Effect of feeding n-3 enriched fish oil to slaughter pigs on pork quality

E. Hallenstvedt[1,2], A.C. Rehnberg[3] & M. Thomassen[1]
[1]Department of Animal and Aquacultural Science, Norwegian University of Life Sciences, P.O. Box 5003, N-1432 Ås, Norway, E-mail: magny.thomassen@umb.no.
[2] Felleskjøpet Fôrutvikling, Bromstadveien 57, N-7005 Trondheim, Norway, E-mail: elin.hallenstvedt@fkf.no.
[3]Animalia - Norwegian Meat and Poultry Research Centre, P.O.Box 396 – Økern N-0513 Oslo, Norway, E-mail: anna.rehnberg@animalia.no.

Abstract

The aim of this study was to increase the level of n-3 fatty acids in pork by feeding EPA and DHA enriched fish oil to male and female slaughter pigs without compromising the sensory quality. Seventy two crossbred (LYDD) male and female pigs were restricted and individually fed with six diets; two low fat diets with or without 0.5% fish oil added, and four medium fat diets added palm kernel oil and fish oil blends from 4.1:0 to 3.4:0.7. Fatty acid composition in *Longissimus Dorsi* was analysed and sensory evaluation according to ISO 6564 was performed on fresh neck meat from females. Increased levels of fish oil in the diet significantly raised the n-3 level in meat, with 0.7% giving 0.38, 0.31 and 0.36% of EPA, DPA and DHA in meat. Less EPA was deposited when feeding 0.5% fish oil in low fat versus medium fat diet. Males deposited significantly more n-3 than females. No significant differences in sensory attributes were found between dietary groups. In conclusion increasing the fish oil up to 0.7% in the diet gave higher deposition of the very long chain n-3 fatty acids but no negative effect on sensory evaluation.

Introduction

The fatty acid profile in pork products can be changed with different fat sources in feed (Wood et al., 2003). Recent years the focus has been on changing the fatty acid profile from saturated (SFA) to more polyunsaturated (PUFA) fatty acids, especially the level of long chain (LC) n-3 fatty acids, giving a healthier product for human consumption. To increase the level of n-3 fatty acids in pork products α-linolenic acid can be used. This fatty acid can be elongated and desaturated into eicosapentaenoic acid (EPA) and docosapentaenoic acid (DPA). Increased level of docosahexaenoic acid (DHA) is obtained when present in diet (Romans, Johnson, Wulf, Libal & Costello, 1995). However these fatty acids are susceptible to oxidation and can have negative impact on the quality such as shelf-life, colour, flavour and smell when given in high inclusion. In addition there has been found an effect of interaction between LC n-3 fatty acids and the level of PUFA (Bryhni, Kjos, Ofstad & Hunt, 2002) in the diet has been observed. A future ban of castration of male pigs is in focus in Norway. Effects of sex on fatty acid deposition has been found in earlier studies where castrated males were shown to have higher levels of SFA and MUFA and lower level of PUFA compared to female pigs (Zhang, Knight, Stalder, Goodwin, Lonergan & Beitz, 2007). Possible differences in fatty acid composition between male and female pigs are less investigated.

In this experiment the effect of different levels of EPA and DHA enriched fish oil in combination with palm kernel oil on pork quality was investigated. The aim of the experiment was: 1.To increase the level of long chain n-3 PUFA without compromising the pork quality and 2.To evaluate the effect of sex on pork fatty acid composition.

Materials and methods

Seventy two crossbred [(Norwegian Landrace x Yorkshire) x Duroc] entire male and female pigs were allotted according to litter, live weight and sex in a randomized block design; six animals of the same sex per pen and six animals per treatment. Live weight at start and in the end of the experiment was 24.3 kg and 95.5 kg respectively. The animals were individually fed according to a restricted scale for growing-finishing pigs.

In the experiment palm kernel oil (PK) and EPA and DHA enriched fish oil (F) were used. They were analyzed according the methods described by AOCS for fatty acid composition and oxidation by the peroxide and anisidin values. Nearly 80 % of the fatty acids in the palm kernel oil were saturated and consisted mainly of C12:0 and C14:0. The fish oil contained 33% C20:5 and C22:6. The anisidine and peroxide value of the fish oil were 9.6 and 6.6 respectively at feed production. Six different experimental diets were formulated and produced. Two low fat diets without (LF) or with 0.5% fish oil (LFF2), and four diets with a medium fat level and the ratio of palm kernel oil and fish oil was as follows: 4.1:0 (PK1),

3.9:0.3 (PK2F1), 3.6:0.5 (PK3F2) and 3.4:0.7 (PK4F3). All diets were formulated to contain the same amount of amino acids per energy unit (MJ) and 212mg/kg of Vitamin E (dl-α-tocopheryl acetat).

Muscle samples of *Longissimus Dorsi* from P2 location (Overland & Sundstol, 1995) were collected the day after slaughter and analyzed for neutral fatty acid profile.

Sensory analysis was performed on female fresh neck of pork. Prior to the sensory evaluation, each chop was divided in two and vacuum packed in bags. The chops were heated in a 75 ºC water bath for 40 minutes. A trained 11-member panel (Nofima Mat, Ås, Norway) evaluated each sample, in random order, for 21 sensory attributes. Fat and meat were evaluated for sensory traits together. Each member evaluated the samples on a computerized system for direct recording of data, using a continuous scale. The computer translated the responses into numbers between 1 and 9, where 1 equals no intensity and 9 equals high intensity. The sensory analysis was performed according to international standards (ISO 6564).

Results and discussion

The fatty acid profile differed between the dietary groups and showed similarities to the fatty acid profile in the diet. The proportion of total MUFA and the fatty acid C18:1 was higher in pigs fed low fat diets compared to PK diets (Table 1). This is most probably due to de novo synthesis of fatty acids and a substantial delta-9-desaturation activity which seemed to be higher in female than male pigs. The diet had a considerably impact on the content of LC n-3 fatty acids in *Longissimus Dorsi.* All pigs had C20:5, C22:5 and C22:6 present in the muscle, but the amount increased with increasing levels in the diet. The percentage of C18:3, C20:5 and C22:6 were lower but C22:5 higher than in the diet. This suggests a substantial elongation from C20:5 to C22:5 in pigs. Higher dietary fish oil inclusion also resulted in a lower n-6:n-3 ratio in the meat making it more preferable for human nutrition. Less EPA was deposited when feeding 0.5% fish oil in low fat versus medium fat diet. Sex had an impact on the fatty acid profile in the muscle even though no difference in lean meat percentage was detected. Males appeared to have less MUFA and higher levels of SFA and PUFA and higher deposition of LC n-3 PUFA compared to females.

There were no significant differences (P<0.05) in sensory attributes between the dietary groups. Table 2 shows 11 of the 21 attributes considered most relevant to give an apprehension on how the added fatty acids affect meat and fat sensory quality. Neck of pork is a rather fatty part of the pig and one should expect negative apprehensions if there was any off-taste related to the fat added to the diet.

Table 1. The effect of diet and sex on fatty acid composition (% of total fatty acids) in *Longissimus Dorsi* at P2 location

	Diet							Sex		
	LF	LFF2	PK1	PK2F1	PK3F2	PK4F3	Sign[a]	Entire male	Female	Sign[a]
C12:0	0.16[a]	0.14[a]	0.77[b]	0.68[b]	0.68[b]	0.72[b]	***	0.61	0.44	***
C14:0	1.49[a]	1.43[a]	2.96[b]	2.81[b]	2.78[b]	2.91[b]	***	2.59	2.21	***
C16:0	24.24[b]	23.01[a]	24.09[b]	24.27[b]	23.97[ab]	24.51[b]	***	24.16	23.86	ns
C16:1 n-7	4.5	3.53	4.01	3.84	3.96	3.98	ns	3.76	4.03	*
C18:0	12.73	13.75	12.95	13.39	12.94	12.99	ns	13.49	12.77	*
C18:1[b]	47.23[b]	47.28[b]	43.41[a]	43.26[a]	43.20[a]	42.58[a]	***	42.92	46.07	***
C18:2 n-6	6.08[a]	6.09[a]	7.31[b]	7.05[ab]	7.39[b]	7.29[b]	***	7.58	6.16	***
C18:3 n-3	0.46[a]	0.48[ab]	0.52[ab]	0.56[ab]	0.57[ab]	0.58[b]	**	0.58	0.47	***
C20:1 n-9	0.75[bc]	0.81[c]	0.68[ab]	0.68[ab]	0.64[a]	0.62[a]	***	0.69	0.70	ns
C20:4 n-6	0.61	0.64	0.68	0.56	0.58	0.50	ns	0.64	0.55	ns
C20:5 n-3	0.05[a]	0.18[b]	0.08[ab]	0.16[b]	0.30[c]	0.38[c]	***	0.23	0.16	***
C22:5 n-3	0.09[a]	0.23[bcde]	0.13[a]	0.22[bcd]	0.29[de]	0.31[e]	***	0.24	0.18	***
C22:6 n-3	0.06[a]	0.20[b]	0.11[ab]	0.19[b]	0.28[bc]	0.36[c]	***	0.22	0.18	*
∑ SFA	38.78[ab]	38.46[a]	40.92[c]	41.31[c]	40.51[bc]	41.29[c]	***	40.98	39.44	***
∑ MUFA	52.03[b]	51.62[b]	48.09[a]	47.77[a]	47.80[a]	47.18[a]	***	47.38	50.79	***
∑ PUFA	7.35[a]	7.82[a]	8.83[ab]	8.73[ab]	9.41[b]	9.41[b]	***	9.49	7.69	***
n6:n3 ratio	10.78[c]	6.51[ab]	9.88[c]	6.97[b]	5.78[ab]	4.82[a]	***	7.23	7.69	ns
P:S[c] ratio	0.26[a]	0.29[ab]	0.29[ab]	0.29[ab]	0.32[b]	0.32[b]	*	0.32	0.27	***

[a] Significance of differences between samples in each row within diet and sex. ns: $p>0.05$; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$.

[b] Sum of C18:1 n-7 and n-9 but mainly n-9 has been present in earlier studies.

[c] P=C18:2, C18:3, C20:4, C20:5, C22:5 and C22:6, S=C12:0, C14:0, C16:0.

Table 2. The effect of diet on sensory attributes of neck of pork from female pigs

	LF	LFF2	PK1	PK2F1	PK3F2	PK4F3	Sign[a]
Odour							
Intensity	6.15	6.20	6.22	6.01	6.30	6.25	ns
Meat	3.88	3.89	4.02	3.94	4.02	3.90	ns
Pork	3.35	3.35	3.11	3.13	3.30	3.16	ns
Rancid	1.18	1.20	1.12	1.11	1.21	1.29	ns
Flavour							
Intensity	5.99	6.03	6.09	5.99	6.08	6.19	ns
Meat	4.35	4.35	4.47	4.51	4.35	4.17	ns
Pork	2.68	2.68	2.60	2.38	2.52	2.52	ns
Rancid	1.26	1.28	1.15	1.18	1.35	1.39	ns
Oily	2.25	2.45	2.50	2.33	2.90	2.91	ns
Texture							
Tenderness	5.24	5.04	5.10	5.22	4.94	5.11	ns
Juiciness	5.06	5.01	5.16	5.05	4.83	5.06	ns

[a]Significance of differences between samples in each row. ns: $p>0.05$; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

Conclusions

The fatty acid profile change with diet and LC PUFA are easily increased in products when given in the diet. In addition the sex had an impact on the fatty acid profile where males had higher levels of SFA and PUFA but a lower level of MUFA. An amount of 0.7 % of fish oil in combination with palm kernel oil up to 3.4 % in the diet does not seem to give the consumers an off-taste when the product is consumed fresh.

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