

PHOSPHOLIPID COMPOSITION OF THREE MUSCLES AS RELATED TO THEIR FIBRE COMPOSITION AND TO THEIR OXIDATIVE PATTERN IN THE CHICKEN.

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INTRODUCTION

Lipid composition of Chicken muscles have been widely studied. Most of authors have compared lipid composition of red and white meat (Jantawat and Dawson, 1980; Grey *et al.*, 1983). For this purpose, they analysed lipids of *Pectoralis* and thigh and drumstick muscles. If *Pectoralis* is a pure glycolytic muscle (100% α W fibres), thigh and drumstick are composed of several muscles with various oxidative pattern. Consequently the relationships between metabolic type of fibres and lipid composition are not clearly established in Chicken muscles up to now. This question is of interest because metabolic type of fibres is one of the major factors involved in variability of meat quality traits. Thus, muscles composed of a large proportion of glycolytic fibres (α W) are less sensitive to oxidation and also less tasty and juicy than muscles formed of a majority of oxidative fibres. To control the quality of meat products, we need more knowledge about composition and *post-mortem* changes in the main components of muscles as related to the metabolic type of the fibres. Within muscle components, phospholipids are very interesting to consider because they are largely involved in meat flavour. Thus, they are very sensitive to oxidation causing off-flavour but they are also required for the formation of desirable cooked meat aroma (Gray and Pearson, 1987; Whitfield, 1992).

In this study, we compared phospholipid composition of three muscles with different metabolic patterns. We determined the relative proportions of fibre types and the metabolic pattern of the 3 muscles. All the parameters were measured in 3, 5, 11 and 55 week old chicken.

MATERIAL AND METHODS

10 to 60 male chickens of X 33 strain (Ricard, 1975) were slaughtered at 3, 5, 11 and 55 weeks of age at a live weight of 285, 670, 1882, 3685 g, respectively. The following muscles were dissected from the carcasses: *Pectoralis major*, *Sartorius* and *Anterior latissimus dorsi* (ALD). Samples used for histological study were frozen in isopentane cooled by liquid nitrogen. Samples used for enzyme activities determinations and lipid analyses were frozen directly in liquid nitrogen. Samples were stored at -80°C until analyses.

Relative proportions of fibre types were estimated on a cross-sections processed for myofibrillar ATPase technique after incubation at pH 4.20, 4.35 and 10.40 (Guth and Samaha, 1969). Fibres were classified as α W, α R, β R and α' and β' (Ashmore and Doerr, 1971). Percentages of each fibre type were calculated using an original computerised image analysis system (Lefaucheur *et al.*, 1992). The glycolytic and oxidative patterns of the 3 muscles were estimated by the measurement of lactate dehydrogenase (LDH, E.C. 1.1.1.27) and citrate synthase (CS, E.C. 13.7) activities (Bass *et al.*, 1969).

Lipids were extracted from 2 to 5 g of meat (Folch *et al.* 1957). Phospholipid content of the muscles was estimated by the phosphorus measurement in total lipid extracts (Bartlett, 1959). After phospholipid purification from total lipid extracts on silica cartridges (Juaneda and Rocquelin, 1985), the relative proportions of the phospholipid classes were determined using the normal phase HPLC method. 200 μg of phospholipids were injected on a column (4.5 x 250 mm, Lichrospher Si 60 5 μm). Phospholipid classes were separated using a solvent gradient and were quantified with a light scattering detector (Leseigneur-Meynier *et al.*, 1989). Results were expressed as % of total phospholipid fraction. Data were subjected to a variance analysis according to the GML procedure of SAS software. The model included the effects of muscle (3 levels) and age (4 levels).

RESULTS AND DISCUSSION.

On the basis of relative proportions of the fibre types, *Pectoralis* is a pure glycolytic muscle (100% α W), *Sartorius* is an intermediate muscle (50% α W, 35% α R, 15% β R) and *ALD* is an pure oxidative muscle (0% α W)(fig. 2). It should be underlined that the oxidative fibres of *ALD* are α' and β' , which have been described only in avian muscles. They differ from α R and β R fibres. One fact of particular interest for this study is their low mitochondria content as compared to the one of typical α R and β R fibres.

LDH or CS activity gives an overall estimation of glycolytic or oxidative pattern of muscles. In this study, the results on the enzyme activities were in a good agreement with the relative proportions of fibre types in the three muscles. Thus, the higher was the α W fibre proportion, the higher was the LDH activity. CS is a mitochondria enzyme belonging to the Kerbs cycle. Its activity is closely related to the mitochondria content of each fibre types. Thus CS activity was very low in *Pectoralis* which contains only α W fibres which are poor in mitochondria. On the contrary, the CS activity is high in *Sartorius* because β R fibres contain a large amount of mitochondria.

In agreement with the published results in various species, the glycolytic muscle (*Pectoralis*) contained less phospholipids than the oxidative ones (*Sartorius* and *ALD*)(fig. 1). This results is attributed to the higher mitochondria content of oxidative fibres. This hypothesis is strongly supported by the higher proportion of cardiolipin in phospholipid fraction of oxidative muscle such as *Sartorius*(fig. 1). Indeed cardiolipin is a phospholipid mainly located in the inner membrane of mitochondria. In spite of its high proportion of oxidative fibres (more than 95%), *ALD* exhibited a low phospholipid and cardiolipin contents and a weak CS activity as compared to *Sartorius* (fig. 1 and 2). This result is consistent with the low mitochondria content of α' and β' fibres.

Figure 1 : Changes in the phospholipid content (-x-) and in the cardiolipin (-◇-), phosphatidyl ethanolamine (-□-) and phosphatidyl choline (-△-) proportions in *Pectoralis major*, *Sartorius* and *Anterior latissimus dorsi* (ALD) during chicken development.

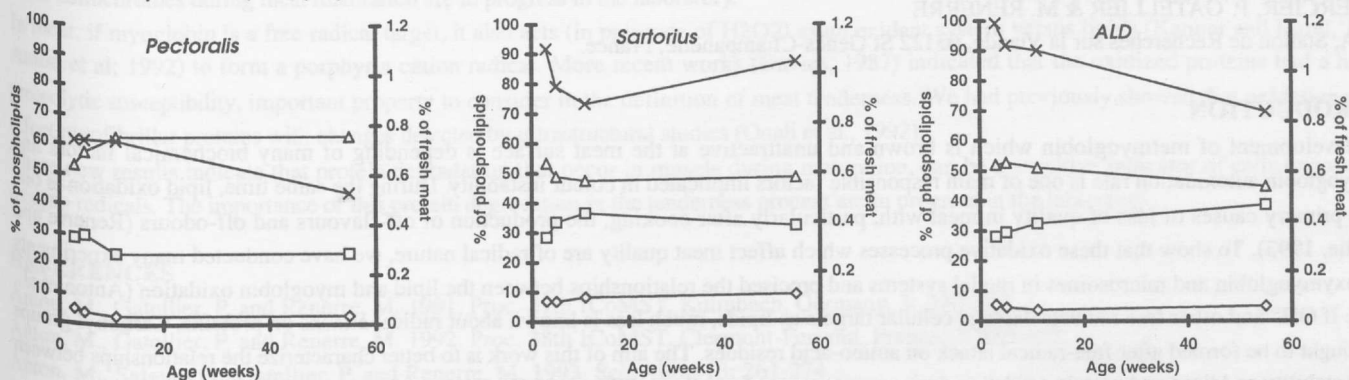
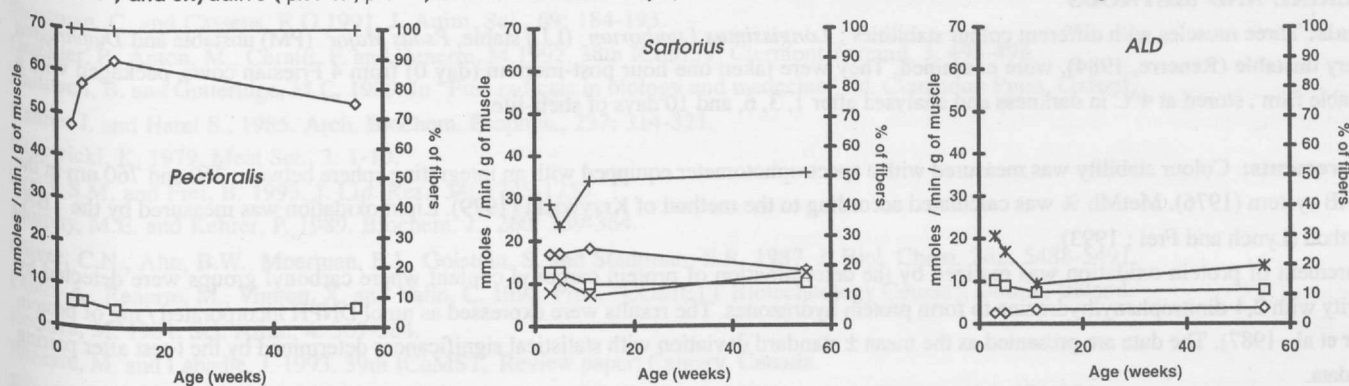


Figure 2 : Changes in the lactate dehydrogenase (-◇-) and citrate synthase (-□-) activities and in the relative proportions of glycolytic (αW : +-+) and oxydative (βR : -x-; β' : -+-) fibres in *Pectoralis major*, *Sartorius* and *Anterior latissimus dorsi* during chicken development



RESULTS AND DISCUSSION

Figure 1 showed that during 10 days storage at 4°C the MDPs in the meat surface increased from 15 to 25 µg for ALD, from 21 to 32 µg for Pectoralis and from 13 to 41 µg for Sartorius with significant differences between muscles only after 10 days storage. This result is in agreement with previous observations obtained from different colour-labile or stable markers (Reardon, 1984; Reardon and Casanova, 1981; Anton et al., 1987) dependent on microbial efficiency. For lipid oxidation, TBA test showed no increase between day 1 and day 10 of storage (figure 2) but at day 10 the quantity of formed MDA is slightly superior in D muscle. However, the increase in formed MDA between day 1 and day 10 was low (less than 0.02) and conversely the increase in formed MDA during the storage was important (0.25). The increase in MDA between day 1 and day 10 was low (less than 0.02) and conversely the increase in formed MDA during the storage was important (0.25). The increase in MDA between day 1 and day 10 was low (less than 0.02) and conversely the increase in formed MDA during the storage was important (0.25). The increase in MDA between day 1 and day 10 was low (less than 0.02) and conversely the increase in formed MDA during the storage was important (0.25).

It was possible for the muscle of βR to be the most oxidized muscle because of the high content of lipid oxidation products between day 10 and day 14 of storage (Reardon et al., 1987) and for the β' it would be better to determine the quantity of phospholipids which are present in the products of the oxidative destruction of lipids (Gruick and Cunniff, 1989) (Table 2) showing the differences between muscles. Protein oxidation has been measured on the total content of the free amino acid nitrogen in muscle between day 1 and day 10 of storage. At day 1, 1.1 µmol FM was found in 100 mg of wet weight of muscle (1.1 µmol/g) and at day 10, 2.3 µmol/g of wet weight. The content of carbonyl groups which is only one of the products of protein oxidation, was higher for D muscle (2.1 µmol/g) which is more oxidative than the other muscles. In different muscles the differences were not significant (figure 3). These values were near to those found by Murphy & Becker (1987) on different muscles of chicken and to those of Reardon et al. (1987) on *Canarium melleum* muscle of rat. The authors showed a higher content of carbonyl groups in βR and β' muscles of the rat (2.4 and 2.0 µmol/g, respectively). Between day 7 and day 10 of storage in aerobic conditions, the carbonyl content of muscle increased from 1.5 to 2.4 µmol/g in the same conditions. This evolution was found 2.1 to 2.4 µmol/g for βR and from 2.1 to 2.7 µmol/g for D muscle. After 10 days storage, the differences between muscles were more evident (P < 0.05) (table 3). A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed. A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed. A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed. A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed. A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed. A significant correlation (r = 0.726, P < 0.05) between carbonyl content and MDPs was observed.