietary lentils. In this study, there were no significant differences in the activity of ALT/GPT, AST/GOT, AP, GGT and LDH between treatments. It indicated that the dietary treatments had no negative effect on liver health. No significant interaction was observed for plasma metabolic profile.

Therefore, we concluded that raw lentil seeds represent an interesting alternative protein source which can improve the quality of broiler meat that can be recommended in healthy, balanced diets to prevent human diseases. Further investigations with different lentil seeds cultivars are needed to promote the use of raw lentil seeds in broiler chickens diets.

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