Influence of dietary protein levels and protein-oleaginous sources on carcass parameters and fatty acid composition of broiler meat

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SUMMARY

The study was conducted to evaluate the influence of different dietary protein levels and two protein-oleaginous sources on carcass parameters and fatty acid composition of meat in broilers at 42 d. A total of 1200 broilers (Cobb 500) were randomly assigned in 6 groups with 4 replications per treatment. Broilers were fed 6 different isocaloric diets in a 3 x 2 factorial design with 3 levels of protein [medium protein (MP), high (HP) and low (LP)] and 2 protein-oleaginous sources [camelina cake (CC) and canola meal (CM)]. The proportion of CC and CM in broiler diets was 80 g/kg. Gas chromatography method was used to determine the fatty acid composition. Carcass yield and the percentage of broilers liver were not affected significantly (P>0.05) by the dietary treatments. Breast, leg and abdominal fat yield were influenced by the dietary protein level, irrespective of protein-oleaginous sources used. In LP diets breast and leg yield decreased (4.3%, P=0.04; respectively 4.4%, P=0.01) vs. MP diets; in contrast, abdominal fat yield was lower in HP and MP diets (0.8 fold) vs. LP diets (P<0.004). There was no significant effect (P>0.05) of dietary protein level or protein-oleaginous sources on the chemical composition of broiler meat. However, the quality of broiler meat, in terms of fatty acids profile was influenced positively by the use of CC as protein-oleaginous source. In broilers fed diets containing CC the n-3 polyunsaturated fatty acids (PUFA), especially α-linolenic was significantly increase in meat (6.36 fold in breast and 7.84 fold in leg meat; P<0.0001), compared to broilers fed with CM diets. Moreover, the use of CC decreased significantly n-6:n-3 PUFA ratio of meat (4.18:1 in breast, respectively 4.97:1 in leg meat; P<0.0001) compared to CM diets, at values recommended for human health. In conclusion, the results

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indicated that LP diets can assure similar quality performance that HP or MP diets and CC improve the n-3 PUFA content of broilers meat.

Keywords: broiler, carcass, fatty acids, protein level, protein-oleaginous source

INTRODUCTION

It is now well documented that the crude protein (CP) level and amino acid (AA) status of diets influences the performance and carcass characteristics of broiler chickens, but conflicting results from these studies do not allow a clear conclusion on the effects of these diets in broiler production. The preponderance of scientifical information suggests that the performance is reduced, and carcass composition is inferior when the dietary CP level is reduced by more than 3%, even when all known nutrient requirements are met (Bregendahl et al., 2002; Sterling et al., 2005; Waldroup et al., 2005; Kamran et al., 2008; Namroud et al., 2008). However, lowering the CP content of broiler diets may reduce feed cost and allow for use of alternate feedstuffs. In recent years, the expansion of the biofuels industry resulted in a significant increase of by-products: meals or cakes (e.g., rapeseed, canola, flax), vegetable sources rich in protein and energy witch can be utilised in poultry diets as low cost feed alternatives. In addition, polyunsaturated fatty acids (PUFA), particularly those of the n-3 family, have received considerable attention in both human and animal nutrition due to healthier benefits.

Poultry meat has been considered as one of the main source of PUFA for human diets, in particular n-3 PUFA, therefore, an appropriate dietary manipulation of broiler diets could modify fatty acid profile in meat and increase its nutritional value (De Smet, 2012; Ribeiro et al., 2013).

The aim of study was to evaluate the influence of different dietary protein levels and protein-oleaginous sources [camelina cakes (CC) and canola meal (CM)] on carcass parameters and fatty acid composition of meat in broilers.

MATERIAL AND METHODS

Birds were treated in accordance with Romanian law no. 305/2006 regarding handling and protection of animals used for experimental purposes. All experimental procedures were approved by the Ethical Committee of the National Research-Development Institute for Animal Biology and Nutrition, Balotesti, Romania.

Broilers, diets and sampling. A total of 1200 broiler chickens (Cobb 500) were randomly divided in 6 dietary treatment groups in a 3 x 2 factorial design with 3 levels of protein [medium protein (MP, 180 g/kg CP), high (HP, 200 g/kg

CP) and low (LP, 160 g/kg CP)] and 2 protein-oleaginous sources (CC and CM). Each group had 4 replicates per treatment and were kept in pens with wood shavings. The birds were subjected to a 1 phase feeding regimen consisting of finisher (23 to 42 d: 13.39 MJ/kg) phase. Analysed composition of protein-oleaginous source is presented in Table 1.

Table 1. Analysed composition of protein-oleaginous source

Item	Camelina Cakes	Canola Meal
Crude protein (%)	30.39	35.32
Crude fat (%)	22.49	0.85
Fatty acid (% of total FAME)[1]		
C14:0 (myristic)	0.15	0.38
C16:0 (palmitic)	7.43	12.04
C16:1 (palmitoleic)	0.24	2.42
C18:0 (stearic)	2.01	1.66
C18:1cis-9 (oleic)	17.69	44.80
C18:2n-6 (linoleic)	21.09	31.60
C18:3n-3 (α-linolenic)	29.47	5.40
C18:4n-3 (octadecatetraenoic)	0.48	0.00
C20:0 (arachidic)	0.92	0.35
C20:1n-9 (eicosenoic)	11.42	0.41
C20:2n-6 (eicosadienoic)	1.33	0.00
C20:4n-6 (arahidonic)	0.86	0.00
C20:5n-3 (eicosapentaenoic)	0.15	0.00
C22:1n-9 (erucic)	2.99	0.00
C22:4n-6 (docosatetraenoic)	0.25	0.00
C22:6n-3 (docosahexaenoic)	0.31	0.00
Total SFA	10.51	14.43
Total MUFA	32.34	47.63
Total PUFA	53.79	37.00
PUFA:SFA ratio	5.11	2.56
Total n-6 PUFA	22.67	31.60
Total n-3 PUFA	30.26	5.40
n-6:n-3 ratio	0.74	5.85

[1]FAME-fatty acids methyl esters; Total SFA = C14:0 + C16:0 + C18:0 + C20:0; Total MUFA = C16:1 + C18:1cis-9 + C20:1n-9 + C22: 1n-9; Total PUFA = C18:2n-6 +C18:3n-3 + C18:4n-3 + C20:2n-6 + C20:4n-6 + C20:5n-3 + C22:4n-6+ C22:6n-3.

The isocaloric diets based on corn, wheat, soybean meal, corn gluten, synthetic amino acid (DL-methionine and L-lysine), were formulated to have similar content of sulphur amino acids, lysine, calcium and phosphorus (Cobb-Vantress, 2008; Table 2). The proportion of CC and CM in diets was 80 g/kg.

Table 2. Nutrient composition and fatty acid profile of finisher experimental diets

Protein level*	MP	HP	LP	MP	HP	LP
Protein-oleaginous source (POS)**	Camelina cakes (CC)			Canola meal (CM)		
ME (Kcal/kg) [1]	3200	3200	3200	3200	3200	3200
Analysed composition[2] (%)						
CP	18.10	20.07	16.20	18.16	19.99	16.08
Lysine, total	1.054	1.057	1.056	1.055	1.053	1.054
Met + cys, total	0.816	0.818	0.819	0.818	0.819	0.820
Calcium	0.89	0.88	0.89	0.88	0.89	0.89
Phosphorus, total	0.83	0.84	0.84	0.82	0.83	0.83
Crude fiber	3.80	3.78	3.89	3.78	3.85	3.80
Ether extract	6.78	7.02	6.03	6.28	7.40	7.52
***Fatty acid** (% of total FAME)[3]*						
C14:0 (myristic)	0.10	0.10	0.10	0.09	0.10	0.10
C16:0 (palmitic)	8.77	8.51	8.96	8.76	9.06	9.29
C16:1 (palmitoleic)	0.24	0.24	0.23	0.21	0.23	0.24
C18:0 (stearic)	2.38	2.41	2.52	2.87	2.88	2.84
C18:1cis-9 (oleic)	19.92	19.25	20.06	24.80	24.67	24.98
C18:2n-6 (linoleic)	45.37	46.05	44.62	61.31	60.96	60.65
C18:3n-3 (α-linolenic)	6.44	6.10	6.41	2.24	1.94	1.46
Total SFA	11.25	11.02	11.58	11.72	12.04	12.23
Total MUFA	20.16	19.49	20.29	25.01	24.90	25.22
C18:2n-6/C18:3n-3 ratio (LA:ALA)[4]	7.04	7.54	6.96	27.37	28.48	27.84

*MP-medium protein; HP-high protein; LP-low protein; **POS - Protein-oleaginous source;
[1]Calculated using regression equations (NRC, 1994); [2]based on analysed chemical composition;
[3]FAME-fatty acids methyl esters; [4]LA-linoleic acid, ALA- α-linolenic acid.

The trial was conducted in an environmentally controlled house. Chickens vaccination was carried out according to the usual schedule. Lighting schedule was 23h light:1h darkness. Feed, in mash form, and water were provided *ad libitum*. During 12 h prior slaughter feed was withdrawn.

At 42 days of age, 10 broilers from each replicate (5 male and 5 female) were randomly selected for carcass evaluation. The broilers were weighed individually, killed by cervical dislocation, bleed, and feathers were removed. The weight of the eviscerated carcass was calculated without feet and shanks removed from the hock joint. Percentage carcass yield, breast and legs (with skin and bone), abdominal fat and liver were calculated based on live body weight. Samples of breast and leg meat (n=4 for each dietary treatments) were removed and stored at −20°C until analysed.

Chemical analyses. The feed ingredients and experimental diets were analysed for dry matter (SR ISO 6496:2001), crude protein (SR EN ISO 5983-2:2009) using Kjeltec Auto 1030, Tecator, ether extract (SR ISO 6492:2001), crude fibre (SR EN ISO 6865:2002), crude ash (SR EN ISO 2171:2010). These standardized methods are according to Commission Regulation (EC) no.

152/2009 (Official Journal of the European Union, 2009). Metabolisable energy (ME) content of the diets was calculated on the basis of the energy content of individual feed ingredients using regression equations (NRC, 1994). Amino acids concentrations were determined using HPLC Thermo Electron system (Thermo Electron Ltd., Cambridge, UK). Calcium content was determined by an atomic absorption spectrometer (Thermo Electron-Solaar M6 Dual Zeeman, Cambridge, UK) and the phosphorus content was determined by spectrophotometry using an UV-Vis spectrophotometer Jasco V-530 (Tokyo, Japan). Samples of breast and leg meat (without skin) were analysed for dry matter (SR ISO 1442:2010), crude protein (SR ISO 937:2007), fat (SR ISO 1444:2008) and ash (SR ISO 936:2009) contents according to Romanian standardized methods (ASRO, 2014).

The muscle tissue, ingredients and diets fatty acid composition was determined by gas chromatography method (SR CEN ISO/TS 17764-2:2008). 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., USA) equipped with an auto sampler, flame ionization detector (FID), and fused silica capillary column (cis/trans FAME), 60 m x 0.25 mm x 0.25 µm film thickness (PerkinElmer, Inc., USA). 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).

Statistical analysis. The experiment was analysed as a completely randomized 3 × 2 factorial design, with 3 protein levels and 2 protein-oleaginous sources using the general linear model (GLM) procedure of SPSS (IBM SPSS Statistics version 20.0, 2011). One-way analysis of variance (ANOVA) with the post hoc Tukey's multiple comparison test was used to evaluate statistical significance of differences between the groups. The results were express as means with standard error of the mean (SEM). The values for fatty acid are expressed as percentage (% of total FAME). Replication was considered as the experiment unit. Differences between means was considered statistically different at $P<0.05$. The GLM test allowed determining the interaction between protein levels and diet.

RESULTS AND DISCUSSION

Carcass parameters. The effects of dietary protein level and protein-oleaginous sources on carcass parameters of broilers at 42 d of age are shown in Table 3.

Table 3. Influence of dietary protein level and protein-oleaginous source on carcass parameters of broilers[1]

Item (%)[2]	Camelina cakes			Canola meal			SEM	p-value		
	MP	HP	LP	MP	HP	LP		Protein level	POS[3]	Interaction
Carcass yield	70.82	71.09	70.71	70.96	71.26	70.75	0.153	0.555	0.730	0.984
Breast	19.15[a]	19.36[a]	18.29[b]	19.48[a]	19.58[a]	18.67[b]	0.127	0.040	0.246	0.852
Legs	17.56[a]	17.99[a]	16.78[b]	17.48[a]	17.77[a]	16.72[b]	0.107	0.010	0.180	0.330
Liver	1.80	1.74	2.05	1.87	1.78	2.01	0.032	0.408	0.631	0.655
Abdominal fat	2.32[b]	2.26[b]	2.89[a]	2.29[b]	2.11[b]	2.72[a]	0.066	0.004	0.502	0.490

[ab]Means within rows with different superscripts are significantly different (P<0.05).
[1]Means of 4 replicates (n = 10 broilers from each replicate) per treatment, at 42 d of age;
[2]based on live body weight; [3]POS - protein-oleaginous sources.

Carcass yield and the percentage of broilers liver were not affected (P>0.05) by the dietary protein level or protein-oleaginous source. Previous studies have reported similar results (Khajali and Moghaddam, 2006; Sterling et al., 2002; 2006; Swennen et al., 2006; Namroud et al., 2008). Breast, leg and abdominal fat yield were influenced by the dietary protein level, irrespective of the protein-oleaginous source used. In LP diets breast and leg yield decreased with 4.3% (P=0.04), respectively with 4.4% (P=0.01) *vs.* MP diets. In broilers fed with HP diets the breast and leg yield increase with 1%, respectively 2% *vs.* MP diets; no significant differences was observed (P>0.05). Similarly, Moran et al. (1992) observed a significant decrease in breast meat yield and increase in leg yield with the reduction in CP level even when the essential amino acid (EAA) were at recommended levels. Also, many other researchers reported that lowering the CP level of broilers diets affect breast meat yield compared with HP diets (Bartov and Plavnik, 1998; Waibel et al., 2000 a, b; Corzo et al., 2005; Widyaratne and Drew, 2011). Contrary, previous studies reported no significant differences in the breast meat yield and leg yield of the broilers when low CP level of diets are used (Rezaei et al. 2004; Sterling et al. 2002, 2006; Horniakova and Abas, 2009). Although is considered that lysine and methionine are exclusively used for protein accretion in the body and breast meat yield in particular, probably the breast and legs yield was decreased due to the poor digestibility of amino acids, other than those supplemented (Baker et al., 2002). Also, Widyaratne and Drew, (2011) suggested that the interaction between protein level and protein digestibility may partially explain the lack of consensus in the literature on the effects of low-protein diets on the performance of broiler chickens.

In contrast, abdominal fat yield was lower (0.78 fold, respectively 0.80 fold) in HP and MP diets compared to LP (CC) diets (P<0.004). Similarly results was obtained in HP and MP (CM) diets (0.77 fold, respectively 0.84 fold) compared to LP diets (P<0.004). The present results were in agreement with

others researchers (Smith et al., 1998; Hai and Blaha, 2000; Sterling et al., 2002) who observed that LP diets resulted in a higher abdominal fat deposition, although it were formulated to satisfy the needs of EAA. No interaction was observed (P>0.05) between the protein level x protein-oleaginous source regarding the carcass parameters of broilers (Table 3).

Chemical composition and fatty acid profile of meat. There was no significant effect (P>0.05) of dietary protein level and protein-oleaginous sources on the chemical composition of breast and leg meat (Table 4 and 5).

Table 4. Influence of dietary protein level and protein-oleaginous source on chemical composition and fatty acids profile of breast meat[1]

Item (%)	Camelina cakes			Canola meal			SEM	p-value		
	MP	HP	LP	MP	HP	LP		Protein level	POS[3]	Interac-tion
Dry matter	31.30	28.98	28.20	29.67	31.77	28.45	0.619	0.709	0.898	0.137
Crude protein	23.64	23.87	22.76	23.82	23.95	22.41	0.223	0.078	0.103	0.216
Fat	1.18	1.09	1.26	1.20	1.11	1.25	0.103	0.626	0.871	0.936
Ash	1.34	1.33	1.10	1.46	1.40	1.31	0.036	0.057	0.197	0.116
Fatty acid (% of total FAME)[2]										
C16:0 (palmitic)	27.06	25.22	27.78	24.59	25.60	26.46	0.475	0.328	0.243	0.481
C16:1 (palmitoleic)	6.07^{a}	5.61^{a}	6.19^{a}	3.74^{b}	4.54^{b}	4.77^{b}	0.267	0.263	<0.010	0.137
C18:0 (stearic)	6.81	7.11	6.61	7.27	7.19	7.21	0.126	0.769	0.166	0.710
C18:1cis-9 (oleic)	31.06	31.63	33.27	31.20	31.70	31.57	0.405	0.473	0.564	0.613
C18:2n-6 (LA)	18.37^{b}	19.41^{b}	15.92^{b}	26.39^{a}	23.77^{a}	22.77^{a}	0.884	0.094	<0.0001	0.403
C18:3n-3 (ALA)	4.16^{a}	4.25^{a}	3.80^{a}	0.41^{b}	0.59^{b}	1.03^{b}	0.364	0.737	<0.0001	0.043
C20:2n-6 (eicosadienoic)	1.47	1.13	1.07	0.32	0.36	0.38	0.150	0.092	<0.0001	<0.002
C20:3n-3 (eicosatrienoic)	0.26	0.28	0.33	0.29	0.33	0.35	0.013	0.225	0.258	<0.002
C20:4n-6 (arachidonic)	0.98^{b}	1.07^{b}	1.29^{b}	1.60^{a}	1.53^{a}	1.63^{a}	0.111	0.776	0.044	0.876
C20:5n-3 (EPA)	0.26	0.61	0.15	0.25	0.20	0.17	0.045	0.631	0.438	0.990
C22:6n-3 (DHA)	0.20	0.19	0.14	0.16	0.15	0.10	0.021	0.083	0.040	0.053
Total SFA	34.87	32.32	34.39	31.86	32.78	33.67	0.484	0.469	0.462	0.616
Total MUFA	37.13	37.24	39.46	34.93	36.24	36.33	0.594	0.382	0.148	0.546
Total PUFA	25.70	26.94	22.70	29.42	26.93	26.43	0.765	0.146	0.159	0.249
PUFA:SFA ratio	0.76	0.83	0.66	0.92	0.82	0.78	0.033	0.175	0.183	0.357
Total n-6 PUFA	20.82^{b}	21.61^{b}	18.28^{b}	28.31^{a}	25.66^{a}	24.78^{a}	0.897	0.147	<0.0001	0.361
Total n-3 PUFA	4.88^{A}	5.33^{A}	4.42^{A}	1.11^{B}	1.27^{B}	1.65^{B}	0.373	0.307	<0.0001	<0.018
n-6:n-3 ratio	4.27^{bB}	4.05^{bB}	4.14^{bB}	25.50^{aA}	20.20^{aA}	15.02^{aA}	1.821	<0.003	<0.0001	<0.003

^{AB}Means within rows with different superscripts are significantly different (P<0.01).

^{ab}Means within rows with different superscripts are significantly different (P<0.05).

[1]n=4 for each dietary treatments, pooled SEM.

[2]FAME- fatty acids methyl esters; Total SFA = C16:0 + C18:0; Total MUFA = C16:1 + C18:1cis-9; Total PUFA = C18:2n-6 + C18:3n-3 + C20:2n-6 + C20:3n-3 + C20:4n-6 + C20:5n-3 + C22:6n-3.

[3]POS - protein-oleaginous sources.

The protein content of breast meat in HP diets increased by 0.97% (CC), respectively with 0.55% (CM) and decreased in LP by 3.7% (CC), respectively by 5.9% (CM) *vs.* MP diets; no significant difference between treatments (P>0.05;

Table 4). In contrast, the fat content decrease in HP by 7.6% (CC), respectively 7.5% (CM) and increase in LP by 6.7% (CC), respectively by 4.17% (CM) *vs.* MP diets (P>0.05; Table 4). Also, the same trend was observed in the protein and fat content of leg meat, but was not affected significantly by dietary treatments (P>0.05; Table 5). These results demonstrated that LP diets allow for similar transformation of protein and energy intake into tissue synthesis and accretion. Similarly, Horniakova and Abas, (2009) reported that decreasing the protein level did not influence significantly the chemical composition of breast and leg meat. As shown in Table 4 and 5, there was no interaction between the protein level x protein-oleaginous source concerning the chemical composition of breast and leg meat (P>0.05).

Table 5. Influence of dietary protein level and protein-oleaginous source chemical composition and fatty acids profile of leg meat[1]

	Camelina cakes			Canola meal				p-value		
Item (%)	MP	HP	LP	MP	HP	LP	SEM	Protein level	POS[3]	Interac-tion
Dry matter	34.86	30.08	31.08	31.31	33.95	33.40	0.632	0.466	0.084	0.339
Crude protein	21.60	22.67	20.62	20.93	21.95	20.24	0.297	0.200	0.103	0.303
Fat	7.00	6.42	8.22	7.50	6.33	8.38	0.517	0.073	0.403	0.970
Ash	1.29	1.10	1.14	1.17	1.11	1.05	0.030	0.323	0.246	0.326
Fatty acid (% of total FAME)[2]										
C16:0 (palmitic)	28.00	24.55	25.69	24.13	25.25	25.23	0.417	0.450	0.120	0.060
C16:1 (palmitoleic)	6.28^{a}	6.17^{a}	7.16^{a}	4.60^{b}	5.15^{b}	5.51^{b}	0.273	0.200	0.020	0.520
C18:0 (stearic)	6.72^{b}	6.54^{b}	6.14^{b}	7.10^{a}	7.11^{a}	6.84^{a}	0.115	0.160	0.030	0.700
C18:1cis-9 (oleic)	33.03	34.09	36.89	35.38	34.68	35.00	0.378	0.080	0.590	0.150
C18:2n-6 (LA)	17.53^{b}	19.65^{b}	15.62^{b}	21.84^{a}	21.80^{a}	20.82^{a}	0.723	0.270	0.005	0.590
C18:3n-3 (ALA)	3.48^{A}	3.28^{A}	3.35^{A}	0.20^{B}	0.44^{B}	0.65^{B}	0.311	0.440	<0.0001	0.020
C20:2n-6 (eicosadienoic)	1.68^{A}	2.08^{A}	1.33^{A}	0.27^{B}	0.28^{B}	0.42^{B}	0.159	0.190	<0.0001	0.012
C20:3n-3 (eicosatrienoic)	0.09	0.10	0.21	0.15	0.13	0.12	0.027	0.680	0.910	0.570
C20:4n-6 (arachidonic)	0.57	0.58	0.66	0.56	0.67	0.66	0.057	0.390	0.800	0.940
C20:5n-3 (EPA)	0.27	0.34	0.40	0.09	0.18	0.28	0.036	0.390	0.120	0.970
C22:6n-3 (DHA)	0.27^{a}	0.23^{a}	0.29^{a}	0.19^{b}	0.13^{b}	0.20^{b}	0.046	0.680	0.030	0.380
Total SFA	34.72	31.09	31.83	31.23	32.36	32.07	0.395	0.262	0.310	0.121
Total MUFA	39.31	40.26	44.05	39.98	39.83	40.52	0.561	0.078	0.405	0.200
Total PUFA	23.89	26.26	21.86	23.30	23.63	23.15	0.738	0.437	0.746	0.555
PUFA:SFA ratio	0.69	0.84	0.70	0.75	0.73	0.72	0.030	0.493	0.973	0.475
Total n-6 PUFA	19.78^{b}	22.31^{b}	17.61^{b}	22.67^{a}	22.75^{a}	21.90^{a}	0.742	0.278	0.046	0.494
Total n-3 PUFA	4.11^{A}	3.95^{A}	4.25^{A}	0.63^{B}	0.88^{B}	1.25^{B}	0.324	0.542	<0.0001	0.557
n-6:n-3 ratio	4.81^{bB}	5.65^{bB}	4.14^{bB}	35.98^{aA}	25.85^{aA}	17.52^{aA}	2.637	0.039	<0.0001	0.033

^{AB}Means within rows with different superscripts are significantly different (P<0.01).

^{ab}Means within rows with different superscripts are significantly different (P<0.05).

[1]n=4 for each dietary treatments, pooled SEM.

[2]FAME- fatty acids methyl esters; Total SFA = C16:0 + C18:0; Total MUFA = C16:1 + C18:1cis-9; Total PUFA = C18:2n-6 + C18:3n-3 + C20:2n-6 + C20:3n-3 + C20:4n-6 + C20:5n-3 + C22:6n-3.

[3]POS - protein-oleaginous sources.

In the present study, there was no significant effect (P>0.05) of dietary protein level on the fatty acid profile of broiler breast and leg meat (Table 4 and 5). The protein-oleaginous sources, especially CC, had a pronounced influence in the fatty acid profile of both type of muscle.

Fatty acids composition of breast meat. The main effect of diet on breast meat showed that the palmitoleic acid was highest (5.62% in CC diets *vs*. 4.35% in CM) (P=0.010; Table 4). The use of CC in the diets decreased significantly (P<0.0001) the LA content in breast meat *vs.* CM diets (17.9% *vs.* 24.31%) and increased significantly the ALA content (P<0.0001) (4.07% *vs.* 0.64%). Eicosadienoic acid was highest (1.22% in CC diets *vs.* 0.35% in CM; P<0.0001). The increase of n-3 PUFA concentration in breast meat (4.87% *vs.* 1.48%; P<0.0001) was associated with a significant decrease of the arachidonic acid concentration in breast meat (1.11% *vs*. 1.59%; P=0.044). Arachidonic acid and EPA are metabolites of LA and ALA (Cooke 1991) and normally arachidonic acid decrease when n-3 PUFA increases (Komprda et al. 2005). These results are consistent with the theory that LA and ALA compete for the same series of enzymes through desaturation and elongation; the n-3 fatty acid are used as the preferred substrate in the desaturation-elongation pathway, decreasing the n-6: n-3 ratio (Cooke 1991). The DHA content was affected by inclusion of CC in diets (0.18% *vs.* 0.13%; P=0.040). The dietary inclusion of CC significantly decreased the n−6:n−3 ratio of breast meat (P<0.0001) from 20.35% to 4.18%.

The interaction between protein level x protein-oleaginous sources was significant for ALA (P=0.043), eicosadienoic and eicosatrienoic acids (P=0.002), total n-3 PUFA (P=0.018) and n-6: n-3 ratio (P=0.003).

Fatty acids composition of leg meat. The fatty acid profile of broiler leg meat (Table 5) indicated also, that the dietary inclusion of CC significantly increased palmitoleic acid (6.30 *vs.* 5.09%; P=0.020), ALA (3.37 *vs.* 0.43%; P<0.0001), eicosadienoic (1.70 *vs.* 0.32%; P<0.0001), DHA (0.26 *vs.* 0.17%; P=0.030). However, in broiler leg meat the LA significantly decreased (17.6% *vs.* 21.5%; P<0.005), affected by inclusion of CC in diets. The significant increase of total n-3 PUFA (4.02 vs. 0.94%; P=0.046) in CC diets, determinate a significant decrease of the n-6:n-3 PUFA ratio from 26.10% to 4.97% (P<0.0001).

As shown in Table 5, there were significant interaction between protein level x protein-oleaginous sources on leg meat for ALA (P=0.020), eicosadienoic acid (P=0.012) and n-6:n-3 ratio (P=0.033).

Our results are in agreement with other studies (Betti et al. 2009; Aziza et al. 2010; Cherian, 2012) who reported that feeding broilers with camelina meal up to 10 % enhanced the n-3 fatty acid content of meat.

The results of present study suggest that inclusion of 80 g/kg camelina cakes in broilers diets improve the nutritional value of broiler meat increasing

the n-3 PUFA, with a concomitant reduction in the n-6:n-3 ratio at values recommended (<5:1) for human health.

Feed efficiency. On the other hand, it is well known that feed represents 60-70% of the cost for poultry production. Finding alternative feed sources of energy and protein, and lowering the protein level could reduce these costs, without affecting productivity and product quality. Also, in our study, was observed that the 10% reduction of the protein level of the amino acid supplemented diets, allows decreasing the cost of feeding per kg gain (~3%), irrespective of the protein-oleaginous source used (Figure 1).

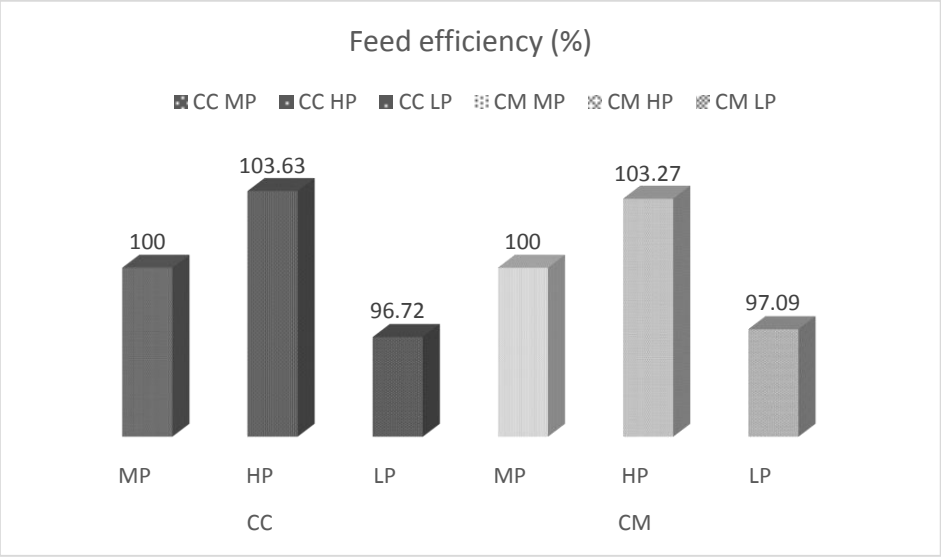

Figure 1. Feed efficiency

CONCLUSIONS

The experimental results showed that the dietary protein levels influenced significantly quantitative carcass parameters (breast and leg yield, abdominal fat) of broilers, irrespective of protein-oleaginous sources used.

Low protein diets can assure similar quality performance (chemical composition) that high or medium protein diets. Also, the 10% reduction of the protein level of the EAA supplemented diets, allows decreasing the cost of feeding per kg gain.

Camelina cakes, as source of n-3 PUFA, improve the fatty acids profile of meat by significantly decrease of n-6:n-3 ratio at values recommended (<5:1) for a good health state, improve the concentration of n-3 fatty acids especially

alpha-linolenic FA, and could be a valuable alternative to other vegetable oilseeds source in broiler diets.

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