

Effect of castration on the protein oxidation and colour stability in aged beef

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Abstract - Changes of pH in muscle *postmortem* can influence antioxidant defence system, protein oxidation reactions, and colour stability in meat. The castration may affect the antioxidant defence system in animal by increasing carcass fat deposition and decreasing antioxidant enzymes activity. Thus, the objective of this work was to investigate the effect of castration on the pH changes, protein oxidation, and pigmentation in aged beef. Twelve male bovines (5 intact and 7 castrated) of the Nellore breed were used. The pH, carbonyl groups and metmyoglobin values were obtained from *Longissimus dorsi* muscles aged for 1, 7, 14 and 21 days. Data were analysed using PROC MIXED program of the SAS and Tukey test at a significance level of 5%. As a result, it was verified that castrated animals had lower pH values than intact animals. No effect of castration was detected for the carbonyl groups and metmyoglobin values. In turn, ageing of beef affected all the studied variables. The pH values increased on day 7 and 14 of ageing and decreased on day 21. The carbonyl groups values elevated since day 7 of ageing, remaining constant until day 21. Yet, the metmyoglobin values increased on day 7 of ageing, decreased on day 14, and remained constant until day 21. These results suggest that the castration modifies pH values, but does not affect protein oxidation and pigmentation of beef. Also, a relationship among pH, carbonyl groups and metmyoglobin values seems to exist along the ageing of beef.

Keywords - Carbonyl, pH, metmyoglobin.

I. INTRODUCTION

The castration of bulls has increased the carcass fat content [1,2], which may elevate the amount of unsaturated fatty acids (UFA). The availability of UFA in association with high temperatures and long-term ageing contribute to meat oxidation. On the other hand, the castration may lead to positive changes in animal behaviour and temperament, which may

decrease the susceptibility of animals to the oxidative stress.

Measurements usually used in meat industry such as ultimate pH are good tools to evaluate meat quality and identify possible undesirable processes. Some authors report to exist variations of this variable between castrated and intact animals, whereas other ones do not [3,4,5].

The meat colour is an attribute that has great impact in buying decision. This attribute is influenced by the amount and chemical status of the myoglobin pigment [6]. The myoglobin oxidation results into metmyoglobin pigment that is responsible for the brown meat colour, whose is an undesirable aspect for the consumers [7].

Another consequence of the protein oxidation in meat is the formation of carbonyl groups. These may be formed from the reaction between reactive oxygen species (ROS) and amino acids [8]. The protein oxidation is a major indicator of meat deterioration [9], leading to biologic changes such as fragmentation, aggregation, and solubility reduction of proteins [10]. In an attempt to minimize the negative effects caused by the oxidation on the fresh meat quality, researchers have used vacuum packaging [11].

Therefore, the objective of this work was to investigate the effect of castration on the pH changes, protein oxidation, and pigmentation in aged beef.

II. MATERIALS AND METHODS

A. Animals

For this experiment, twelve male bovines (5 intact and 7 castrated) of the Nellore breed (*Bos indicus*) with 23 months of age were used. All the animals were confined for 140 days with a common diet composed of sugarcane bagasse, corn grain, soybean meal, soybean hull, urea and mineral trace. The animals

were slaughtered at an average weight of 516.2 ± 32.89 kg.

B. Muscle

After 48 hours *postmortem*, the *Longissimus dorsi* muscles were collected from carcasses and cut into steaks with 2.5 cm thick. Next, the steaks were vacuum-packaged (Cryovac, BB-2800) and aged for 1, 7, 14 and 21 days at 2 ± 2 °C. Analyses of pH, carbonyl groups [12], and metmyoglobin [13] were carried out.

C. Statistical Analysis

A completely randomized design with repeated measures on time was used to investigate the effect of sex and day of ageing on the studied variables. The data were analysed by the PROC MIXED procedure [14], using the *Tukey-Kramer* test at a significance level of 5% for the least squares means contrasts.

III. RESULTS

A. Effect of Sex

For the studied variables, there only was effect of sex ($P < 0.05$) for the pH values of the steaks (Table 1). The pH values in steaks from intact animals were higher ($P < 0.05$) than in steaks from castrated animals.

Table 1 Values of pH, carbonyl groups, and metmyoglobin for the *Longissimus dorsi* muscle from intact and castrated animals

Variable	Sex		P
	Intact	Castrated	
pH values in meat	5.59 (0.040)*	5.46 (0.033)	0.03
Carbonyl groups ^a	1.86 (0.083)	1.81 (0.068)	0.61
Metmyoglobin (%)	0.05 (0.007)	0.05 (0.006)	0.95

^anmol/mg of protein

*Least squares means (Standard error)

B. Effect of Day of Ageing

There was effect of day of ageing ($P < 0.05$) for all the variables. It was observed that the pH values increased ($P < 0.05$) on day 7 and 14 of ageing and

decreased ($P < 0.05$) on day 21, reaching similar values ($P > 0.05$) to the day 1 (Fig. 1).

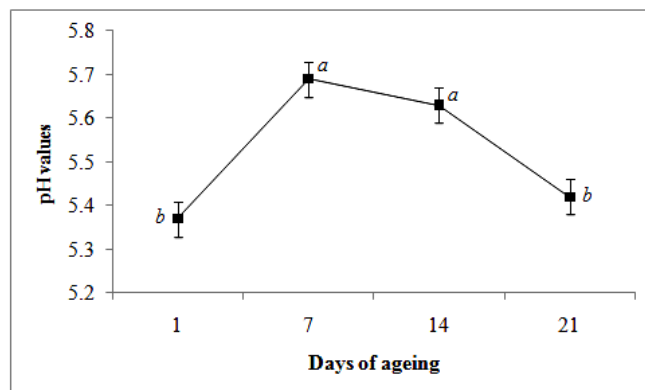


Fig. 1 Values of pH in *Longissimus dorsi* muscle of aged beef.

^{a,b}Least squares means followed by different letters differ statistically at significance level of 5% by *Tukey-Kramer* test

In turn, the carbonyl groups values elevated ($P < 0.05$) since day 7 of ageing, remaining constant ($P > 0.05$) until day 21 (Fig. 2).

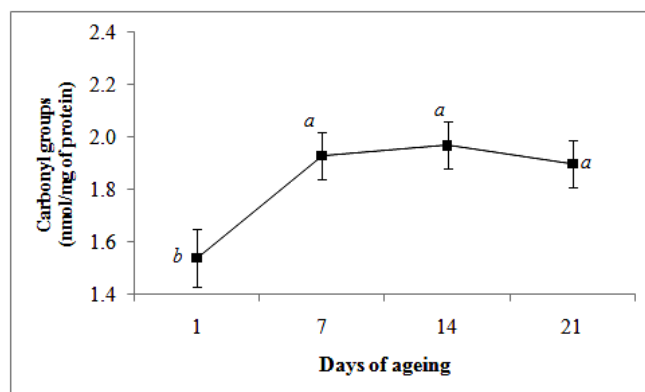


Fig. 2 Carbonyl groups content in *Longissimus dorsi* muscle of aged beef.

^{a,b}Least squares means followed by different letters differ statistically at significance level of 5% by *Tukey-Kramer* test

At last, the metmyoglobin percentage increased ($P < 0.05$) on day 7 of ageing, decreased ($P < 0.05$) on day 14, and remained constant ($P > 0.05$) until day 21 (Fig. 3).

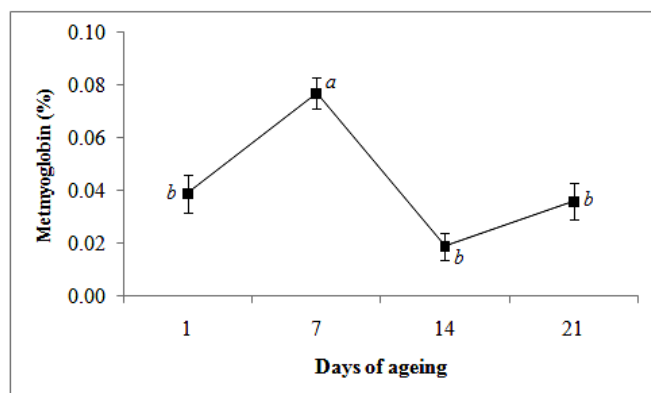


Fig. 3 Metmyoglobin percentage in *Longissimus dorsi* muscle of aged beef

^{a,b}Least squares means followed by different letters differ statistically at significance level of 5% by Tukey-Kramer test

IV. DISCUSSION

A. Effect of Sex

The higher pH values for the intact animals when compared to the castrated animals may possibly be attributed to the higher susceptibility of intact animals to pre-slaughter stress. This could have affected glycogen deposition in muscle, leading to a more elevated ultimate pH [3].

B. Effect of Day of Ageing

The pH values in *Longissimus dorsi* muscle increased on day 7 and remained high until the day 14. In these first days of ageing, there probably was an attempt to balance the pH values in steaks. On day 21, the pH values may have decreased due to the growth of lactic anaerobic bacteria.

Increase in carbonyl groups may be an indicator of protein oxidation [15]. This elevation was observed on day 7 of ageing, which remained constant until 21 days. In a natural meat tenderisation process, the most of the protein fragmentation given by the calpain enzymes occurs during the seven first days of ageing [16]. As protein breakdown may give rise to carbonyl groups, a great change in this variable may have happened between the day 1 and 7 of ageing. From

day 7 to 21 of ageing, it is possible that there was stability in formation of carbonyl groups.

Although there were changes of metmyoglobin percentage in *Longissimus dorsi* muscle across the days of ageing, the magnitude of these changes were very small and may not be perceived by consumers. The myoglobin is continually and slowly oxidised to the metmyoglobin when oxygen is present [17,18]. Such results could be a consequence of the absence of oxygen in vacuum-packaged steaks.

V. CONCLUSIONS

The results of this preliminary work suggest that the castration modifies pH values, but does not affect protein oxidation and pigmentation of beef. In addition, a relationship among pH, carbonyl groups and metmyoglobin values seems to exist along the ageing of beef.

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