DIETARY TREATMENT AND OXIDATIVE STABILITY OF MUSCLE AND MEAT PRODUCTS: NUTRITIVE VALUE, SENSORY QUALITY AND SAFETY.

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ABSTRACT

Positive effects on cholesterol level in human blood have been demonstrated in a dietary intervention study in human subjects, in which pig meat and fat from animals raised on a feed with an increased fraction of mono-unsaturated fatty acids from added 6% vegetable oil had replaced traditionally produced meat and fat. Processed meats based on this high mono-unsaturated pork need supra-nutritional vitamin E in the feed to be oxidatively stable, while fresh meat is less affected. The fat source was, however, found to be more important for development of lipid derived flavour volatiles in the processed meat than dietary vitamin E level. The fat source is also important for vitamin E uptake in pigs and poultry, with chicken having the best uptake. Copper salts added as a growth promoter have little if any prooxidative effect in these meats. While vegetable fat sources like rape-seed oil gives no oxidative stress in the live animal, plasma vitamin E was partly depleted in the humans after the high mono-unsaturated meat period and vitamin E from other sources may be important. Certain regionally produced traditional meat products made from the nutritive improved pork does, however, not meet regulatory or quality standards (to high unsaturation, smearing or insufficient drying), and a lower level like 2% of vegetable oil in the feed may for certain productions be advisable.

INTRODUCTION

With the overall objective of providing a better scientific understanding of the effects of dietary modifications for pigs and poultry on the physiological status while alive and on any technology modifications necessary for production of muscle foods, based on animals raised on a modified feed, with optimum shelf-life, colour stability, flavour, overall wholesomeness, nutritive value and toxicological safety, the EU Commission sponsored the partners (listed in the references) to form the DIET-OX consortium in the projects period 1995-97. The project has covered important aspect of quality in meat and meat products produced from pigs, chicken and turkeys, which in different regions of Europe was exposed to different feeding regime partly based on local crops and tradition. High mono-unsaturated lipids as dominant in the Mediterranean diet are known to have positive effects on blood parameters since substitution of saturated fatty acid with mono-unsaturates lower the cholesterol level. Since the fatty acid distribution, in particular in the adipose lipids, in monogastric animals like the pig is highly dependent on the fatty acid distribution in the feed, especially for high fat feeds, the nutritive value of meat and fat can be improved by a change toward more unsaturation in the animal feed, provided that lipid oxidation in the feed, in the live animal and in the meat products can be controlled. Improved nutritive value of meat has thus been attempted by the use of the 10 feeding regimes of Table 1, which included different levels of α-tocopherol as a natural antioxidant and of copper as a growth promoter together with a standard feed as reference.

RESULTS AND DISCUSSION

Dietary inclusion of 6% high oleic rape-seed or sunflower oil markedly decreased saturated fatty acid concentration of backfat in pigs (from 41-45% to 30-32%) to a lesser degree of intramuscular neutral fat and hardly changed the phospholipids. Moreover, dietary inclusion of vegetable oil also enhanced the concentration of α-tocopherol in tissue and reduced susceptibility of the resulting meat to lipid peroxidation. However, certain quality characteristics like appearance, fat consistency and likely flavour were negatively affected, especially for processed meat, although a correct combination of added fat and added vitamin E gave the nutritional improved meat products acceptable functional properties. Vitamin E accumulation in tissue was found to be directly related to the α-tocopherol concentration in the diet but also to depend on the level and type of oil added to the feed. While fresh meat showed little peroxidation independent of feeding regime, chilled stored meat packed in high oxygen atmosphere in order to improve colour, chill stored pre-frozen pork or highly processed products like dinner sausages made from meat from pigs raised on the oil-enriched feed needed dietary supplementation with vitamin E to the production animals in order to prevent rancidity. For Iberian hams no differences in lipid oxidation were found between products made from extensively raised pigs fed acorn and grass and

pigs raised on a commercial feed provided that the latter was supplemented with 100 ppm vitamin E. However, the sensory properties were clearly different as the Montanera hams had a more intense and more acorn-like odour and flavour. Vitamin E supplementation reduced, however, the development of the secondary lipid oxidation product hexanal. For the Italian products, only Salami had a higher peroxide value when made from meat from oil-supplemented pigs; other products like Coppa and Parma ham had rather similar development of primary and secondary lipid oxidation products and cholesterol oxides independent of feeding regime. However, a high sunflower oil supplementation gave a too high degree of unsaturation in Parma ham, and similarly 6% addition of rape-seed oil resulted in meat which was not suitable for production of typical German raw Salami-type sausages due to smearing and insufficient drying. A reduction to 2% rape-seed oil supplementation, however, seems to constitute a viable compromise for production of sausages with improved nutritive value and acceptable functional properties.

Table 1. Feeding regime. The basis of the project[1]

1. Basal diet based on barley[2]
2. Basal diet plus 6% vegetable oil[2]
3. Basal diet plus 6 % vegetable oil plus 100 mg Vit.E
4. Basal diet plus 6% vegetable oil plus 200 mg Vit. E[2]
5. Basal diet plus 6% vegetable oil plus 35 mg Cu
6. Basal diet plus 6% vegetable oil plus 35 mg Cu plus 100 mg Vit. E
7. Basal diet plus 6% vegetable oil plus 35 mg Cu plus 200 mg Vit. E
8. Basal diet plus 6% vegetable oil plus 175 mg Cu
9. Basal diet plus 6% vegetable oil plus 175 mg Cu plus 100 mg Vit. E
10. Basal diet plus 6% vegetable oil plus 175 mg Cu plus 200 mg Vit. E

[1] This feeding plan was used by the Danish and German pig line with high oleic rape-seed oil. In a second feeding trial with the German pig line only 2 % rape-seed oil was added. For the Italian pig line sunflower oil was used.

[2] Meat and lard from pigs raised on these three feeds used in the controlled randomised single-blind dietary intervention study in healthy, human subjects.

Copper added as a growth promoter improved performance in most cases but no signs of copper accumulation in muscles were found and copper added to feed did not have any peroxidative effect in the meat or any of the meat products investigated. Neither was copper found to have any negative effect on vitamin E level in meat. These results apply both to pork and chicken meat.

As for poultry, a clear vitamin E effect was found on the oxidative stability. For pre-cooked chicken patties, the dietary oil (tallow or olive oil) had no effect on the oxidative processes, while 200 ppm vitamin E in the diet clearly improved the sensory quality of the product. For cooked turkey meat, however, both the oil source and the vitamin E level affected lipid oxidation, as higher unsaturation increased the level of secondary lipid oxidation products, which again could be reduced by an increased vitamin E level. For frozen turkey meat, lipid oxidation was also affected by dietary fat (rape seed ~ soy > tallow) and specific muscle effects were noted (Sartorius > Pectoralis). The decrease in vitamin E in the meat during frozen storage was surprisingly similar and independent of feeding regime. In chicken, β-carotene had a pro-oxidative effect under certain conditions while an anti-oxidative effect was demonstrated for other conditions. β-carotene most clearly showed an anti-oxidative effect in chicken meat, when tissue vitamin E was above a certain threshold. In a storage experiment which chilled chicken meat from birds fed different combinations of β-carotene and vitamin E, vitamin E appeared to be oxidised in the presence of β-carotene and it seems like β-carotene acts like an antioxidant only when tissue vitamin E is high.

In one case, for the Danish pig line, meat, lard and meat products were used to perform a controlled randomised single-blind dietary intervention study in human subjects in order to evaluate the effect of three of the treatments of pork meat and pork fat on risk markers for coronary heart disease and to measure the content and availability of vitamin E and selenium from the diets. This study shows that it is possible to improve the nutritional value of pig fat by changing the feeding regime for the pig. Inclusion of 6% rape-seed oil in the pig feed resulted in a fatty acid composition of the fat giving a significantly lower total cholesterol concentration in young, healthy, male subjects when a diet based on meat and fat from these pigs was given over three weeks.

CONCLUSION

For several pig lines, for turkeys and chicken dietary modifications have been shown to be a valuable tool in changing the fatty acid profile of the meat in a more healthy direction. Moreover, the health effect was demonstrated in a dietary intervention study in healthy human subjects. For any product certain percussion in relation to protection against oxidation should, however, always be considered and studied. Such protection has for a number of traditional European pork and poultry products been shown to be possible also through feed modifications. Vitamin E addition to the feed is most important for meat, which is processed, while fresh meat is hardly affected by the change in fatty acid towards more unsaturation. Depending on the type of meat and on the degree of processing, different levels up to 200 ppm vitamin E may be recommended for addition to the feed.

In the DIET-OX project it has thus been possible to study effects of changes in animals fed on the performance, on physiological parameters in the live animal, on the oxidative stability of meat and meat products and on the improvement in nutritive value. Besides this integration along the production chain from feed to food and beyond, the European dimension was also covered, since traditional products from different European regions were included also with the goal of changing the fatty acid profile of meat produced in the Northern part of Europe toward a more Mediterranean profile.

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REFERENCES

The results of the DIET-OX project will be or has been published in scientific papers by the individual partners, who were:
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