Research on the qualitative interactions in pigs due to the transformation of lipids along the forage – animal food chain

Veronica Hebean, C. A. Iliescu, Mihaela Hăbeanu, Mariana Ropotă

National Research-Development Institute for Animal Biology and Nutrition, Calea Bucuresti nr.1, 077015 Balotesti, Ilfov, Romania

ABSTRACT

In order to improve meat quality, by increasing the level of linoleic acid, an experiment was conducted on 24 Large White pigs with initial weigh of 67 kg, assigned to two equal groups (C and E) fed for 42 days on two types of compound feeds. For C group we used conventional compound feeds (based on corn, full fat soy, soybean meal, sunflower meal), while for E group we used compound feeds made from organic cultivated plants (corn, sunflower meal, toasted soy beans, Camelina oil obtained by cold pressing with 46.71% linoleic acid anti oxidant premix based on Jerusalem Artichoke, nettle, buckthorn and flax meal). Growth performances have been taken into consideration, and at the end of the experiment 6 pigs from each group were slaughtered in order to determine fatty acids profile and cholesterol content of *longissimus dorsi* muscle and of the haunch. The forage had 9.05% ω3 acid, and this lead to the modification of ω-3:ω-6 ratio in E group, reducing it from 1:28.55 in *l. dorsi* and 1:23.69 in the haunch, to 1:10.55 and 1:12.04. The cholesterol content (mg cholesterol / 100 g meat sample) has significantly decreased in E group from 37.6 in *l. dorsi* and 36.8 in the haunch, to 32.9 and 16.4.

Key words: pigs, Camelina, linoleic acid, linolenic acid, anti oxidant premix

INTRODUCTION

High quality animal products must meet the consumer's requirements, not only with regards towards meat content in lipids, but also in the lipids composition. The lipid composition modifies meat's technological characteristics, organoleptic and dietary proprieties. (Chilliard, 1999).

Polyunsaturated fatty acids are responsible for: increasing the serum concentration in lipoprotein cholesterol, growth hormones, insulin and HDL (good cholesterol) concentration.

Linoleic acid (polyunsaturated fatty acid n=6) is essential, and represents the predecessor of eicosanoids, while polyunsaturated fatty acids like n=3 have an important role in the lipids membrane, especially in the retina and in the nerves. The lack of α – linoleic (n=3) fatty acid will lead to clinical deficiency symptoms and dermatitis. (The National Academy of Science, 2002).

As a result of these important roles, there are recommendations for increasing the amount of polyunsaturated fatty acids in human food, especially long chain fatty acids like n=3, to an ratio of 5:1, between ω6:ω3. (Weiseman, 2006).

The changes made in pigs nutrition, are an efficient method for changing fat content in fatty acids, thus modifying fatty acids from human diet. N-3 long chain PUFA level can be increased by using in pigs' nutrition various plants rich in n-3 fatty acids, such as flax oil seeds with more than 50% 18:3 n-3 (M. Kouba, 2003).

This study had the same objective: increasing the meat's content in linolenic acid by using Camelina oil, oil that has more than 46% linolenic fatty acid. This research is part of CEEX 8/2005 Project, where INCDBNA was the project manager.

MATERIALS AND METHODS

The project took place in INCDBNA – IBNA Balotesti, using 24 Large White pigs, divided into 2 equal groups (pilot group and experimental group), and dividing them equally by sex. Both groups where raised in the same shelter. The experiment lasted 42 days (March – April), and the initial average weight was 67 kg.

The compound feeds were in accordance with pig weight, and were formulated according to NRC 98 recommendations (table 1). The differences between the compound feeds formulations were:

- for the control group we used standard forages (such as corn, sunflower meal and full fat soy;
- for the experimental group, we used organic forages, from farms with organic certifications (such as corn, sunflower meal, toasted soy beans, Camelina oil obtained by cold pressing) and anti oxidative premix based on plants manufactured by Hofigal S.A. – CEEX 8 partner.

Table 1 – Compound feeds structure

Ingredients	**C**	**E**
Corn*	69.6	57.6
Sunflower meal **	8.0	15.0
Soybean meal	8.0	-
Full fat soy ***	9.0	-
Camelina oil	-	3.0
anti oxidative premix based on plants ****	-	2.0
Choline premix	0.1	0.1
Monocalcium phosphate	2.45	2.45
Calcium	1.45	1.45
Salt	0.4	0.4

Vitamin - mineral premix	1.0	1.0
Total	100	100
Analyzed		
Gross protein (%)	14.71	14.44
Metabolic energy Kcal/kg	3107	3146
Mj/kg	13.0	13.16
Lysine %	0.68	0.68
Methionine + Cystine %	0.55	0.58
Calcium %	0.99	1.04

* In E we used corn from organic farms

** In E we used sunflower meal obtained through cold milling, from organic farms

***In E we used soy from organic farms

****The antioxidant premix consisted of: Jerusalem Artichoke, nettle, buckthorn, flax seeds meal.

Table 2 shows the fatty acids profile of the feed ingredients and of the finished compound feeds. Pigs had free access to the water. The feed was given in two daily meals and the pigs had free access to the feed.

At the beginning and at the end of the experiment the weight for each pig was registered.

Six pigs from each group were slaughtered and samples of *longissimus dorsi* and haunch were collected and assayed for dry matter, gross protein, ash, fatty acids and cholesterol.

Table 2 – Fatty acid profile for the forages used in the experiment

Fatty acids (g/100 g GB)	**Corn**	**Full fat soy**	**Sun flower meal**	**Camelina oil**	**Anti oxidant premix**	**CF – C**	**CF - E**
Saturated fatty acids	11.29	11.82	6.05	4.45	21.06	11.46	9.37
- myristic (14:0)	0.28	0.07	0.07	0.00	1.26	0.46	0.10
- palmitic (16:0)	11.01	10.02	4.68	4.45	19.80	10.66	7.81
- stearic (18:0)	0.00	1.73	1.30	0.00	0.00	0.34	1.46
Unsaturated fatty acids:	88.71	88.19	93.61	95.55	78.60	88.22	88.9
monounsaturated:	18.43	16.69	12.70	16.13	53.72	22.95	15.20
-myristoleic (14:1)	0.00	0.00	0.00	0.00	30.24	0.00	0.00
-oleic (18:1)	18.43	16.69	12.70	16.13	23.48	22.95	15.20
Polyunsaturated	70.28	71.5	80.91	79.42	24.88	65.27	73.70
-linoleic (18:2)	70.28	65.20	80.86	24.51	9.06	62.51	64.65
-linolenic (18:3)	0.00	6.30	0.05	46.71	15.82	2.76	9.05
-arachic (18-4, n:3)	-	-	-	8.20	-	0.00	1.73
Other fatty acids	-	-	0.31	-	0.34	0.32	-
Saturated fatty acids / Unsaturated fatty	1/7.83	1/7.46	1/15.47	1/21.47	1/3.79	1/7.69	1/9.49

acids							
MUFA / PUFA	1/3.81	1/ 4.28	1/ 6.37	1/ 4.9	1/ 0.46	1/ 2.84	1/ 4.85
Fatty acids ω6/ω 3	-	-	-	-	-	22.64:1	7.14:1

The experimental data was analyzed statistically, using the Student test in order to determinate the differences.

RESULTS AND DISCUSSION

Regarding combined forages content in fatty acids, in E we can observe a bigger content of polyunsaturated fatty acids (more than 13%). This content is due to the high concentration in linoleic acid (9.05 g), acid that came especially from Camelina oil. This content is much bigger than the one Leskanich et al. obtained in 1997 by adding rapeseed oil and fish oil.

The production performances of the animals (table 3) place them within the limits of the breed.

The daily feed intake was much higher in E which resulted into a higher final weight, into an increased daily gain, but the obtained differences were not significant. ($P \geq 0.05$).

Table 3 – Feed intake, weight gain and ADG

Specification	MU	Group M	Group E
Average daily intake	Kg	3.38	3.67
Feed conversion ratio	Kg compound feed/kg gain	4.53	4.43
Average initial weight	Kg	67.90^{a}	66.30^{a}
Average final weight	Kg	99.19^{a}	101.07^{a}
Average daily gain	Kg	0.745^{a}	0.828^{a}

^{a} means in the same row with the same superscript don't differ significantly ($P \geq 0.05$).

Carcass quality (tables 4 and 5), which was the main objective of this research, was different between the two groups, especially as fatty acids profile and in cholesterol content.

Table 4 – Gross chemical composition for *longissimus dorsi* and haunch

Specification	C		E	
	***L.d.* muscle**	**Haunch**	***L.d.* muscle**	**Haunch**
Dry matter (%)	29.62^{a}	30.47^{a}	29.95^{a}	25.49^{b}
Gross protein	23.29^{a}	19.45^{a}	23.51^{a}	20.89^{b}
Gross fat	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}

$^{a, b}$ mean values within the same column with different superscript differ significantly ($P \leq 0.05$).

The dry matter, protein, fat and ash content were almost similar for *L.dorsi* muscle in both groups. In the haunch we observed that E group had significantly lower content in ash, dry matter and fat, and a higher content in protein.

For both groups, protein, and lipids content in *l. dorsi* and haunch, is within the limits reported by Banu (2003), but under the limits indicated by Favier (1995).

By adding Camelina oil and anti oxidative premix in the forages used for group E, we significantly ($P \leq 0.05$) modified fatty acids profile. Saturated fatty acids from *l. dorsi* are in smaller quantities in C group, and their value is given especially by palmitic acid. In the haunch, SFA quantity is significantly smaller for E group. In both groups, SFA content is bellow the values indicated by Bout (1988) – 40.74% for Large white, and even bellow the average values given by Rampon in 1994 – 36.4% (quoted by Dinu et al. 2002). Likewise, SFA content obtained from both groups is close to the one obtained by Leskanich et al. 1997, when he also tried to modify the fatty acid profile from pork, by using rapeseed oil and fish oil. Warmants, 1999 by using full fat soy obtained smaller values concerning SFA content for some groups.

Table 5 – Fatty acid profile from L. dorsi., haunch, and cholesterol content

	C		**E**	
Fatty acids g/100g fat	**L.d. muscle**	**Haunch**	**L.d. muscle**	**Haunch**
Saturated:	33.58^a	30.23^a	36.44^b	25.73^b
- myristic	1.17^a	1.30^a	1.55^b	1.03^b
- palmitic	27.13^a	28.21^a	33.76^b	24.70^b
-stearic	5.28^a	0.72	1.13^b	0.00
Unsaturated:	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
- palmitoleic	2.23^a	2.59^a	2.79^b	1.89^b
-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
- linoleic	9.42	17.79^a	10.34^b	18.79^b
- linolenic	0.33	0.54^a	0.98^b	1.56^b
- C20: (4n=6)	0.79	0.95^a	0.41^b	1.17^b
Other fatty acids	1.37	0.55^a	1.91	0.24^b
Saturated fatty acids / unsaturated fatty acids	1:1.94	1:2.29	1:1.69	1:2.88
Monounsaturated fatty acids/Polyunsaturated fatty acids	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
Cholesterol (mg la 100 g sample)	37.60^a	36.80^a	32.90^a	16.40^b

[a, b] mean values within the same column with different superscript differ significantly ($P \leq 0.05$).

SFA content is significantly smaller in *l.dorsi* samples from group E when compared to the content of group C. This is due to the oleic acid content, but PUFA content is significantly higher ($P \leq 0.05$) for all fatty acids in both samples taken from group E. The largest differences can be seen in linoleic acid content (ω:3), where E group has three times the amount determined for C group. These values are close to the ones obtained by Warmants 1999, Bushboom 1991, (using Canola as part of the compound feeds) and by Leskainich 1997, but they aren't over the maximum level recommended by Rampon, quoted by Dinu 2002.

By analyzing the entire fatty acid profile from the two groups, we can observe an improvement in pigs' meat quality, improvement that is over the NLSMB recommendations regarding SFA/PUFA ratio.

The ω:3:ω:6 ratio is greatly improved in E group as a result of using Camelina oil. The ration is 1:10.55 for the *l. dorsi* muscle and 1:12.04 for the haunch, and is over the ratio recommended by M.J. Azain (2004 – 1:1 towards 1:4).

In both groups we can observe that the cholesterol content is quite low, (37.6 and 36.8 in C group, and 32.9 and 16.4 mg/100 g sample in E group), and the difference is significant ($P \leq 0.05$). The values obtained in our experiment are much lower than the ones indicated by Favier (1995: 61 mg/100 g sample) Rappa (2000: 81 – 94 mg/100 g sample) and Bragagnola (2006: 42-53 mg/100 g sample.

CONCLUSIONS

By using 3% Camelina oil obtained through cold pressing, with more than 46% linolenic acid, an indigenous energy source, we can obtain compound feed for pigs in the finishing phase with more than 9% linolenic acid.

The high quantity of linolenic acid from the compound feeds, has significantly modified in a positive way, the ω:3:ω:6 ratio, reducing it from 1:28.55 (in *l. dorsi*) and 1:23.69 (in the haunch) in C group to 1:10.55, and 1:12.04 in E group.

Because of the negative correlation between PUFA and cholesterol content, in group E cholesterol was significantly decreased.

All these allow us to conclude that by adding Camelina oil in finishing pigs compound feeds we can modify fatty acids profile and lowers the cholesterol from the meat, and therefore improve meat quality.

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