INFLUENCE OF DIETARY SUPPLEMENTATION WITH OILS IN THE PRESENCE OR ABSENCE OF VITAMIN E ON LIPID PEROXIDATION IN DUCK MEAT

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Background

Lipid oxidation is one of the primary causes of quality deterioration in meat and meat products. The susceptibility of stored meat to lipid oxidation depends on a number of factors, the most important being the degree of unsaturation of the fatty acids present and the balance of pro- and antioxidants in the muscle system (Morrissey *et al.*, 1994). The addition of fat in poultry diets is a cheap source of energy (Sanz *et al.*, 1999). Duck meat is affected more by diet than chicken meat since ducks are known to consume twice as much feed during growth than broiler chicks (El-Deek *et al.*, 1997). While increasing the PUFA content of duck diets may result in an increase in the degree of unsaturation of muscle and a subsequent increase in its nutritive value, the low levels of antioxidants may give rise to an increase in lipid peroxidation in meat. The addition of an antioxidant, such as α-tocopheryl acetate, has been shown to inhibit lipid oxidation in turkeys (Wen, 1996) and chickens (O'Neill, 1996), but little is known of the effects of diets composed of lipids and antioxidants on the oxidative stability of duck meat.

Objective

The objective of this study was to measure the effects of oils varying in the degree of unsaturation with a control and a supplemented level of α-tocopheryl acetate on the α-tocopherol content, fatty acid profile and oxidative stability of breast and thigh muscles of ducks.

Methods

One day old ducklings were fed basal (20 mg) or supplemented (400 mg) α-tocopheryl acetate per kg of feed which contained 25 g/kg of oils (tallow, sunflower oil, olive oil or linseed oil) over a 7 week period forming eight separate diets (denoted by the first letter of oil and the level of vitamin E in the diet, i.e., T20, T400, S20, S400, O20, O400 and L20, L400 for tallow, sunflower oil, olive oil and linseed oil, respectively). Breast and thigh muscle samples were collected following slaughter. Vitamin E levels were determined by HPLC according to the method of Buttriss and Diplock (1984). Lipids were extracted from muscle samples according to the method of Folch *et al.* (1957). Fatty acid composition of the lipids was then determined by gas chromatography of the fatty acid methyl esters (FAME). Meat patties were formed from both muscle samples, overwrapped in cling film (6000-8000 cm^3/m^3/ 24 h at STP) and were stored in a refrigerated display cabinet (4 °C) over a 10 day period. The extent of lipid oxidation in the meat samples was assessed by the 2-thiobarbituric acid (TBA) method of Ke *et al.* (1977) at days 0, 2, 4, 6, 8 and 10.

Results and discussion

Overall, it was shown that α-tocopheryl acetate supplementation of diets for ducks increased ($p<0.05$) α-tocopherol levels in both breast and thigh muscle samples (Figure 1) irrespective of the dietary oil feed, and other authors reported similar findings for other poultry muscle systems (Nama *et al.*, 1997; Mercier *et al.*, 1998). For the supplemented α-tocopheryl acetate diets (400 mg/kg feed/ day), the tallow fed group had the greatest content of vitamin E in breast muscle samples whereas the group fed linseed oil reported highest vitamin E values for thigh muscle samples. Ducks fed olive oil and supplemented α-tocopheryl acetate were found to have lowest vitamin E in both breast and thigh muscles. Vitamin E levels were reported to be higher in thigh muscles than breast muscles in diets O20, O400, S400 and L400. Lin *et al.* (1989) suggested that differences in vitamin E between these muscle classes were attributed to a more highly developed vascular system in the thigh muscle. In general, the greater the amount of endogenous vitamin E present in muscles, the better protection the muscle had against oxidative attack.

From the fatty acid methyl ester (FAME) analysis, high levels of $C_{16:0}$, $C_{18:0}$, $C_{18:1}$, $C_{18:2}$ and $C_{20:4}$ fatty acids were present in both breast and thigh muscles (Figures 2 and 3). In both breast and thigh muscles, the total saturated fatty acid (SFA) content was high from ducks fed diets containing tallow ($p< 0.05$). Generally, for both muscle samples, ducks fed olive oil had the highest levels of monounsaturated fatty acid (MUFA) and diets containing sunflower oil had the highest level of polyunsaturated fatty acid (PUFA).

All dietary groups supplemented with α-tocopheryl acetate were shown to be oxidatively stable over the ten-day period of analysis and had significantly lower TBARS ($p < 0.05$) values than groups fed the basal diet irrespective of the oil fed (Figures 4 and 5). The TBARS values for muscle samples from ducks fed basal diet with linseed oil were higher than TBARS reported for the other seven dietary groups and this may be attributed to the higher content of PUFA in these samples. Muscle samples from ducks fed basal diets with tallow or olive oil had lower TBARS than the other dietary groups, suggesting that meat containing a high level of saturated fat are more resistant to oxidation than those with high levels of PUFA. In support of these findings, Sklan *et al.* (1983) reported that meat samples of turkeys fed unsaturated soya oil were more oxidised than those fed tallow.

Conclusions

Supplementation of duck diets with α-tocopherol acetate was found to increase tissue vitamin E concentration and oxidative stability of the muscle samples analysed irrespective of the dietary oil used. The composition of the dietary oils fed in the diets affected the fatty acid composition in breast and thigh muscles. Feeding ducks with more unsaturated oils such as linseed and sunflower oil, compared to tallow or olive oil led to more rapid oxidation processes. While it is nutritionally advantageous from a consumer viewpoint to introduce PUFA into the diets of ducks, these fatty acids have been shown to affect the oxidative stability of muscle. However, supplementation of these high PUFA content diets with α-tocopheryl acetate was shown to decrease oxidation in all muscle samples.

References

Buttriss, J.L. and Diplock, A.T. **1984**. High performance liquid chromatography methods for vitamin E in tissues. *Methods in Enzymology*, 104: 131-138.

Folch, J., Lees, M., Sloane Stanley, G.H. **1957**. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.*, 226:497-509.

Ke, P.J., Ackman, R.G., Linke, B.A., Nash, B.A. **1977**. Differential lipid oxidation in various parts of frozen mackerel. *J. Food Tech.*, 12: 37-47.

Lauridsen, C., Buckley, D.J. and Morrissey, P.A. **1997**. Influence of dietary fat and vitamin E supplementation on α-tocopherol levels and fatty acid profiles in chick muscle membranal fractions and on susceptibility to lipid peroxidation. *Meat Science* **46**, 9-22.

Lin, C.F., Gray, J.I. Asghar, A., Buckley, D.J. Boreen, A.M. and Flegal, C.J. **1989**. Effects of dietary oils and α-tocopherol supplementation on lipid composition and stabil of broiler meat. *Journal of Food Science*, **54**, 1457-1462.

Mercier, Y., Gatellier, P., Viau, M., Remignon, H. and Renerre, M. **1998**. Effect of dietary fat and Vitamin E on colour stability and on lipid and protein oxidation in turk meat during storage. *Meat Science*, **48**, 301-318.

Morrissey, P.A., Buckley, D.J. and Sheehy, P.J.A., **1994**. Vitamin E and meat quality. *Proceedings of the Nutrition Society*, **53**, 289-295.

Nama K.T., Leea H.A., Minb, B.S. and Kanga C.W. **1997**. Influence of dietary supplementation with linseed and vitamin E on fatty acids, tocopherol and lipid peroxidati in muscles of broiler chicks. *Animal Feed Science Technology*, **66**, 149-158.

Sklan, D., Tenne, Z. and Budowski, P. **1983**. The effect of dietary fat and tocopherol on lipolysis and oxidation in turkey meat stored at different temperatures. *Poul Science*, **62**, 2017-2021.

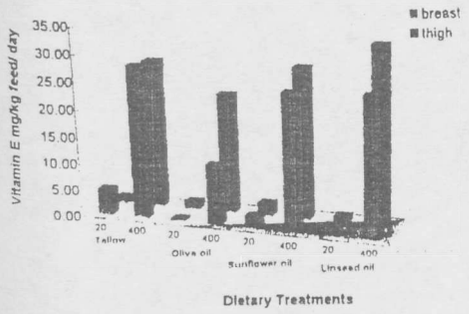

Figure 1. Vitamin E content mg/kg breast and thigh muscles for the eight dietary groups

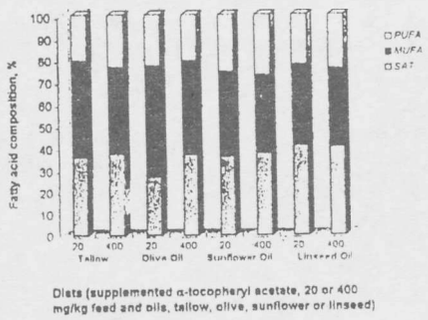

Figure 2. Fatty acid composition of breast meat from eig dietary treatments

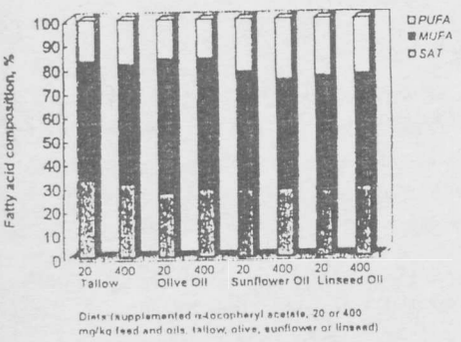

Figure 3. Fatty acid composition of thigh meat from eight dietary treatments

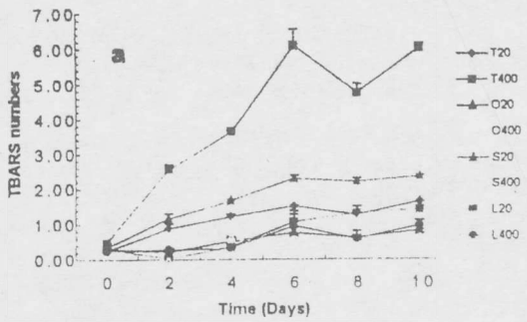

Figure 4a

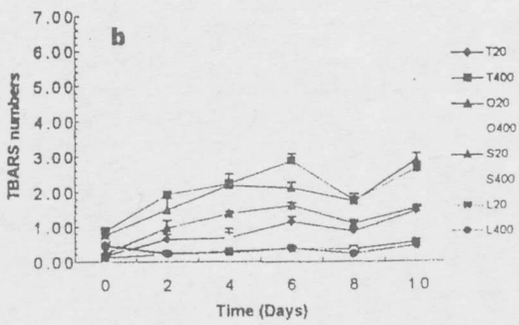

Figure 4b

Figures 4a,b. Effect of dietary α-tocopheryl acetate supplementation (20 or 400 mg Vitamin E/kg) with dietary tallow (T), olive oil (O), sunflower oil (S) or linseed oil (L) as a function of time on the oxidative stability of fresh duck breast patties (figure 4a) or thigh patties (figure 4b) overwrapped and held in a refrigerated (4 °C) display cabinet.