Effect of various levels of corn germ on growth performance, carcass characteristics and fatty acids profile of thigh muscle in broiler chickens

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SUMMARY

In an experiment with 1,200 day-old Cobb 500 broiler chickens, the effect of partial replacement of corn with corn germ (CG) on growth performance, carcass characteristics and fatty acids profile of thigh muscle was done. Another objective of this study was to determine shelf stability of CG without or with natural antioxidant (ROVIMIX® E50, DSM Company, Courbevoie, France) under real life conditions. The broilers were allocated for 32-d experimental period to tree dietary treatments: Control, Group I and Group II (containing 0, 11 and 21% of CG, respectively, as replacements of 0, 13 and 25% of corn) of 400 birds each, and received a diet *ad libitum*. Gas chromatography method was used to determine the fatty acid profile of ingredients and thigh muscle. The oxidative stability index at room temperature (20°C), was determined for CG sample as analysed by peroxide value and percentage of free fatty acids or acidity. Results found that CG was oxidatively stable; the peroxide value did not significantly increase until after six weeks of storage, and was less than 2.12 ml sodium thiosulphate 0.01N/g fat in sample of the without antioxidant, after four months of storage. Replacement of corn with CG, at inclusion levels up to 210 g/kg of diet, resulted in similar growth performance (P >0.05). The carcass yield, breast, leg, abdominal fat deposition and liver weight did not differ significantly among groups (P >0.05). However, the percentage yield of the breast and leg was higher in both CG groups compared to control group (P<0.0001). Feeding CG diets increased the concentration of linoleic acid (C18:2n-6; P<0.0001) and PUFA (P<0.0001) in thigh muscle when compared with the control group. Also, had a tendency to increase linolenic acid (C18:3n-3; P<0.10). We can conclude that, CG can be used as an alternative protein-energy source to replace corn and oil in broiler diets, at inclusion levels up to 210 g/kg diet.

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INTRODUCTION

Poultry diets in most parts of the world are still based essentially on a corn-soybean meal mix. Prices of corn and other cereals have continued to rise. Forecast has indicated that this trend will continue and that the use of corn in poultry diets will be limited (Waldroup, 2001) not only because of their use by other livestock but also its demand in human nutrition and as a raw material for the ethanol and biodiesel production. There is therefore an increasing pressure on nutritionists to continue the search for alternative raw materials if the already high feeding cost (60 to 70% of the production cost) in intensive broiler production is maintained. Using alternative ingredients to replace a part of the corn and soybean meal can be an attractive strategy to reduce the diet cost for poultry. Dietary energy sources represent a major cost in poultry diets (Donohue and Cunningham, 2009). Because supplemental fat is typically added to the diet as liquid, specialized equipment, such as storage tanks and pumps, is required, which can limit the use of supplemental fat in poultry diets.

Dry-grind and wet milling of corn results in multiple co-products, including distillers dried grains with solubles, corn gluten meal, corn gluten feed, crude corn oil, and corn germ meal (Rausch and Belyea, 2006). Dry-mill fractionation of corn is used to separate bran, germ, and endosperm (starch industry). As new fractionation processes develop, the resulting co-products will continue to evolve. Consequently, nutrient values are guaranteed for these “new generation” corn co-products because of their altered chemical composition. In addition, some previous study restricted using of the corn germ in broiler diets. It is of utmost importance that we understand the potential limitation and challenges of using high inclusion levels of corn germ (CG) in broiler diets. Shukla and Cheryan (2001) showed that the germ fraction of the corn is the portion of the kernel that contains the majority of the albumin and globular proteins as well as the structural proteins, which are high in lysine. Because CG contains a high proportion of linoleic acid or polyunsaturated fatty acids (PUFA), we hypothesized that adding vitamin E might inhibit oxidation by reacting with free radicals, which are formed early in oxidation process, blocking the formation of fatty acid radicals and terminate the chain reaction. Rancidity deteriorates the nutritive value of ingredients or feeds and thus causes economic losses by adversely affecting performance and health of broiler birds (Engberg et al., 1996). Award et al. (1983) reported that the consumption of poultry diets containing rancid fat (0.2-6.0%) was associated

with high mortality (65%), diarrhoea, reduced feed intake and reduced body weight gains. On the other hand, because some fatty acids from feed are deposited directly in the muscle and other body tissues, diet directly affects the composition of broiler meat, especially thigh muscle due to higher fat percentages when compared with breast muscle (Wood and Enser, 1997). Therefore, this study was designed to address some of those concerns: 1) determine the oxidative stability of CG without or with natural antioxidant under real life conditions 2) evaluate whether CG can be used as a protein and energy replacement for corn in diets of broiler, without affecting growth performance and carcass characteristics, and 3) determine if various levels of CG influence fatty acid composition of thigh muscles.

MATERIAL AND METHODS

Birds were treated in accordance with Romanian legislation (law no. 305/2006) for handling and protection of animals used for experimental purposes. This study protocol was approved by the Ethical Committee of The National Research Development Institute for Animal Biology and Nutrition Baloteşti, Romania.

Broilers, diets and performance measurements

A total of 1,200 day-old Cobb 500 broiler chickens were used, obtained from a local commercial hatchery and growth for 42 d. In total, 12 floor pens with wood shaving (surface area 7.5 m^2) were used, each containing 50 male and 50 female broilers, to give 4 pen replicates and a total of 400 birds per treatment. All bird received the same starting diets containing corn-soybean meal and soybean oil. From 11 days, three experimental diets (Table 1) were formulated containing 0, 11 and 21% of CG, respectively (designated as Control, Group I and Group II, respectively), as partial replacements of corn (11 and 21%, respectively). The ingredients and chemical composition of the control and experimental diets are shown in Table 1. All these diets were calculated to be isonitrogenous, isocaloric, and with similar content of total sulphur amino acids (met + cys) and lysine, calcium and available P (Table 1), for each growth phase. Diets were in mash form and were formulated as starter, grower and finisher diets in accordance with the feeding recommendations of this hybrid (Cobb-Vantress, 2008). The broilers were given *ad libitum* access to feed and water. A lighting schedule of 23L:1D was imposed throughout the experimental period. Ambient temperature was gradually decreased imposed throughout the experimental period. Ambient temperature was gradually decreased from 32°C on d 1 to 22°C at the end of the experiment. Control parameters, such as temperature, humidity, light,

ventilation and vaccination, were the same for all groups. In order to determine the performance of broilers, the body weight gain, feed intake and feed conversion ratio were measured for starter, grower and finisher, as well as for the total experimental period. In cases where mortalities were observed, the numbers and weights of such mortalities were recorded accurately to make necessary corrections in calculating feed intake and feed conversion ratio. At the end of the experiment (42 days of age), eight chicks from each replicate were selected at random for slaughter and dissection. During 12 h prior slaughter feed was withdrawn. To determine carcass yield, body weight of broilers before slaughtering and carcass weight without offal was recorded. Carcass yield was calculated as a proportion of carcass weight after evisceration to body weight of broilers before slaughtering. Leg and breast muscles used for determination of their proportion to total carcass weight were deboned and weighted. Proportions of leg and breast muscles, abdominal fat and liver were calculated as weights of individual parts to carcass weight after evisceration. To determine fatty acid profile the samples (n=32) of thigh muscles were deboned, skin removed, packed into polyethylene bags, sealed and immediately stored in the deep freezer at -20°C.

Chemical analysis

The proximate composition of feed components and the diets (dry matter, crude protein, crude fiber, crude ash, ether extract) was analysed using the Foss Tecator procedures according to Commission Regulation (EC) no.152/2009 (Official Journal of the European Union, 2009). Gross energy value was determinated using regression equations based on its chemical composition (Schiemann et al., 1971). Metabolizable energy (ME) content of the diets was calculated on the basis of the energy content of individual feed ingredients using regression equations from the NRC (1994).

Macro minerals were estimated after microwave mineralization by hydrochloric acid and hydrogen peroxide, calcium by flame atomic absorption spectrometry using Solaar M6 Dual Zeeman Atomic Absorption Spectrometer (Thermo Electron Ltd., Cambridge, UK) at wavelengths of 422.7 nm (Ca) and phosphorus spectrophotometrically as vanadate yellow using an UV/VIS Spectrophotometer (Jasco V-530, Tokyo, Japan) at wavelengths of 422 nm. The amino acid concentration was analyzed by HPLC chromatography (Thermo Electron-Finningen Surveier fitted with a quaternary system for solvent pumping and with Diode Array Detector). We used a C18 chromatographic column and the following solvents: phosphate pH 7.8 buffer and methanol-acetonitrile mixture. Amino acid standards certified and purchased from Sigma-Aldrich were injected for mixture. Amino acid standards certified and

purchased from Sigma-Aldrich were injected for the qualitative and quantitative determinations. All reagents were certified and had HPLC purity.

Table 1. Ingredients and chemical composition of starter, grower and finisher diets

	Starter (0-10 days)	Grower (11-22 days)			Finisher (23-42 days)		
		Control	Group I	Group II	Control	Group I	Group II
Ingredients (g/kg)							
Corn	649.8	670.9	583.1	502.2	674.7	586.5	506.4
Soybean meal (45.7% CP)	227.9	222.0	211.3	201.5	227.6	217.0	207.2
Corn germ (11.53% CP)	-	-	110.0	210.0	-	110.0	210.0
Corn gluten meal	70.0	40.0	40.0	40.0	20.0	20.0	20.0
Vegetable oil	-	16.5	7.3	-	29.9	21.0	12.8
Monocalcium phosphate	16.7	16.3	15.4	15.0	15.0	14.4	14.0
Calcium carbonate	17.3	16.6	15.2	13.6	15.6	14.0	12.5
Salt	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin-mineral premix with coccidiostatic [1,2]	10.0	10.0	10.0	10.0	-	-	-
Vitamin-mineral premix without coccidiostatic [3]	-	-	-	-	10.0	10.0	10.0
DL-methionine (99%)	1.6	1.7	1.7	1.7	1.7	1.7	1.7
L-lysine HCl (78%)	3.7	3.0	3.0	3.0	2.5	2.4	2.4
Calculated nutrient composition (g/kg)							
Crude protein	210.0	190.0	190.0	190.0	180.0	180.0	180.0
ME (MJ/kg)	12.55	13.10	13.10	13.10	13.29	13.29	13.29
Lysine, total	12.0	11.0	11.0	11.0	10.5	10.5	10.5
Lysine, digestible	10.9	9.9	9.9	9.9	9.5	9.4	9.4
Methionine, total	5.3	5.0	5.0	5.0	4.7	4.7	4.7
Methionine, digestible	5.1	4.8	4.7	4.7	4.5	4.5	4.5
Methionine + cystine, total	8.9	8.2	8.2	8.2	7.8	7.8	7.8
Methionine + cystine, digestible	8.1	7.4	7.4	7.3	7.0	7.0	6.9
Calcium	10.0	9.6	9.6	9.6	9.0	9.0	9.0
Phosphorus, available	4.5	4.3	4.3	4.3	4.0	4.0	4.0
Crude fat	31.9	48.1	87.0	124.0	61.0	100.3	135.9
Crude fibre	25.6	25.3	32.2	38.5	25.4	32.3	38.5

[1] Supplied per kg diet: retinyl acetate, 4.47 mg; cholecalciferol, 0.12 mg; DL-α-tocopheryl acetate, 80 mg; menadione sodium bisulphite, 4 mg; thiamine mononitrate, 4 mg; riboflavin, 9 mg; pyridoxine-HCl, 4 mg; cyanocobalamin, 0.020 mg; Ca-panthotenate, 15 mg; niacin, 60 mg; folic acid, 2 mg; choline (choline chloride), 500 mg; Mn, 100 mg; Zn, 100 mg; Fe, 40 mg; Cu, 15 mg; I, 1.0 mg; Se, 0.30 mg; Co, 0.25 mg.

[2] Avatec (60 mg of lasalocid sodium per kg of feed), Alpharma Inc. (Bridgewater, NJ).

[3] Supplied per kg diet: retinyl acetate, 2.90 mg; cholecalciferol, 0.12 mg; DL-α-tocopheryl acetate, 50 mg; menadione sodium bisulphite, 3 mg; thiamine mononitrate, 2 mg; riboflavin, 8 mg; pyridoxine-HCl, 3 mg; cyanocobalamin, 0.015 mg; Ca-panthotenate, 12 mg; niacin, 50 mg; folic acid, 1.5 mg; choline (choline chloride), 500 mg; Mn, 100 mg; Zn, 100 mg; Fe, 40 mg; Cu, 15 mg; I, 1.0 mg; Se, 0.30 mg; Co, 0.25 mg.

The ingredients and muscle tissue fatty acid composition was analysed using a gas chromatography system. Total lipid (SR ISO 1444:2008) was extracted from muscle tissue samples according to Romanian standardized methods (ASRO, 2010). Fatty acid methyl esters (FAME) were prepared from total lipid extract using methanolic HCl as the derivatizing agent. Analyses of FAME were performed with a Clarus 500 gas chromatograph (PerkinElmer, Inc., SUA) equipped with an autosampler, flame ionization detector (FID), and fused silica capillary column (cis/trans FAME), 60 m x 0.25 mm x 0.2 µm film thickness (PerkinElmer, Inc., SUA). The calibration and the peak determinations were based on authentic standards fatty acids from Sigma-Aldrich (St. Louis USA). The results were expressed for each fatty acid (as % of total FAME).

The peroxide values and percentage of free fatty acids or acidity are useful for determining the relative stability of CG without or with natural antioxidant (ROVIMIX® E50, DSM Company, Courbevoie, France) to predict shelf stability under real life conditions [stored at room temperature (20°C)]. Samples of CG were taken once a week for 16 weeks.

Peroxide value is the concentration of the peroxides resulting from fat self-oxidation. The determination was done according to the volumetric method STAS 12266-84 (ASRO, 2010), whose working principle is the extraction of the dietary fat using ethyl alcohol, acid treatment of the fat solution with potassium iodide, moment when the peroxides free the iodide, which is thereafter titrated with sodium thiosulphate.

The percentage of free fatty acids or acidity was done according to the volumetric method STAS 12266-84 (ASRO, 2010), whose working principle is the extraction of the dietary fat using ethyl ether or ethyl alcohol and titration of the free fatty acids with KOH 0.1N solution and the results are expressed in mg of KOH/g of fat or ration. Each CG sample was analysed in triplicate for peroxide values and fat acidity and the mean is reported.

Statistical analysis

All data were analysed by the General Linear Models (GLM) procedure using the SPSS software version 17 (SPSS Inc, Chicago IL, USA). One-way analysis of variance (ANOVA) with the post hoc Tukey's multiple comparison tests was used to evaluate statistical significance of differences among the control and experimental groups. The results are given as means and standard error of the mean (SEM). Differences were considered significant at $P \leq 0.05$. Replication was considered as the experimental unit for determined performance parameters.

RESULTS AND DISCUSSION

The chemical analysis (Table 2) of CG shows that it contained 47.07% oil, 11.53% crude protein, 8.36% crude fibre, 0.67% calcium and 0.89% phosphorus. Although its total amino acid levels were lower (Table 2), the CG contained a relatively high level of lysine and when lysine was calculated as a % of crude protein, it was found to be almost 3 times greater than corn. The high fat percentage, gives a high energy value to this by-product.

Table 2. Chemical composition of germ and corn

Item	Germ (CG)	Corn
n	3	3
Dry matter (%)	90.60	87.70
Gross Energy (MJ/kg)	27.03	16.45
Crude protein (%)	11.53	7.73
Ether extract (%)	47.07	3.56
Crude fibre (%)	8.36	1.87
Ash (%)	1.41	1.15
Calcium (%)	0.12	0.01
Phosphorus (%)	0.39	0.23
Amino acids (g/100g):		
Lysine	0.73	0.22
Methionine	0.22	0.16
½ Cystine	0.13	0.07
Threonine	0.48	0.27
Leucine	0.90	0.97
Arginine	0.98	0.35
Histidine	0.32	0.22
Isoleucine	0.35	0.29
Valine	0.66	0.39
Phenylalanine	0.45	0.38
Tyrosine	0.33	0.30
Aspartic acid	0.87	0.72
Serine	0.51	0.37
Glutamic acid	1.48	1.20
Proline	0.69	0.56
Glycine	0.58	0.28
Fatty acids profile (% of total FAME - fatty acids methyl esters):		
Myristic (C14:0)	0.10	0.12
Palmitic (C16:0)	12.81	12.66
Palmitoleic (C16:1n-7)	0.11	0.16
Stearic (C18:0)	1.92	1.54
Oleic (C18:1n-9)	28.10	25.05
Linoleic (C18:2n-6)	56.65	59.17
α- linolenic (C18:3n-3)	1.20	1.10

The fatty acids composition of CG was similar to that of corn (Table 2). Linoleic acid was the major fatty acid (56.65% of total FAME), followed by oleic acid (28.10%) and palmitic acid (12.81%) in CG. These findings were in agreement with reports of Firestone (2006). Other studies have reported similar fatty acid content of corn germ (Brito et al., 2005; Kim et al., 2008; Winkler-Moser and Vaughn, 2009).

The peroxide value (Fig. 1) varied from 0.45 to 1.27 ml sodium thiosulphate 0.01N/g fat in CG sample with antioxidant and from 0.63 to 3.66 ml sodium thiosulphate 0.01N/g fat in sample without antioxidant. The percentage of free fatty acids or acidity (Fig. 2) ranged from 3.05 to 6.08 mg KOH/g fat in sample of the CG with antioxidant and from 5.99 to 12.53 mg KOH/g fat in sample of the CG without antioxidant. Spiridon et al. (1981) have suggested that for each 1% of increase in acidity, 10 kcal of metabolizable energy is lost per kg of diet/ingredient. The results of this study are in agreement with those of Winkler-Moser and Breyer (2010) found that corn germ oil was oxidatively stable; when stored at room temperature, the peroxide value of centrifugally extracted thin stillage oil from the raw starch ethanol process did not significantly increase until after six weeks of storage, and was less than 2.0 mequiv peroxide/kg oil after three months of storage.

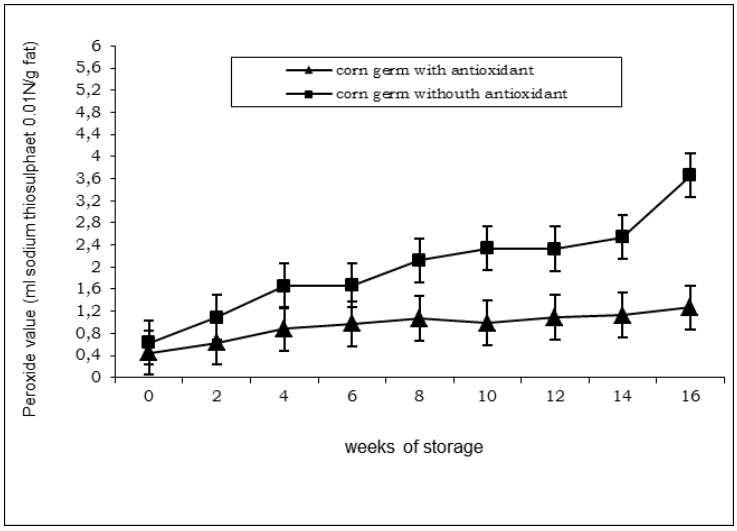

Figure 1. Peroxide value of CG during storage at 20°C

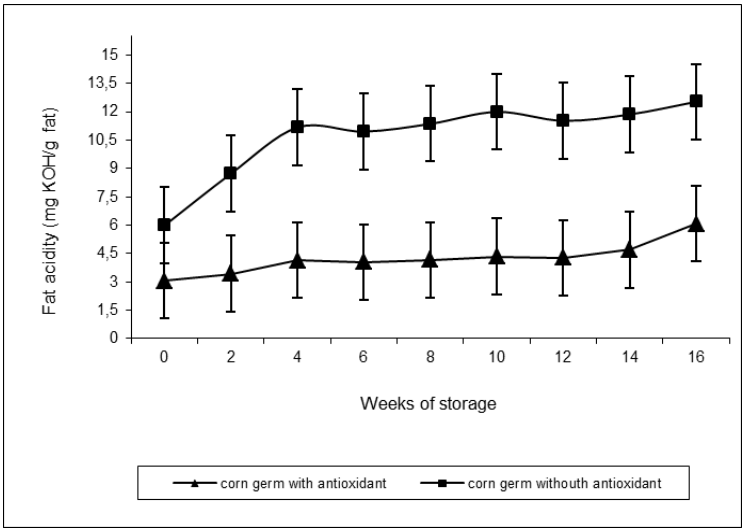

Figure 2. Fat acidity (percentage of free fatty acids) of CG during storage at 20°C

The mean value for body weight gain, total feed intake, feed conversion ratio and mortality for treatment groups are presented in Table 3.

Table 3. Effects of levels of corn germ on growth performance in broiler chickens

	Dietary treatment				
	Control	Group I	Group II	SEM	P-value
Starter, 1-10 d					
Weight gain, g	210.68	212.55	209.66	1.780	0.435
Total feed intake, g	263.65	268.25	264.30	3.795	0.137
Feed conversion ratio	1.251	1.262	1.261	0.023	0.996
Grower, 11-22 d					
Weight gain, g	754.70	762.83	750.12	10.506	0.166
Total feed intake, g	1218.40	1226.79	1214.47	9.224	0.205
Feed conversion ratio	1.614	1.608	1.619	0.255	0.882
Finisher, 23-42 d					
Weight gain, g	1480.92	1517.07	1492.54	20.810	0.238
Total feed intake, g	2921.50	2973.65	2936.20	31.805	0.441
Feed conversion ratio	1.973	1.960	1.967	0.204	0.987
Total period					
Weight gain, g	2352.72	2368.60	2349.35	22.782	0.245
Total feed intake, g	4377.32	4360.54	4316.78	34.192	0.160
Feed conversion ratio	1.861	1.841	1.837	0.207	0.998
Mortality, %	1.43	1.67	1.91	0.054	0.099

[a,b]Means within a row with the same or no letter do not differ significantly (P>0.05)

The diets had no influence on weight gain, feed intake or feed conversion ratio among treatments in the starter, grower and finisher, as well as the total experiment period (P>0.05). However, during the total experimental period, the lowest feed conversion ratio in the Group I and Group II showing no significant difference (P>0.05), compared with control group (1.841 and 1.837 *vs.* 1.861). The mortality was negligible, with no difference among all groups (Table 3). No significant (P>0.05) effect of the dietary levels of CG on mortality was observed at any time and the mortality of the broilers was in the expected range. The present study showed that the diets containing higher inclusion levels of CG (up to 210 g/kg of diet) did not affect final body weight and feed conversion ratio at the end of the experiment, compared to the control diet. Generally, these results agree with those of several researchers. Kim et al. (2008) found that broilers responded better to a corn germ diet (14% inclusion) than broiler fed with 7% corn germ or conventionally diet. On the other hand, Brito et al. (2005) recommended for broiler diets inclusion 21.9% and 22.55% corn germ meal from 8 to 21 days and from 22 to 38 days, respectively. Moreover, this result is in agreement with the results of Fuller and Rendon (1977), Sizemore and Siegel (1993), who did not find any effect of dietary fat concentration when the energy to protein ratio remained constant. These responses were also verified by Vieira et al., (2002) and Pucci et al. (2003), who observed that the inclusion of fats in feeds positively influences broiler performance and enhances feed palatability. Other authors also did not detect differences in the performance of broilers fed different oil sources (Crespo and Esteve-Garcia, 2002).

There was no significant effect of feeding broiler chickens increasing levels of CG on the carcass yield, breast, leg, abdominal fat deposition and liver weight (Table 4).

Table 4. Effects of levels of corn germ on carcass characteristics

	Dietary treatment				
	Control	Group I	Group II	SEM	P-value
Carcass yield, %	72.76	73.23	73.35	2.165	0.205
Breasts, g	332	334	336	12.902	0.139
Breasts, %	21.45^{b}	22.58^{a}	22.70^{a}	0.084	< 0.0001
Legs, g	398	402	407	13.781	0.441
Legs, %	26.07^{b}	27.86^{a}	28.14^{a}	0.095	< 0.0001
Abdominal fat, %	2.06	2.12	2.18	0.063	0.178
Liver, %	2.14	2.26	2.37	0.052	0.206

^{a,b}Means within a row with the same or no letter do not differ significantly (P>0.05)

However, the percentage of the breast yield was higher in the Group I and Group II compared to control group (22.58 and 22.70 *vs.* 21.45%, P<0.0001). In

the Group I and Group II leg percentage yield tend to be higher than in control group (28.14 and 27.86 *vs.* 26.07%, *P*<0.0001). The higher dietary fat content associate with increasing levels of dietary CG no affect abdominal fat deposition and liver weight (*P*>0.05). These results confirms the effect observed by Vilá and Esteve-Garcia (1996) who reported lower percentages of abdominal fat in chickens fed diets supplemented with different vegetable oils. Contrary, Wiseman (1984) found that if diets containing PUFA result in more fat absorption. It could be presumed that unsaturated fats may lead to higher energy absorption than diets containing saturated fatty acids (SFA). This presumption implies that if energy retention increased when SFA were given, energy expenditure should increase when PUFA are fed, independently of the changes in lipid synthesis. It is possible that feeding PUFA results in higher oxidation of dietary fatty acids. More oxidation of dietary PUFA could lead to more synthesis of endogenous fatty acids from carbohydrates, with a higher energy cost than if they were directly deposited from the diet (Emmans, 1994).

Table 5. Effects of levels of corn germ on fatty acids profile of thigh muscle in broiler chickens

Fatty acid profile (% of total FAME)[1]	Dietary treatment				
	Control	Group I	Group II	SEM	P-value
C16:0	19.70	19.58	19.33	0.286	0.524
C16:1n-7	6.92[a]	5.21[b]	5.43[ab]	0.117	0.038
C18:0	7.37[a]	6.69[b]	6.26[b]	0.111	< 0.0001
C18:1n-9	34.54	33.72	33.86	0.464	0.208
C18:2n-6	20.48[b]	24.35[a]	24.52[a]	0.266	< 0.0001
C18:3n-3	2.26	1.64	1.72	0.084	0.077
C20:4n-6	0.63	0.70	0.68	0.052	0.232
C22:6n-3	0.04	0.06	0.09	0.006	0.126
SFA	27.37[a]	26.27[b]	25.59[b]	0.443	0.0001
MUFA	41.46[a]	38.93[b]	39.29[b]	0.676	0.003
PUFA	23.41[b]	26.75[a]	27.01[a]	0.833	< 0.0001

[a,b]Means within a row with the same or no letter do not differ significantly (*P*>0.05); [1]FAME-fatty acids methyl esters; SFA - saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids.

The composition of experimental diets affected the fatty acid profile of thigh muscle lipid (Table 5). Thighs muscle from broiler fed CG diets showed significantly higher proportion of linoleic acid (C18:2n-6; P<0.0001) and lower concentration of palmitoleic acid (C16:1n-7; P<0.05) and stearic acid (C18:0; P<0.0001) than control diet. Feeding CG diets also had a tendency to increase linolenic acid (C18:3n-3; P<0.10) when compared with the control. In addition, the most significant variation among treatments was observed with PUFA.

Feeding CG diets increased high significantly (P<0.0001) the concentration of PUFA in thigh muscle when compared with the control, and the 210 g/kg CG diet had more PUFA than 110 g/ kg CG diet. Our results are in agreement with data obtained by other authors who suggest that the composition of the fatty acids added to diets affects body fat composition in broilers (Heath et al., 1980; Fisher, 1984; Scaife et al., 1994; Leeson et al., 1996; Wiseman and Lewis, 1998; Waldroup and Waldroup, 2005) and therefore body fat growth pattern can be modified by dietary fat (Crespo and Esteve-Garcia, 2002). Also, Wiseman (1984) showed that the young broilers are capable of digesting and absorbing fats rich in PUFA, whereas fats with high saturated fatty acids content are poorly utilized. Therefore, current research reveals that increasing CG level will affect fatty acid composition due to increased concentrations of PUFA in the feed.

CONCLUSIONS

The results of this experiment suggest that CG can replace corn without any adverse effects on growth performance. Also, there was no significant effect of feeding broiler increasing levels of CG (up to 210 g/kg of diet) on the carcass yield, breast, leg, abdominal fat deposition and liver weight. However, feeding greater than 110 g/ kg of CG in broiler diets results in increased linoleic acid and PUFA in broiler thigh muscle. Also, had a tendency to increase linolenic acid. Simultaneously, our results found that CG was oxidatively stable; when stored at room temperature (20°C), the peroxide value did not significantly increase until after six weeks of storage, and was less than 2.12 ml sodium thiosulphate 0.01N/g fat in sample of the without antioxidant, after four months of storage. In addition, CG would reduce the use of supplemental fats, thus reducing feed costs.

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