FEEDING QUALITY OF THE MEAT FROM BROILERS TREATED WITH UNCONVENTIONAL FEED INDUSTRY BY-PRODUCTS

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Abstract

A feeding trial was conducted on 75, ROSS 308 broiler chicks (0-42 days), to evaluate the feeding quality of the meat from broilers treated with unconventional food industry by-products. The feeding trial was performed under controlled environmental conditions, under experimental conditions. The broiler chicks were assigned to 3 groups (C; E1 and E2), housed in digestibility cages (5 broiler chicks/cage), which allowed monitoring the production parameters. During the first phase (starter), the broiler chicks received a conventional compound feed formulation. For phases II (grower) and III (finisher), the experimental compound feeds formulations (E1 and E2) included a mixture of cereal and oleaginous grains (corn, flax oil, barley and peas – VMLO) as follows: 4 and 7.5%, respectively, for E1, and 10 and 12.5% respectively, for E2. The dietary concentration of ω:3 polyunsaturated fatty acids (ω:3 PUFA) in E2 diet increased with the dietary level of VMLO by-product (4.95% ω:3 PUFA for the grower period and 6,10% ω:3 PUFA for the finisher period). Six broilers/group were slaughtered at 42 days and breast meat, thigh meat and liver were collected and analysed. The analytical results indicate an improved feeding quality of the broiler meat as showed by significant (P≤0,05) changes in the basic chemical composition of the broiler meat and in the fatty acids profile and cholesterol concentration. The fat level decreased significantly (P≤0,05) in the breast meat from group E2 (0.91±0.09 g fat): 18.75% lower than in group C (1.12±0.07 g fat) and 5.35% lower compared to group E1 (1.06±0.09 g fat). Group E2 also recorded the best values for the omega 3 fatty acids, essential to human health, determined in the breast meat (3.99 g /100g total fatty acids), thigh meat (3.89 g /100g total fatty acids) and liver (5.12 g/100g total fatty acids) samples.

Key words: broiler, unconventional by-products, broiler meat, feeding quality, ω:3 PUFA

INTRODUCTION

One of the greatest challenges for animal production in the 21st century is and will be to provide enough healthy foods for the increasing global population. Poultry meat is one of the foods whose consumption increases globally [24]. Because the prevention of cardiovascular diseases is related to the dietary supply of cholesterol and saturated fatty acids (SFA), the human diets should be balanced in terms of the fatty acids profile and cholesterol level [12].

The cholesterol concentration in chicken meat can be changed by varying diet composition, age and sex [29]. The use of diet formulations rich in omega 3 fatty acids can improve the Ω3 content of the eggs and meat, which thus become an alternative for higher daily intakes of omega 3 [16].

The inclusion of essential fatty acids, such as α-linolenic and linoleic, in poultry feeding decreases the noxious serum lipids by increasing HDL concentration [3]. Nutritionists are thus trying to define new feeding solutions which can meet both consumer quality demands, and the economic criteria of the farmers. Among the oil extraction industry by-products, meals there

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are vegetable raw materials that can be used in animal feeding [20]. The meals obtained from oleaginous seeds rich in polyunsaturated fatty acids, essential to human health [26, 27] have a positive influence on the feeding quality of the final products and on the health state of the animals by decreasing the level of noxious lipids in the blood serum, by hypolipemia [1, 3, 8, 14, 15, 17]. Among them, the *pumpkin meal* is a natural source of proteins, rich in phytosterols [28], polyunsaturated fatty acids [23], in vitamins, antioxidants such as carotenoids and tocopherol [11, 28] and in oligo-elements, such as fi zinc. Both the pumpkin meal and seeds are complete feeds [18, 20], rich in proteins, amino acids, essential fatty acids, phytosterols, minerals and vitamin E.

However, the best results regarding the feeding quality of the chicken meat are obtained when oleaginous meals are used, which have a high level of oil. Among these there is the flax meal, which has a high level of linolenic acid (57% of the total fatty acids). In terms of chemical composition [4], the flax meal has 34.3% crude protein and 9.42% fat, being rich in fatty acids (total content of: saturated FA, 12.50%, monounsaturated 24.21%, n-3 43.23% and n-6 20.06%); the flax seeds contain 35-45% oil, with 45-52% α-linolenic acid [6].

The presence of biologically active phyto-chemicals, considered to have anticancerogenic properties, increased the interest for flax seeds and meal, which was traditionally used in animal feeding. Being a considerable source of residual oil, the flax seeds meal is a source of omega-3 fatty acids, particularly of α- linolenic acid, so that the producers of chicken meat can use this valuable source to improve chicken meat production in line with consumer expectation for healthy foods.

The objective of our study was to evaluate the effect of using nonconventional by-products from the food industry in broiler feeding on the feeding quality of the chicken meat.

MATERIAL AND METHOD

A feeding trial was conducted on 75 ROSS 308 broiler chicks (42 days), in agreement with the field legislation in Romania (Law 206/2004, ordinance 28/31.08.2011, law 43/11.04.2014, directive 2010/63/EU). The trial was conducted in a hall with controlled environmental conditions (average temperature/total period 27.07±2.75^{0}C; humidity 64.80±9.57%; ventilation/broiler 0.50±0.24%; CO2 level 686.39±104.38 ppm). The light regimen was adequate to the age of the broilers (23h light/1h darkness). The chicks, weighed individually, were assigned to three groups (C, E1 and E2) homogenous in terms of body weight, housed in digestibility cages (5 chicks/cage), which allowed the daily registration of the feed intake and excreta. The chicks had free access to the feed and water. The compound feeds formulations were tailored according to the objective of the feeding trial, species, hybrid, age and feeding requirements of ROSS 308 chicks (Broiler Management Guide, 2008). All broilers received the starter conventional compound feed for the first 10 days. Compared to the conventional formulation given to group C, the experimental formulations (E1 and E2) also included pumpkin meal (E1) and a mixture of corn, peas, rice and flax oil (E2), termed vegetable mixture with linseed oil (VMLO). The inclusion rate of these vegetal raw materials in the compound feeds formulation varied with the growth stage of the broilers (Table 1).

The vegetal by-products used to manufacture the feed formulations, the pumpkin meal (E1) and the vegetable mixture with linseed oil (E2) were analysed to determine their chemical composition, therefore their feeding value so as to optimise the diets (Table 1).

A 500 g sample was collected from each batch of compound feeds (one batch/group/development stage) and assayed chemically and microbiologically. After 42 days, 6 chicks/group were slaughtered and samples of breast meat, thigh meat and liver were collected. The protocol for this study was approved by the ethic commission of IBNA Balotesti (decision no. 52/30.07.2014).

Table 1 Compound feeds formulation according to the stage of broiler development

Specification	*Stage II – grower (11 – 28 days)*			*Stage III – finisher (29 - 42 days)*		
	C	E1	E2	C	E1	E2
		%			%	
Corn	51.32	51.34	45.23	60.23	60.6	52.57
Soybean meal	38.32	34.41	35.74	30.04	22.68	27.11
Pumpkin meal	-	*4.00*	-	-	*7.5*	
Vegetable mixture with linseed oil (VMLO)	-	-	*10.00*	-		*12.5*
Vegetal oil	5.73	5.61	4.57	2.41	4.79	3.68
Lysine	0.02	0.16	-	0.36	0.38	-
Methionine	0.25	0.30	0.22	0.32	0.33	0.19
Choline	0.05	0.05	0.05	0.05	0.05	0.05
Calcium carbonate	1.67	1.50	1.68	1.45	1.22	1.51
Monocalcium phosphate	1.23	1.22	1.10	1.15	1.06	1.01
Salt	0.41	0.41	0.41	0.39	0.39	0.38
Premix A1	1.00*	1.00*	1.00*	1.00**	1.00**	1.00**
Total	**100**	**100**	**100**	**100**	**100**	**100**

*** IBNA 1kg premix (A1)** contains: = 1100000 IU/kg vit. A; 200000 IU/kg vit. D3; 2700 IU/kg vit. E; 300 mg/kg Vit. K; 200 mg/kg Vit. B1; 400 mg/kg Vit. B2; 1485 mg/kg pantothenic acid; 2700 mg/kg nicotinic acid; 300 mg/kg Vit. B6; 4 mg/kg Vit. B7; 100 mg/kg Vit. B9; 1.8 mg/kg Vit. B12; 2000 mg/kg Vit. C; 8000 mg/kg manganese; 8000 mg/kg iron; 500 mg/kg copper; 6000 mg/kg zinc; 37 mg/kg cobalt; 152 mg/kg iodine; 18 mg/kg selenium; coccidiostat

**** IBNA 1kg premix (A1)** with out coccidiostat

The collected samples were labelled and transferred in to plastic bags, then stored at -20^{0}C, upon processing, the biologic samples were thawed, weighed, ground and dried in two stages in a drying cabinet (48 h at the temperature of +65^{0}C and 48 h at the temperature of +103^{0}C).

The basic chemical composition analyses (dry matter, protein, fat, ash), the fatty acids and the cholesterol level were determined on samples dried at 65^{0}C.

-the crude protein of the meat was determined using a semiautomatic classical Kjeldahl method using a Kjeltek auto 1030 – Tecator (SR ISO 973, 2007).

- the meat fat was extracted using an improved version of the classical method by continuous extraction in solvent, followed by fat measurement with Soxhlet after solvent removal (SR ISO 1444, 2008).

- the meat ash was determined by calcinations at 550^0 C (SR ISO 936, 2009).

- the meat fatty acids composition was determined by gas chromatography. After lipid extraction from the samples, the fatty acids were transformed into methyl esters by transmethylation, and the components were separated in the capillary chromatograph column. The fatty acids were identified by comparison with blank chromatograms and were subsequently determined quantitatively as percent for 100 g fat.

- the method used to determine the cholesterol was in agreement with AOAC International standard, 2002 (Cholesterol in multicomponent foods – Gas Chromatographic method. Assoc. of Anal. Chem. Arlington, VA). The working principle is the saponification of the sample followed by extraction is petrol ether, concentration and addition of chloroform. The sample is split in the GC, it is separated in the chromatographic column, and the results are compared with the standard chromatograms by measuring the peak area. It was used a Perkin Elmer-Clarus 500 chromatograph fitted with flame ionization detector (FID) and capillary separation column HP-5, 30 in length, and 0.320mm inner diameter, 0.10µm thick film.

- the polyphenol content of the methanol extracts has been determined according to the method described by [19], modified. We used a UV-VIS Thermo Scientific spectrophotometer.

- the determination of the antioxidant capacity of the methanol extracts has been

done using the DPPH method. The antioxidant capacity has been estimated by calculating the difference between the control and the sample, compared to a standard curve which used Trolox (synthetic antioxidant analogue to α-tocopherol), as standard antioxidant. We used a UV-VIS Analytik Jena Specord 250 Plus spectrophotometer with thermostatic carousel.

- the potential health hazard of the compound feeds samples for the broilers was evaluated by comparison with the legal limits regarding the quality and salubrity *parameters for the manufacture, import, quality* parameters for compound feeds and feed additives, as per Order 358/2003 approving the *Norms regarding the quality and salubrity inspection, selling and using simple concentrate feeds, compound feeds, feed additives, premixes, energy substances, minerals and special feeds*.

Statistically analysis: The analytical data were compared by variance analysis (ANOVA) using STATVIEW for Windows (SAS, version 6.0). The difference between the means was considered significant at $P<0.05$. The results were expressed as mean ± standard deviation.

RESULTS AND DISCUSSIONS

The vegetal by-products used to manufacture the feed formulations, the pumpkin meal (E1) and the vegetable mixture with linseed oil (E2) were analysed to determine their chemical composition, therefore to optimise the diet formulations (Table 1).

Table 2 data show that the two vegetal by-products have a high protein level. Researchers like [18] reported similar results for the pumpkin meal, which also has hypoglycaemic properties [7, 15].

On the other hand, the high fibre level determined in the analysed by-products (Table 2) was the limiting factor for their dietary level. There were no differences in the fat level of the two by-products, but the lipid profile is completely different (Table 2). Compared to the pumpkin meal, the vegetable mixture with linseed oil (VMLO) has a high level of Ω3 acids from the oil component, which is a rich source of Ω3 acids, with about 57% α- linolenic acid [6, 22].

Table 2 Feeding characterization of the vegetal by-products *

Specification	Pumpkin meal	*Vegetable mixture with linseed oil (VMLO)*
Dry matter, %	90.78	91.47
Crude protein, %	35.55	20.85
Ether extractives, %	13.26	14.19
Fibre, %	27.00	10.73
Ash, %	4.95	4.49
Σ SFA,	17.05	14.87
Σ MUFA	33.14	26.18
Σ PUFA, of which	49.81	58.57
Σ Ω:3	0.77	23.43
Σ Ω:6	49.04	35.14
Σ Ω:6/ Ω:3	63.91	1.50
Concentration of polyphenols (mg/g)	2.50	1.83
Antioxidant capacity (mMTrolox/g)	14.80	5.69
Concentration of flavonoids (mg equivalents rutin/g sample)	8.01	3.16

where: DM=dry matter; CP=crude protein; EE= ether extractives; CF=crude fibre; Ash=ash; Σ= sum; SFA = saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA= polyunsaturated fatty acids

Table 2 also shows that the pumpkin meal has a much higher antioxidant capacity, given particularly by the total content of polyphenols, than the vegetable mixture. Researchers like [30] reported similar results, but the reference values differ with the method of extraction [2, 5, 21].

The classes of fatty acids from the dietary fat (Table 3), for the two stages of growth, show that the concentration of omega 3 polyunsaturated fatty acids was significantly higher ($P\leq0.05$) in E2 formulation (VMLO) than in C and E1 (pumpkin meal). The concentration of polyunsaturated fatty acids in E2 formulation increased 4.8 times during the grower stage and 4.12 times in the finisher stage. Omega 6/omega 3 ratio in E2 formulation was 19% (grower) and 22.26% (finisher) lower than in C formulation.

The microbiological determinations (Table 3) showed, for all examined samples,

the absence of Salmonella. A slight exceeding for Escherichia coli was determined for group C, only during the grower stage, because of the working conditions and manner of work in the compound feeds mill.

Table 3 Chemical composition of the compound feeds

Specification	*Stage II – grower (11 – 28 days)*			*Stage III – finisher (29 - 42 days)*		
	C	E1	E2	C	E1	E2
Basic chemical composition						
Metabolisable energy, kcal/kg	3150.8	3150.2	3150.7	3200.9	3200.4	3200.3
Dry matter, %	89.17	87.51	89.11	89.10	88.91	89.29
Crude protein, %	22.12	21.70	22.13	18.80	19.47	19.82
Ether extractives, %	7.51	7.41	7.29	7.22	8.00	7.26
Fibre, %	4.06	5.21	4.09	3.87	5.75	4.83
Ash, %	5.60	6.27	5.98	6.02	4.93	7.80
Fatty acids profile of the CF						
SFA, %	12.15	12.23	13.95	13.17	14.94	13.35
MUFA, %	28.24	28.76	28.85	29.32	29.65	28.73
PUFA (%), of which	59.09	58.70	57.98	57.07	55.10	57.28
Σ Ω:3	1.03	0.99	4.95	1.48	1.11	6.10
Σ Ω:6	58.06	57.72	53.03	55.59	53.99	51.18
Σ Ω:6/ Ω:3	56.36	58.49	10.71	37.69	48.72	8.39
Microbiological determinations						
Coliform bacteria, (E. Coli) Count/g DM	26.14×10^2	3.4×10^2	1.2×10^2	5.8×10^2	36	2.61×10^2
Salmonella	negative	negative	negative	negative	negative	negative

where: DM=dry matter; CP=crude protein; EE= ether extractives; CF=crude fibre; Ash=ash; Σ= sum; SFA =saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA= polyunsaturated fatty acids

A significant ($P \leq 0.05$) decrease of the fat percentage was determined in the breast meat samples (Table 4) from groups E1 and E2, compared to group C. Unlike the breast meat samples, the fat percentage was significantly ($P \leq 0.05$) higher in E2 samples than in the samples from groups C and E1. Researchers like [17] reported a significant decrease of the abdominal fat in the chicks treated with 10% pumpkin meal. Similar results have been reported by [1] who noticed less abdominal fat from the dietary use of 0; 33; 66 and 100 g pumpkin meal/kg compound feed. No significant differences between groups were noticed in the cholesterol level of the breast meat (Table 4). A significantly ($P \leq 0.05$) higher cholesterol concentration was determined, however, in the thigh samples from group C, compared to groups E1 and E2. The lower value of cholesterol concentration in the thigh samples from group E1, compared to group C, was due to the dietary pumpkin meal, which has hypocholesterolaemic effect [1]. In the case of group E2, the lower value of cholesterol concentration in the thigh samples, compared to group C, is probably due to the high omega 3 PUFA concentration from the vegetable mixture of oleaginous crops [10].

Table 4 Basic chemical composition of the broiler meat and cholesterol concentration (average values/group)*

Specification	Control (C)	Pumpkin meal (E1)	*VMLO* (E2)
Chicken breast			
Dry matter, %	24.07±1.23	25.18±0.53	24.00±0.53
Crude protein, %	22.09±1.72	22.93±0.42	21.86±0.47
Ether extractives, %	1.12±0.07 ^{bc}	1.06±0.09 ^{ac}	0.91±0.09 ^{ab}
Ash, %	1.19±0.10	1.14±0.06	1.16±0.05
Cholesterol, g col./100g sample	0.114±0.014	0.103±0.022	0.103±0.022
Chicken thigh			
Dry matter, %	25.51±1.06 ^{c}	26.72±1.21 ^{c}	29.71±3.38 ^{ab}
Crude protein, %	18.96±0.62	18.66±0.87	18.86±2.06
Ether extractives, %	4.08±0.37 ^{c}	4.48±0.63	4.67±0.55 ^{a}
Ash, %	0.99±0.06	0.87±0.07	0.86±0.11
Cholesterol, g col./100g sample	0.1250±0.009 ^{bc}	0.1040±0.01 ^{a}	0.0900±0.006 ^{a}

Where: a,b,c significant differences (P≤0.05) from C, E1, E2;

The concentration of omega 3 polyunsaturated fatty acids (Ω:3 PUFA) in the breast meat samples increased significantly (P≤0.05) in E1 and E2 samples compared to group C (Table 5). The concentration of α-linolenic acid (C18:3n3) was 36.32% and 79.18 % lower in the breast meat samples from group C, than in the samples from groups E1 and E2, respectively. The docosapentaenoic (C 22:5n3) and docosahexaenoic (C 22:6n3) fatty acids too, were determined in lower concentrations in group C samples than in the samples from groups E1 and E2. Thus, the docosapentaenoic fatty acid in the breast meat samples was 48.6% (E1) and 83.82% (E2) higher than in group C, while the docosahexaenoic fatty acid was 1.13% (E1) and 64.79% (E2) higher than in group C. The highest concentration of Ω:3 polyunsaturated fatty acids was determined in the breast meat samples from group E2 (3.99 g/100 g total fatty acids), 48.07% higher than in group E1. On the other hand, the highest concentration of Ω:6 polyunsaturated fatty acids was determined in group E1, which doubled Ω:6/Ω:3 ratio (17.87:1) compared to group E2 (8.367:1).

The concentration of Ω:3 polyunsaturated fatty acids in the chicken thigh (Table 6) was noticed in F2 samples (3.89 g/ 100 g total fatty acids). Same as for the breast meat, the highest concentration of Ω:6 polyunsaturated fatty acids was determined in group E1, and lowest in group C (Table 6). In conclusion, Ω:6/Ω:3 ratio is higher in E1 thigh samples. The results reported by [9] show that the use of various sources of fatty acids (tallow, olive oil, sunflower and flax oil) is influenced by lipid retention and by lipid metabolism. It was proved that the use of flax under different forms in chicken diets increased the level of ω 3 PUFA in animal foods [25]. Researchers like [6] reported finding 300 mg omega-3 acids per 100 g chicken breast, after 26.2 days, feeding 10% flax seeds meal. Other researchers like [22] documented the increase of α- linolenic acid proportion from 30 to 99.4 and 139 mg /100 g in in the white meat, when the broilers were treated with 2 and 4% flax oil. In this case, eicosapentaenoic acid (EPA) concentration increased from 7.2 to 7.8 and 16.8 mg/100 g white meat. However, in nutrition, the oil had no effect on the content of docosahexaenoic acid (DHA) in the breast meat. Similarly, the flax oil increased the content of omega-3 fatty acids in the red meat. The α – linolenic acid from the red meat increased from 57 to 158 and to 233 mg/100g in in the white meat, when the broilers were treated with the same concentration of flax oil. The eicosapentaenoic acid increased from 6.2 to 7.9 in the red meat and to 16.1 mg/100 g in the white meat under the same feeding conditions. Researchers like [13] treated the broilers with 10% flax and reported the increase of ALA from 11 to 54 mg /100g in the skinned breast and from 43 to 183 mg/100g boiled skinless thigh. The content of omega-3 long-chain fatty acids also increased from 17 mg to 89 mg/100 g in the boiled skinned breast, and to 23 mg/100 in the thigh.

Table 5 Fatty acids concentration in the meat

Specification *	Breast					Thigh				
	Control (C)	Pumpkin meal (E1)	*VMLO* (E2)	Value of p	SEM	Control (C)	Pumpkin meal (E1)	*VMLO* (E2)	Value of p	SEM
Capric (C10:0)	0.037	0.088	0.033	0.2825	0.016	0.06	0.06	0.06	0.9250	0.005
Lauric (C12:0)	0.093 ^{bc}	0.072 ^{a}	0.038 ^{a}	0.0002	0.007	0.05 ^{b}	0.11 ^{ac}	0.06 ^{b}	<0.0001	0.008
Myristic (C14:0)	0.527	0.633	0.43	1.169	0.055	0.49 ^{b}	0.42 ^{ac}	0.48 ^{b}	<0.0001	0.009
Myristoleic (C14:1)	0.200 ^{c}	0.165	0.157 ^{a}	0.0615	0.008	0.18 ^{bc}	0.10 ^{ac}	0.15 ^{ab}	<0.0001	0.008
Pentadecanoic (C15:0)	0.297 ^{bc}	0.490 ^{a}	0.432 ^{a}	0.0141	0.030	0.46 ^{bc}	0.13 ^{a}	0.14 ^{a}	<0.0001	0.037
Pentadecenoic (C15:1)	0.457 ^{bc}	0.252 ^{a}	0.233 ^{a}	<0.0001	0.027	0.46 ^{c}	0.36	0.26 ^{a}	0.0227	0.030
Palmitic (C16:0)	20.143 ^{bc}	17.228 ^{ac}	17.993^{ab}	<0.0001	0.324	19.52 ^{bc}	15.16 ^{ac}	16.28 ^{ab}	<0.0001	0.449
Palmitoleic (C16:1)	1.968 ^{b}	1.377 ^{ac}	1.928^{b}	<0.0001	0.070	2.39 ^{b}	1.65 ^{ac}	2.37 ^{b}	<0.0001	0.084
Heptadecanoic (C17:0)	0.172 ^{b}	0.238 ^{ac}	0.180 ^{b}	0.0002	0.009	0.19 ^{bc}	0.30 ^{ac}	0.26 ^{ab}	<0.0001	0.011
Heptadecenoic (C17:1)	0.207	0.245	0.207	0.1671	0.010	0.24	0.25	0.23	0.8075	0.009
Stearic (C18:0)	8.38 ^{bc}	7.687 ^{a}	7.575 ^{a}	<0.0001	0.100	7.76 ^{bc}	6.90 ^{ac}	5.98 ^{ab}	<0.0001	0.179
Oleic cis (C18:1n9c)	32.338 ^{bc}	28.775 ^{ac}	29.758 ^{ab}	<0.0001	0.374	31.48 ^{bc}	27.05 ^{ac}	29.68 ^{ab}	<0.0001	0.449
Oleic cis (C18:1n7c)	1.485 ^{b}	1.218 ^{a}	1.335	0.0359	0.440	1.35 ^{bc}	1.19 ^{ac}	1.09 ^{ab}	<0.0001	0.030
Linoleic cis (C18:2n6)	26.418 ^{bc}	32.297^{ac}	29.46 ^{ab}	<0.0001	0.625	27.35 ^{bc}	38.45 ^{ac}	34.28 ^{ab}	<0.0001	1.112
Arachidic (C20:0)	0.172 ^{b}	0.02^{ac}	0.170 ^{b}	0.0884	0.020	0.16 ^{b}	0.27 ^{ac}	0.19 ^{b}	<0.0001	0.013
Linolenic α (C18:3n3)	0.447 ^{bc}	0.702 ^{ac}	2.147 ^{ab}	<0.0001	0.183	0.38 ^{bc}	0.78 ^{ac}	2.58 ^{ab}	<0.0001	0.243
CLA (C18:2)	0.180 ^{b}	0.257 ^{a}	0.185	0.0830	0.016	0.36 ^{bc}	0.07 ^{a}	0.15 ^{a}	<0.0001	0.035
Octadecatetraenoic (C18:4n3)	0.382 ^{bc}	0.217 ^{a}	0.19 ^{a}	<0.0001	0.021	0.32 ^{bc}	0.03 ^{ac}	0.15 ^{ab}	<0.0001	0.032
Eicosadienoic (C20:2n6)	0.247	0.205	0.30	0.1887	0.021	0.31 ^{b}	0.20 ^{ac}	0.29 ^{b}	<0.0001	0.012
Eicosatrienoic (C20:3n6)	0.500 ^{b}	0.587^{ac}	0.528 ^{b}	0.0010	0.011	0.37 ^{b}	0.47 ^{ac}	0.34 ^{b}	<0.0001	0.015
Eicosatrienoic (C20:3n3)	0.297 ^{bc}	0.362^{ac}	0.323 ^{ab}	<0.0001	0.008	0.26 ^{b}	0.40 ^{ac}	0.29 ^{b}	<0.0001	0.015
Arachidonic (C20:4n6)	1.732 ^{bc}	2.567 ^{ac}	2.265 ^{ab}	<0.0001	0.090	1.68 ^{b}	2.98 ^{ac}	1.62^{b}	<0.0001	0.154
Docosadienoic (C22:2n6)	0.225 ^{bc}	0.335 ^{a}	0.337 ^{a}	0.0024	0.017	0.51 ^{bc}	0.20 ^{ac}	0.32 ^{ab}	<0.0001	0.033
Docosatrienoic (C22:3n6)	0.262 ^{c}	0.265	0.337 ^{a}	0.0792	0.016	0.49 ^{bc}	0.19 ^{ac}	0.36 ^{ab}	<0.0001	0.032
Eicosapentaenoic (C20:5n3)	0.418 ^{c}	0.425 ^{c}	0.257 ^{ab}	<0.0001	0.020	0.68 ^{bc}	0.32 ^{ac}	0.49 ^{ab}	<0.0001	0.037
Lignoceric (C24:0)	0.488	0.453	0.470	0.2448	0.008	0.71 ^{bc}	0.34 ^{ac}	0.57 ^{ab}	<0.0001	0.039
Nervonic (C24:1n9)	0.597 ^{b}	0.993 ^{ac}	0.545 ^{b}	<0.0001	0.050	0.48 ^{bc}	0.79 ^{ac}	0.35 ^{ab}	<0.0001	0.048
Docosatetraenoic (C22:4n6)	0.177 ^{b}	0.322 ^{ac}	0.162 ^{b}	<0.0001	0.020	0.15 ^{b}	0.24 ^{ac}	0.13 ^{b}	<0.0001	0.013
Docosapentaenoic (C22:5n3)	0.055 ^{bc}	0.107 ^{ac}	0.34 ^{ab}	<0.0001	0.030	0.06 ^{bc}	0.10 ^{ac}	0.15 ^{ab}	0.0002	0.010
Docosahexaenoic (C22:6n3)	0.175 ^{c}	0.177 ^{c}	0.497 ^{ab}	<0.0001	0.040	-	0.15	0.24	<0.0001	0.025
Other fatty acids	0.772	0.797	0.862	0.6182	0.037	0.73 ^{bc}	0.34 ^{a}	0.36 ^{a}	0.0103	0.063

Where: a,b,c significant differences (P≤0.05) from C, E1, E2; * Fatty acids (g /100g total fatty acids)

Table 6 Fatty acids profile in the chicken meat

	Control (C)	Pumpkin meal (E1)	*VMLO* (E2)	Value of p	SEM
Breast					
Σ SFA	30.252 ^{bc}	27.002 ^{a}	27.438 ^{a}	<0.0001	0.405
Σ MUFA	37.248 ^{bc}	33.027 ^{ac}	34.165 ^{ab}	<0.0001	0.443
Σ PUFA, of which	31.727 ^{bc}	39.175 ^{ac}	37.533 ^{ab}	<0.0001	0.811
Σ Ω:3	1.865 ^{bc}	2.072 ^{ac}	3.99 ^{ab}	<0.0001	0.234
Σ Ω:6	29.68 ^{bc}	36.847 ^{ac}	33.36 ^{ab}	<0.0001	0.747
Σ Ω:6 / Ω:3	15.97 ^{bc}	17.869 ^{ac}	8.367 ^{ab}	<0.0001	1.019
Thigh					
Σ SFA	29.60 ^{bc}	23.73 ^{ac}	24.13 ^{ab}	<0.0001	0.653
Σ MUFA	36.57 ^{bc}	31.38 ^{ac}	34.13 ^{ab}	<0.0001	0.520
Σ PUFA, of which	33.11 ^{bc}	44.55 ^{ac}	41.38 ^{ab}	<0.0001	1.174
Σ Ω:3	1.75 ^{c}	1.76 ^{c}	3.89 ^{ab}	<0.0001	0.258
Σ Ω:6	31.00 ^{bc}	42.72 ^{ac}	37.34 ^{ab}	<0.0001	1.166
Σ Ω:6 / Ω:3	17.70 ^{bc}	24.30 ^{ac}	9.80 ^{ab}	<0.0001	1.458

Where: a,b,c significant differences (P≤0.05) from C, E1, E2; Σ= sum; SFA =saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA= polyunsaturated fatty acids; * Fatty acids (g /100g total fatty acids)

The results obtained for the liver samples collected at slaughter (Table 7) show a significantly (P≤0.05) higher content of fat in group C compared to the experimental groups E1 and E2. The concentration of Ω:3 polyunsaturated fatty acids, essential to the human organism (α-linolenic, docosapentaenoic and docosahexaenoic acids) were significantly (P≤0.05) higher in the liver samples from group E2, which decreased omega 6/omega 3 ratio.

Table 7 Chemical composition of the liver (average values/group)

Specification	Control (C)	Pumpkin meal (E1)	*VMLO* (E2)
Dry matter, %	26.73±2.57	25.23±1.04	25.81±0.85
Crude protein, %	18.11±1.10	18.34±0.39	19.04±0.82
Ether extractives, %	3.92±1.15 ^{bc}	3.22±0.36 ^{a}	2.90±0.31 ^{a}
Ash, %	1.21±0.15	1.31±0.04	1.30±0.10
Σ SFA,	38.32±1.64 ^{b}	35.69±3.85 ^{a}	38.19±0.76
Σ MUFA	24.71±3.32 ^{bc}	19.61±1.54 ^{a}	17.15±3.41 ^{a}
Σ PUFA, of which	36.85±3.92 ^{bc}	44.63±3.99 ^{a}	44.60±3.80 ^{a}
Σ Ω:3	1.90±0.31 ^{b}	2.25±0.25 ^{c}	5.12±0.78 ^{ab}
Σ Ω:6	34.84±3.73 ^{bc}	42.24±3.83 ^{a}	39.42±3.17 ^{a}
Σ Ω:6/ Ω:3	18.58±2.48 ^{c}	18.87±1.84 ^{c}	7.79±0.72 ^{ab}
cholesterol, g col./100g sample	0.19±0.016 ^{bc}	0.164±0.019 ^{a}	0.16±0.016 ^{a}

where: DM=dry matter; CP=crude protein; EE= ether extractives; Ash=ash; Σ= sum; SFA =saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA= polyunsaturated fatty acids.
*Chemical composition on dry matter (DM) basis;

CONCLUSIONS

The use of vegetal by-products (pumpkin meal and a mix of cereals and oleaginous plants – corn, flax oil, barley and peas) improved the feeding quality of the chicken meat, leading to significant (P≤0.05) changes both in the basic chemical composition of the meat and in the fatty acids profile and cholesterol.

The fat level in the breast meat decreased significantly (P≤0.05) in group E2 (treated with flax oil), being 18.75% lower than in group C and 5.35% than group E1 (pumpkin meal).

Also group E2 scored the best values for omega 3 fatty acids, essential to human health, determined in the breast, thigh and liver samples.

Therefore, the vegetal by-products rich in nutrients can be used in poultry feeding (with limits given by their fibre content), which can improve the feeding quality of the chicken meat. This depends much on the composition of the used product and also, on its economic value.

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