EFFECT OF FREEZING TIME ON QUALITY OF THAWED LOINS

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Background

About 30% of the Danish pork export is sold as deboned, frozen meat ready for further processing or for catering (table meat). The quality of the meat after thawing will a.o. depend on the freezing process. 70% of the meat is water that during the freezing process changes from fluid to a solid form. Støier & Borup (1995) found that the rate of freezing, defined as the time it takes the temperature of a product to decrease from 5°C to a core temperature of –12°C, has a great impact on the quality. When the water starts freezing ice crystals will develop. These crystals will increase as more and more water freezes on the surface of the ice crystals. The rate of freezing is important with respect to the number and size of the ice crystals. A quick freezing process will generate many small nuclei and crystals, whereas a slow freezing process results in few nuclei and big crystals. Añon & Calvelo (1980) found that during freezing of beef there is a critical zone in relation to the freezing rate at which zone the amount of drip loss is at its maximum. Before this critical zone is reached only intra cellular crystals develop whereas in the critical zone intra- as well as extra cellular crystals develop. In the succeeding zone only extra cellular crystals developed and the drip loss after thawing was constantly at a level lower than the critical zone.

Martino et al (1998) found that the time of freezing could be reduced to 1/3 when freezing took place in liquid N_2 compared to an air-blast freezing (–30°C). Martino et al (1998) also found that a freezing process involving N_2 resulted in fewer ice crystals in the meat both on the surface as well as in the centre of the meat thus causing less damage to the membrane structure of the cells. Ngapo et al (1999) found that the level of drip loss in small meat samples of 6 grams after a quick freezing process (centrifugal method) was similar to that of fresh meat samples. After a storage period of 4 weeks it was no longer possible to observe an effect of the freezing rate.

Objective

The aim of this study was to investigate the meat quality after thawing of entire pork loin muscles either for further processing or direct consumption, the freezing process being either liquid N_2 or air blast freezing. The study was carried out in two trials. Trial A investigated the quality of meat for processing, and trial B investigated the quality of meat for direct consumption.

Methods

Pork loins for the investigation were selected from carcasses on the slaughter line based on slaughter weight, meat content, ultimate pH and reflection in the meat. This procedure was chosen to ensure a minimal variation in the raw meat quality.

Each loin was wrapped in polyethylene before freezing in order to reduce weight loss during freezing and storage. Then the loins were placed on steel conveyors to obtain maximum contact with the freezing medium. Freezing took place either in a standard blast freezer in which air chilled to a temperature of –20°C was circulated above the products, or in a freezer using liquid N_2 (–196°C) as freezing medium. The frozen loins were stored for 3 weeks (Trial A) or 4 months (Trial B) at –20°C before being thawed. The quality assessments took place after thawing. The thawing loss and the cooking loss were calculated as follows: *thawing loss* = (unfrozen weight – thawed weight)/unfrozen weight; *cooking loss* = (weight before cooking-weight after cooking)/weight before cooking. Meat colour was measured with the Minolta CR300 and the shear force value (80 % compression) with Volodkevitch jaws.

Thawing of loins from Trial A commenced with injection of 45 °C air for 30 minutes, then for 90 minutes with 15 °C air and then with 5 °C air until the thawing was completed the following day. After 17½ hours the centre temperature of the loins was 5 °C which temperature was maintained until processing.

Thawing of loins from Trial B took place in a refrigerator at 4 °C. The loins rested here for 48 hours prior to quality measurement and sensory assessment. Before measuring the meat colour, cooking loss, and eating quality the loins were cut in chops of 2 cm. A sensory panel of 8 panellists investigated the eating quality using a scale for intensity ranging from 0-15, where 15 represents high intensity. The score was calculated as the average of the scores given by the panellists.

The statistical analysis comprised a t-test at 5% level, the hypothesis tested being H_0: The average result of the two test samples was identical irrespective of the freezing process.

Results

Trial A. The freezing time for loins in the air-blast freezer was 14½ hours to reach a core temperature of –12 °C, while the freezing time was 1½ hour for loins in cryogen. All loins were thawed under identical conditions in a thawing cabin.

There was a significant difference in thawing loss depending on the freezing process and time. Freezing in liquid N_2 reduced the thawing loss, which means that the manufacturer obtained a higher yield and more raw materials for further processing. There was no difference in cooking loss, and neither in the colour of the processed meat products. There was a slight difference in shear force of the processed products; loins frozen in liquid N_2 were more tender.

Trial A. Processed meat, loin for curing and cooking.

	Air (–20 °C)	Nitrogen (–196°C)	Significance
No. of loins	16	16	
Thawing loss %	3.8	1.5	**
Cooking loss %	8.0	8.4	ns
Minolta L-value	73.7	74.1	ns
Minolta a-value	9.3	9.7	ns
Shear force (Newton)	9.6	6.6	*

ns: not significant; *: 95% significance; **: 99% significance

Trial B. In this trial the freezing time in the air-blast freezer was 12 hours, whereas the time was two hours for liquid N_2.

Trial B. Meat for consumption, pork loin

	Air (–20 °C)	Nitrogen (–196°C)	Significance
No. of loins	20	20	
Thawing loss %	2.4	1.6	**
Cooking loss %	16.8	15.2	**
Tenderness	9.2	9.8	*
Juiciness	9.2	10.1	**
Minolta L-value	51.2	51.0	ns
Minolta a-value	6.7	7.0	ns

ns: not significant; *: 95% significance; **: 99% significance

There was no difference in colour of the uncooked meat, and in this experiment thawing loss as well as cooking loss were significantly lower than if the loins had been frozen in liquid N_2. Again the meat was more tender and juicy after freezing in liquid N_2.

Discussion and conclusions

Both trials proved that the use of liquid nitrogen reduced the freezing time with 85% compared to freezing in a blast freezer.

Loins frozen in nitrogen had a lower thawing loss irrespective of storage time and cutting. This trial comprising entire pork loins did not confirm the findings of Ngapo et al (1999), who concluded that in small meat samples the storage time equalizes the positive effect of the freezing rate on drip loss.

Añon & Calvelo (1980) explained the effect of freezing rate on drip loss by the fact that intra cellular frozen water more easily reabsorbs than water frozen extra cellularly because extra cellular ice crystals will damage the muscle fibres resulting in a poorer absorption capacity. This could account for the differences observed with respect to the thawing loss between the two freezing processes.

Meat for further processing such as salted, cooked products as well as meat for fresh consumption will, when frozen in liquid nitrogen, be of a better quality than meat that has been blast chilled. This quality improvement will be maintained after a storage period of up to 4 months irrespectively of the thawing process being accelerated (Trial A) or slow (Trial B). Freezing damage did not appear on the loins after thawing because the products had been wrapped in tight polyethylene before being frozen.

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