THE EFFECT OF FREEZING AND DURATION OF FREEZING ON THE QUALITY OF PORK LOIN

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Abstract – Pork loins were overwrapped with PVC sheets and stored frozen for three, six, nine, 12 and 18 months at -20°C. Frozen loins were compared with fresh cuts. Drip loss of frozen samples was higher than fresh samples but duration of freezing did not affect drip loss. For aroma, flavor and off-flavour, samples at nine months of freezing started to deteriorate but at 18 months the negative effects were most significant. Fresh samples were more tender than frozen samples although the negative effect of freezing only became significant at nine months of freezing. It can be concluded that freezing pork loins for nine months or longer will increase the risk of poor eating quality in terms of tenderness. Freezing however, will in all circumstances contribute to higher drip loss.

Key Words – extreme freezing duration, colour, pork, tenderness.

I. INTRODUCTION

Freezing is one of the technologies used to preserve fresh meat for long-term storage [1]. This also normally applies for imported meat as it travels far distances over long durations and is often then stored for further use when needed. Meat products can be found at supermarkets either fresh or frozen. Estvéz *et al*. [1] stated that frozen meat has a stigma because freezing is perceived to reduce meat quality even though this perception is not clearly supported by scientific evidence.

Freezing affects the functional properties of muscle proteins that could in turn affect colour, water holding capacity, tenderness and the characteristics of processed meat [2]. While most chemical processes are slowed down during freezing, prolonged freezing shows that frozen storage can affect the oxidative stability of pork which in turn can affect taste and consumer acceptability of fresh and processed meat [3].

In this study we simulated the process of importing frozen pork loins that are stored and evaluated the effect of freezing time on various quality parameters.

II. MATERIALS AND METHODS

Fresh deboned pork loins (n=36) were purchased from a meat retailer over a period of 18 months. The loins were purchased and frozen at 18 (n=6), 12 (n=6), nine (n=6), six (n=6) and three (n=6) months before evaluation so that cuts from the five storage durations could be evaluated at the same time. The loins were overwrapped with Polyvinyl Chloride and frozen at -20°. At the time of evaluation another six loins were purchased and used as fresh samples.

Four loin chops of 30 mm thick of each frozen loin primal were cut, vacuum-packed and thawed at 4°C for 12 hours. Four loin chops were also cut from the fresh loins and vacuum-packed. Three of the four chops were oven-broiled (dry-heat cooking) at 200 °C (pre-set) to 70 °C internal temperature [4]. Two chops were used for sensory analyses. A ten member trained sensory panel evaluated the cooked samples of meat and fat for typical pork meat and fat aroma and flavour tenderness and juiciness, and for fishy and rancid flavour overtones of the cooked fat. An 8-point hedonic scale was used where 1 denotes extremely bland or absence of specific flavours and aromas, extremely dry and extremely tough meat, while a score of eight describes extremely intense flavours and aromas, extremely juicy and extremely tender meat. The third chop was cooled down to 18°C for

Warner Bratzler shear force (WBSF). Six round cores (12.7 mm diameter) were removed from one chop parallel to the muscle fibres [4], and sheared perpendicular to the fibre direction by a Warner Bratzler shear device mounted on a Universal Instron apparatus. The mean value of the six recordings used as a shear value.

The fourth chop of each loin was thawed and thawing loss calculated as the difference in weight between the frozen and thawed chop expressed as a percentage of the frozen weight. Thawing loss of the fresh sample was regarded as zero. Drip loss of thawed loin chops was determined by suspending cubes (10 x 10 x 20 mm) of muscle from a pin inside a sample bottle (200 ml). Duplicate samples were stored for three days at 4°C. Drip loss was calculated as the difference in sample weight before and after storage expressed as a percentage of sample weight before storage.

Data were subjected to analysis of variance with the 6 treatment groups used as main effects. Means separation was achieved by Fisher's protected t-test least significant difference (LSD) at the 5% level.

III. RESULTS AND DISCUSSION

Thawing loss of loins frozen for 18 months was lower than those of the other frozen loins, but no plausible reason could be given for this phenomenon (Table 1). In contrast, loins frozen for 18 months recorded higher total cooking losses than all other treatments, except the 12-month group. Drip loss of frozen samples was twice as high as for fresh samples but duration of freezing had no effect on drip loss. The cooking loss of samples frozen for 18 months was higher than that of fresh samples and samples frozen for 3 to 9 months. Cooking loss also tended to increase from 6 months to 18 months of freezing. Leygonie *et al*. [5] noted that freezing and thawing damage the ultrastructure of muscles cells so that pro-oxidants such as mitochondrial and lysosomal enzymes, haem iron are released that give rise to increased oxidation. Oxidation of the myofibrillar proteins leads to aggregation and coagulation (denaturation) of myosin and actin that causes lateral shrinkage of the inter-filamental space and the decrease in capillary force leading to higher drip in addition to other protein changes due to oxidation [6]. Farouk et al. [7] and Ngapo et al. [8] reported a decrease in water holding capacity with prolonged frozen storage and contributed this to loss of protein functionality and recrystallization changing small ice crystals into large ones that damaged muscle ultrastructure. Apart from higher cooking loss at 18 months, this tendency was not found in our study.

Sensory scores for roasted pork meat and fat aroma did not differ between fresh loins and those frozen for three to nine months. However, scores for these two attributes started to decline at nine months of freezing and was significantly lower at 12 months compared with 6 months of freezing. Fat aromas described as "fishy" and rancid" followed exactly the opposite trend as roasted pork fat and meat aromas. The mean scores for the "negative" aromas (rancid, fishy) were much lower than those of the "typical" aromas since the panelists only scored for these attributes when they were recognized. Nevertheless, the significant differences among treatments (freezing times) indicate the consumer will most likely distinguish between freezing durations.

Table 1: Mean values and statistics indicating the effect of freezing and duration of freezing on moisture properties and WBSF of pork loins

	Freeze time						*P*	SEM
	Fresh	**3**	**6**	**9**	**12**	**18**		
WBSF (kg)	4.0^{a}	4.7^{ab}	4.7^{ab}	4.5^{ab}	6.2^{c}	5.3^{bc}	0.494	0.052
Thawing loss (%)	0.0^{a}	3.4^{c}	3.1^{c}	3.2^{c}	3.1^{c}	2.1^{b}	<0.001	0.313
Drip loss (%)	3.1^{a}	6.1^{b}	6.5^{b}	6.0^{b}	5.9^{b}	5.6^{b}	<0.001	0.4780
Total cooking loss (%)	25.1^{a}	25.4^{a}	25.4^{a}	27.0^{a}	29.0^{ab}	32.0^{b}	0.012	1.451

^{a,b,c} Values in the same row with different letter differ significantly (P<0.05)

Figure 1: Effect of freezing and duration of freezing (3 – 18 months) on selected pork loin fat aroma overtones

[a,b,c] Different letters within each trait indicate significant differences (P<0.05)

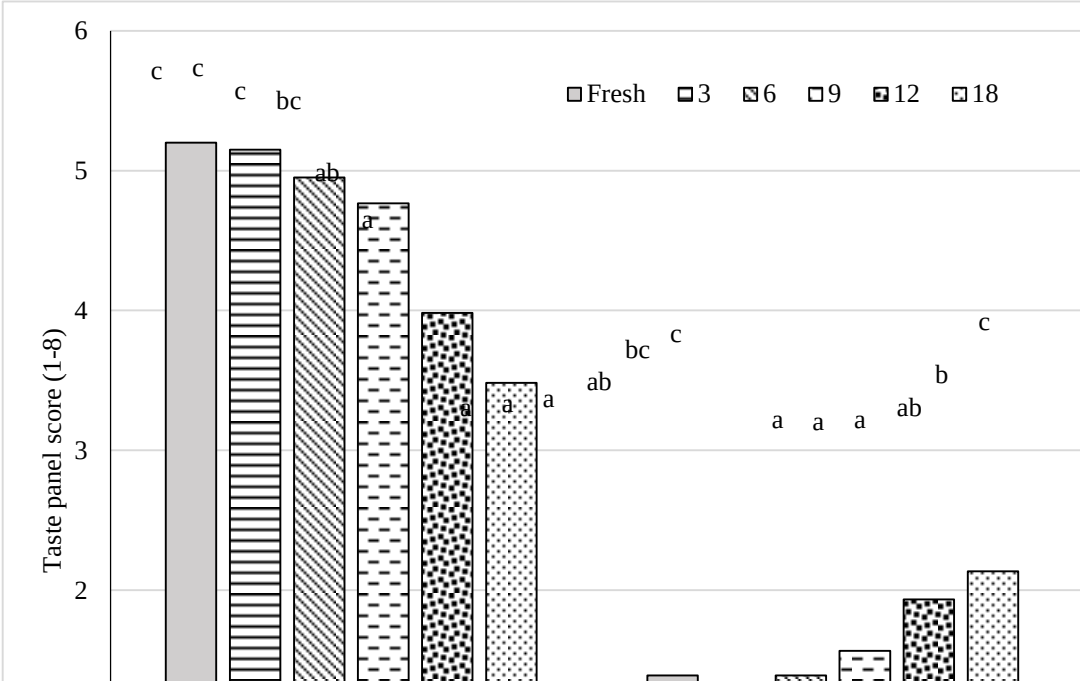
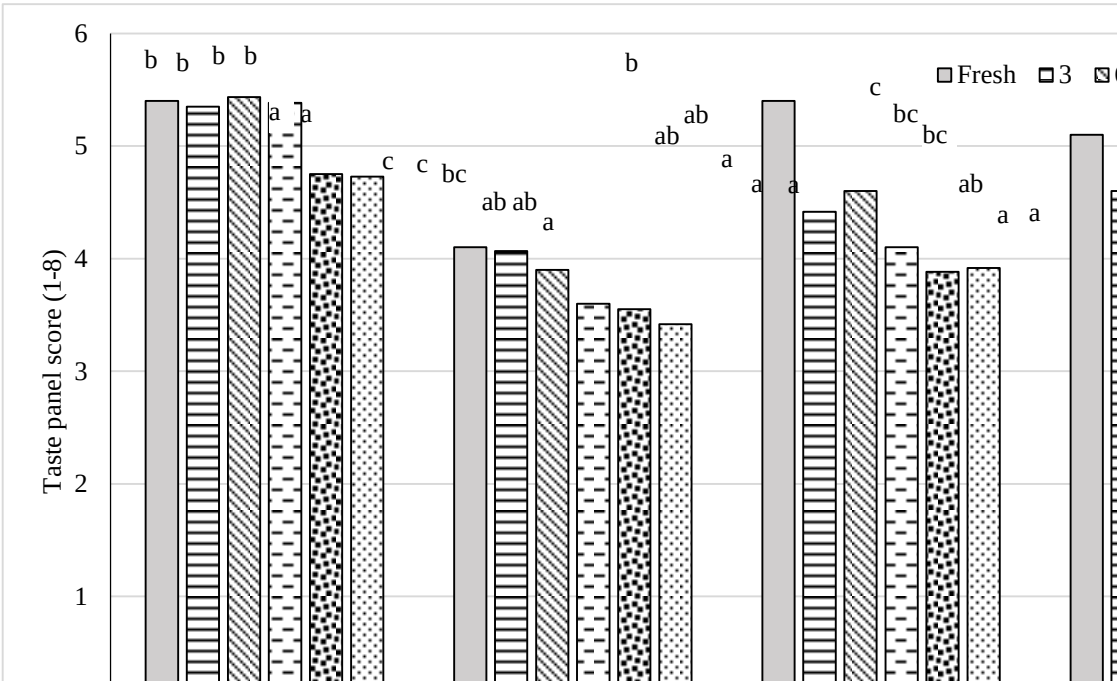


Figure 2: Effect of freezing and duration of freezing (3 – 18 months) on pork loin meat tenderness, juiciness and selected aroma and flavour overtones.

[a,b,c] Different letters within each trait indicate significant differences (P<0.05).



Duration of freezing had the same effect on pork flavour as on typical pork aroma and was scored lower for loins frozen for 12 or 18 months compared to fresh loins or loins frozen for three months. Leygonie et al. [5] noted that the unfrozen water fraction in frozen meat at temperatures around -20 °C may lead to primary lipid oxidation that will lead to secondary oxidation during thawing, causing off-flavours (rancid, fatty, pungent) [9]. In addition, the release of pro-oxidants, especially the haem iron, due to cell membrane damage, will accelerate fat oxidation and formation of off-flavours. No reports could be found suggesting the rate of deterioration.

Loins frozen for nine months or longer were significantly tougher than fresh samples, while duration of freezing also showed a slight downward trend. WBSF complimented the tenderness scores, measuring more than 2 kg higher for loins frozen for 12 months than for fresh samples. In contrast to our results, most studies report an increase in meat tenderness (lower shear values) as a result of freezing and that this effect is correlated with length of frozen storage [5]. The improvement is related to increased exposure of muscle structure to proteolytic enzymes and to structural damage by growing ice crystals. In agreement with our study Lagerstedt *et al.* [2] reported lower sensory scores but also lower shear force values for frozen vs. fresh beef loin. Fresh loins were scored higher for juiciness than loins frozen for 12 or 18 months. As with tenderness, a general downward trend was observed with duration of freezing and this could be attributed to an increase in structural damage and a drier cooked product although results for cooking loss and drip loss did not support this.

IV. CONCLUSION

It can be concluded that freezing pork loins for longer than nine months increases the risk of poor eating quality in terms of flavour, aroma, tenderness (including WBSF) and juiciness. This is in contrast to the recommendations of 12 months as stated by Cano-Munoz [10]. Duration of freezing did not affect moisture properties.

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