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EFFECT OF TWO COOKING METHODS – HOT WATER AND STEAM – ON THE QUALITY PARAMETERS OF *SEMITENDINOSUS* MUSCLES

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Abstract

Cooking methods such as in hot water and steam at 70 °C and 80°C were evaluated to eliminate *Clostridium botulinum* type E. This is a risk-pathogen for cooked, vacuum packed and chilled products. Non-aged standard weight, *Semitendinosus* beef cuts were 1) steamed with direct vapor injection in incubators, and 2) heat-treated in a hot water cooker. Internal temperature of the samples was measured via a thermocouple attached to a sensor during the experiment. Data obtained based on the D values for this pathogen, D (82.2ºC) and Z (8.8 min), and pasteurization (P) were estimated for each method tested. Cooking loss and objective tenderness attributes were analyzed to measure the quality of the cooked meat cuts. Results showed that the pasteurization of the products occurred at 80°C; the objective tenderness evaluated through shearing force was not affected by either of the cooking methods used and levels of temperature. Significant difference between these two cooking methods (which greater in hot water than in steam), temperature levels (which were greater at 80^{o}C than at 70^{o}C), and interaction between temperature and type of heating for cooking losses. Sensorial evaluation revealed that juiciness had a positive influence, while the presence of collagen had a negative effect on the tenderness of the meat cuts.

Introduction

Cooked meat cuts undergo strict processing controls during industrial production. This control must analyze various aspects of pathogenic microorganisms and the positive consequences of the treatment process on the yield of the meat and on the final product, thus resulting in proper sensorial characteristics for the consumer. *Clostridium botulinum* type E is a microorganism that is associated with microbiological risks inherent in cooked, chilled and vacuum packed meat products, since it is able to grow and produce toxin at 3°C. The cooking process causes the denaturation of insoluble proteins and is time-dependent. The resulting denaturation is shown by the low measurement values given by the Warner- Bratzler Shear Force machine (Powell, Dikeman & Hunt, 1999). The objectives of this study were to evaluate 1) the effectiveness of thermal treatments utilized in meats for antimicrobial purposes with *C. botulinum* type E as a target pathogen; 2) evaluate the measurement results for the cooking loss variables (%) and Warner-Bratzler shear values (kg) when comparing to the cooking methods and

temperature levels, and 3) at which stage flavor, presence of collagen and juiciness of samples cooked at 70 and 80°C in water or steam influences the subjective tenderness.

Material and Methods

Vacuum packed samples were cooked at 70ºC and 80ºC in water by utilizing two different heat-treatment methods: a hot water cooker and a vapor injection incubator. Controls and the monitoring of the internal temperatures of the samples were conducted with thermocouples attached to sensors. The effectiveness of the cooking process was evaluated based on thermobacteriology principles with *Clostridium botulinum* E as a reference-microorganism. The D (82.2º) and Z (8.8 min) concept values were utilized for this microorganism. The pasteurization value P was estimated for each treatment conducted. The objective tenderness was measured through the shear force analysis by utilizing the Warner- Bratzler Shear Force device. Percentage values for cooking loss were estimated as follows: [(weight of the raw sample – weight of the cooked sample)/weight of the raw sample] x 100. The sensorial evaluations were conducted with 13 trained panelists by utilizing quantitative tests for tenderness, juiciness, presence of collagen, and flavor attributes.

Analysis of variance, Tukey test, correlation analysis and multiple regression analysis were used to evaluate the data obtained (Montgomery, 1991, Montgomery and Peck, 1992).

Results and Discussion

Results from Table 1 show that the reduced decimal values found for the samples treated at 70°C were not sufficient to obtain an inactivated *C. botulinum* E safety product, since adequate pasteurization occurs only when the decimal reduction values are between 5 and 10. These findings corroborate with those reported by Lawlor et al. (2000), who conducted experiments with cooked turkey meat followed by the inoculation with *Clostridium botulinum* B, and found that 72.2ºC was inadequate to eliminate this microorganism. The D value for this pathogen is between 0.1-0.2, which is lower than that necessary to eliminate *C. botulinum* E (D value = 0.3–3.0) (Gonçalves and ; Germer, 1992). Therefore, the cooking temperature at 70ºC was considered too low to obtain satisfactory pasteurization indexes for *C. botulinum* even when applied for longer periods.

With the objective to evaluate two factors together, the cooking method and the temperature utilized, in relationship to the Warner-Bratzler shear values and Cooking loss indexes, the following factorial model for each index was adopted: $Y_{ij} = \mu + X_{2i} + X_{3j} + (X_2 * X_3)_{ij} + E_{ij}$, where Y was the dependent variable, i.e., for each of the measurements (Warner-Bratzler shear values and Cooking Loss); $X2_i$ corresponded to the cooking method tested (i=2); X_{3j} was the temperature tested (j=2), and $X_{2ij} * X_{3ij}$ corresponded to the interaction between these parameters (Tables 2 and 3). Statistic differences were found for temperature levels (which were greater at 80°C than at 70°C), cooking method (which were greater in hot water than in steam), and interaction between temperature and type of heating for the cooking loss attribute. Analyses conducted by Palka and Daun (1999) with *Semitendinosus* beef showed an increase of 10.3 and 9.7% in the loss of

fluids during the cooking period at 50ºC-60°C and between 70ºC-80°C, respectively. According to these authors, the loss of fluids was due to the two basic alterations in the protein structure of the meat: the actomyosin complex and collagen. No significant differences (P>0.05) were observed for the cooking methods and levels of temperature at the Warner-Bratzler shear values (Tables 4 and 5).

The interaction between the following parameters was observed during the sensorial evaluation on the presence of conjunctive tissue, tenderness, flavor and juiciness. The tenderness parameter was considered the variable that greatly influenced the quality of the product, and was correlated with other sensorial attributes. To estimate how the presence of collagen, flavor and juiciness attributes influenced the tenderness, a regression multiple linear model was developed to understand which variables were positively or negatively affecting its quality. The model used was: $Y_1 = \beta_0 + \beta_1 X_{i\,1} + \beta_{\,2} X_{i\,2} + \beta_{\,3} X_{\,i\,3} + E_i$, where Y_i = tenderness; $X_{i\,1}$ = succulence/juiciness; $X_{i\,2}$ = collagen; $X_{i\,3}$ = flavor, and E_i = the random error associated with the model. The estimated model for the steamed samples was: $Y_1 = 0.683\ X_{i\ 1} + 0.204\ X_{i\ 2} + 0.0507\ X_{i\ 3} + 2.470$. The presence of collagen influenced negatively, while the succulence/juiciness attribute showed a positive effect on the tenderness of the samples ($P < 0.01$). For samples heat-treated in the hot water cooker, the estimated model was: $Y_1 = 0.657\ X_{i\ 1} + 0.136\ X_{i\ 2} + 0.0191\ X_{i\ 3} + 2.721$. In this case, juiciness was the only variable that had a significant effect on this model ($P < 0.01$). Flavor did not show a correlation with any other attribute analyzed, thus agreeing with results reported by Otremba et al. (2000), who evaluated the succulence/juiciness, firmness, fibrosis, tenderness, and the easiness of chewing attributes of cooked cuts of *Semitendinosus* muscles. On the other hand, Wheeler et al. (1998) conducted a study for this type of muscle utilizing belt grilled and open hearth electric broiler methods and found differences for the belt grill-cooked samples had lower ($P < 0.01$) percentage of cooking losses (21.5 vs 25.8%) and higher ($P < 0.01$) shear force values (4.6 vs 4.3 kg) than electric broiler-cooked samples.

Table 1. Decimal reduction values obtained for cooking, cooking loss and objective tenderness of *Semitendinosus* muscle heat-treated in hot water or steamed at 70°C and 80°C.

Treatment	Decimal reductions values observed
Water at 70°C	0.51
Steam at 70°C	0.73
Water at 80°C	11.29
Steam at 80°C	10.12

* Each treatment had two repetitions

Table 2. Variations observed in the cooking loss for *Semitendinosus* muscle heat-treated in hot water or steamed at 70°C and 80°C.

Source	Sum of Squares	Df	Mean	F	Sig.
Corrected Model	2442,241[a]	3	814,080	79,380	0,000
Intercept	109978,891	1	109978,891	10723,880	0,000
X2	732,203	1	732,203	71,396	0,000
X3	1704,534	1	1704,534	166,207	0,000
X2 * X3	126,150	1	126,150	12,301	0,001
Error	1189,639	116	10,256		
Total	137839,977	120			
Correct Total	3631,880	119			

Table 3: Overall means for cooking loss (%)

	Cooking method		Total
Temperature	Steam	Water	
70°C	24.40	31.80	28.11
SE	1.27	0.16	
80°C	34.57	37.64	36.11
SE	0.52	0.28	
Total	29.49	34.72	

SE = standard error

Table 4. Variations in the Warner-Bratzler shear values (kg) observed for *Semitendinosus* muscle heat-treated in hot water or steamed at 70°C and 80°C.

Source	The sum of squares (Type III)	Df	Mean Square	F	Sig.
Corrected Model	12,423[a]	3	4,141	0,848	0,471
Intercept	4183,350	1	4183,350	856,385	0,000
X2	7,073	1	7,073	1,448	0,231
X3	0,267	1	0,267	0,055	0,816
X2 * X3	1,536	1	1,536	0,314	0,576
Error	566,648	116	4,885		
Total	5260,323	120			
Corrected Total	579,071	119			

Table 5: Overall means for Warner-Bratzler shear values (kg)

Temperature	Cooking method: Steam		Water	Total
70°C	6.45		6.17	6.31
SE	0.28	0.28		
80°C	6.50		5.83	6.17
SE	0.52	0.28		
Total	6.48	6.00		

SE = Standard error

Table 6: Sensorial evaluation scores given for *Semitendinosus* muscle after heat-treatments in hot water or steamed at 80°C.

Treatment	Tenderness	Juiciness	Collagen	Flavor
Water at 80ºC	5.91[a]	4.63[b]	1.75[c]	5.05[d]
Steam at 80ºC	5.47[a]	4.51 [b]	2.63 [c]	5.41 [d]

Note: The results correspond to an evaluation conducted by utilizing a non-structured scale from 0 to 10, with 0 equal to the lowest scores and 10 to the highest scores according to the perception of each panelist given for each sensorial attribute tested.

Conclusion

The complete pasteurization of the products occurred at 80ºC. The objective tenderness evaluated through shearing force analysis was not affected by the cooking methods tested. A significant difference ($P< 0.01$) was found between the cooking methods in relationship to the cooking loss variable. The sensorial evaluation showed that juiciness had a positive correlation ($P< 0.01$), while collagen had a negative correlation with tenderness. Flavor was not influenced by either of the cooking method tested.

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