Effects of some oleaginous ecologic ingredients on pig meat quality

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Abstract

The aim of this study is to identify the locally available ecologic resources, to determine their nutritional value and to formulate compound feed appropriate for obtaining a higher quality of pig meat. The chemical composition in fatty acids (FA) was determined by gas chromatography method using Perkin Elmer-Clarus 500 chromatograph. Intramuscular fat was determined gravimetrically by Soxlet method and protein content by Kjeldhall method. The chemical composition of camelina was favourable for including it in the diet. The content in C18:3n-3 was higher in experimental groups than control group. Using 3% Camelina oil produced by cold pressing, with 46.71 % linolenic acid allowed obtaining a compound feed for the finishing pigs with 9.05% linolenic fatty acid. The high content of linolenic acid in the compound feed modified significantly, in a favourable way, the ω3 to ω6 ratio in the pig meat. This allows us to conclude that the supplementation of Camelina oil in the compound feeds for the finishing pigs can be used to modify the fatty acids profile and to reduce pig meat cholesterol, improving thus its quality

Keywords: camelina oil, ecologic, fatty acid, feed composition, pigs.

1. Introduction

Due to implications inherent of animal products on human health, a rigorous analysis of the difficulties arising from nutrition and feeding of pigs in organic system is required. Information regarding this feeding system is much less available than those on industrial growth. Organic growths of pigs increase regularly and should be planned within the limit of this production system, where genetic and nutritional factors and interaction between them are crucial. This system more expansive is ultimately accepted by consumer due to implications on environmental sustainability, the quality of their products and their impact on human health. Meat produce in organic condition can be considered superior to conventional in term of quality, safety, labelling, production methods and its value. Availability and price of organic meat were the key elements that led to consumer reluctance to buy it. Scientific researches in recent years are focused on finding just the essential arguments that can ensure developing of this sector.

Among the nutritional components of the pig meat, lipids are the nutrients very important which deeply control nutritional quality / health value and sensorial quality of the meat. Their quality, the ratio between the saturated and unsaturated fatty acids (FA), can modify the technological, organoleptic and dietetic characteristics of the animal foods ([6] 2001, [10], 2001, [15], 1997) having a great importance in the development and progression of atherosclerosis. Recommendations on human nutritional intake are oriented to increase fatty acids (FA) ω3 (ω3) consummation, ω6 (ω6) family reduce and the tendency to reduce the n-6: n-3 ratio to around 5 (ideal ratio reached for humans is 5:1 ([13], 2006). During human evolution, ω3 FA was in all consumed food (meat, wilds plants, eggs, fish, and berries). Moreover, fast dietary changes in short period of time in the last 100-150 years are evolutionary phenomena that remain.

The aim of this study is to identify the locally available organic forages resources, to determine their nutritional value and to formulate compound feed appropriate for obtaining a higher quality of meat.

2. Materials and methods

Animal and diets

To increase the content of polyunsaturated fatty acids (ω_3) in the meat pig lipids and to avoid the lipid peroxidation processes, the compound feed for fattening-finishing pigs was supplemented with Camelina oil and an mixture of plant extracts rich in polyphenols (buckthorn meal, flax seeds meal, topinambur flour, kettle). Thirty Large White pigs with an average weight of 67 kg were assigned to 3 groups of 10 pigs each and fed for 42 days three compound feeds formulations: group C received a compound feed made of conventional ingredients (corn, sunflower meal, soybean meal, toasted soybeans); group E1 received a compound feed made of ecological feed ingredients grown in certified ecological farms (corn, sunflower meal obtained by cold pressing, toasted soybeans) supplemented with Camelina oil (containing over 47% linolenic acid) obtained by cold pressing, and E2 group like E1 group but in addition a plant extract premix rich in polyphenol.

Chemical analysis

The chemical analyses of the feed ingredients were done in the laboratory of chemistry and nutrition physiology of INCDBNA. The following determinations were performed: dry matter (DM); crude protein (CP); amino acids; ether extractives (EE); fatty acids; crude fibre(CF); gross ash (Ash), expressed by 100 g DM. The crude protein was determined using a semiautomatic classical Kjeldahl method using a Kjeltek auto 1030 – Tecator. The 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. The crude fibre was determined with a classical semiautomatic Fibertec-Tecator method and the ash by calcination at 550^0 until constant mass ([3], 2003). The nitrogen-free extractives (NFE) were calculated from the formula: NFE = DM - (CP + EE + CF + Ash). The metabolisable energy (ME) was calculated with regression equations developed by the „Oskar Kellner": ME = 5.01 × DP + 8.93 EE + 3.44 CF + 4.08 DNFE. The chemical composition in fatty acids was determined by gas chromatography method. We used a Perkin Elmer-Clarus 500 chromatograph with capillary injection system (splitting ratio 1:100), with flame ion detection (FID) and programmed heated capillary oven; the separation capillary column had a high polarity stationary phase (TR-Fame, 60 m × 0.25mm inner diameter, 0.25µm film); or high polarity cyanopril phase, which give a similar resolution for different geometrical isomers THERMO TR-Fame 120m × 0.25mm ID x 0.25µm film. Hydrogen was the carrier gas.

Cold pressing was used as ecologic method for oil extraction. The oils extracted with this method a better in terms of content and they preserve unaltered the nutritive quality of he seeds. The yield is 38-45% oil.

Measuring and Statistic calculation

In the end of the experiment, 6 animals each were slaughtered from groups C and E2 and samples of *Semitendinosus* and *Longissimus dorsi* muscle were collected for analyses to determine the dry matter, crude protein, fatty acids and cholesterol levels.

The experimental data are presented as means. Effects were considered significant at P≤0.05. Student tests and ANOVA was used to process the experimental to determine the

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significance of the difference and the tendency between groups.

3. Results and discussion

Feed composition

In 2008, at the initiative of FAO [16], was reconsidered relation between biodiversity, nutrition and health, establishing key nutrition indicators (food composition, e.g.) that can help promote biodiversity conservation and the fight against hunger and malnutrition, dietary diversification and safety food, issues rarely included in nutrition program. This situation is due in particular to insufficient data on the nutritional value of local resources, also lack of method to obtain, analyse and use the biodiversity data on studies related to food composition and consumption. In this context we identified and analysed some local ecologic ingredients aimed to use them for testing on pigs.

Table1 shows the chemical composition of some feed ingredients produced under ecological conditions. We determined the organic matter content (CP, EE, CF, NFE), the ME and the Ash. These nutrients were expressed in g/100 g DM because of the different DM content. ME was expressed by kg DM.

The producers presently wonder whether the organic procedures really are healthier, if the taste can be affected by the use of pesticides in the conventional crops and if there really are discernable nutritional differences. Very few studies have shown that the organic ingredients have a higher level of nutrients than the conventional ones ([12], 2007).

Table 1.Chemical composition and nutritive value of the main feed ingredients produced under ecologic conditions and used in pig feeding (g/100g DM)

Specification	Corn	Wheat	Barley	Peas	Sunflower seed	Rapeseed	Camelina seed
Dry matter (%)	87.70	88.83	88.07	87.87	96.56	92.90	91.87
Metabolisable energy (kcal/kg)	3802	3723	3295	3779	4140	4432	4497
Crude protein	8.06	12.06	9.30	24.50	15.07	26.03	22.65
Ether extractives	3.14	2.25	1.87	1.00	38.85	27.86	34.13
Crude fibre	364	3.74	6.85	7.23	23.61	15.09	15.08
Crude ash	1.21	1.86	2.77	3.55	2.48	4.14	4.83
Nitrogen-free extractives	83.93	80.10	79.21	63.71	19.19	26.88	23.30

When we speak of human health, not all the fats or oils are equivalent, so that the interest for the specific fatty aids profile is quite an urgent topic for some while. Among the feed ingredients surveyed in this study, the camelina had the highest content of linolenic acid, (46.71 g/100 g fat for the ecologic Camelina, table 2). It is very important that traces of eicosanoids were detected in some ingredients, knowing their favourable influence on human health. The values were close to the data reported by Dubois, 2007 [4].

Table 2. Chemical composition in fatty acids of some ecologic and conventional ingredients used in pig feeding (g/100 g fat).

Ingredients	Total saturated FA	Total unsaturated FA	Saturated fatty acids			Unsaturated fatty acids					
			Miristic 14:0	Palmitic 16:0	Stearic 18:0	Palmit-oleic 16:1	Oleic 18:1	Linoleic 18:2n-6	Linolenic 18:3n-3	Eico-sanoic 20:1	Eicosa dienoic 20:2
Conventional feed ingredients											
Soybeans*	15.10	84.90	0.10	10.30	3.80	0.20	22.80	51.00	6.80	0.20	-
Sunflower*	10.60	89.40	-	5.40	3.50	0.20	45.30	39.80	0.20	-	-
Rapeseds*	7.40	92.60	-	4.00	1.80	0.20	56.10	20.30	9.30	3.60	-
Corn*	13.30	86.70	-	10.90	1.80	-	24.20	59.00	0.70	-	-
Ecologic feed ingredients											
Camelina**	10.43	89.57	0.19	7.76	2.48	0.21	16.57	20.22	48.47	0.47	1.55
Soybeans **	11.82	88.18	0.07	10.02	1.73	-	16.68	65.20	6.30	-	-
Sunflower **	10.90	89.10	0.10	7.66	3.14	0.11	25.89	61.10	0.08	-	-
Rapeseds **	8.26	91.74	0.18	6.24	1.84	0.36	21.71	20.17	28.61	-	0.71
Corn **	14.32	85.68	0.12	12.66	1.54	0.16	25.05	59.37	1.10	-	-
Camelina**	4.45	95.55	-	4.45	-	-	16.13	24.51	46.71	-	-

*[17];
** INCDBNA-Balotesti analyses

Performance and meat quality

Based on this data we have developed an experimental plan focused on the formulation of feed compound which could improve meat quality (increase 18:3n-3 FA content and decrease 18:2n-6:18:3n-3 ratio, particularly).

Initial average weight was similarly between the groups. Final average weight was 99 kg for C group, 100 kg for E1 group and 101 kg for E2 group. The amount of feed consumed was much higher in groups E which resulted into a higher final weight, into an increased daily gain, but the differences obtained were not significant (P>0.05). Feed conversion ratio (gain: feed) was not different between the groups (4.43 kg compound feed/ kg gain in pigs fed with camelina oil as supplement lipid and 4.55 in pigs fed with camelina oil and also with addition as antioxidant compared to pigs of control group where gain : feed was 4.53 kg compound feed/ kg). Average daily gain was 7.6% higher in group with camelina oil and plant extract than control group.

The dietary lipid supplement as camelina oil did not modify significant the productive performance, but influence the qualitative parameter due to Camelina oil which is now being researched for the reason this is an exceptionally source of ω3 fatty acids, which is uncommon in vegetable sources. Over 50% of the fatty acids in cold pressed Camelina oil are polyunsaturated. The major components are alpha-linolenic acid - C18: 3 (ω-3FA, approx 35 - 45%) and linoleic acid - C18:2 (ω6 FA, approx 15-20%) and eicosanoid acids (14.8 - 15.2%). The chemical composition of camelina oil used in this experiment is closed to the value obtained by Dubois et al., 2007 [4].

Carcass quality was different in the E2 groups, particularly as concerns the fatty acids profile and the cholesterol level. The dry matter, protein, fat and ash content were closer between the two groups for the *Longissimus dorsi*, but for the *Semitendinosus* E2 had a significantly lower dry matter, fat and ash content and higher protein content (table 3).

Table 3. Gross chemical composition of *Longissimus dorsi* and *Semitendinosus*

Items	C		E2	
	Longissimus dorsi	*Semitendinosus*	*Longissimus dorsi*	*Semitendinosus*
Dry matter (%)*	29.62[a]	30.47[a]	29.95[a]	25.49[b]
Crude protein*	23.29[a]	19.45[a]	23.51[a]	20.89[b]
Ether extractives*	4.95[a]	9.38[a]	5.13[a]	3.50[b]
Gross ash*	1.06[a]	3.58[a]	1.11[a]	1.08[b]

* Different superscripts, significant differences ($P \leq 0.05$)

The protein and lipid content of the muscle *Longissimus dorsi* and *Semitendinosus* from E2 and of the muscle from C were within the limits determined by Habeanu et al, [7], 2004 but lower than the data reported by Favier [5], 1995. The supplement of Camelina oil and of antioxidant premix for group E2 modified significantly ($P \leq 0.05$) the fatty acids profile (table 4), which confirm that tissue FA composition reflects the FA composition of the diet ([11], 1996, [2], 2005). The saturated fatty acids (SFA) from the *Longissimus dorsi* were in lower amount in group C, mainly due to the palmitic acid. In the *Semitendinosus*, the amount of SFA was significantly lower in E2 group ($P<0,05$). The amount of SFA in the meat from the two groups is close to the values reported by Leskanich et al. [9] in 1997, who tried to modify the fatty acids profile in the pig meat by adding fish oil and rapeseed oil. Warmants, [14], 1999 used full fat soybeans in growing-fattening pigs and have obtained lower values for the saturated fatty acids in some groups. Kouba et al. [8], 2002 showed that feeding a diet containing 6% whole crushed linseed reduced the n-6:n-3 ratio in *Longissimus* muscle to 3.9 in only 20 days from 40 kg live weight compared with a ratio of 7.6 in controls group. Ratio were 3.0 at 60 days and 3.1 at 100 days on the linseed diet, corresponding to 18:3 concentrations of 3.0 and 2.2% in *Longissimus* total lipid at 60 and 100, days respectively. This supports the conclusion of Warnants et al., [14] 1999 that maximal feeding effects with essential fatty acids can be achieved within 40 days, with half of the effect occurring within 2 weeks.

Table 4. Fatty acids profile in *Longissimus dorsi* and *Semitendinosus* muscles in C and E2 groups

Fatty acids (g /100g fat)	Control group		Camelina oil + antioxidant premix group	
	Longissimus dorsi	*Semitendinosus*	*Longissimus dorsi*	*Semitendinosus*
SATURATED, OF WHICH:	33.58[a]	30.23[a]	36.44[b]	25.73[b]
14: 0 myristic	1.17[a]	1.30[a]	1.55[b]	1.03[b]
16:0 palmitic	27.13[a]	28.21[a]	33.76[b]	24.70[b]
18:0 stearic	5.28[a]	0.72	1.13[b]	0.00
UNSATURATED, OF WHICH:	65.05[a]	69.22[a]	61.64[b]	74.03[b]
☞*monounsaturated:*	54.51[a]	54.94[a]	49.91[b]	52.51[a]
16:1 palmitoleic	2.23[a]	2.59[a]	2.79[b]	1.89[b]
18:1 oleic	52.28[a]	52.35[a]	47.12[b]	50.62[a]
☞*polyunsaturated*:	10.54[a]	14.28[a]	11.73[b]	21.52[b]
18:2 n-6 linoleic	9.42	17.79[a]	10.34[b]	18.79[b]
18:3 n-3 α-linolenic	0.33[a]	0.54[a]	0.98[b]	1.56[b]
C20:4 n-6 arachidonic	0.79	0.95	0.41	1.17
Other fatty acids	1.37	0.55	1.91	0.24
Saturated FA acids / Unsaturated FA	1 : 1.94	1 : 2.29	1 : 1.69	1 : 2.88

MUFA / PUFA	5.17 : 1	3.85 : 1	4.25 : 1	2.44 : 1
linolenic acid: linoleic acid	1 : 28.5	1 : 23.69	1 : 10.55	1 : 12.04

**different superscripts = significant differences (P≤0.05), the significance was calculated between groups for the same meat quality.*

The content of unsaturated fatty acids was significantly lower in the muscle of E2 group than in group C. This is due to the content of oleic oil, but the content of polyunsaturated fatty acids (PUFA) was significantly higher (P≤0.05) for all types of fatty acids both in the *Longissimus dorsi* and in the *Semitendinosus* in group E2. Higher differences were noticed for the linolenic acid (ω_3), which is about three times higher in E2 compared to C group. These values are close to those reported by Warmants [14], 1999, who used Canola seeds in pig feeding. Analysis of the entire fatty acids profile in the pig meat from the two groups shows an improvement of the fat quality which exceeds the 0.30 ratio of the saturated fatty acids to the polyunsaturated fatty acids. The $\omega_3 : \omega_6$ ratio following the introduction of the Camelina oil was much improved in E2, being of 1:10,55 and 1:12.04 in the *Longissimus dorsi* and *Semitendinosus*, but it higher than the ratio reported by Azain, [1], 2004, of 1 : 1 towards 1 : 4.

The cholesterol level in both type of muscles was reduced in group fed with camelina oil and premix antioxidant but significant (P<0.05) only in the *Semitendinosus*, following: 32,9 mg / 100 g sample (*Longissimus dorsi*) and 16,4 mg/ 100 g sample (*Semitendinosus*) less with 55% than group C *Semitendinosus*) in group E2 compared with group C where the cholesterol level was 37,6 mg / 100 g sample (*Longissimus dorsi*) and 36,8 mg/ 100 g sample (*Semitendinosus*). This is possible to be linked with the level of linolenic fatty acids in the diet (9.05 in E2 vs. 2.76 g/100 crude fat).

4. Conclusions

As expected, the nutritive value of the ecologic ingredients generally is close to that of the conventional ingredients. This study allowed us to set a feeding strategy for testing on finishing pigs which allowed us to observe the effects on the animal products, knowing that we can manipulate their quality through the diet. Using 3% Camelina oil produced by cold pressing, with 46.71 % linolenic acid allowed obtaining a compound feed for the finishing pigs with 9.05 % linolenic acid. The high content of linolenic acid in the compound feed modified significantly, in a favourable way, the ω_3 to ω_6 ratio in the pig meat. Correlated negatively with the amount of polyunsaturated fatty acids, the cholesterol level of the pig meat from group E2 was significantly lower. This allows us to conclude that the supplementation of Camelina oil in the compound feeds for the finishing pigs can be used to modify the fatty acids profile and to reduce pig meat cholesterol, improving thus its quality.

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