Structural and Biochemical Changes During Aging of Hot Deboned and Electrically Stimulated Bovine Muscles

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SUMMARY

Effect of electrical stimulation on the structural changes and condition of myofibrillar proteins from hot deboned bovine muscles was investigated during postmortal aging.

Three muscles were excised from both halves of warm carcasses, 1 hour p.m.: M. longissimus dorsi (LD), M. biceps femoris (BF) and M. semimembranosus (SM). Muscles from left halves were used for control. Both groups of muscles were cut into 4 pieces, wrapped in PVC foil and aged at 0°C. Tenderness - sensory and instrumentally and solubility of total proteins were determined in all muscles. The content of free amino-acids and the ultrastructural changes were determined only in SM: 1, 8, 21 and 42 days after aging.

The obtained results show that ES prevents cold shortening in LD and SM, while in BF it was not estimated neither in ES nor NS muscles. The tenderness of NS muscles reached between 21st and 42nd day, was achieved in ES muscles between 8th and 21st day.

The increase of tenderness during the whole aging period was accompanied by protein solubility increase til the 8th e.g. 21st day, and after that by decrease in both groups. In the same time, the cross-striation in ES muscles disappeared, and in NS muscles the zig-zag form of the Z-membrane was observed.

INTRODUCTION

As it is well known, tenderness of bovine muscles increases during aging. However, aging is a long process, so the way how to shorten it is permanently investigated.

In electrically stimulated muscles pH droppes in a short time to the value optimal for the activity of proteolytic enzymes. So activity of these enzymes is expected to start earlier,and in that way, the aging e.g. tenderization of the meat can be accelerated (Savell et al, 1977; Sorinmade et al, 1978; Dution et al, 1980; Pommier et al, 1987; Gorschkova et al, 1988).

Somewhat more literature data are available on influence of electrical stimulation on the quality of cooled muscles excised from carcasses early post mortem (Shivas et al, 1985; Seman et al, 1986; Eikelenboom, 1987; Koh et al, 1987; Kondos and Taylor, 1987; Ring and Taylor, 1988).

There are very few data available on the influence of electrical stimulation on the characteristics of hot-deboned muscles during aging. So the aim of this work was to investigate this influence.

MATERIALS AND METHODS

Domestic versicolored heifers, 12-18 months of age (400-550 kg wt) were used for the investigation. Stunning and bleeding were performed in the usual way. After the treatment on the line, before weighing and final washing, approximately 35-40 min. p.m. three muscles were excised from both carcasses: M. longissimus dorsi (LD) from the 8th lateral til the last lumbar vertebra, M. semimembranosus (SM) and M. biceps femoris (BF).

Muscles from the right halves were electrically stimulated (ES) (after excising) for 120 sec. with 14 Hz pulses, with constant peaks of 32 for 5 msec and pauses of 70 msec - using a device of our construction (Petrović Ljiljana et al, 1987). The muscles from the left halves were not stimulated (NS).

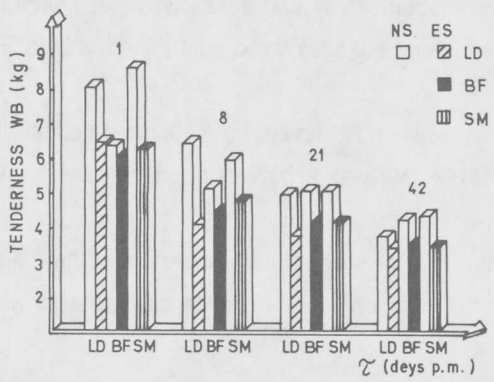
One hour p.m. all excised muscles were cut into 4 pieces, packed in PVC foil under vacuum and kept in the refrigerator at 0°±0.5°C till the moment of investigation. The samples were investigated after 1, 8, 21 and 42 days p.m. Two 3 cm thick steaks were cut from every sample. One steak was used for instrumental investigation of tenderness using Warner-Bratzler apparatus (WB). The other cut was treated by grilling to an internal temperature of 55°C. The tenderness was determined sensorily in still hot samples.

From the remaining piece, a sample was taken (always from the same place) for the investigation of ultrastructure with electron microscop, and after the removing of outside fatty and connective tissue it was ground, homogenized and kept in hermetically closed containers. This sample was used for the determination solubility of total proteins in 1 M KCl pH=7.2 (Awad et al, 1968) and content of free amino-acids (only SM was used).

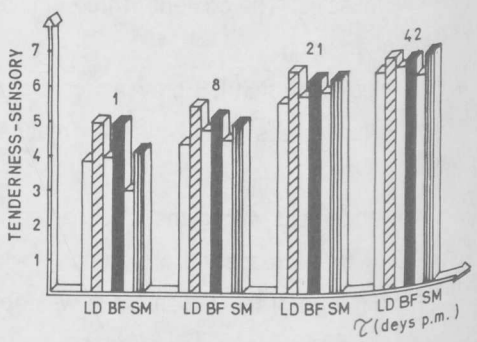
Six samples from both groups (NS and ES) were investigated, and the results were statistically analyzed (Hadživuković, 1984) using analysis of variance.

RESULTS AND DISCUSSION

The results obtained during our investigations are presented in 4 graphs, 1 table and 2 pictures.



Graph. 1. Tenderness (WB) in three muscles excised early p.m. (NS and ES), during aging (n = 6)



Graph 2. Sensorily evaluated tenderness in three muscles excised early p.m. (NS and ES), during aging (n = 6)

The first day p.m. the lowest tenderness was determined in NS muscles: SM (8.65 kg), followed by LD (8.07 kg) and BF (6.93 kg). In the same period, the ES muscles were more tender: LD and SM more (6.53 e.g. 6.29 kg), and BF somewhat less (6.08 kg).Both NS and ES muscles became more tender during aging, and the difference between the tenderness of ES and NS muscles remained till the end of aging. It is important to underline that the tenderness estimated in ES muscles after 21 day of aging was achieved in NS muscles at the end of the aging period e.g. after 42 days.

The influence of muscle kind on the tenderness (WB) is not significant, neither of tested treatments (Table 1). However, the influence of applied process (ES) and aging time is highly significant (P<0.001).

Table 1. Analysis of variance of the influence of muscle kind, treatment and aging time on the investigated characteristics

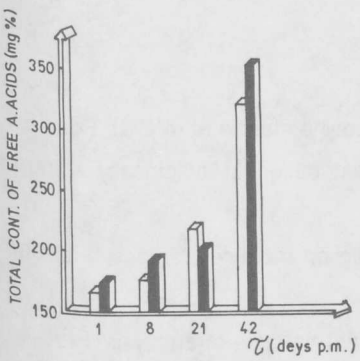
Source of variation	Degree of freedom	F-value		
		Tenderness		Solubility of total proteins
		WB	sensory	
Muscle (M)	2	2.25	3.33*	0.28
Treatment (Tr)	1	37.29***	39.48***	1.10
Time (T)	3	56.11***	98.03***	19.08***
Interaction M-Tr	2	1.82	0.62	0.02
Interaction M-T	6	1.37	1.36	1.66
Interaction Tr-T	3	0.89	2.07	0.33
Remainder	126	-	-	-
Total	144	-	-	-

significantly different: * (P<0.05); ** (P<0.01); *** (P<0.001)

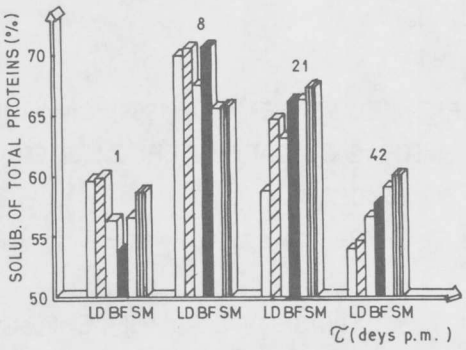
The results presented in graph 2 show that the sensorily evaluated tenderness of thermically treated ES muscles is higher one day p.m. than the one of NS muscles. It is especially the case with SM., where the tenderness of NS muscle was graded 2.99 and of ES muscle 4.22. During aging, all NS and ES muscles became more tender. Though at the end of the aging the ES muscles were evaluated as more tender than the NS ones, the difference determined the first day p.m. gradually decreased til the 42nd day, especially in the case of LD.

The analysis of variance showed (Table 1) that the influence of kind of muscle ($P<0.05$), and the applied treatment and time of aging are significant ($P<0.001$) for the tenderness evaluated by sensory method, what is not the case with their interaction.

It was found that the free amino-acids (graph. 3) was increasing til the end of aging.



Graph. 3. Content of total free amino acids in SM excised from carcasses early p.m. (NS and ES), during aging (n=6)



Graph 4. The solubility of total proteins of three muscles excissed early p.m. (NS and ES),.during aging (n=6)

Between the 21st and 42nd day of aging, a more significant increase of free amino-acids content was estimated and it was higher in ES than in NS muscles

The determination of total proteins solubility resulted in oposite findings (graph. 4). Namely, the solubility increases til the 8th day of aging both in NS and ES muscles: LD and BF, and in SM til the 21st day. In all groups of muscles (NS and ES) solubility decreased further on. However, the solubility was somewhat higher in ES muscles.

a)

b)

Figure 1. Electron micrographs of SM muscle after 42 days of aging (x 30.000) a) NS muscle, b) ES muscle

CONCLUSIONS

The results of tenderness determination indicate that eletrical stimulation prevents cold shortening in hot-boned LD and SM. In BF this phenomenon was not observed neither in ES nor in NS muscles.

The tenderness estimated in NS muscles between 21st and 42nd day of aging was achieved in ES muscles between 8th and 21st day.

During the whole aging period the content of free amino acids was increasing. The solubility of total proteins increased till the 8th (LD and BF) e.g. 21st day (SM), and after that decreased in both investigated groups.

In the same time, the tenderness increase in ES muscle was accompanied with the loss of cross-striation, and in NS muscles with the zig-zag form of Z-membrane.

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