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Comparison of melting frost layers after 2 frozen methods in pork cuts *(longissimus dorsi)*

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Abstract

The frost formation and fusion of ice crystal on complex materials have a great importance, since they modify quality meat characteristics. Furthermore, changes take place in fiber morphology by formation of ice crystal during freezing. The aim of this work was to measure the frost formation and melting. Morphological frost difference was found, and the fusion times were different too. All the results can be useful to complement and understand the complex thermal processes with phase change at low temperatures. This study implicates thermal and mass concepts; they explain the frost formation and the melting process as an opposing phenomenon.

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Keywords: Freezing; melting; meat damages.

1. Introduction

The frost formation and melting in complex materials such as meat, have a great importance since modifies visible quality characteristics like color [1] and those not perceptible by the consumer, like the fiber structural damage. Research around meat freezing and collateral effects caused by this process, require further investigation to determine the measurement uncertainty level in the muscle fibers destruction or deterioration, to understand the thermodynamic variables behaviour of that occur in such complex compositions like pork meat, which by temperature and freezing time effect express chemical, physical and mechanical changes on its structure.

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There are studies related to the measurement of frost thickness in metal plates [2, 3] under controlled relative humidity (HR) and temperature (T) conditions in foods such as meat and some other products [4], relating the effect on weight loss, applied in commercial freezers that present own variations in compressor stop and start cycles, which is manifested in temperature variation.

For a mechanical freezing by forced convection, temperature fluctuations are presented by compressor stop/start cycles or other thermal and mass exchanges caused by doors opening and closing. These temperature fluctuations usually occur during the transport, storage or consumption; repeated freezing-thawing cycles are very common in retail, at home or in a restaurant, which leads to an irregular growth of structure damage, thereby contributing to more drastic changes in the meat system, having a lower thermal stability. Gormeley *et al.* (2002) [5] and Hansen *et al.* (2004) [6] have studied the temperature fluctuations effect in the process and frozen storage on different physical alterations, relating them to the ability of link and distribute the water during the process and modifications on fatty compounds.

During cryogenic freezing, the water contained in the cells is quickly frozen (greater than 5 *cm/h*); it is done with liquid nitrogen whose boiling temperature is -196° *C*. This type of freezing maintains product quality better than others due to: ice micro-crystal creation which does not deform the cell, avoiding loss of texture and dehydration, maintaining the product quality, since there is no mass exchange with air.

Cheng and Cheng (2001) [7], cite that the frost formation can help to minimize food dehydration by sealing the juices or water exit with agents who promote taste by the formation of a crust on the outside layer of a foodstuff; however, this practice is common in sea products such as fish and shrimp that are subjected to frozen storage, activity known as "Glaze" which is the formation of a thin ice coating formed on the product surface by spraying it with water, or approved additives, or by submerge it. Vanhaecke *et al.* (2010) [8] and Laguerre and Flick (2007) [1] cite that often, in packaged vegetables during storage, the frost formation is accompanied by superficial dehydration. This dehydration can induce color change, rancidity and weight loss among other disadvantages. As regards the frost formation, have been developed theoretical and experimental, empirical and semi empirical, models that consider the effects of temperature, air rate and relative humidity, material surface temperature on frost thickness [7,9] and frost density [10]. However, these are only for non-food products such as copper or aluminium plates, with application of electric field to avoid frost formation, with and without an electric field [11], in forced and natural convection [12], in a capillary cylinder [13], in cryogenic tanks exposed to atmospheric conditions [14] and in frost morphology [15], assuming the importance of heat and mass transfer during the frost formation in all cases. Broadly speaking, these are some of the considerations made by above authors: (1) the frost density is uniform at any moment with one-dimensional transport processes. (2) The frost layer grows in the perpendicular direction to the surface of cold plate. (3) Both heat and mass transfer coefficients in the frost surface are constant, (4) ideal gas law prevail, (5) gas phase total pressure is constant along the porous frost layer and equal to normal atmospheric pressure and (6) the convection and radiation effects are negligible within the frost structure, among other things, that for the freezing of food has not been tested.

For the frost thickness determination, Cheng and Shiu (2002) [16] used microscopic imaging with a photographic camera system and a luminescence unit (without thermal radiation), a zoom (158 *X*) a lens unit, taking photos of the frost formation in an adjustable time interval. A computer equipment with a color digitizer receives the data image and these are analyzed with a microscale image processor. Wang *et al.* (2004) [11] using three cameras that took frost lateral and surface pictures. The image sensor was 1/4 *in* to obtain 410 K *pixels* with a scanning system of 525 *lines* and 60 *fields/s.* Qu *et al.* (2006) [15] measured the frost thickness using a laser scroll bar. The morphology of the frost surface was observed and recorded with a CCD camera. Do *et al.* (2004) [17] mentioned that the crystals formation during freezing is generally difficult to observe due to their dynamic variations in morphology, size, configuration, color and transparency, so is also difficult to determine the frost characteristics.