Post mortem evolution in the *Pectoralis superficialis* muscle from two turkey breeds : relationship between pH and colour changes

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SUMMARY

An experiment was carried out to evaluate the rate and the extent of the *post mortem* pH fall in the *Pectoralis superficialis* muscle of turkeys from two breeds (high and low production performance) in relation to meat colour. Changes in ATP and PC levels were followed using ^{31}P NMR. Colour coordinates were determined using spectrophotometry in CIELAB system. In the first assay, as soon as possible after slaughter, *Pectoralis superficialis* muscle of 12 week old turkeys were placed in decreasing temperature conditions in an attempt to stimulate slaughterhouse chilling conditions. The initial rate of pH fall was 2.2 pH unit/hour; ultimate pH was reached 35 min *post mortem*.

In the second assay, *Pectoralis superficialis* muscle of 32 week old turkeys were placed at a temperature of 25°C. In the high performance breed, the rate of pH fall was 1.4 fold faster and the colour less stable than in the low performance breed. The ultimate pH was correlated to redness a* (R = 0.80).These experiments showed that the onset of *rigor mortis* in the *Pectoralis superficialis* turkey muscle was extremely rapid and similar to the onset of *rigor mortis* in the PSE pig muscle but with a higher ultimate pH.

INTRODUCTION

It is now established that a close relationship exists between the rate of pH fall and meat quality. The rate of pH fall is generally considered as abnormal when pH value is under 6 less than one hour after slaughter. This rapid pH fall has an unfavourable effect on the colour and the water holding capacity of pork. A rapid pH fall is observed in turkey breast especially in the *Pectoralis superficialis* muscle (VAN HOOF, 1979). The ultimate pH is reached in less than one hour. Since several years, colour instability in turkey meat has been observed, especially concerning the *Pectoralis superficialis* muscle (LEMEE (1986), METZ (1983) unpublished results). The aim of our study was to evaluate and to compare the rate and the extent of *post mortem* pH fall in the *Pectoralis superficialis* in two different breeds, which are differentiated by production performance. The first one called "Christmas turkey" is characterized by a low carcass weight and more pigmented muscles. The second one is characterized by a high carcass weight (especially *Pectoralis superficialis* and *Pectoralis profondus* muscles) and is used for cutting. We used ^{31}P-NMR to study *post mortem* pH changes and their effect on colour stability.

MATERIAL AND METHODS

In the first experiment, 12 weeks old turkeys were slaughtered in our laboratory. As soon as possible after slaughter, the *Pectoralis superficialis* muscle was excised and placed in conditions of decreasing temperature. The change in temperature was programmed to simulate slaughterhouse conditions (from 40°C to 20°C in 5 hours) for colour measurement. In the second assay, 32 weeks old turkeys from two breeds (high and low production performance) were slaughtered in our laboratory. The *Pectoralis superficialis* muscle was excised and placed in a water bath maintained at 25°C during 5 hours.

Muscle preparation

Samples were collected from *Pectoralis superficialis* muscle of each bird and put into a NMR tube (8mm internal diameter)

^{31}P-NMR conditions

^{31}P-NMR spectra were recorded at 162 MHz on a Bruker AM400 spectrometer. The field homogeneity was obtained by optimization of the water proton spectrum of the muscle. Each spectrum was an average of 32 scans accumulated in a total time of 10 min. with a recycle time of 2s. 45° pulse angles, a sweep width of ±3000 Hz and a exponential line broadening of 20 Hz were used. NMR measurements began 30 min after slaughter and lasted 5 h. The temperature was decreasing for the first assay (from 40°C to 20°C) and maintained at a constant value (25°C) for the second one.

Calculations

ATP, Phosphocreatine (PC), phosphate sugars (SP) and inorganic phosphate (Pi) were estimated from NMR spectra. pH was deducted from NMR using chemical shift of inorganic phosphate.

Colour measurements

Samples were collected at different *post mortem* times : 10 min, 2 h, 5 h, 24 h, 48 h, 7 days and 14 days. Each sample was oxygenated 1 hour before the measurement. Kontron Uvikon spectrometer was used. Spectra were obtained between 360 and 760 nm. The results were expressed as lightness (L*), redness (a*), yellowness (b*) in the CIELAB (1976) system. The rates of meat discolouration were determined by measuring reflectance differences at 630 and 580 nm.

RESULTS and DISCUSSION

The rate of pH fall

NMR spectra were used to calculate pH values. The rate of pH fall is presented on figure 1. Ultimate pH was reached very rapidly while the temperature was still around 40°C. Ultimate pH values were between 5.56 to 5.80, in the same range than those described by WAKEFIELD (1989). The first pH value was obtained only 30 min *post mortem*, the time required for NMR spectrometer setting. The onset of *rigor mortis* in *Pectoralis superficialis* muscle was very rapid (30 min.). The rate of pH fall was 2.2 pH unit/hour.

This phenomenon has been frequently observed in pigs where the ultimate pH is frequently reached in less than one hour. SAYRE (1963) has studied pH fall rate in three pig breeds and pointed out that one of these breeds (Poland China) was susceptible to rapidly reach the ultimate pH. PSE traits were also described in chicken broilers where pH measured 15 minutes after slaughter of birds was shown to be 5.7 or below (NIEWIAROWICZ, 1978).

ATP and PC

Fig. 2 shows a series of spectra obtained from *Pectoralis superficialis* muscle between 30 min. and 5 h *post mortem*. Each spectrum corresponds to 10 min. of observation. At 30 min *post mortem*, inorganic phosphate signal appeared on spectrum, ATP and PC signals have disappeared. Although, ultimate pH is reached, it would be necessary to determine biochemically the ATP and PC levels to complete these results. VAN HOOF (1979) has evidenced that immediatly after slaughter, residual amounts of ATP were not higher than 0.3 µmol/g in the *Pectoralis superficialis*. At the opposite, WOOD (1975) has determined about 6 µmol/g of ATP after slaughter but this is a value that we obtained in biopsies and therefore, the ATP level in our *post mortem* samples is probably much lower.

In the second experiment the evolution of pH is illustrated in Fig 3, 4, 5 and 6. In spite of individual differences noticed in the low performance breed, the pH fall rate tended to be lower in this breed than in the high performance one. The rate of pH fall was 1.4 fold faster in the high performance production group. pH measurements were obtained at temperature of 25°C in order to lower pH fall rate and *post mortem* metabolism.

Results, as shown in Table 1, indicate similar trends for a* values (with a decrease after 2 days according to FRONING (1978)) and b* values, though slightly higher a* values were noted in the low performance breed. Analysis of data comparing high and low production performance revealed significant differences in a* values 1 day, 2 days and 7 days *post mortem* (respectively $P<0,01$, $P<0,05$, $P<0,001$). Yellowness b* was increased during storage. Complete oxygenation of myoglobin was reached at 1 day *post mortem*. After 2 days, metmyoglobin amount was strongly increased. This agrees with previous work (FRONING 1972) where the rate of myoglobin oxidation was found to be fast and exhibited a higher rate than that reported for beef myoglobin. In the high performance breed, ultimate pH is correlated to redness a* ($R =+ 0,80$) (Fig 7). No significant relation was noticed in the low performance breed with statistical analysis.

CONCLUSIONS

These experiments showed that the onset of *rigor mortis* in the *Pectoralis superficialis* turkey muscle was extremely rapid and similar to the onset of *rigor mortis* in the PSE pig muscle but with a higher ultimate pH. Redness is the most discriminating factor between these two breeds. In the low performance breed, a* values were higher than in the higher performance breed during ageing. Moreover, in the high performance breed, ultimate pH was correlated to redness.

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Fig.3 : Evolution of pH (high performance production breed)

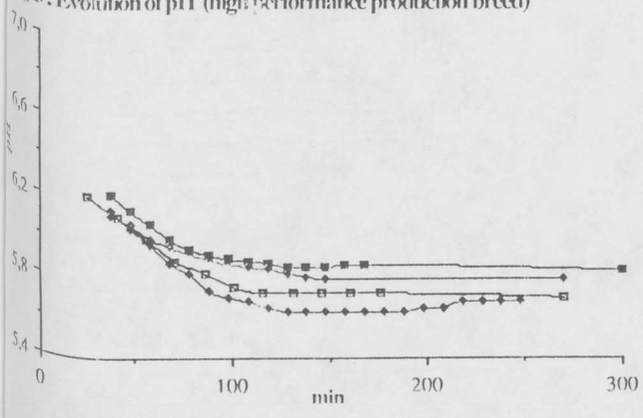

Fig. 4 : Evolution of pH (low performance production breed)

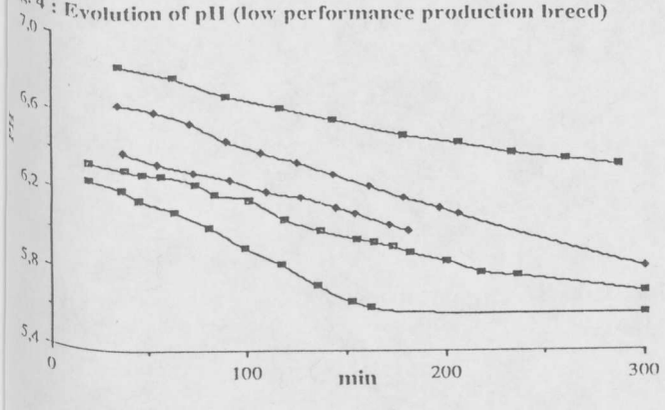

Fig. 5 : NMR spectra from high performance turkey breed (temperature 25°C)

Fig. 6 : NMR spectra from low performance turkey breed (temperature 25°C)

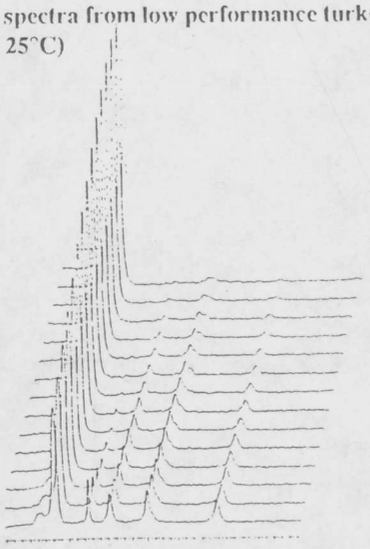

Fig. 1 : Evolution of pH of 12 week old turkeys (high performance production)

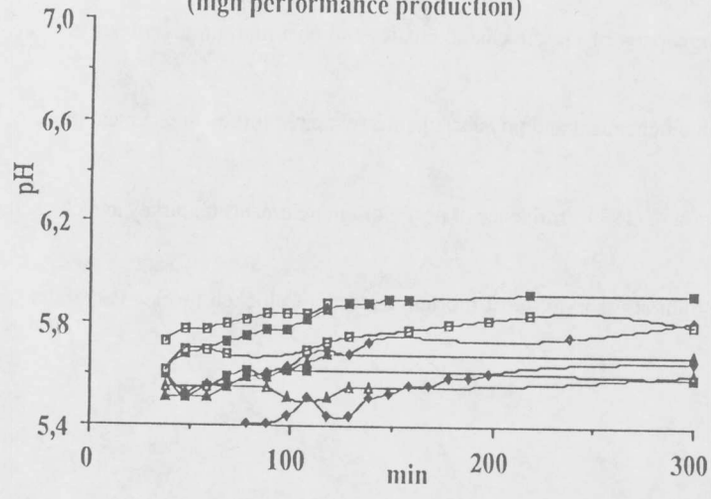

Fig. 2 : NMR spectra from 12 week old turkey (in decreasing temperature condition)

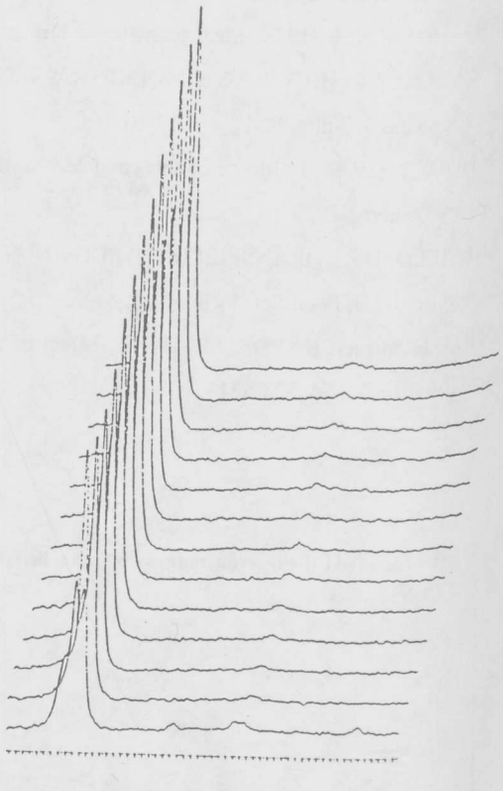

Table 1 : Evolution of a*, b* ,L* and R630-R580 during storage

LOW PERFORMANCE

	0 h	2 h	5 h	1 d	2 d	7 d
a*	3,5	3,4	4,0	5,1	5,8	4,4
sd	1	0,9	1	0,6	0,8	0,5
b*	4,3	5,0	4,8	5,7	6,2	7,6
sd	0,7	0,8	0,8	0,8	1,2	1,2
L*	43	43	44	45	44	47
sd	2	2	4	1	2	1
R630-R580	5,7	5,7	7,0	8,1	8,2	4,7
sd	0,5	1	1	0,6	1,5	0,9

HIGH PERFORMANCE

	0 h	2 h	5 h	1 d	2 d	7 d
a*	2,3	2,6	2,9	3,9	4,4	3,2
sd	0,7	0,7	0,9	0,9	0,9	0,9
b*	2,7	3,0	3,6	4,8	5,6	5,7
sd	0,9	0,7	0,4	0,9	0,7	0,6
L*	43	45	41	47	46	48
sd	2	3	4	3	2	2
R630-R580	4,9	5,4	6,7	8,3	7,5	5,0
sd	0,7	0,9	0,7	1	0,8	1,2

Fig. 7 : Correlation between the ultimate pH and redness (7 days post mortem)