TECHNOLOGICAL RESPONSE OF TWO BOVINE MUSCLES SUBJECTED TO FREEZE-DRYING PROCESS

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Abstract – The aim of this research was to determine the performance of *Semitendinosus* and *Spinalis dorsi* muscles submitted to cooking, freeze-drying and rehydration process. Even though freeze-drying is an expensive method, it constitute an excellent option to be considering in an instant meal processing, specially ones to be use in natural disaster. After rehydration, *Semitendinosus* samples were darker and more red when compare to cooked ones. A different behavior was seen for *Spinalis dorsi* samples because they separated and fragmented after freeze-drying was carried out. Results showed a general better performance of *Semitendinosus* muscle under the present processing conditions, even though the microstructure of the cell was mainly modified.

Keywords—freeze-dried; color stability; SEM; bovine muscles.

I. INTRODUCTION

It is well known that processes may affect the quality of a food product. Indeed, various changes in physical, chemical and/or biological characteristics in food may occur during processing. These changes alter the physical aspect such as color and structure. Many authors have reported the application of freeze-drying as an important method for food preservation (1, 2, 3, 4, 5, 6, and 7). The popularity of this method is based on some well-known advantages: sample stability at room temperature, easy reconstitution by the addition of water, defined porous product structure, reduction in weight, and the possibility of easy sterile handling (8, 9). Color measurement in cooked, freeze-dried and rehydrated meat can provide reliable information about eating quality attributes (10). As it was stated there are numerous publications on freeze-drying, researcher have studied this process for different fields: potatoes (11); lipid changes in meat (12); thickness in Broiler chicken (3) among others. The aim of this research was to determine structure characteristic and color changes in two bovine muscles when they were submitted to cooking, freeze-drying and rehydration process. This research was an approach to evaluate consumer perception.

II. MATERIALS AND METHODS

Samples.

Semitendinosus (ST) and *Spinalis dorsi* (SD) muscles were purchased at a local market. They were cut in 3 cm steaks and were grilled in aluminum-folded strips and cooked to an end point temperature of 71.5 ± 0.5 °C (13) using an electric grill. Steaks were cooled at room temperature during 30 min and then chilled in a refrigerator at 4 ± 1 °C for 24 h. Each ST cooked steak was cut with a cork-bore to a cylindrical form with 13 mm diameter and 3 cm high. Then, each cylinder was sliced in units of 2 mm of thickness. A similar procedure was done with SD steak, but in this case samples were cut in a rectangular shape of 2 cm with 2 mm of thickness. The shape of each beef portion was defined in order to permit that a person can eat it without cutting. After that, samples were stored at 3 °C until freeze-drying process.

Freeze-drying process and samples storage.

An experimental non continuo's freeze-drying equipment supplied with four trays (Rificor,™ Argentina) was used. Parameters for freeze-drying process were according to Georgieva *et al.* (12) with modifications: freezing temperature: -50 ± 1 °C; time to reach in the fluid: 24 h. Drying process, was carried out at 40 ± 1 °C and at maximum vacuum (pressure: 0.346 Pa) during

48 h. After freeze-drying process, samples were vacuum packaged (CRYOVAC™ BB4L, Sealed Air Corporation, Bs. As. - Argentina) and stored in a dark place at room temperature. Freeze-dried samples were rehydrated in tap water at room temperature for 5 min, at a ratio of 10 g sample in 150 ml of water.

Analyses of samples.
Color parameters were determined using a spectrocolorimeter B-K Gardner Spectro guide 45/0 gloss, with a D65 iluminant. The CIE Lab System was implemented, which provided the values for color components: L*, a*, and b*. Each sample was measured four times. Chroma (C*) was calculated as $(a^{*2}+b^{*2})^{1/2}$, it is a measure of color saturation. The angle H*, the color hue, was expressed in degrees (H*=arctg(b*/a*)

Water activity, in Cooked and freeze-dried samples, was performed using a Water Activity Meter (AquaLab 4TE®). Linear offset is checked by using a calibration standard (Decagon®) and distilled water daily. Calibration standards used were: LiCl 13.41 molal in H_2O (aw: 0.250 ± 0.003) and NaCl 6.0 molal in H_2O (aw: 0.760 ± 0.003). Samples were analyzed thrice according to instruction of the AquaLab operator´s manual.

Scanning electron micrographs (SEM) was performing according to Palka *et al.* (14). Cooked and freeze-dried samples were mounted on holders and coated with gold (Polaron model E5100). Microscopic evaluation was performed using a Scanning Electron Microscope Conventional high vacuum Model Philips 515. Micrograph pictures were built-in image scanning device dials Model Genesis Version 5.21.

Statistical analyses were performed using GLM procedures (SAS, 1999) considering one effect with three levels according to: cooked, freeze-dried and rehydrated samples. All mean values were compared by Bonferroni Test. Water activity was analyzed as mean values.

III. RESULTS AND DISCUSSION

Color data results are shown in Table 1.

Table 1. Color parameters of *Spinalis dorsi* (SD) and *Semitendinosus* (ST) samples.

Parameters	Cooked		Freeze-dried		Rehydration	
	SD	ST	SD	ST	SD	ST
L*	40.04 b	51.05 a	53.63 a	50.07 a	52.90 a	47.52 b
a*	6.70 b	3.12 b	8.02 b	6.50 a	6.65 b	5.32 a
b*	15.02 c	15.97 b	20.88 a	19.13 a	16.79 bc	15.23 b
C*	16.45 c	16.16 b	22.37 a	20.20 a	18.06 bc	16.13 b

Lowercase letter indicate statistical differences for treatment effect (Bonferroni Test p<0.05).

Color ST data results show that lightness (L*) decrease as follows in cooked, freeze-dried and rehydrated samples. A higher L* value indicates a lighter color, which is desirable in order to ensure that the meat products will have high consumer acceptance. Cooked samples had lower a* values when compared to rehydrated ones. Besides, b* and C* were similar for both samples. H* values for cooked and rehydrated samples were between 78.99 and 70.78, respectively. H* represents the change from the true red axis, where a larger number indicates a greater shift from red to yellow.
SD rehydrated samples had the highest L* compare to cooked samples; even though no difference were seen in the other parameters. During freeze-dried process, SD samples were slightly separated and fragmented. After color measurements and due to the necessary handling of the samples, they resulted totally fragmented. Jeong *et al.* (15) reported in *Semimembranosus* muscles that when raw meat was submitted to freeze process, effect of protein denaturation and/or shrinkage of the myofibrils tend to increase light scattering giving higher L* values.

For a_W values no significant differences were observed between muscles studied for each treatment (Cooked: 0.994 ± 0.002; Freeze-dried: 0.212 ± 0.004). Serra *et al.* (16) reported that when *Biceps femoris* muscle samples were submitted to drying process at 15 ± 2 °C (until constant weight), a_W decreased from 0.90 to 0.70; the differences in those values could be due to both, the different freeze-drying conditions and type of muscle.

The study of the microstructure of ST muscle, cooked and freeze-dried, provided further

information to the results and allowed a more complete interpretation about treatments applied.

Figure 1 shows micrographs taken of transverse sections of cooked ST muscle.

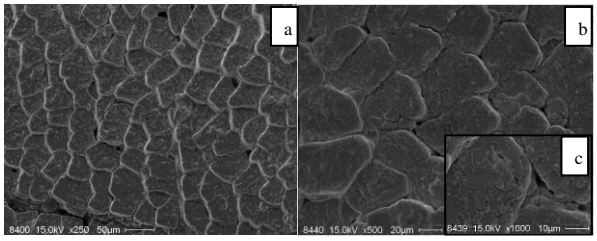

Figure 1. Scanning electron micrographs of *Semitendinosus* cooked sample at 71 °C, a:x250; b:x500; c:x1000.

Cooked samples showed an organized structure with compacted fibers and without gaps among them.

Figure 2 shows micrographs obtained for freeze-dried samples. The structure appeared disorganized compared to cooked sample, showing gaps among fibers bundles and between fibers.

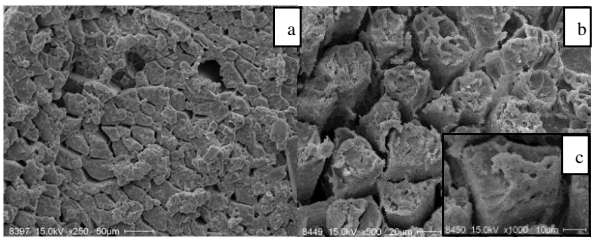

Figure 2. Scanning electron micrographs of *Semitendinosus* freeze-dried samples, a:x250; b:x500; c:x1000.

Myofibrils were dehydrated, separated and partially fragmented. Rehydrated sample of ST showed to be more organized but presented gaps among fibers (not shown figure).
Palka *et al.* (14) reported in cooked *Semitendinosus* muscle at different temperatures that granulation between muscle fibers in the range of 70 - 100 °C was visible. With increasing heat temperature (over 70 °C) the meat structure became more and more compact. On the other hand, decrease in fiber diameter was observed when samples were heated to the endpoint temperatures of 60 and 121 °C.
Jones *et al.* (17) reported in bovine *Semitendinosus* muscle for samples cooked at 50, 60 and 90 °C for 45 min, that endomysial collagen appeared to be unaffected at 50 °C but was congealed at 60 and 90 °C. In the other hand, the sarcolemma became granular at 60 °C. The most important changes in myofibrillar structure at 60 and 90 °C were an evident increase in coagulation and compactness of the A-band portion of the sarcomeres and disintegration of the I-band with occasional loss of whole sarcomeres from myofibrils.
A general view of all micrographs (cooked, freeze-dried and rehydrated samples) showed that microstructure of the cell was mainly modified.
As it is stated previously, after color measurements SD samples resulted totally fragmented. Due to this situation was not possible to achieve a correct micrograph.

Separation and fragmentation of SD samples could be due to muscle characteristics, cooking process and, in this case, it could have increased when freeze-dried process was applied.

IV. CONCLUSION

As a conclusion of this work, *Semitendinosus* muscle results suitable for freeze-drying processing. However, it is an expensive muscle. Considering that the final purpose of our work is to design an instant meal suitable for natural disaster, it is necessary to continue testing other more economic options.

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