INFLUENCE OF THE RAW HAM QUALITY AND TUMBLING TIME ON YIELD AND PRODUCT QUALITY OF COOKED HAM

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Abstract – In this study the influences of tumbling time (5h30, 19h and 26h) and raw ham quality, e.g. superior (pH ± 5.8), inferior (pH ± 5.5), and mixed batches, on the technological yields, e.g. tumbling yield (TUY, %), cooking losses (COL, %) and the total yield (TOY, %) of cooked ham were evaluated. In addition, the effect on water holding capacity (WHC) and texture (hardness and springiness) of the cooked ham as end product were considered. Despite the positive effect of tumbling time and the use of superior quality hams on the COL (%), the yields were only influenced by tumbling time. At a prolonged tumbling time (≥19h), the TUY (%) slightly decreased while the final yield of the cooked ham (TOY%) increased. Concerning the quality of cooked ham, neither of both texture parameters were affected by alterations in tumbling time or ham quality. Nevertheless, when the total yield was maximized by a prolonged tumbling time (≥19h), the WHC could be increased by the use of superior quality hams.

Key Words – cured meat, cooking losses, water holding capacity

I. INTRODUCTION

In the production of high quality cooked ham, the use of additives is strictly limited. For example, polyphosphates, normally added for the extraction and solubilisation of the myofibrillar protein complex [1], is excluded. As a consequence, the quality of the cooked ham product will depend on the selection of raw meat materials and its subsequent processing. During the mechanical action of tumbling process, muscles undergo structure disruption resulting in tenderization [2]. In addition, tumbling ensures a better distribution of the injected brine, as well as the extraction of functional, myofibrillar proteins from the muscle fibers, which ensures the water holding capacity (WHC) [3] and the binding of meat pieces upon cooking. In this aspect, it is obvious that a longer tumbling time reduces cooking losses [3], however it is less clear to which extent the technological yields (tumbling yield and total yield) and end quality of the cooked ham is affected by prolonged tumbling processes. In addition, the functionality of the proteins is greatly influenced by the raw ham characteristics. For instance, pale, soft and exudative (PSE) meat, is characterized by a low pH and increased protein denaturation due to a fast glycolysis and slow temperature fall *post mortem* [4]. In this way, it might be expected that the WHC and thus the technological yields will be compromised.

The aim of this study was to investigate the combined effect of tumbling time and raw pork ham quality on the technological yields of polyphosphate free cooked ham. In addition the quality of the cooked ham product in terms of water binding capacity and texture was investigated.

II. MATERIALS AND METHODS

Preparation of cooked ham:

To evaluate the influence of (1) the raw ham quality and (2) the tumbling time on the quality of cooked ham, polyphosphate free cooked ham preparations were made at pilot scale. The selection of raw hams was based on pH measured 12h *post mortem* at a local meat wholesale supplier. The selected hams were divided in three quality classes, i.e. (1) superior (pH ± 5.8), (2) inferior (pH ± 5.5), and a (3) mixture of both qualities. After deboning and defatting (24h *post mortem*) the quality of the whole-leg hams was characterised by measuring pH, PQM (PQM-I, Intek) and colour (L*, a*, and b*-values, MiniScan EZ, HunterLab) on the *M. Semimebranosus*. All measurements were done in triplicate. Consecutively, all hams were injected with 12% brine, consisting of 203 mg/l nitrite curing salt, 56 mg/l dextrose, and 11 mg/l sodium ascorbate. The hams were then tumbled (repeated phases: (a) 10 min, 8 rpm, 90% vacuum, (b) 20 min, 0 rpm, 90 % vacuum, (c) 10 min, 8 rpm, 0% vacuum, and (d) 20 min, 0 rpm, 0 % vacuum) for (1) a short (5.30h), (2) intermediate (19h), or (3) long (26h) time. Thereafter, the netted hams were pasteurised at 70°C until a core temperature of 67°C was reached. The nine variations (3×3) were manufactured in duplicate, whereby each batch consisted of 8 hams.

Technological yields:
Of each ham, the masses (g) of the raw material (m_{RAW}), of the tumbled ham (m_{TUM}), and of the end product (m_{PROD}) were measured in order to calculate the following technological yields:
- Tumbling yield (%):
$$TUY = 100\%.(m_{TUM} - m_{RAW})/m_{RAW}$$
- Cooking loss (%):
$$COL = 100\%.(m_{PROD} - m_{TUM})/m_{TUM}$$
- Total yield (%):
$$TOY = 100\%.m_{PROD}/m_{RAW}$$

Quality characteristics of the end product
The quality of the final cooked ham products was characterised by determining the water holding capacity (WHC), expressed as the ratio area meat/area water (cm²/cm²) after applying the filter paper press method (1 kg on 0.3 g meat sample for 5 min)[5]. In addition, the texture parameters (hardness and springiness) were determined using texture profile analysis (TPA, LF plus, Lloyd Instruments).

Statistical evaluation:
Results are expressed as mean values ± standard deviation (n=16). To evaluate the quality of the raw hams, one-way analysis of variance (ANOVA) were performed. The effect of raw ham quality and tumbling time on the yields and quality of the cooked ham was evaluated by two-way ANOVAs. Tukey's *post hoc* test was performed and a significance level of $p<0.05$ was used for all tests.

III. RESULTS AND DISCUSSION

Determination of the raw ham quality
In table 1 the quality parameters (pH, PQM and colour values) are given for each quality class. After deboning, a significant pH difference ($p<0.01$) was observed between the three different quality classes. With regard to the PQM, no significant differences could be observed between the superior and mixed quality classes. Only the inferior hams showed significantly higher PQM values ($p<0.01$). No significant differences in lightness (L*) and redness (a*) were observed for the different quality classes. Only the b* values (yellowness) were slightly lower with increasing quality ($p<0.05$).

Table 1 Quality parameters of the hams, measured after deboning and defatting (24h).

Parameter	Quality class		
	Superior	Inferior	Mixed
pH_{24h}	5.70±0.15^{c}	5.56±0.10^{a}	5.62±0.10^{b}
PQM_{24h}	11.5±3.4^{a}	13.1±2.9^{b}	10.1±3.1^{a}
L^*_{24h}	47.32±3.35	47.36±2.73	47.84±3.69
a^*_{24h}	10.02±2.08	10.94±2.41	10.57±1.97
b^*_{24h}	15.73±1.46^{a}	17.12±2.05^{b}	16.16±1.48^{a,b}

Different letters indicate significant differences between the quality classes.

Influence on the technological yield
For the production of cooked hams, the raw hams were tumbled in order to absorb the brine and to solubilize the myofibrillar proteins. Ideally, when the injected amount of brine is effectively incorporated, a tumbling yield of 12% is expected. However, the mechanical damaging of the meat structure by tumbling, causes a weight loss as the dissolved proteins partially remain in the drum after tumbling. Therefore, a small but significant ($p<0.01$) decrease of tumbling yield at processing times longer than 5h30 were observed (fig. 1). In contrast, the quality of the raw hams had no significant effect on the tumbling yield.

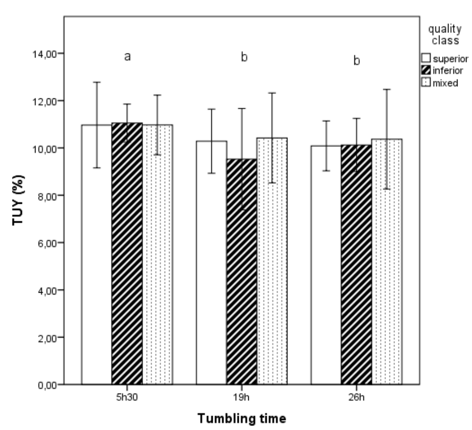

Figure. 1. Tumbling yield (TUY, %) influenced by raw ham quality and tumbling time, different letters indicate significant differences between the tumbling times.

During cooking the hams, especially when prepared without polyphosphate, are prone to lose water. In this study, a significant interaction (*p<0.05*) of the quality of the raw hams and the tumbling process on the cooking losses was observed (fig. 2). For all quality classes, a longer tumbling time, significantly reduced the cooking losses (*p<0.001*) which can be explained by the higher degree of protein functionalization. However, in comparison to a tumbling time of 19h, the extension to 26h had no additional effect on the COL (%). In addition, the cooking losses of the inferior hams decreased less extensively in function of increasing tumbling time. This might be explained by the partial degradation of proteins in inferior quality hams which cannot be fully compensated by a longer tumbling process.
As can be seen in figure 3, an increase of the tumbling time from 5h30 to 19h significantly increased the total yield of the cooked ham production (*p<0.01*). However, a further extension of the tumbling time did not contribute to an additional increase of the total yield. Although the cooking losses were influenced by the use of different qualities of raw hams, no significant differences between the quality classes could be observed for the total yield.

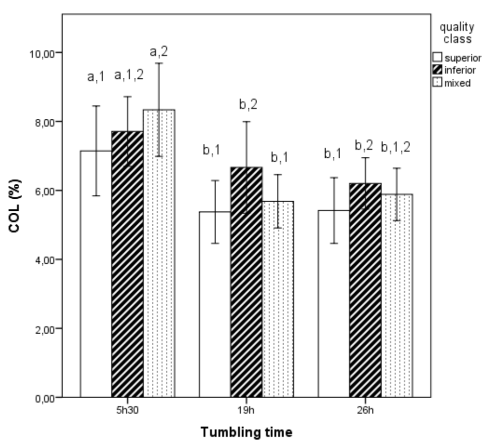

Figure 2. Cooking loss (COL, %) influenced by raw ham quality and tumbling time, different letters indicate significant differences between the tumbling times within quality class, different numbers indicate significant differences between quality classes within tumbling time.

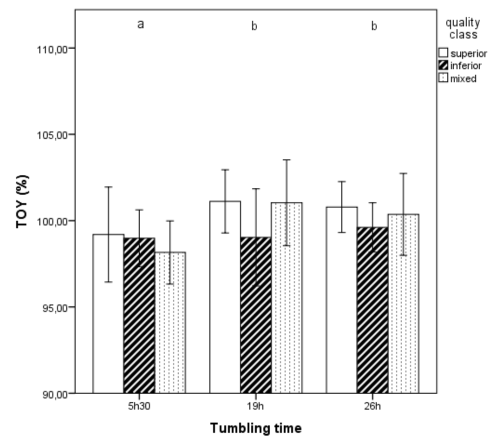

Figure 3. Total yield (TOY, %) influenced by raw ham quality and tumbling time, different letters indicate significant differences between the tumbling times.

Influence on the quality of cooked ham

During the preparation of cooked ham, the tumbling of brine-injected hams causes a disintegration of the muscle texture and the swelling of myofibrils [6]. Therefore, the WHC and the texture parameters such as hardness and springiness were measured to evaluate the effect of the tumbling time and raw ham quality on the quality of the cooked ham product. In this study, the WHC was expressed as the ratio area meat/area water (cm^2/cm^2) and can therefore be correlated to juiciness [5]. A significant interaction (*p<0.001*) of the quality of the raw hams and the tumbling process on the WHC was observed (fig. 4). When cooked hams were made with superior quality meat, the WHC gradually increased with longer tumbling times. This may indicate the importance of tumbling time for the functionalization of the meat proteins. In contrast, the WHC of the cooked hams prepared with inferior quality was the highest at short tumbling process but gradually decreased during longer processing times. Partially degraded proteins, as can be expected to be present in inferior hams, might lose their functionality during an extensive tumbling process.
It is expected that tumbling of the hams contribute to the tenderization of the meat muscles [2]. However, no effects on the texture parameters hardness and springiness were observed at different tumbling times and meat ham quality (table 2).

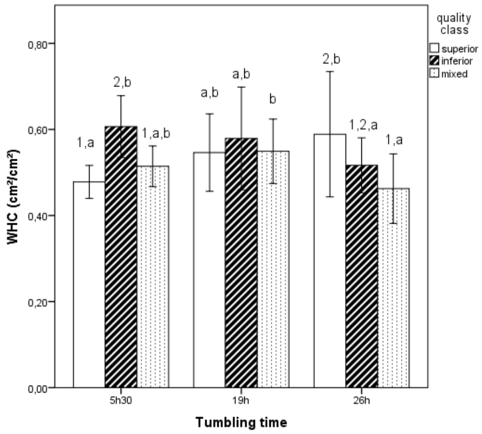

Figure 4. Water holding capacity (WHC, cm²/cm²) influenced by raw ham quality and tumbling time, different letters indicate significant differences between the tumbling times within quality class, different numbers indicate significant differences between quality classes within tumbling time.

Table 2 The texture parameters of the cooked hams.

		Quality class		
Parameter	Time	Superior	Inferior	Mixed
Hardness	5h30	21.5±2.4	21.9±2.0	21.8±2.1
	19h	21.6±3.0	20.3±3.0	19.7±2.2
	26h	21.2±2.2	19.0±1.4	21.6±3.3
Springiness	5h30	1.01±0.11	1.05±0.11	0.99±0.03
	19h	1.04±0.05	1.02±0.05	1.01±0.08
	26h	1.02±0.05	0.98±0.06	1.05±0.09

IV. CONCLUSION

The tumbling yield decreased slightly by longer tumbling, since a higher amount of dissolved proteins remained in the drum. In contrast, the cooking losses, certainly of superior hams, were reduced at increased tumbling times. Assumable, the prolongation of the tumbling leads to a better functionalization of the proteins. Despite the effect of ham quality on the cooking losses, the total yield was only improved by increased tumbling times.

The texture of the cooked ham was not influenced by different tumbling processes and raw meat materials. In contrast, the evolution of WHC was dependent of the raw ham quality. When superior hams were used, the WHC increased at longer tumbling times, probably due to an increased functionalization of the proteins. In the case of inferior hams, the WHC is negatively affected due to intensive tumbling.

In conclusion, the technological yield is mainly determined by the tumbling process. Nevertheless, in the consumers' interest, the quality of the cooked ham, the WHC, which is correlated to juiciness, may be influenced by the quality of the raw hams.

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REFERENCES

1. Hullberg, A. & Lundstrom, K. (2004). The effects of RN genotype and tumbling on processing yield in cured-smoked pork loins. Meat Science 67: 409–419
2. Lachowicz, K., Sobczak, M., Gajowiecki, L., & Żych, A. (2003). Effects of massaging time on texture, rheological properties, and structure of three pork ham muscles. Meat Science 63: 225–233.
3. Sharedeh, D., Vénien, A., Favier, R., Chekrar, F., Gatellier, P., Astruc, T. & Daudin, J. (2012). Incidence of mechanical action during tumbling of meat on mass transfer, tissue structure and protein solubilisation. In proceedings EFFoST, 20-23 November 2012, Montpellier, France.
4. Fernandez, X., Forslid, A., & Tornberg, E. (1994). The effect of high post-mortem temperature on the development of pale, soft and exudative pork: Interaction with ultimate pH. Meat Science, 37: 133–147.
5. Van Oeckel, M. ., Warnants, N., & Boucqué, C. (1999). Comparison of different methods for measuring water holding capacity and juiciness of pork versus on-line screening methods. Meat Science, 51: 313–320.
6. Katsaras, K., & Budras, K. (1993). The relationship of the microstructure of cooked ham to its properties and quality. Lebensmittel-Wissenschaft Und-Technologie 26: 229-234.