Dietary fat and vitamin E supplementation affect lipid oxidation in cooked turkey meat

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BACKGROUND Oxidation is one of the major causes of the development of off-flavours in muscle foods, particularly after cooking. Susceptibility of meats to oxidative reactions results from their content in polyunsaturated fatty acids (PUFA) and from the balance between pro-oxidative and anti-oxidative activities (Gray et al., 1996). Accordingly, turkey meat which is one of the less stable meat toward oxidative process, contains high quantities of PUFA and generally low levels of vitamin E. In previous studies, we have established that the fatty acid composition and the vitamin E content of the diet affected PUFA and vitamin E status of turkey muscles (Genot et al., 1997 ; Viau et al., 1998) and consequently the susceptibility of turkey meat to oxidation during refrigerated (Mercier et al., 1998a) and frozen storage (Mercier et al., 1998b).

Objective The present study deals with the effects of dietary fat and vitamin E supply on lipid oxidation in cooked *Pectoralis* muscle of turkey.

MATERIALS AND METHODS

Male turkeys of British United Turkey (BUT) strain were reared at the Station of Poultry Researches (INRA, Tours). Animals were divided into 6 batches of 6 animals fed *ad libitum* for 16 weeks with basal diets containing 6 % fat (tallow : T ; rapeseed oil : R or soya oil : S) and 200 mg/kg (E) or no (control = C) added α-tocopheryl acetate (Hoffman-Laroche, France)

Pectoralis muscles were dissected immediately after slaughter, placed on trays, overwrapped with an O_2 permeable PVC film and stored at + 4°C in darkness for 72 hours. Muscles were cut into escalopes (2 cm thickness) which were weighed and cooked in a wet oven (RH = 100 ; temperature = 120°C) to internal temperature 75°C. After cooling for one hour at ambient temperature, escalopes were individually wrapped in O_2 impermeable bags, sealed under mild vacuum and kept overnight at +4°C in the dark. The day after, meat samples were wiped and weighed. Cooking yields were calculated to relate results to raw meat weight.

Polyunsaturated fatty acid (PUFA) percentages and quantities in phospholipids (PL) and triglycerides (TG) of raw meat were determined following the procedure described in Leseigneur-Meynier and Gandemer (1991). Vitamin E content was determined on raw meat according to the method of Buttriss and Diplock (1984). The results were expressed in µg of vitamin E / g of raw meat.

Thiobarbituric acid reactive substances (TBA-rs) were extracted from ground raw and cooked meat with 5 % trichloroacetic acid and reacted with 20 mM TBA at 70°C for 30 min (Salih et al., 1987 ; Bostsoglou et al., 1994). To decrease the limit of detection and enhance the reproducibility of the method, the absorbance at 532 nm (A532) was corrected from the drift of the baseline using the following equations : (i) raw meat : A532corrected = A532 - [(A508 - A600) x (600 - 532) / (600 - 508)] - A600 ; (ii) cooked meat : A532corrected = A532 - [(A473 - A600) x (600 - 532) / (600 - 473)] - A600. Results were expressed as mg equivalent malondialdehyde / kg raw meat (mg eq. MDA/kg raw meat) using the molar extinction coefficient of MDA-TBA adduct ($1.56\ 10^5\ M^{-1}\ cm^{-1}$).

Volatile compounds were extracted from 1-2 g minced cooked samples and analysed by the dynamic head space method with a purge-and-trap system paired with a gas-liquid chromatograph and either a flame ionisation detector for quantification or a mass spectrometer for identification (Meynier et al., 1998). Results were expressed in ng eq. nonane/g raw meat.

RESULTS

Vit E and PUFA in raw meat. As expected, dietary fat and vitamin E supply affected vitamin E and PUFA status of turkey *Pectoralis* muscle (Table 1). Changes in FA composition were more pronounced in TG than in PL.

Table 1 *Effect of dietary fat and vitamin E supply on PUFA and vit E in raw meat and on lipid oxidation in raw and cooked meat.*

	Dietary fat						Variance analysis		
	Tallow		Rapeseed oil		Soya oil				
	Control	Vit E	Control	Vit E	Control	Vit E	Fat	Vitamin	Fat x Vit
Raw meat									
Vit E (1)	0.5 *a*	4.0 *e*	1.0 *b*	3.4 *d*	0.4 *a*	2.9 c	***	***	***
PUFA in TG (2)	17.9 *a*	18.0 *a*	28.2 *b*	26.8 *b*	45.8 *c*	46.9 *c*	***	NS	NS
PUFA in PL (2)	41.3 *b*	41.3 *b*	39.6 *a*	39.2 *a*	47.2 *c*	47.7 *c*	***	NS	NS
TBA-rs after 72 h at +4°C (3)	0.04 *a*	0.03 *a*	0.11 *b*	0.05 *a*	0.13 *b*	0.04 *a*	***	***	**
Cooked meat									
TBA-rs (3)	0.74 *b*	0.17 *a*	0.63 *b*	0.32 *a*	1.62 *d*	0.94 *c*	***	***	**
hexanal (4)	1418 *b*	289 *a*	1812 *b*	2176 *b*	3929 *d*	3189 c	***	**	**
1-octen-3-ol (4)	76 *b*	19 *a*	80 *b*	73 *b*	200 *c*	123 b	***	***	**

*(1) : mg/kg muscle ; (2) : % total FAME ; (3) : mg eq MDA/kg raw meat ; (4) : ng eq. nonane/g raw meat ; n=6 ; on the same lines values superscript with different letters were significantly different. NS : not significant, ** P<0.05, *** P<0.01.*

Lipid oxidation in fresh meat. Twenty-four hours *post mortem,* TBA-rs of *Pectoralis* muscle were low and similar whatever the diet (0.04 mg eq. MDA/kg raw meat). After 72 hours of ageing at + 4°C, TBA-rs increased significantly in meat of animals fed control diets and vegetable oil (RC and SC) and remained very low in other batches (Table 1).

Lipid oxidation in cooked meat. Cooking induced to a sharp increase in lipid oxidation whatever the diet as shown by TBA-rs (Table 1). It also causes the formation of numerous volatile compounds among them approximately 50 molecules were identified. The major compounds were hexanal and 1-octen-3-ol which were formed *via* the oxidation of n-6 fatty acids such as linoleic and arachidonic acids (Meynier et al., 1998). Dietary fat and vitamin E supply affect lipid oxidation. Lipid oxidation was the lowest in the muscles of animals fed tallow and vitamin E (TE) and the highest for SC muscles. Vitamin E reduced significantly the amount of TBA-rs whatever the fat. It also reduced the quantities of hexanal and 1-octen-3-ol except for rapeseed oil samples. However, the level of oxidation in SE samples remained far higher than in other samples, indicating that vitamin E present in SE samples was less effective to reduce lipid oxidation during cooking than in other samples. One may suggest that a higher level of vitamin E addition in diet, inducing a further increase of Vit E in muscles, would improve the stability of meat of turkeys fed a high PUFA diet (soya oil).

PUFA/Vit E ratio in raw meat and lipid oxidation in cooked meat. To take into account the fact that lipid oxidation in cooked meat depends on both promoting and inhibiting factors present in raw meat, PUFA/Vit E ratio (W/W) were calculated in TG and PL of raw meat (Fig. 1).

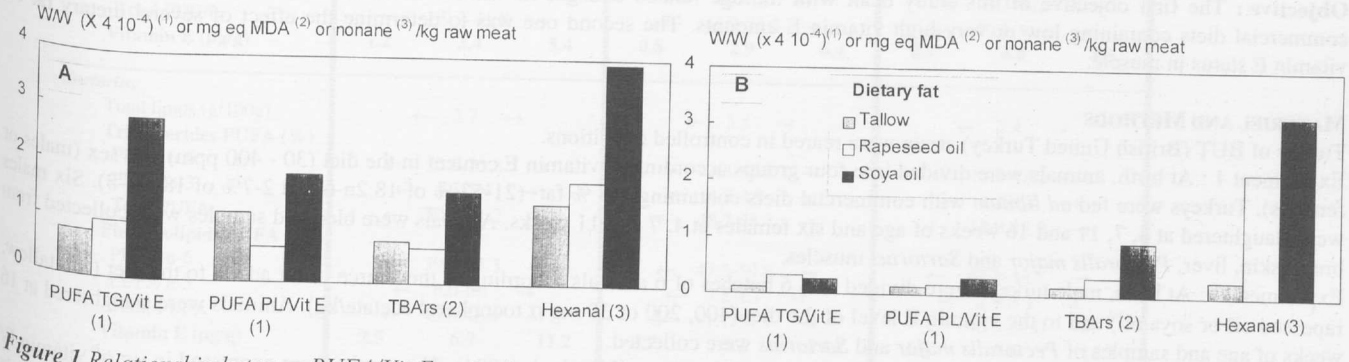

Figure 1 *Relationship between PUFA/Vit E ratios in raw meat and lipid oxidation in cooked Pectoralis of turkeys fed 0 (A) or 200 (B) mg/kg α-tocopherol acetate and different dietary fats.*

In cooked meat of control turkeys (Figure 1-A), lipid oxidation was clearly related to PUFA TG/Vit E ratio while it was related to PUFA PL/Vit E ratio in supplemented animals (Fig. 1-B). Thus these ratios were better predictors of the level of meat oxidation in cooked meat than PUFA or vitamin E contents of raw meat. They give an first evaluation of muscle oxidability even if they cannot reflect the influence of all parameters involved in lipid oxidation in cooked meat.

CONCLUSION : In raw meat stored 72 hours at +4°C, vitamin E supply was efficient to reduce lipid oxidation whatever dietary fat. In cooked meat, both dietary fat and vitamin E supply influenced lipid oxidation. Addition of vitamin E (200 mg/kg) to a "low PUFA" diet (tallow) and to an "intermediate PUFA diet" (rapeseed oil) reduced largely oxidation in cooked turkey meat. Vitamin E added to a "high PUFA" diet (soya oil), also decreased significantly lipid oxidation, but was not sufficient to prevent the reaction. PUFA/vit E (W/W) ratios take into account both influences of vitamin E status and PUFA content of muscles on meat oxidability. Further investigations will be required to understand why lipid oxidation in cooked meat is related to PUFA TG/Vit E ratio in raw meat of control turkeys and to PUFA PL/VitE ratio in supplemented ones.

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