Influence of muscle, freezing/thawing prior processing, and storage temperature on the formation of a white film on dry-cured meat

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I. INTRODUCTION

Drying during dry-cured meat production can lead to supersaturation of the residual water causing substances with low solubility to precipitate as crystals. The crystals can form within the muscle tissue influencing the texture or on the surface of dry-cured meat affecting its appearance [1]. Even if several studies on these crystals were conducted (e.g. [1-4]), the reason why and when precipitation primarily occurs on the surface or in the dry-cured meat is still unknown. Tyrosine is identified as one of the main components but also other aromatic amino acids as well as peptides and protein fragments have been identified [2]. Once formed, crystals can not necessarily be washed off permanently. Thus, ways to prevent crystallization must be found leading to the hypothesis that the muscle, freezing/thawing, and the storage temperature of dry-cured meat have a multifactorial influence on crystallization. Exemplarily the influence of loin and rump, freezing prior production (fresh *vs*. frozen and thawed), and the storage temperatures of 2 and 20 °C were investigated.

II. MATERIALS AND METHODS

Twelve pork loins and twelve pork rumps were purchased at 2 days postmortem. Six loins and six rumps were immediately frozen at -18 °C and thawed at day 4 p.m. at 20 °C. Other muscles were kept at 2 °C. At day 5 p.m. all muscle parts were salted with 3.6 % nitrite curing salt with 0.5 % $NaNO_2$, 0.7 % Tari Mix (ICL BK Giulini GmbH, Ladenburg, DE) and 0.02 % starter culture RPW consisting of *Staphylococcus xylosus* and *Staphylococcus carnosus* and *Debaryomyces hansenii* (AVO-Werke August Beisse GmbH, Belm, DE). Meat was stored at 2 °C and turned each third day. After 14 days, meat was rinsed with cold water and stored on a grid at 2 °C. After 3 days, grids were placed in a ripening chamber (KR 1 · 100 / E, Autotherm Ludwig Brümmendorf GmbH & Co KG, Waxweiler, DE) hold at 22 °C and 86 % relative humidity (rh) for 36 h, followed by 20 min smoking at 20 °C, and ripening for 24 h at 16 °C and 80 % rh. The parameters for drying were set at 15 °C and 75 % rh. Dry-cured meat was weighed weekly and pH was measured at d0, after salting (d22) and after ripening (d47) (testo 205, Testo, Lenzkirch, DE). Then, meat was vacuumized and stored at 2 °C. After an equalization period of 14 days, each loin and rump were cut in half and vacuumized. One half was stored at 2 °C and the other half at 20 °C. Appearance of crystals on the cut were monitored weekly. Statistical analysis of weight loss and pH was performed using the t-test and differences in the appearance of a white film were analyzed using Three-Way-ANOVA and Tukey's post-hoc test ($p < 0.05$) in SigmaPlot 15.0 (Systat Software Inc., San Jose, CA, USA).

III. RESULTS AND DISCUSSION

The pH-value of frozen/thawed loin is on d22 significantly ($p < 0.05$) higher than the pH of the fresh loin, whereas the pH of the fresh rump is significantly ($p < 0.05$) higher on d47 than of the frozen/thawed rump (Table 1). The weight loss is significantly ($p < 0.05$) higher for the frozen/thawed rump which is due to the destruction of cells by freezing [4]. However, no significant differences in the weight loss exist between fresh and frozen/thawed loin. These findings indicate that the muscle influences the weight loss during dry-cured meat production due to thawing, which was also illustrated by Bañón *et al.* [4], who showed significant different ($p < 0.05$) moisture contents in dependence of the muscle.

On the cut, only a white film of small crystals and not individual larger crystals have been identified starting with storage week 1 (Table 2). Contrary to Bañón *et al.* [4], who found more dry-cured meat with precipitates when meat was frozen and thawed in comparison to fresh meat, less dry-cured frozen/thawed

Table 1. pH-value and weight loss of dry-cured loin and rump with either fresh or frozen/thawed meat prior production.

	loin				rump			
pH ( )	**fresh**		**frozen/thawed**		**fresh**		**frozen/thawed**	
d0	5.54 ± 0.06		5.59 ± 0.06		5.57 ± 0.04		5.59 ± 0.06	
d22	5.44 ± 0.05		5.53 * ± 0.05		5.52 ± 0.07		5.49 ± 0.09	
d47	5.51 ± 0.07		5.55 ± 0.04		5.62 ± 0.05		5.53 * ± 0.04	
Weight loss (%)								
d0 to d22	6.05 ± 0.94		8.08 ± 1.01		2.95 ± 0.68		4.92 * ± 0.67	
d0 to d30	30.75 ± 1.99		32.66 ± 1.90		21.45 ± 1.68		24.19 * ± 1.14	
d0 to d47	46.04 ± 2.35		47.22 ± 1.99		32.28 ± 1.86		34.80 * ± 1.42	

*indicate significant differences ($p < 0.05$) between fresh and frozen/thawed meat, determined using the t-test

loin and rump showed a white film than dry-cured meat made from fresh meat. This could be due to similar proteolysis indices of fresh and frozen/thawed meat [2]. Variations in the proteolysis between muscles [4] could have contributed to the significant different ($p = 0.012$) count of white films between dry-cured loin and rump in storage week 2, which was analyzed using Three-Way-ANOVA. Interestingly, in storage week 1 only 5 dry-cured rumps made of frozen/thawed meat, stored at 2 °C, showed a white film which vanished from week 1 to week 2 on four dry-cured rumps and was found again in week 3. Most of the other samples developed a white film from storage week 1 to week 2 or week 3. The white film on dry-cured meat stored at 20 °C vanished from week 5 to week 6 – except for 3 rumps made of fresh meat – indicating that a higher storage temperature leads to the white film being reduced. This is underlined by the Three-Way-ANOVA, which indicated significant differences ($p = 0.002$) between the storage temperatures in week 6.

Table 2. Count of appearance of a white film on the fresh cut surfaces of dry-cured loin and rump, from fresh or frozen and thawed meat. The dry-cured meat were stored at 2 °C or 20 °C (n = 6).

Muscle	**loin**				**rump**			
Prior processing	**fresh**		**frozen/thawed**		**fresh**		**frozen/thawed**	
Storage temperature	**20 °C**	**2 °C**	**20 °C**	**2 °C**	**20 °C**	**2 °C**	**20 °C**	**2 °C**
Storage week 1	0	0	0	0	0	0	0	5
Storage week 2	5	6	4	6	1	4	2	1
Storage week 3	6	6	6	6	6	6	5	5
Storage week 4	6	6	6	6	6	6	4	6
Storage week 5	6	6	6	5	6	6	4	6
Storage week 6	0	6	0	6	3	6	0	6

IV. CONCLUSION

A higher storage temperature (20 *vs*. 2 °C) of vacuumized dry-cured meat results in the disappearance of a white film on both, loin and rump, after six weeks of storage ($p = 0.002$). Moreover, more dry-cured loins showed a white film than did dry-cured rumps which could be due to the different muscle properties, e. g. muscle fiber sizes. However, short freezing prior production had no influence on the appearance of crystals on the cut, neither of dry-cured loin nor rump. As these findings are somewhat contrary to earlier studies, crystals contributing to the white film, should be characterized, the proteolysis index determined, the study extended and checked for differences in the crystallization in connection with the weight loss.

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