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Effects of Freezing Temperature and Defrosting Method on Pork Quality Characteristics

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Abstract: Twenty-eight pieces of *Longissimus dorsi* were collected at 24 h postmortem and used to evaluate two freezing temperatures (FT) and two defrosting methods (DM). The treatments were the result of the combination of FT (commercial temperature: -23.0°C and domestic temperature: -14.3°C) and DM (immersion in water at room temperature for no more that 2 h, and in refrigeration at 4°C for 24 h). The characteristics evaluated were: pH, color (L*, a* and b*), shear force (SF), drip loss (DL), and water holding capacity (WHC). Data were analyzed by analysis of variance for a completely randomized design with sub sampling using ANOVA procedure of SAS. Luminosity (L*) was affected by FT but not by MD ($p>0.05$). Interactions of FT and DM were significant ($p<0.05$) for pH, a*, DL and WHC. Higher DL percentages corresponded to DM at 4°C for 24 h independent of FT. Values for WHC were higher in domestic FT at -14.3°C independent of DM. Defrosting of meat by immersion in water caused less DL independent of FT. In addition, defrosting time was essential in the performance of the characteristics that determine the quality of meat.

Key words: meat quality, freezing temperatures, frozen meat

INTRODUCTION

Freezing fresh meat after buying it is a common practice performed by the consumer. The reason for this is to extend the life of the meat, preserve its original properties, and prevent the proliferation of bacteria. Meat can be frozen for months in domestic refrigerators at temperatures between 0 and -15°C, or in commercial freezers at temperatures between -20 and -30°C. Some changes that affect certain properties of fresh meat can occur while frozen, such as, water holding capacity, pH, color, firmness, and texture[1], being the most important effects to the structure of the tissue as a result of the crystallization process that is determined by the size and location of the ice crystals[2]. Also, the method used for defrosting can produce changes, such as a decrease of water holding capacity, because the water exudated in frozen meat can not be reabsorbed affecting the general appearance of meat and causing loss of proteins, vitamins, and minerals[3]. The consumer usually defrosts the meat by two methods, at refrigeration temperature, and/or by immersion in water. However, it is not known the magnitude of both effects together, freezing and defrosting over the properties related with the quality of meat. Therefore, the objective of this research was to evaluate the effect of two freezing temperatures and two methods of defrosting on the physical and chemical properties of pork meat.

MATERIALS AND METHODS

A sample of 28 pieces of *Longissimus dorsi* was obtained randomly at 24 h postmortem from pork carcasses in a meat packing plant (TIF No. 54) in Mexicali, Baja California, Mexico. The chilled meat pieces were transported to the laboratory for analysis. Each piece of meat was subdivided into four segments of approximately 500-600g and placed into separated plastic bags. Each of these segments represented an experimental unit. The half of the total experimental units generated, were frozen at -14.3°C, which is similar to the temperature used in domestic freezing, and the other half were frozen at -23°C which is similar to the temperature used for commercial freezing.

A completely randomized design with sub sampling experiment was conducted. The design consisted of 2x2 factorial arrangement testing the main effects freezing temperature [(FT) (-23.0 vs –14.3°C)] and defrosting method [(DM) (at 4°C for 24 h vs immersion in water at room temperature for no more than 2 h to avoid microbial growth)] on pork meat quality characteristics. All the analyses were performed on defrosted meat.

For the pH analysis, a portable pH meter with a punction electrode (DELTA Trak, System Inc., ISFET pH 101, Pleasanton, Ca. E.U.A.) was used. Water holding capacity (WHC) was measured using the compression technique described by Owen *et al.*[4]. Using 0.3 g of a meat sample was placed between two layers of filter paper and two plaques of acrylic Plexiglas for 15 min. Drip loss (DL) was measured using the technique previously described by Honikel *et al.*[5]. To obtain Shear Force (SF) values, meat pieces of 1 cm of diameter previously cooked were taken parallel to the muscle fibers orientation. The measurements were determined using a Texturometer (Salter, E.U.A.) equipped with Warner-Bratzler shear blades. The colour values L* (lightness), a* (redness) and

Table 1: Mean values for pork meat quality characteristics evaluated by treatment. The treatments result of the combination of freezing temperature (FT) and defrosting method (DM)

	Treatments			
	FT Domestic		FT Commercial	
Variables	DM in Immersion	DM in Refrigeration	DM in Immersion	DM inRefrigeration
pH	5.49[b]	5.50[b]	5.70[a]	5.77[a]
L*	56.69[a]	59.09[a]	55.73[a]	54.49[a]
a*	3.82[b]	3.31[b]	4.49[a]	5.04[a]
b*	14.07[a]	14.25[a]	14.13[a]	14.25[a]
SF (kgf)	4.70[a]	4.09[a]	4.23[a]	4.31[a]
DL (%)	5.23[c]	10.27[a]	7.79[b]	10.77[a]
WHC (%)	49.39[a]	48.19[a]	45.71[b]	45.44

[a,b,c] Means followed by different letters within row are different ($p<0.05$); L*= Lightness; a*= redness; b*=yellowness; SF= shear force; DL= Drip loss WHC=Water holding capacity

b* (yellowness) were measurement with a Minolta CM-2002 spectrophotometer (Minolta Camera, Co., Ltd, Japan) utilizing the integrated specular component (SCI), a D_{65} illuminator, and an observer at 10°. All measurements were performed in triplicates.

To assure microbiological quality of the meat, *Salmonella spp* analysis, determination of total and fecal coliforms, and mesophils standard count, were performed following the methodology described by Mexican Official Norm (NOM)[6-8], respectively.

The response variables were analyzed using ANOVA procedure of SAS[9]. When the effects were significant, the mean values were compared using orthogonal contrasts[10].

RESULTS

There was significant ($p<0.05$) FT x DM interaction effect for pH mean values (Table 1), with higher values (5.70 and 5.77) in meat frozen using commercial temperatures, compared to those pH values obtained when domestic FT were used (5.49 and 5.50).

L*-values did not differ among treatments ($p>0.05$). Contrasting the main effects only the effect of FT was found to be significant ($p<0.05$), 57.89 for commercial FT, and 55.11 for domestic FT.

The interaction FT x DM was significant ($p<0.05$) over a*. The a*- values were higher in meat frozen at commercial FT, independent of DM, with mean values of 4.49 in meat defrosted by immersion, and 5.04 in meat thawed in refrigeration, and different significantly ($p<0.05$) those obtained in meat frozen at domestic FT with mean values of 3.82 and 3.31 for meat defrosted by immersion and in refrigeration, respectively.

Mean values for b* and shear force (SF) did not differ ($p>0.05$) for any of the treatments evaluated. Mean values obtained were 14.16 ± 0.09 and 4.39 ± 0.31 kgf, respectively.

For the variable DL, the interaction FT x DM differed significantly ($p<0.05$). Higher percentage of water loss was observed in meat defrosted in refrigeration, independent of the FT applied, with mean values of 10.27% for domestic FT, and 10.77% for commercial FT.

Mean values for water holding capacity were different ($p<0.05$) for effect of the treatments (Table 1).

DISCUSSION

The pH values obtained in this study were similar to normal pH values registered in 24 h postmortem meat ($5.4<pH<6.0$), as reported by many researchers[3,11,12].

Higher values for a* were obtained from meat stored at commercial FT and were the result of a higher accumulation of pigments during the freezing process which originated the transformation of myoglobin to metmyoglobin resulting in the presence of a darker color in the meat[2]. However, mean values corresponded to those reported by other researchers (4.0) for meat that has been frozen.

Lawrie[13] reported that meat is tenderer or has lower shear force values after being frozen due to the structural damage as a consequence of the ice crystal formation in the fibers. It is known that there is a relationship between pH and tenderness, because at high pH, enhance the proteolytic activity of calpains which provoke a more tender meat. Although this study showed significant differences ($p<0.05$) in pH values for FT effect, they did not affect the shear force values. Hence, a pH between 5.5 and 5.7 did not modify meat tenderness.

Shear force values obtained in this study fall in the range of meat at 24 h postmortem, 2.63 to 5.09 kgf[14]. This range points out that a drip loss of a 5-10 % of meat weight does not modify tenderness even after being exposed to different FT and distinct DM. The lowest DL was observed when meat was defrosted by immersion in water, with a value of 5.23% for meat frozen at domestic FT, and 7.79% frozen at commercial FT. Such a low DL may be attributed to the short exposure time of the meat (2 h) when defrosted by immersion in water, compared to a longer exposure time (24 h) when defrosted in refrigeration. This support the idea that a slow defrosting as it happened at refrigeration temperature causes more

damage through crystal ice crystallization in the meat, because the freed fluid from fibers it is not reabsorbed by the meat. This suggests that the amount of water lose by drip is directly related with velocity rate of defrosting[1].

Mean values for DL at 24 h postmortem of <5% have been previously reported[12,15,16]. However, in this study a higher mean value for DL was found (10.77%) when meat was defrosted in refrigeration. This supports the fact that a slow defrosting, like that done in refrigeration, causes more damage trough re-crystallization of the ice crystals in the meat since the liquids released from the fibers can not be re-absorbed by the meat[2,18].

Percentage of WHC was higher when meat was frozen at -14.3°C, with values of 49.39% for meat defrosted by immersion, and 48.19% for meat defrosted in refrigeration. The lowest values were obtained when meat was frozen at commercial temperature. When meat is frozen at temperatures under -20°C, a higher migration of water inside the extracellular spaces and therefore a deformation of the myofibrillar structure is exhibited, causing dehydration of the fibers and a distinctive increase in the concentration of solutes resulting in the denaturalization of proteins[2,17].

Meat defrosted in refrigeration showed the lowest values for WHC, an opposite relation to the behavior of DL variable. So, when meat is subjected to a slower defrosting period, there is a bigger chance of re-crystallization of the ice crystals that results in a higher loss of water outside the fibers. Mean values for WHC between 47.28 and 50.11% have been reported in meat at 24 h postmortem[19,20]. WHC value was similar to that of meat at 24 h postmortem when there were water losses greater than 10% as a result of freezing and thawing of the meat.

Pork meat subjected to two different freezing temperatures and defrosted by applying two different methods did not show differences in the presence of total and fecal coliforms, and *Salmonella sp.* Also, in spite of the freezing temperature applied, meat defrosted in refrigeration showed the highest values for aerobic mesophils (20,650 CFU g^{-1}), while meat thawed by immersion in water showed values of 4,440 CFU g^{-1}; this may be due to the fact that meat defrosted in refrigeration (24 h) took longer than meat defrosted by immersion (2 h), facilitating the growth of the microorganisms. However, these values fall between the normal ranges that guarantee the microbiological quality of the meat, which can be up to 100,000 CFU g^{-1}[21].

CONCLUSIONS

Values for pH, L*, b*, and shear force in this study were not affected on pork meat when subjected to different FT and DM.

The highest DL values were observed when pork meat was frozen at a commercial temperature and defrosted in refrigeration.

It is important to consider the time the consumer takes to defrost the pork meat since this will influence the behavior of the variables that determine the quality of the meat.

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