

EFFECTS OF GENOTYPE, AGE AND NUTRITION ON INTRAMUSCULAR LIPIDS AND MEAT QUALITY

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ABSTRACT

By combining genotype, age and nutrition it is possible to achieve modulation within a wide range of intramuscular lipid levels. Increasing lipid levels mainly results in increased triglyceride, saturated and mono-unsaturated fatty acids in duck meat. The activity of glycolytic energy metabolism is decreased while that of oxidative energy metabolism is stimulated. Lightness, yellowness, juice loss after cooking, tenderness, and flavour of meat are increased. The composition of intramuscular lipids can be also modified according the fatty acid composition of the diet. Finally, it is possible to prevent duck meat oxidation during cold storage by supplementing diets with vitamin E.

KEY WORDS: Age, Duck, Lipids, Genotype, Overfeeding, Muscle.

INTRODUCTION

From 1993 to 2005, the world duck production almost doubled, and meat production rose from 1.72 to 3.45 million tons (Magdelaine, 2006). Asia is the leading production region (83% of duck meat output in 2005). In Europe, France is the leading producer with 248,000 tons in 2005. The main species used to produce duck meat are Pekin (*Anas platyrhynchos*), Muscovy (*Cairina moscata*, mostly in France) and mule ducks (mostly in France for the production of fatty liver and Taiwan). The mule duck is the crossbreed between Muscovy male and common female ducks (mainly Pekin) and benefits from a heterosis effect for ingestion capacity and fatty liver production (greater liver weight and lower lipid release after heating). It therefore provides the major part of duck fatty liver (“foie gras”) produced in France (97% of ducklings reared for fatty liver production in 2002 according Ofival, 2003) and represents 55% of total French duck meat production (Magdelaine, 2006). The hinny duck is the reverse crossbreed. Other duck species are used mainly for egg production and meat is a by-product.

Duck meat is red. Lipid levels and oxidative energy metabolism are higher in duck meat than in chicken or turkey meat. Lipids are therefore an important component of duck meat. The effects of the main factors (genotype, age and nutrition) involved in the variability of intramuscular lipid levels (quantity and quality) and on technological and sensorial quality of duck meat will be detailed.

MODULATION OF INTRAMUSCULAR LIPID LEVELS

Comparing Pekin and Muscovy ducks and their crossbred mule and hinny ducks, Chartrin *et al.* (2006b) showed that genotype had a significant effect on lipid levels in muscles (Table 1). The Pekin duck had the highest lipid, phospholipid and triglyceride levels in breast and

thigh muscles and the Muscovy duck had the lowest levels. The proportion of monounsaturated fatty acids (neo-synthesised by the liver) was also highest in muscles of Pekin ducks while the proportions of saturated and polyunsaturated were lowest (Chartrin *et al.*, 2006b). The Muscovy duck exhibited the reverse. The hybrid ducks had intermediate values to parental species for these parameters. In muscles, lipids mainly accumulate in adipocytes, the relative area measured on cross-sections of breast and thigh muscles being highest in Pekin ducks (Chartrin *et al.*, 2005). Lipids also accumulate in muscle fibres, particularly those with oxydo-glycolytic energy metabolism (type IIa), the triglyceride content of which is highest in breast muscles of Pekin ducks (Chartrin *et al.*, 2005).

Table 1. Genotype effects on lipid, triglyceride, phospholipid and saturated, mono- and polyunsaturated fatty acids (SFA, MUFA, PUFA), the relative area occupied by adipocytes on cross-sectional area of muscles and lightness (Lc RO) of oxydo-glycolytic fibres (type IIa) induced by triglyceride deposition (red oil staining) in breast muscles of 14 weeks-old ducks (mean \pm SE, n = 16, Chartrin *et al.*, 2005 ; 2006a)

	Muscovy	Hinny	Mule	Pekin
Lipids (g/100 g)	2.95 \pm 0.42 d	4.90 \pm 1.19 b	4.18 \pm 0.75 c	6.08 \pm 0.74 a
Triglycerides (g/ 100 g)	1.69 \pm 0.36 d	3.27 \pm 0.79 b	2.73 \pm 0.66 c	4.52 \pm 0.71 a
Phospholipids (g/100 g)	1.14 \pm 0.14 b	1.48 \pm 0.39 a	1.32 \pm 0.18 a	1.40 \pm 0.14 a
SFA (% total FA)	38.6 \pm 1.4 a	35.9 \pm 2.6 b	37.4 \pm 1.5 a	32.9 \pm 1.2 c
MUFA (% total FA)	41.8 \pm 1.9 d	45.7 \pm 2.9 b	43.9 \pm 2.3 c	50.4 \pm 2.0 a
PUFA (% total FA)	19.6 \pm 1.6 a	18.4 \pm 1.1 a	18.7 \pm 2.4 a	16.7 \pm 1.4 b
Adipocytes (% surface)	1.73 \pm 0.45 c	2.75 \pm 0.56 b	2.79 \pm 0.85 b	3.76 \pm 1.28 a
LcRO fibres IIa	137 \pm 24 a	111 \pm 29 b	132 \pm 26 ab	115 \pm 26 ab

a-d: significant effect of genotypes, P < 0.05. Lightness is negatively correlated with the amounts of triglycerides stored in muscle fibres.

Overfeeding-stimulated hepatic lipogenesis also induces an accumulation of lipids in muscles containing mainly triglycerides rich in monounsaturated fatty acids. The relative surface occupied by adipocytes and the triglyceride content of muscle fibres are significantly increased (Chartrin *et al.*, 2005; 2006b).

When considering the slaughter period, age also results in increasing muscle lipid content (Baéza *et al.*, 2000; 2002) and modified lipid composition, as previously described, with preferential storage in intramuscular adipocytes (Chartrin *et al.*, 2006c).

Finally, genotype, overfeeding and age have similar effects on the variations in lipid content, lipid composition and lipid localisation. In breast muscle, the lipid content is 2-fold higher in Pekin ducks than in Muscovy ducks, 1.6 higher in overfed ducks than in ad libitum fed ducks and 1.4-fold higher in 98-day-old mule ducks than in 75-day-old mule ducks fed ad libitum (Chartrin *et al.*, 2006b; 2006c).

When lipid content in muscles is increased the activity of glycolytic energy metabolism is decreased and that of oxidative energy metabolism is stimulated (Baéza *et al.*, 2005).

By combining genotypes (Muscovy and Pekin ducks and their crossbred hinny and mule ducks) and feeding levels (overfeeding and ad libitum feeding), Chartrin *et al.* (2006a) were able to obtain a wide range of lipid content in breast meat (from 1.72 to 8.35%). Sensorial analysis showed that increase in muscle lipid content increases lightness, yellowness, juice

loss after cooking, tenderness and flavour of meat, with significant correlation coefficients (0.49, 0.47, 0.54, 0.43 and 0.28, respectively, Figure 1). The increase in lipid content of breast muscle with age may be involved in the increase in meat flavour (Baéza *et al.*, 1997; 2000; 2002).

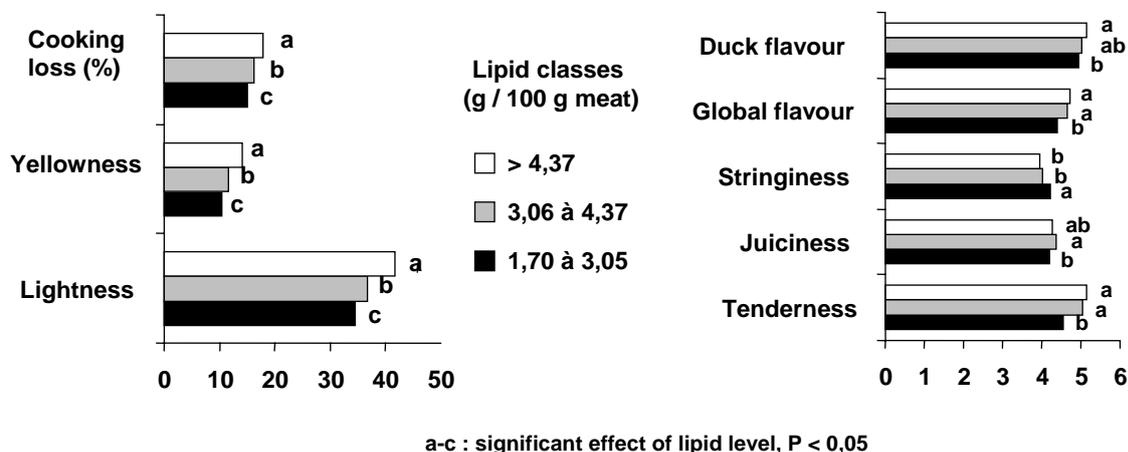


Figure 1. Consequences of increased lipid levels on breast meat quality of ducks.

MODULATION OF INTRAMUSCULAR LIPID COMPOSITION

The composition of intramuscular lipids can be also modified according the fatty acid composition of the diet without changing lipid levels. It is possible to enrich duck meat in ω -3 fatty acids by including fish meal or fish oil in the diet, but the sensory acceptance of such meat is lower than meat from ducks fed with diet containing soybean meal (El-Deek *et al.*, 1997; Schiavone *et al.*, 2004).

Duck meat has higher lipid content than chicken and turkey meat. As the meat of other poultry species, it contains high levels of unsaturated fatty acids (around 60% of total fatty acids) and also high levels of haeminc pigments (haemoglobin and myoglobin, Baéza *et al.*, 2002) rich in iron which is a good catalyst of oxidation reactions. The susceptibility of duck meat to oxidation is thus higher than chicken or turkey meat. There are many studies concerning the supplementation of diet with high levels of vitamin E to limit the oxidation of turkey and chicken meat but there are few studies on duck meat. Only Romboli *et al.* (1997) and Salichon *et al.* (1998) have demonstrated the value of a diet supplemented with vitamin E to prevent duck meat oxidation during cold storage.

CONCLUSION

Duck meat is highly appreciated as it combines the characteristics of a red meat (containing for example high levels of phospholipids, precursors of aromas) and the dietetic characteristics of poultry meat (containing for example high levels of unsaturated fatty acids, representing around 60% of total fatty acids). By combining genotype, age and nutrition it is possible to achieve modulation within a wide range of intramuscular lipid levels. The duck is therefore a good model to study the metabolic mechanisms responsible for these variations and their consequences on sensorial (particularly the determination of cooked meat flavour) and technological (particularly the storage ability of crude and processed meat) quality.

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