The contribution of conventional and organic production systems to turkey breast meat nutritional quality

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Abstract— **Consumers increasing attention on animal production systems have contributed to an increased interest on free range and organic production systems. Nowadays, conventional and organic poultry meats are available to consumer in regular supermarkets all over the Europe, but little is known about their nutritional quality. Therefore, it was our objective to compare turkey breast meat quality of conventional and organic free range production systems. A total of 29 samples of turkey breast meat (pectoralis major muscle) were collected (13 samples from organic turkey (OT) and 16 from conventional turkey (CT)). Meat samples in analysis represent the commercial standard quality of both production systems. Meat quality was assessed by the quantification of total fatty acids, total cholesterol, fatty acid profile and vitamin E contents.**

The results of the study show that both production systems were able to produce lean breast meat, but the CT was even leaner than OT (0,60/0,96 g/100g of meat) The lipid fraction of turkey breast meat from both production systems share more similarities than differences, displaying similar proportions of SFA, MUFA, PUFA and TFA. Major differences between the 2 production systems were found in cholesterol contents (significantly higher in OT 27,3/24,4 mg/100g of meat), n-3PUFA (significantly higher in OT 3,34/2,67 g/100g of FAME).

As conclusion, organic turkey breast meat was characterized by increased contents of total fat, total cholesterol and n-3 long chain PUFA (EPA and DHA). The higher total lipid contents in organic breast meat may contribute to increased sensorial attributes. The higher cholesterol content can be considered an inconvenient characteristic while the higher contents in EPA and DHA are healthy characteristics to human health, concerning their biological properties and scarceness in human diet.

Keywords— ***pectoralis major*, organic production, intensive production, fatty acid profile, cholesterol**

I. INTRODUCTION

The human diet in the second half of the 20th century was characterized by an increased proportion of meat, which was associated with an increased proportion and amount of animal fat (cholesterol and saturated fat) in human diet. The increased amounts of cholesterol and cholesterol-promoting fats (saturated fat and trans fat) in human diet have been correlated with an increased occurrence of cardiovascular diseases [1, 2], colon cancer [3, 4] and type 2 diabetes [5-7].

It is fairly well established that there is a close relationship between diet and health, such correlation has promoted an increased interest over food composition and the correlation between food chemistry and health or disease [8].

Nowadays, poultry meat represents almost one-third of meat produced and consumed worldwide. Globally, production of poultry meat has been rising rapidly, the overall poultry production has increased 52% between 1995 and 2005, during the same period turkey meat consumption has followed the rising poultry tendency, with an increase of 13%. Such trend is the result of consumer preference for these high-quality and relatively low price meat [9].

Despite preference for poultry meat, consumer's conscientiousness is nowadays aware to animal production systems, their environmental impact; implications in animal welfare and concern with the relationship between food quality and human health. Such awareness has guided consumers to demand for organic produced meat, including organic produced poultry, which is considered beneficial to animals, environment and consumers [10]. Nowadays, conventional and organic poultry meats are available to consumer in regular supermarkets all over Europe, but little is known about their nutritional quality. As far we know, there is no available reference focusing on lipid characterization of turkey pectoralis major muscle from free range organic production systems. Therefore, considering consumer trends and expectancies, it was our objective to compare turkey breast meat quality of conventional and organic free range production systems.

II. MATERIAL AND METHODS

3.1 Animals, sampling and diets

Portuguese prime turkey producers from both organic and conventional production systems agreed to submit turkey breast to comparison. Meats in comparison represent the standard turkey meats from both production systems differing in the strain and age at slaughter.

Turkeys from the conventional production system belonged to the BUT 9 strain; females were slaughtered at the age of 14 weeks old while males were slaughtered at the age of 18 weeks old. Organic turkeys belonged to Betina strain and both sexes were slaughtered at the age of 24 weeks.

Turkey breast filets (*Pectoralis major* muscle) were obtained from the slaughterhouse on the day of slaughter, from turkeys approved for consumption. Breast muscle fillets were collected boneless, stored under refrigeration and transported to the laboratory for final processing. All breast filets were trimmed of skin, connective and adipose tissues before blending in a food processor. Blended meat was then vacuum packed and stored frozen at -70 ºC until analysis. In both production systems, turkey breast fillets were collected randomly among each batch providing 16 breast fillets in conventional production system (8 breast fillets of each sex) and 13 breast fillets in the organic production system (7 from male and 6 from female turkeys). Therefore, Organic turkeys were kept in free range with access to green forage, and were housed by night with access to organic cereal-based diet. The cereal based diet used during the finishing period was analyzed to assess its chemical composition. Therefore, table 1 encloses the nutritional composition for both conventional (C) and organic (O) finishing diets.

Table 1 – Fatty acid profile total lipid and vitamin E contents in turkey finisher diet

Fatty acid profile[1]	CP	OP
C14:0	2.45	1.34
C16:0	13.35	11.4
C18:0	2.34	3.05
C18:1 cis-9	26.85	24.27
C18:2 n-6	51.93	54.07
C18:3 n-3	3.09	5.87
Vitamin E homologues[2]		
α-tocopherol	78.35	58.8
γ-tocopherol	3.10	2.9
Total lipids[3]	11,2	5.5

[1](% wt/wt); [2](mg/ kg of diet); [3](mg/g of diet)

Analytical procedures: Total meat lipids were extracted from the lyophilized meat samples (0.25 g) and measured gravimetrically. Lipid extracts were dissolved in 1 ml of dry toluene, then fatty acids methyl esters were prepared by base-catalyzed transesterification with sodium methoxide for 2 hours at 30ºC. Fatty acid methyl esters were analysed using a GC chromatograph equipped with a flame-ionization detector (GC-FID) and a fused-silica capillary column (CP-Sil 88; 100 m × 0.25 mm i.d. × 0.20 mm film thickness; Chrompack, Varian Inc.). The column temperature of 100 ºC was held for 15 min, increased to 150 ºC at a rate of 10 ºC/min and held for 5 min, then increased to 158 ºC at 1 ºC/min and held for 30 min, and finally increased to 200 ºC at a rate of 1 ºC/min and maintained for 65 min. Helium was used as carrier gas. The injector and detector temperatures were held at 250 and 280 ºC, respectively. Identification was accomplished by comparison of sample peak retention times with those of FAME standard mixtures (Sigma, St. Louis, MO, USA).

The simultaneous determination of total cholesterol, and tocopherols was performed as previously described [11]. The contents of total cholesterol and tocopherols were estimated in duplicate for each sample based on the external standard technique from the standard curve of peak area versus compound concentration.

Statistical analysis: Statistical differences between means were determined by one-way ANOVA and the level of significance was set at $P < 0.05$.

III. RESULTS

The breast meat from conventional production was leaner (P<0.001) and had a lower (P<0.001) content of total cholesterol than meat from organic production (Table 2).

Table 2 – Total lipids, total cholesterol and vitamin E (homologues contents in turkey breast meat from organic (OP) and conventional production (CP) systems (data presented as mean±SEM)

Turkey	OP	CP	P
Total lipids[1]	0.96±0.08	0.60±0.06	***
Total cholesterol[2]	27.3±0.32	24.4±0.28	***
α-Tocopherol[3]	1.97±0.29	2.10±0.27	n.s.
γ-Tocopherol[3]	1.15±0.22	0.13±0.10	***

OP – Organic production; CP – Conventional production
[1] g/100g of meat; [2] mg/100g of meat; [3] µg/g of meat
n.s. no significant; ** P<0.01; *** P<0.001

Thirty five fatty acids (FA) were quantified in turkey breast meat of both origins, 16 were saturated fatty acids (SFA), 5 were monounsaturated fatty acids (MUFA), 14 were polyunsaturated fatty acids (PUFA), but only major fatty acids (higher than 0.5% of total FA) and the nutritionally relevant fatty acids (as EPA) are presented in Table 3.

Table 3 – Fatty acid composition in turkey breast meat from organic and conventional production systems

Fatty acids (FA)	OP	CP	P
Saturated FA			
C14:0	0.70±0.04	0.73±0.04	n.s.
C16:0	19.69±0.63	20.82±0.57	n.s.
C18:0	10.98±0.37	10.24±0.33	n.s.
Monounsaturated FA			
C16:1cis-9	2.25±0.39	3.58±0.35	*
C18:1cis-9	21.45±1.02	19.88±0.92	n.s.
Polyunsaturated FA			
C18:2 n-6	24.78±1.25	25.95±1.12	n.s.
C18:3 n-3	1.61±0.14	1.40±0.13	n.s.
C20:3 n-6	0.19±0.03	0.50±0.03	***
C20:4 n-6	5.86±0.59	5.99±0.54	n.s.
C20:5n-3	0.11±0.01	0.15±0.01	*
C22:4 n-6	0.63±0.08	1.21±0.07	***
C22:5 n-3	0.73±0.08	0.66±0.07	n.s.
C22:6 n-3	0.82±0.09	0.39±0.08	***

OP – Organic production; CP – Conventional production
Fatty acids presented as % wt/wt; (mean±SEM)
n.s. no significant; ** P<0.01; *** P<0.001

Major saturated fatty acids (C14:0, C16:0, C18:0) on turkey breast meat shown no significant differences between groups. Otherwise, significant differences in some MUFA and PUFA were observed.

The palmitoleic acid (C16:1cis-9) content was higher ((P<0.05) in conventional produced turkeys than in organic produced turkeys. Linoleic acid (C18:2 n-6), linolenic acid (C18:3 n-3), araquidonic acid (C20:4 n-6) and the docosapentaenoic acid (C22:5 n-3 did not differed between groups, while eicosatrienoic (C20:3n-6), eicosapentaenoic acid (C20:5n-3; EPA), docosatetraenoic acid (C22:4n-6) and docosahexaenoic (C22:6n-3; DHA) differed (P<0.001) between the two groups.

Table 4 – Turkey breast meat partial sums of fatty acids (%wt/wt) and nutritional ratios from organic and conventional production systems

	OP	CP	P
∑ SFA	32.51±0.71	32.51±0.64	n.s.
∑ MUFA	23.98±1.38	23.74±1.24	n.s.
∑ PUFA	35.11±1.53	36.83±1.38	n.s.
∑ n-6	31.76±1.40	34.16±1.26	n.s.
∑ n-3	3.34±0.16	2.67±0.15	**
PUFA/SFA	1.11±0.06	1.13±0.05	n.s.
n-6/n-3	9.63±0.32	12.85±0.29	***

n.s. no significant; ** P<0.01; *** P<0.001

As shown in Table 4, turkey breast meat lipids, from both organic and conventional production systems had higher polyunsaturated fatty acids content (35.1-36.8% of total fatty acids) followed by saturated fatty acids (32.5% of total fatty acids) and monounsaturated fatty acids (23.7-24.0% of total fatty acids). Organic and conventional turkey breast revealed no difference (P>0.05) on the total sums of SFA, MUFA, PUFA and n-6PUFA and in the PUFA/SFA ratio. Significant differences between organic and conventional turkey breast meat were limited to the n-3PUFA, which has conditioned significant differences in the n-6/n-3 ratio.

IV. DISCUSSION

The higher total lipid contents found in organic turkey meat in comparison with conventional turkey meat could be consequence of several factors as strain (different genetics), feeding management and age. The organic turkeys were slaughtered considerably older than their conventional counterparts (6 to 10 weeks older for males and females respectively) and age at slaughter is considered an important factor concerning total lipid contents, since it increases with turkeys age [12].

Organic turkey breast meat cholesterol content was significantly above the cholesterol content registered by conventional turkey breast meat ($P<0.001$). Possible factors responsible for this higher cholesterol content as: physical exercise, diet, genetics and age at slaughter.

Turkey breast meat from conventional and organic production systems shows no difference in α-tocopherol content, vitamin E major homologue in poultry meat. Significant difference was observed in γ-tocopherol content, with organic breast meat displaying almost 10 times the content of conventional turkey meat, such difference does not seem to be associated with differences in turkey finisher diet (Table 1), being probably the result of green pasture intake, which is rich in vitamin E and γ-tocopherol in particular.

The top five major fatty acids in turkey breast meat from both production systems (palmitic, stearic, oleic, palmitoleic and acids) are responsible for 82.8-82.9% of total fatty acids and were coincident with major fatty acids in turkey meat reported by Baggio et al. [13].

Differences found in the fatty acid profile between organic and conventional turkey breast meat could be dependent of several factores, as 1) diet fatty acid profile of finisher diet (as observable in Table 1); 2) organic production provides access to other feeding options as grass and terrestrial worms; 3) breast meat total lipid content, which will influence the proportion of polar and neutral lipid fractions, which can contribute to differences in the fatty acid profile. Organic turkey breast meat higher contents in n-3 long chain fatty acids (EPA and DHA), which are considered beneficial to human diet due to their beneficial biological properties and scarceness in human diet.

Concerning turkey breast meat nutritional ratios, the PUFA:SFA ratio (1.11-1.13) is in agreement with nutritional recommendations for this ratio, which states that it should be above 0.4, while the n-6/n-3 ratio (9.6-12.9) are undoubtedly above nutritional recommendations that recommend not exceed 4.0 [14].

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