Growth performance and carcass and meat quality of broiler chickens fed diets containing micronized-dehulled peas (*Pisum sativum* cv. Spirale) as a substitute of soybean meal

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ABSTRACT An experiment was carried out to evaluate the effects of diets containing peas on productive traits, carcass yields, and fatty acid profiles (breast and drumstick meat) of broiler chickens. Hubbard strain broiler chicks, divided into 2 groups, received from 14 d to slaughtering age (49 d) a wheat middlings-based diet containing soybean (190 g/kg) or micronized-dehulled peas (400 g/kg) as the main protein source. The inclusion of peas did not significantly change the growth performance of birds. The pea level had no effect on the dressing percentage, the percentage of breast or drumstick muscles, and abdominal fat. The muscles of birds fed the pea diet had significant ($P < 0.05$) lower L* (lightness) and b* (yellowness, drumstick muscle) values and fat content. Instead, total collagen and water-holding capacity values were higher in the pea treatment. The polyunsaturated fatty acid concentration in breast and drumstick muscles was significantly increased with the alternative protein source inclusion, whereas the saturated fatty acid was similar among treatments. The n-6/n-3 polyunsaturated fatty acid ratio of the broiler drumstick meat decreased significantly in the pea group. Dietary pea inclusion improved the saturation index of meat without altering atherogenic and thrombogenic indexes. It can be concluded that the pea treatment tested had a positive effect on the performance and meat quality of broiler chickens.

Key words: broiler, pea, growth, carcass characteristic, meat quality

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INTRODUCTION

The increased cost and limited supply of conventional vegetable proteins have required contemporary research efforts geared toward the study of food properties and potential utilization of protein from locally available food crops, especially from underused high-protein legumes (Khattab et al., 2009). Moreover, the measures adopted by the European community to deal with bovine spongiform encephalopathy have made it necessary to find a feeding system able to satisfy dietary requirements of livestock and the quality of final product. The ban on animal protein supplements (European Commission Decisions No. 98/272/CE and 2000/374/CE) induced breeders to use soybean (*Glycine max* L. Merr.), which has a particularly high protein content and is therefore one of the most used and efficient components in feed formulation. Nevertheless, in many areas, soybean has led to consumer resistance because much of it comes from genetically modified crops, unsuitable for use in organic farming (Vicenti et al., 2009). These circumstances have stimulated research on genetically modified-free feeds that can satisfy protein requirements.

Peas (*Pisum sativum* L.) are widely produced in the Mediterranean area and could be used as an alternative protein source to soybean because of their good nutritive value (Ravindran and Blair, 1992; Castell et al., 1996), although today their use is very limited in poultry diets. In comparison to most cereal grains, pea seeds are considerably high in starch. As a nutrient, starch is the greatest single dietary source of energy. However, pea starch is less susceptible to enzyme hydrolysis than starch in any of the cereal grains (Longstaff and McNab, 1987).

Processing procedures that eliminate or inactivate antinutritive substances from peas and alter starch structure to improve accessibility of starch granules to enzyme hydrolysis offer promise of improving the nutritive value of peas for poultry (Igbasan and Guenter, 1997). Micronization is a dry-heat process using infrared electromagnetic short waves produced by burning industrial propane over ceramic tile or nichrome wire

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Table 1. Ingredients and chemical analysis of experimental diets

Item	Experimental diet	
	Soybean	Pea
Ingredients, g/kg as-fed basis		
Durum wheat middlings	741.5	538.5
Soybean meal (48% CP)	195.0	—
Peas	—	400.0
Soybean oil	17.0	15.0
Calcium carbonate	14.0	16.0
Dicalcium phosphate	13.0	12.0
Sodium chloride	2.5	2.5
Sodium bicarbonate	2.0	2.0
Vitamin-mineral premix[1]	5.0	5.0
L-Lys HCl	4.4	2.5
Enzyme[2]	2.0	2.0
DL-Met	1.6	2.5
Choline chloride	1.0	1.0
Coccidiostat[3]	1.0	1.0
Chemical analysis, %		
DM	89.75	90.21
CP	20.56	20.49
Crude fiber	3.21	2.68
Crude fat	3.93	3.54
Ash	5.20	4.99
Calculated analysis		
ME, MJ/kg of diet	12.1	12.1
Lys, %	1.15	1.15
Ca, %	1.02	1.01
Met + Cys, %	0.79	0.78
Available P, %	0.31	0.31
Fatty acids,[4] %		
ΣSFA	31.02	35.15
ΣMUFA	33.66	24.55
ΣPUFA	35.32	40.30
Total n-6	31.55	37.21
Total n-3	1.67	2.12

[1]Supplied per kilogram of diet: vitamin A, 12,000 IU; vitamin E, 10 mg; vitamin D_2, 200 IU; niacin, 35.0 mg; D-pantothenic acid, 12 mg; riboflavin, 3.63 mg; pyridoxine, 3.5 mg; thiamine, 2.4 mg; folic acid, 1.4 mg; biotin, 0.15 mg; vitamin B, 0.03 mg; Mn, 60 mg; Zn, 40 mg; Fe, 1,280 mg; Cu, 8 mg; I, 0.3 mg; and Se, 0.2 mg.

[2]Provided per kilogram of product: endo-1,4-β-glucanase, 800,000 U; endo-1,3(4)-β-glucanase, 1,800,000 U; and endo-1,4-β-xylanase, 2,600,000 U.

[3]Provided 33 g of robenidine hydrochloride/kg of feed.

[4]SFA = saturated fatty acid; MUFA = monounsaturated fatty acid; PUFA = polyunsaturated fatty acid.

elements to heat grains (Mercier, 1971), and Douglas et al. (1991) reported that micronization improved the nutritive value and increased protein content of ingredients for growing pigs and chicks.

Therefore, the aim of this study was to assess the effect of diets containing high-protein micronized peas (*Pisum sativum* cv. Spirale) as an alternative source on growth performance and meat quality of broiler chicks.

MATERIALS AND METHODS

Birds and Dietary Treatments

The trial was carried out observing the animal welfare (Directive No. 91/629/EEC, received in Italy by Legislative Decree 533/92 and modified by Legislative Decree 331/98). An experiment with 160 female Hubbard strain broiler chicks was conducted from 14 to 49 d of age and involved 2 dietary treatments. Broilers, from a commercial hatchery, were raised in a conventional environment and fed a common diet until 14 d of age that contained 20.5% CP and 12.3 MJ of ME/kg of diet, designed to satisfy the recommendations of the NRC (1994). On d 14, birds were individually weighed and randomly divided among 16 pens in a commercial poultry facility located in the Province of Bari, Italy. Each diet (treatment) was replicated 8 times, with each replicate comprising 1 pen of 10 birds. From 14 d to slaughtering age (49 d), birds were fed 2 diets containing soybean meal, 48% CP, or micronized and dehulled peas (*Pisum sativum* cv. Spirale), 31% CP and 1.7% crude fiber, as previously reported by Laudadio et al. (2009), as the main protein sources. Feed (pelleted form) and water were provided ad libitum.

Pea seeds, locally grown, were tempered overnight to the preferred moisture content (240 g/kg) as recommended by Khattab et al. (2009) using distilled water. Tempered seeds were heated up to 130°C using a small experimental bench-top micronizer composed of a tubular quartz infrared lamp (115 V) with a tungsten wire filament enclosed in a ceramic casing (Research Inc., Eden Prairie, MN). Processing times for pea were 1.5 min. Dehulling was accomplished with the aid of a roller mill and the hulls were separated from the cotyledons by air classification. Ingredient and chemical composition of the diets are shown in Table 1.

Sample Collection

On d 49 of the trial, 3 broilers from each pen were selected according to average BW within the pen following a 12-h fasting, weighed individually, and killed by cervical dislocation and then were immediately bled. The abdominal fat, breast (pectoralis major), and drumstick (peroneous longus) muscles were removed and weighed. Some muscles from the breast and drumstick were immediately stored at −80°C for assessing crude fat content, and others were stored individually in plastic bags at 4°C for analysis of meat quality.

Meat Quality Measurements

Muscle pH. At 24 h after killing, the breast and drumstick muscle pH was tested at a depth of 2.5 cm below the surface. This was done using a combined glass-penetrating electrode (Ingold, Mettler Toledo, Greifensee, Switzerland).

Color Measurements and Drip Loss. Color measurements were assessed on the carcass surface over the breast and drumstick muscles and on a freshly exposed cut surface of muscle. A Minolta CR-300 chromameter (Minolta, Osaka, Japan) was set to the L* (lightness), a* (redness), and b* (yellowness) CIE scale, as described by Combes et al. (2008). Drip loss was determined by the filter paper method of Kauffman et al. (1986).

Water-Holding Capacity. The water-holding capacity (**WHC**) of the breast and drumstick meat was measured immediately after killing according to the method described by Sun and Luo (1993). A 0.3-g breast muscle or drumstick muscle sample was pressed onto an oven-dried Whatman 125-mm filter paper (Maidstone, Kent, UK) at 207 bar. The WHC values were calculated as the ratio of the area of expressed water to the area of the pressed meat sample as measured with a planimeter (model 4236, Keuffel and Esser, Hoboken, NJ).

Chemical Analysis. Meat samples were analyzed for moisture and ash by oven method, protein by Kjeldahl method (AOAC, 2000), and total lipids were extracted according to the method of Folch et al. (1957). Values are expressed as percentage on a fresh matter basis. Total collagen was extracted following the method of Sörensen (1981). Determination of 4-hydroxyproline was performed according to the procedure suggested by Kindt et al. (2003) using electrospray mass spectrometry (LCQ, Thermo Electron, Waltham, MA) to avoid any derivatization step.

Fatty Acid Composition of Meat. In preparation for the analysis of fatty acid (**FA**) composition, samples of breast and drumstick meat (5 g each) were freeze-dried and then ground. Methyl heptadecanoate (no. 51633, Fluka, St. Louis, MO) was dissolved into *n*-hexane (1 mg/mL) as an internal standard. Methyl esters of the FA were prepared (Sukhija and Palmquist, 1988); samples (300 mg each) and 5 mL of internal standard were incubated (2 h at 80°C) with methanolic acetyl chloride in a total volume of 9 mL. After cooling to room temperature, 7 mL of 7% (wt/vol) K_2CO_3 was added with mixing, and then the organic phase was collected after centrifuging at 1,500 × *g* for 2 min at 4°C. The FA methyl esters were fractionated over a CP-SIL883 column (100 m × 0.25 mm i.d., film thickness 0.20-μm fused silica; Varian, Palo Alto, CA) in a Shimadzu (model 2GC17A, Shimadzu, Kyoto, Japan) gas chromatograph with a Hewlett-Packard HP 6890 gas system (Palo Alto, CA) and using flame ionization detection. Helium was used as the carrier gas at a constant flow rate of 1.7 mL/min. The oven temperature was programmed as follows: 175°C, held for 4 min; 175 to 250°C at 3°C/min; and then maintained for 20 min. The injector port and detector temperature was 250°C. Samples (1 μL) were injected with an auto-sampler. Output signals were identified and quantified from the retention times and peak areas of known calibration standards. Composition was expressed as percentages of the total FA.

The saturation (saturated FA:unsaturated FA ratio, **S:P**), atherogenic index (AI), and thrombogenic index (TI) were calculated according to Ulbricht and Southgate (1991) as follows:

$$\text{S:P} = (\text{C14:0} + \text{C16:0} + \text{C18:0})/\Sigma\text{MUFA} + \Sigma\text{PUFA};$$

$$\text{AI} = (\text{C12:0} + 4 \times \text{C14:0} + \text{C16:0})/[\Sigma\text{MUFA} + \Sigma(\text{n-6}) + \Sigma(\text{n-3})];$$

$$\text{TI} = (\text{C14:0} + \text{C16:0} + \text{C18:0})/[0.5 \times \Sigma\text{MUFA} + 0.5 \times \Sigma(\text{n-6}) + 3 \times \Sigma(\text{n-3}) + \Sigma(\text{n-3})/\Sigma(\text{n-6})];$$

where **MUFA** = monounsaturated FA; **PUFA** = polyunsaturated FA.

Statistical Analysis

A completely randomized design was used with 2 treatments and 8 replicates (pens) per treatment. Data were statistically analyzed by the GLM procedure and means were compared by the Student-Newman-Keuls method when appropriate (SAS Institute, 2000).

RESULTS AND DISCUSSION

Growth Performance and Carcass Traits

Dietary protein source had no effect on broiler growth performance (Table 2). Castanon and Perez-Lanza (1990) and Perez-Maldonado et al. (1999) found that the inclusion of field peas in poultry diets did not affect BW and mortality. Diaz et al. (2006), however, observed reduced BW and decreased feed conversion efficiency when broilers were fed extruded pea seeds, but this outcome could stem from one or more of the antinutritional factors present in peas treated with extrusion. Therefore, in our study, the effect of heat treatment (micronization) of peas on broiler productive performance could reflect the degree of feed utilization, as also indicated by Valencia et al. (2009). Similar findings of no changes in BW gain, feed consumption, and feed efficiency in broilers fed micronized and dehulled peas have been reported previously by Igbasan and Guenter (1996).

Table 2. Effect of dietary protein source on growth performance of broiler chickens at 49 d of age

	Experimental diet			
Item	Soybean	Pea	SEM	*P*-value
BW, g	2,549	2,529	15.72	0.407
ADG, g	50.4	49.9	0.41	0.521
ADFI, g	105.0	106.1	0.69	0.096
FCR,[1] g:g	2.03	2.05	0.02	0.102
Mortality, %	1.2	1.1	—	0.745

[1]FCR = feed conversion ratio.

The carcass traits, expressed as percentages of BW at slaughter, are reported in Table 3. The dietary protein source had no effect on carcass traits. This result is in agreement with the previous studies conducted by Masoero et al. (2005) that examined the effect of different protein sources on carcass characteristics of broiler chickens. Dressing percentage and breast and drumstick percentages were not modified by dietary alternative protein source.

The use of peas did not significantly change abdominal fat content in broiler chickens. Previous studies have shown that the pattern of fat deposition can be modified by dietary protein source. For example, Cherian et al. (2002) found less accumulation of abdominal fat in broiler chickens fed diets containing high levels of sorghum compared with soybean meal. The reduction of abdominal fat in chickens fed alternative protein source was accompanied by a reduction in muscle fat contents. These changes in fat deposition most likely resulted from changes in lipid metabolism.

Meat Quality

The effect of diets on pH, color, drip loss, and chemical composition of breast and drumstick of broiler muscles are shown in Table 3. The variables related to pH 24 h postmortem were not influenced by the dietary treatment, indicating an acidification process of meat in agreement with that described in literature (Mourão et al., 2008).

Meat color is one of the first characteristics noted by customers, especially in boneless products, and is also an indictor of meat quality. In our study, the source of variability of diet influenced the colorimetric indexes of muscles. There was a significant effect of pea inclusion in diet on the color in both muscles from birds fed the pea diet in comparison with birds fed the soybean diet. However, L* values were in the normal range and would not be considered to be excessively pale (Woelfel et al., 2002). The a* (redness) values progressively did not vary because the diets contained alternative protein content. Conversely, the changes in b* (yellowness) were significant ($P < 0.05$) in the drumstick muscle in the group fed the pea diet. This result may be explained by lower lipid content in drumstick muscle and there may be less lipid-soluble pigments such as xanthophylls.

The variable WHC was influenced by dietary treatments (Table 3). Water-holding capacity was higher in birds fed the peas diet ($P < 0.01$) in both muscles. In particular, the WHC had a higher range of variation in drumstick muscle than in breast muscle. Water-holding capacity is an important attribute of meat quality,

Table 3. Effect of dietary protein source on carcass yield and meat quality parameters of broiler chickens at 49 d of age (n = 16)

	Experimental diet			
Item	Soybean	Pea	SEM	*P*-value
Carcass traits[1]				
Eviscerated carcass	70.4	70.7	0.04	0.356
Breast muscle	9.08	9.87	0.06	0.213
Drumstick muscle	14.15	14.32	0.08	0.411
Abdominal fat	2.47	2.79	0.09	0.203
Meat parameters				
Breast muscle				
pH_{24}[2]	6.09	6.12	0.15	0.270
L* (lightness)	46.77	45.05	0.97	<0.05
a* (redness)	8.87	9.15	0.78	0.098
b* (yellowness)	2.01	1.96	0.44	0.102
WHC,[3] %	17.23	19.64	0.53	<0.01
Drip loss, %	2.01	1.81	0.11	0.107
Total collagen, %	5.12	6.03	0.61	<0.05
Moisture, %	75.18	76.33	0.45	0.144
Protein, %	22.04	21.95	0.57	0.085
Fat, %	1.94	1.01	0.16	<0.05
Ash, %	0.84	0.71	0.11	0.206
Drumstick muscle				
pH_{24}	6.03	6.09	0.12	0.393
L* (lightness)	49.96	47.91	0.79	<0.05
a* (redness)	10.98	10.72	0.64	0.212
b* (yellowness)	1.97	0.43	0.57	<0.05
WHC, %	15.21	24.22	0.76	<0.01
Drip loss, %	1.69	1.47	0.15	0.113
Total collagen, %	6.08	7.81	0.67	<0.01
Moisture, %	76.01	76.89	0.85	0.402
Protein, %	18.75	18.83	0.66	0.144
Fat, %	4.68	3.77	0.21	<0.05
Ash, %	0.56	0.51	0.12	0.326

[1]Percentages of BW at slaughter.

[2]pH_{24} = pH at 24 h postmortem.

[3]WHC = water-holding capacity.

which can be estimated by drip loss. If WHC is poor, whole meat and further-processed products will lack juiciness (Gentry et al., 2004). There were no differences in drip loss of breast and drumstick muscles due to dietary treatment.

The source of variability in diets influenced total collagen and fat amounts in both considered muscles (Table 3). Muscles collected from broilers in the pea treatment registered a higher total collagen content ($P < 0.05$, breast and $P < 0.01$, drumstick) than soybean treatment. However, the collagen content does not appear to be related to other parameters considered, confirming the influence on tenderness of many other factors such as contractility, the length of the sarcomers, and the dimensions and conservation state of the muscle fibers as found by Wheeler et al. (2000). The percentage of fat in the breast and drumstick muscle of broilers fed pea was around one percentage point lower ($P < 0.05$) compared with birds fed the conventional diet. The PUFA level was higher in the pea diet. It is well known that PUFA have a negative effect on lipid synthesis, which could explain the lowest lipid level in muscles from birds fed with the pea diet. Moisture, protein, and ash content recorded in the present work was similar among experimental groups, further confirming that the alternative treatment did not negatively affect the quality of meat.

FA Composition of Muscles

In the present study, the dietary treatment affected meat FA profiles. We could not locate any literature concerning the effects of dietary pea inclusion on FA composition of broilers' muscles; therefore, this subject should be considered in new investigations.

The FA composition of muscles reflected the FA composition of diets. Broilers fed peas had higher levels of palmitic acid (C16:0) in breast and drumstick muscles (Tables 4 and 5). The higher levels of palmitic acid led to an increase in total saturated FA (**SFA**) in the muscles when compared with birds fed the control diet containing a conventional protein source. The total n-3 FA were higher in birds fed the pea diet when compared with the control soybean diet. This result was contributed by a significant increase in n-3 FA such as eicosapentaenoic acid (C20:5n-3) and docosahexaenoic acid (C22:6n-3) in breast and drumstick muscles.

The content of arachidonic acid (C20:4n-6) was similar in the breast and drumstick muscle of birds fed both diets. Significant difference ($P < 0.05$) was observed in the linoleic acid (C18:2n-6) content of breast and drumstick muscles of broilers fed the pea diet, whereas linolenic acid (C18:3n-3) content did not change in both analyzed muscles. Linoleic and linolenic acids are the parent FA of long-chain n-6 and n-3 FA such as arachidonic acid, eicosapentaenoic acid, docosapentaenoic acid, and docosahexaenoic acid through elongation and desaturation.

Feeding peas resulted in a significant ($P < 0.05$) reduction in MUFA. The content of total n-3 FA was significantly increased ($P < 0.05$) in the breast and drumstick muscles of broilers fed an alternative protein source compared with those fed the control soybean diet. Although all muscles contained the same content of

Table 4. Effect of dietary protein source on the fatty acid composition (% of total fatty acids) of breast muscle from broiler chickens at 49 d of age (n = 16)

	Experimental diet			
Item[1]	Soybean	Pea	SEM	*P*-value
C12:0	1.92	1.87	0.55	0.076
C14:0	4.74	4.97	0.72	0.087
C14:1n-5	0.49	0.46	0.09	0.202
C16:0	19.38	20.11	1.05	<0.05
C16:1n-7	4.96	4.65	0.67	0.189
C18:0	0.45	0.44	0.08	0.312
C18:1n-9	35.52	33.43	1.32	<0.05
C18:2n-6	28.02	29.03	1.23	<0.05
C18:3n-6	0.75	0.67	0.09	0.355
C18:3n-3	0.33	0.35	0.07	0.401
C20:4n-6 (ARA)	0.78	0.81	0.18	0.235
C20:5n-3 (EPA)	1.22	1.43	0.79	<0.05
C22:5n-3 (DPA)	1.03	1.21	0.91	0.117
C22:6n-3 (DHA)	0.41	0.57	0.11	<0.05
ΣSFA	26.49	27.39	1.14	0.063
ΣMUFA	40.97	38.54	1.97	<0.05
ΣPUFA	32.54	34.07	1.56	<0.05
Total n-6	29.55	30.51	1.18	<0.05
Total n-3	2.99	3.56	0.84	0.061
n-6:n-3	9.88	8.57	0.95	<0.05
S:P	0.36	0.38	0.09	0.337
Atherogenic index	0.55	0.58	0.13	0.098
Thrombogenic index	0.55	0.56	0.14	0.113

[1]ARA = arachidonic acid; EPA = eicosapentaenoic acid; DPA = docosapentaenoic acid; DHA = docosahexaenoic acid; SFA = saturated fatty acid; MUFA = monounsaturated fatty acid; PUFA = polyunsaturated fatty acid; n-6:n-3 = PUFA n-6:PUFA n-3 ratio; S:P = SFA:unsaturated fatty acid ratio.

Table 5. Effect of dietary protein source on the fatty acid composition (% of total fatty acids) of drumstick muscles from broiler chickens at 49 d of age (n = 16)

	Experimental diet			
Item[1]	Soybean	Pea	SEM	*P*-value
C12:0	2.37	2.22	0.54	0.098
C14:0	4.81	5.46	0.63	<0.05
C14:1n-5	0.55	0.50	0.21	0.103
C16:0	20.20	21.30	1.17	<0.05
C16:1n-7	5.50	5.72	0.61	0.179
C18:0	0.56	0.55	0.09	0.217
C18:1n-9	36.50	33.28	1.64	<0.05
C18:2n-6	26.20	27.00	1.31	<0.05
C18:3n-6	0.80	0.77	0.10	0.344
C18:3n-3	0.45	0.49	0.08	0.315
C20:4n-6 (ARA)	0.20	0.22	0.25	0.401
C20:5n-3 (EPA)	0.45	0.63	0.86	<0.05
C22:5n-3 (DPA)	1.10	1.31	0.92	0.081
C22:6n-3 (DHA)	0.31	0.55	0.15	<0.05
ΣSFA	27.94	29.53	1.26	0.061
ΣMUFA	42.55	39.50	1.69	<0.05
ΣPUFA	29.51	30.96	1.41	<0.05
Total n-6	27.20	27.99	0.12	0.116
Total n-3	2.31	2.98	0.88	<0.05
n-6:n-3	11.76	9.41	1.01	<0.05
S:P	0.39	0.42	0.23	0.087
Atherogenic index	0.58	0.64	0.31	0.063
Thrombogenic index	0.61	0.64	0.25	0.071

[1]ARA = arachidonic acid; EPA = eicosapentaenoic acid; DPA = docosapentaenoic acid; DHA = docosahexaenoic acid; SFA = saturated fatty acid; MUFA = monounsaturated fatty acid; PUFA = polyunsaturated fatty acid; n-6:n-3 = PUFA n-6:PUFA n-3 ratio; S:P = SFA:unsaturated fatty acid ratio.

n-3 FA, the significant increase in total PUFA may suggest that the content of long-chain n-6 and n-3 PUFA is affected by different protein source content of diet. This finding was noted in the breast and drumstick meat of birds fed the diet containing peas. This increase in n-3 FA was contributed by a significant increase in C22n-3 FA. Total SFA was lower ($P < 0.05$) in the kinsman diet when compared with mason diets. Total MUFA was reduced in birds fed the pea diet ($P < 0.05$).

The significant increase in linoleic acid observed in birds fed peas in the present study demonstrates that peas could replace a conventional protein source in broiler rations without affecting production and meat parameters. These results agree with the findings of some authors (Ayerza and Coates, 2002), who fed oilseed or other ingredients in diet, which were high in SFA, to poultry and rabbits. Several studies have highlighted that vegetable fat-enriched diets generally increase the unsaturation of depot lipids and reduce their n-6:n-3 ratio (Peiretti and Meineri, 2008).

In the present study, the n-6/n-3 ratio decreased in the drumstick meat of broilers fed the alternative pea diet. These ratios are similar to those found by Peiretti et al. (2007) in the longissimus dorsi muscle of rabbits fed diets with increasing false flax (*Camelina sativa* L.) seeds inclusion.

A decreasing S:P ratio was observed in the breast tissues of broilers fed diets with peas. The n-6:n-3 and S:P ratios are a commonly used criterion to describe the dietetic value of fat (Peiretti and Meineri, 2008). Moreover, Ayerza and Coates (2002) found that alternative protein sources, when fed to broiler chicks, significantly lowered the SFA content as well as the S:P and n-6:n-3 ratios of the meat compared with the control diet. The use of peas or soybean in diets did not cause any difference in atherogenic and thrombogenic indexes of broiler breast and drumstick muscles (Tables 4 and 5). These data indicate that peas inclusion in diets for broilers represented an interesting functional food that could be recommended in healthy balanced diets to prevent human diseases, as also reported in meat rabbits (Peiretti and Meineri, 2008) and bulls (Vicenti et al., 2009).

In conclusion, peas (*Pisum sativum* cv. Spirale) are a suitable dietary protein source in European countries for broiler chicks, and they can replace traditionally used protein sources without adverse effects on the productive performance, carcass parameters, meat quality and saturation, and atherogenic and thrombogenic indexes of the meat. However, further studies with different pea cultivars and higher levels of inclusion are needed to promote the use of peas in broiler diets.

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