Influence of dietary fat source and vitamin E on quality of frozen pork meat products

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Introduction Increasing monounsaturates in pork and pork meat products increases nutritive value and gives meat a healthy image, but unwanted changes of functionality and oxidative stability has so far been concerning the meat industry. The content of monounsaturates in pig meat can easily be increased by changing the fatty acid composition of the dietary fat (Morgan *et al.,* 1992). Rape seed oil (canola) has relative high amounts of oleic acid and feeding high amounts of rape seed oil will increase monounsaturates, but will at the same time increase the content of linolenic acid which has detrimental effects on the oxidative stability of pig meat and pig meat products (Miller *et al.,* 1990).

Incorporation of vitamin E in pig muscle by increasing dietary vitamin E levels has been shown to be an efficient method to improve oxidative stability of pig meat lipids (Jensen *et al.,*1997; Monahan *et al.,* 1992). Dietary vitamin E has also been found to decrease drip loss (Asghar *et al.,*1991) and to improve color stability of pork chops (Monahan *et al.,*1992).

The activity of lipid oxidation reactions in meat and meat products are determined by a number of factors; level of vitamin E, amount of highly oxidizable polyunsaturated lipids and content of prooxidative species. Copper ions are an effective prooxidant and are used in animal production as a growth promoter in the form of $CuSO_4$. This study was undertaken to study the effects of rape seed oil, vitamin E and $CuSO_4$ on color stability, drip loss and lipid oxidation on prefrozen pork chops and on lipid oxidation in vacuum packed frozen stored dinner sausages.

Materials and Methods Eighty Danish Landrace pigs were divided into groups of eight and given a control diet and 9 different rape seed oil (Canola) diets differing in content of $CuSO_4$ (0, 35 and 135 mg/kg) and vitamin E (0, 100, 200 mg/kg). The pigs were reared at the Danish Institute of Animal Science, Research Centre Foulum, Tjele, Denmark, as will be described in a separate paper (C, Lauridsen *et al.,* to be published). Following slaughter, the carcasses were chilled over night, the loins were removed and cut into bone less pork chops. The chops were packed in oxygen permeable film and stored at -25°C. After 10 months of frozen storage chops were placed on polystyrene trays, wrapped in an oxygen permeable PVC film and thawed over night at +4°C. Chops were then placed in an illuminated chill cabinet at +4°C for up to 7 days. Surface color (L, a and b-values) were recorded using a Minolta Colorimeter CM901i. Drip loss was calculated as the percentage reduction in weight from the weight of the frozen sample. Lipid oxidation was measured as the development in thiobarbituric acid reactive substances (TBARS) using the method described by Vyncke, 1977. The level of vitamin E, expressed as mg α-tocopherol/kg meat was determined using the method described in Jensen *et al.,* 1997. Dinner sausages containing 15% fat was produced from individual animals, vacuum packed in oxygen impermeable film and stored at -25°C. After 7 months of storage sausages was thawed at +4°C overnight and vitamin E and TBARS was determined according to Vyncke, 1975 and Jensen, *et al.,* 1997, respectively.
The measurements of vitamin E, TBARS, surface color and drip loss were analyzed by analysis of variance including main effects of rape seed oil, Cu and vitamin E, as well as interaction between factors. Analysis of variance was performed by the procedure GLM in SAS® (SAS/STAT User's Guide, 1990) and significant differences were estimated by the procedure of Least Significant Difference (LSD). Only control feed and feed no 1 was included when the effect of rape seed oil was analyzed, whereas the effect of vitamin E was performed on feed 1 to 9.

Results and discussion Cu supplementation was found not to influence levels of quality of prefrozen pork chops or frozen dinner sausages and results were pooled accordingly.

The amount of vitamin E found in chops after 7 months of frozen storage is presented in Table 1. A significantly higher amount of vitamin E was found in pigs fed rape seed oil and no vitamin E compared with pigs fed the control feed. Increasing vitamin E supplementation in pigs fed rape seed oil resulted in increased vitamin E muscle levels (Table 1). Vitamin E levels decreased in all chops during the 7 days of illuminated chill storage, the relative loss of vitamin E was highest in chops from control pigs (32%). In chops from pigs fed rape seed oil the relative loss was 22%, 20% and 18%, when pigs were fed 0, 100 and 200 mg vitamin E, respectively.

Development of lipid oxidation measured as TBARS during chill storage is summarized in Figure 1. In pigs fed rape seed oil, lipid oxidation in chops from vitamin E supplemented pigs were significantly lower compared with pigs fed non-supplemented diets. Chops from control pigs produced the highest TBARS numbers after 0 and 4 days of chill storage compared to pigs fed rape seed oil and no vitamin E, but this difference was not observed after 7 days of storage. The observed loss of endogenous vitamin E during chill storage seems well correlated to lipid oxidation activity as the most profound loss of vitamin E was seen in chops having the highest TBARS numbers. Lipid oxidation activity seems to be highly correlated to vitamin E muscle levels and a markedly protection by vitamin E is observed in chops from pigs fed 100 or 200 mg vitamin E. Feeding pigs high amounts of rape seed oil did not accelerate lipid oxidation in prefrozen pork chops, as the highest numbers of TBARS was found in chops from control pigs, which had received no rape seed oil.

Dietary treatments did not influence drip loss (Table 1), or surface color (results not shown). The absent effect of vitamin E on drip loss has been reported previously (Jensen *et al.,* 1997), whereas others have found muscle vitamin E levels to decrease drip loss (Asghar *et al.,* 1991). Monahan *et al.,*1994 have shown a close relation between lipid oxidation and myoglobin oxidation in prefrozen pork chops during chill storage and suggested that myoglobin oxidation preceeds lipid oxidation. In the present study we found no relationship between color stability and lipid oxidation, which is in accordance with previously reported results on fresh meat (Jensen *et al.,* 1997, Lanari et al., 1996).

The content of vitamin E and TBARS in vacuum packed dinner sausages after 7 months of frozen storage is summarized in Table 2. In pigs fed rape seed oil the level of sausage vitamin E reflected dietary vitamin E levels. The lower vitamin E levels found in dinner sausages compared to pork chops, are due to loss of the vitamin caused by mincing and heating of the product. Although, sausages were vacuum packed, high numbers of TBARS was found. The TBARS numbers were significantly lower in dinner sausages from pigs fed rape seed oil diets supplemented with vitamin E, when compared to pigs fed rape seed oil and no vitamin E. The level of lipid oxidation was significantly lower in dinner sausages produced from control pigs compared to the level found in sausages from pigs fed rape seed oil and no vitamin E. The high activity of lipid oxidation in sausages from control pigs fed rape seed oil and no vitamin E compared to sausages from control pigs can be explained by the incorporation of higher

amounts of polyunsaturated fatty acids originating from the rape seed oil. The effect of dietary fat source is more pronounced in the dinner sausages as the average fat content is 15% compared to 2% in pork chops. The detrimental effects of feeding rape seed oil on the lipid stability of dinner sausages are eliminated in sausages from pigs fed the vitamin E supplemented rape seed oil diets.

Conclusion Feeding rape seed oil to pigs changes the fatty acid profile towards more monounsaturates but does not influence the quality of prefrozen pork chops negatively. Increasing muscle vitamin E levels significantly protects prefrozen pork chops against lipid oxidation during chill storage.

Production of high fat pork products such as the Danish dinner sausages from pigs fed rape seed oil results in increased lipid oxidation in these products, but the negative effects of dietary rape seed oil on lipid oxidation can easily be eliminated by increasing muscle vitamin E levels.

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Table 1 Muscle vitamin E levels and drip loss in prefrozen pork chops from pigs fed different levels of rape seed oil and vitamin E during chill storage.

Dietary Rape seed oil	Dietary vitamin E (mg/kg)	n	Chill storage 0 days		Chill storage 4 days		Chill storage 7 days	
			Vitamin E (mg/kg)	Drip loss (%)	Vitamin E (mg/kg)	Drip loss (%)	Vitamin E (mg/kg)	Drip loss (%)
0% (Control)	0 mg	8	1.7^{a} (.6)	11.9 (2.0)	na	15.1 (2.8)	1.2^{a} (0.5)	18.3 (1.7)
6%	0 mg	24	2.5^{b} (.8)	12.8 (3.8)	na	15.1 (4.3)	2.0^{b} (.9)	17.2 (4.2)
6%	100 mg	24	4.0^{c} (.9)	12.7 (1.1)	na	14.3 (1.7)	3.2^{c} (1.2)	17.1 (2.6)
6%	200 mg	24	5.0^{d}(1.2)	13.8 (2.1)	na	15.0 (2.4)	4.1^{d} (0.9)	17.7 (2.0)

^{a,b,c,d} Means with different superscripts within a column differ significantly (P<0.05)

Table 2 Lipid oxidation and vitamin E content in vacuum packed dinner sausages after 7 months of frozen storage (-25° C) produced from pigs fed different levels of rape seed oil and vitamin E .

Dietary	Dietary α-	n	Vitamin E	TBARS
0 %	0	8	1.3^{a} (0.4)	6.0^{a} (3.1)
6%	0	24	1.9^{a} (0.60)	10.7^{b} (2.6)
6%	100	24	3.8^{b} (0.9)	5.8^{a} (1.6)
6%	200	24	4.1^{b} (0.9)	5.8^{a} (1.2)

^{a,b} Means with different superscripts within a column differ significantly (P<0.05)

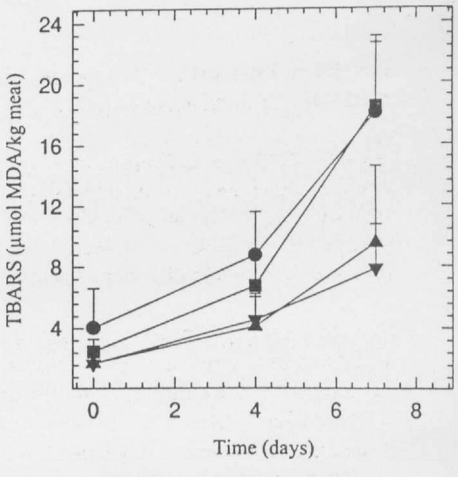

Figure 1 Development in lipid oxidation measured as TBARS i prefrozen pork chops during chill storage. Pigs were fed ● control diet, ■ rape seed oil and 0 mg vitamin E, ▲ rape seed oil and 100 mg vitamin E or ▼ rape seed o and 200 mg vitamin E