COMPARISON OF DRY-CURED FORMED HAM PRODUCED FROM SMALLER MEAT PIECES AND TRADITIONAL RAW HAM FROM A WHOLE MUSCLE

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Abstract – The viability of using microbial transglutaminase and glucono-δ-lactone for manufacturing dry-cured formed ham was evaluated. The effects of processing time on physicochemical, sensory and microbiological properties of dry-cured formed ham compared to regular traditional raw ham were analyzed. Due to the larger specific surface area of formed samples the counts of mesophilic aerobic bacteria and lactic acid bacteria in formed samples were up to four log cycles higher than in traditional raw ham. The sensory quality of all dry-cured formed hams depended on the factors processing time and binding system.

Key Words – restructured ham, transglutaminase, alginate

I. INTRODUCTION

Binding of meat pieces can be realized by (i) thermally-induced denaturation of myofibrillar proteins, (ii) chemically-induced gelation of a binding agent, or by (iii) enzymatically-induced cross-linking of proteins. For the manufacture of formed meat through agglomeration of meat pieces resembling dry-cured ham only a cold-set binding system (ii and iii), such as alginates (ii) [1], fibrinogen and thrombin (iii) [2] or transglutaminase (iii) [3] could be used. However, in terms of consumer acceptance, the use of ”meat glue“ such as enzymes and alginate is considered critical. An alternative binding system, which has not yet been investigated in terms of the production of dry-cured formed ham, could be based on the use of native salt soluble myofibrillar proteins in combination to acidification as it is known from texture formation in dry-fermented sausages. In this instance, glucono-δ-lactone (GdL) can be used as a fast acidulant. Such a binding system may gain more acceptance by the consumer. The aim of this study was to compare the application of the commercially available binding system, transglutaminase (TG), to the suitability of native salt-soluble myofibrillar proteins as natural binding system after denaturation by acid (GdL). Through physicochemical analysis it is expected to obtain a better understanding of the binding effects of TG and GdL, and to evaluate their influence on sensory and microbiological properties of dry-cured formed ham compared to regular traditional raw ham produced from a whole muscle. In addition, the impact of processing time on physicochemical characteristics of dry-cured formed ham compared to traditional raw ham was investigated.

II. MATERIALS AND METHODS

Preparation of dry-cured formed ham

The manufacturing steps of dry-cured hams are displayed in Figure 1. Fresh pork meat (*M. longissimus dorsi*) was purchased 48 h post mortem from a local slaughterhouse (Schiller Fleisch GmbH, Hof, Germany). Visible fat, tendons and connective tissue were trimmed off. The meat was diced (Treif Dicer, Type 84/2, Treif Maschinenbau GmbH, Oberlahr, Germany) to an edge length of approximately 2 cm. Whole pieces of *M. longissimus dorsi* were used as control samples. Meat cubes and control samples were salted in a tumbler (Frig-o-Vac System Type 180/14, BTE Maschinenbau GmbH, Murg, Germany) for 10 min and mixed with the following ingredients at 7 rpm and 2 °C under a vacuum of 20 kPa: 3% nitrite curing salt (95.5% sodium chloride + 0.5% nitrite, Südsalz GmbH, Heilbronn, Germany), 0.5% saccharose (Merck KGaA, Darmstadt, Germany), 0.5% glucose

(D(+)-glucose monohydrate, Merck KGaA, Darmstadt, Germany), and 0.05% ascorbate (sodium L(+)-ascorbate, Merck KGaA, Darmstadt, Germany), TG (Activa PB, Ajinomoto Foods GmbH, Hamburg, Germany) or GdL (Raps GmbH & Co. KG, Kulmbach, Germany).

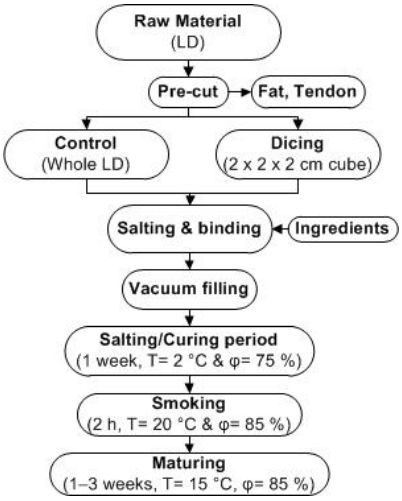

Figure 1. Flow chart showing the manufacturing steps (LD: *M. longissimus dorsi*; φ: relative humidity; Ingredients: $NaNO_2$, saccharose, glucose, ascorbate, cold-set binder: transglutaminase or GdL).

Subsequently, the non-formed samples were filled manually into cellulose casings, calibre 90 mm (Nalo cellulose casing, Kalle GmbH, Wiesbaden, Germany). The meat cubes were filled into the same type of casings using a vacuum filling machine (Handtmann VF 12, Albert Handtmann Maschinenfabrik GmbH & Co KG, Biberach/Riss, Germany) applying a vacuum of 10 kPa. The latter were hung at 2 °C and 75% relative humidity (rH) in a refrigeration room for 7 days. Samples were then placed in a single rack smoke generator (Klima Rauchsystem, MC 3.2, Maurer AG, Reichenau, Germany) and smoked for 2 hours at 20 °C and 85% rH. Following smoking, samples were transferred to a chamber (Allround System Rondair, MC 3.2, Maurer AG, Reichenau, Germany) in which a temperature of 15 °C and a rH of 85% were maintained until the end of the experiment. The influencing factors and response variables are shown in Table 1.

Table 1. Influencing factors and response variables (F: Formed; NF: non formed/control).

Name	Dimension	Level codes
Influencing factor		
Processing time/ measuring day	Day	0, 7, 14, 21, 28
Binding system		TG, GdL
Form		F, NF
Response variable		
Mesophilic aerobic bacteria	log cfu/g	
Lactic acid bacteria	log cfu/g	
Nitrite	mg/kg	
Nitrate	mg/kg	
pH		
Sensory response variable		
Coherence	Points	1, 2, 3, 4, 5
Recognizable binding site	Points	1, 2, 3, 4, 5
Sourness	Points	1, 2, 3, 4, 5
Glutinousness	Points	1, 2, 3, 4, 5

Physicochemical and microbial analyses

All physicochemical (Tab. 1) and microbial analyses (Tab. 1) were carried out according to the methods described in §64 LFGB according to the German Official Collection of Methods of Analysis for sampling and examination of foods [5,6,7].

Sensory evaluation

The samples were evaluated by a trained panel of ten panelists in a pass-through cubicle-type sensory evaluation room. Overall evaluation was ranked on a five-point scoring scale (Tab. 1; 1 = very bad; 5 = very good).

III. RESULTS AND DISCUSSION

Development of pH during processing

Changes in pH of dry-cured samples during processing are shown in Figure 2. In the case of GdL samples the binding between the meat pieces is based on partial denaturation of the proteins followed by aggregation. Therefore, the pH of the GdL samples is of crucial importance for the binding. It was observed that formed samples had

lower pH values than non-formed samples ($p < 0.001$).

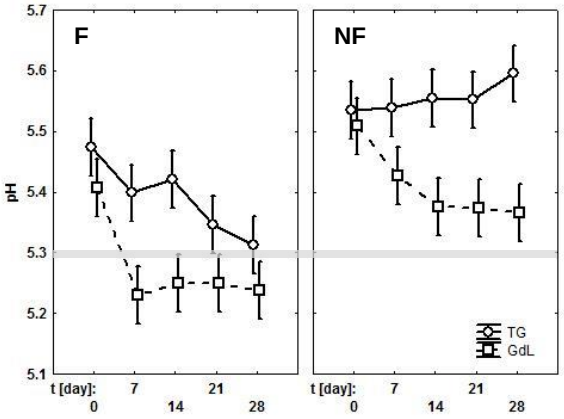

Figure 2. Changes in pH of dry-cured hams during processing grouped by sample type (TG: transglutaminase, GdL: glucono-δ-lactone; NF: non-formed; F: formed; data are means of 6 replicates; bars represent 95% confidence interval; horizontal grey line shows the isoelectric point of fibrillar proteins).

According to Hamm [8] the isoelectric point (IEP) of myofibrillar proteins is about pH 5.3 (marked in Figure 2 as horizontal grey line). The pH of GdL samples dropped already significantly ($p < 0.001$) below the IEP within the first week. GdL as an acidulant being hydrolyzed into gluconic acid in the presence of water, reduces the pH of meat by slow dialysis [9]. The slow pH decline below the IEP of the myofibrillar proteins caused a swelling of the meat and consequently the meat pieces to agglomerate within the first week. In case of TG samples, the pH value and acidification were not primarily responsible for the agglomeration, and thus for texturing of the meat pieces. In TG samples, the binding between the meat pieces is based on cross-linking of amide covalent bonds among γ-carboxyl groups of glutamine residues with the primary amino groups of a variety of amines present in myofibrillar proteins [3].

Changes in nitrite and nitrate concentration during the production process

According to Commission Regulation (EU) No. 1129/2011 of 11 November 2011, the maximum residual amount in the final meat product is 50 mg/kg nitrite and 250 mg/kg nitrate. Throughout the entire production time the maximum residual amounts permitted for nitrite and nitrate were not achieved or exceeded. It was observed that the formed samples had a significantly ($p < 0.001$) higher nitrite concentration in comparison to the non-formed samples.

Microbiological analysis

The growth of lactic acid bacteria (LAB) throughout the manufacturing process of formed and non-formed dry-cured hams is presented in Figure 3.

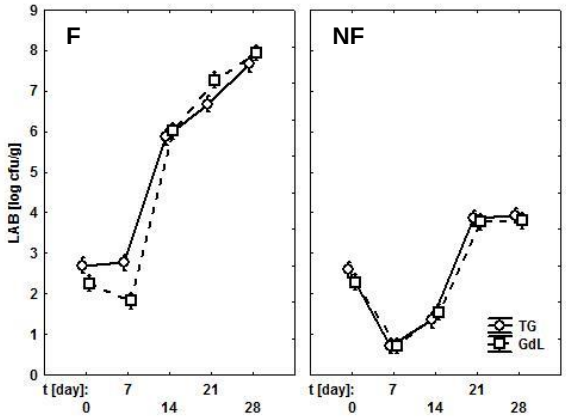

Figure 3. Growth of lactic acid bacteria (LAB) throughout the manufacturing process of dry-cured hams grouped by sample type (TG: transglutaminase, GdL: glucono-δ-lactone; NF: non-formed; F: formed; data are means of 6 replicates, bars represent 95% confidence interval).

In all samples, LAB dominated the microflora during the manufacturing period. Due to the larger specific surface area of formed samples, where microorganisms had better access to nutrients (proteins) promoting their growth, also the microbiological characteristics were changed. The results showed, in general, that the counts of MAB (data not shown) and LAB in formed samples were ca. four log cycles higher (from day 14 until day 28). In non-formed samples, microorganisms were present only on the surface of the meat. In contrast, in formed samples, the growth of microorganisms was promoted and the microbiota was distributed rather uniformly throughout the product, including the inner parts.

Sensory evaluation

In order to render a formed meat product looking similar to an intact muscle from a sensory point of view, the properties, such as cohesion of meat pieces and recognisability of binding sites are of importance. Generally, the sensory evaluation showed that the trained sensory panel was able to differentiate the dry-cured formed hams from the traditional hams throughout the entire production time. The non-formed samples had always been evaluated significantly better than formed samples. Concerning the formed samples, after one week, with respect to the aforementioned sensory parameters, a significant difference between the binding systems was observed. TG samples were evaluated higher than GdL samples. In case of TG samples, it was observed that one week, and in case of GdL samples four weeks of processing is sufficient to guarantee sufficient cohesion of the meat pieces. However, the characteristic property glutinousness is of crucial importance regarding the progress of maturation, which is an important prerequisite for the marketability of dry-cured ham. For this reason, in case of TG samples, a processing time of three weeks, and in case of GdL samples, four weeks is recommended. Furthermore, the visual recognition of the binding sites decreased with increasing processing time, because the stability of the cohesion increased concurrently. Regarding sourness, GdL samples were rated significantly worse.

IV. CONCLUSION

Due to larger specific surface area of formed samples compared with non-formed samples, not only the microbiological but also the physicochemical characteristics of the samples were changed resulting in a higher MAB and LAB counts as well as a higher nitrite concentration, although the maximum residual amounts permitted for nitrite and nitrate were not achieved or exceeded. In case of GdL as a binding system, the processing time and the pH drop are the most important factors for the coherence between the meat pieces. Finally, it can be stated that the sensory panel preferred the TG hams over the GdL formed hams.

REFERENCES

1. Beneke, B., Ehlers-Rozecki, B. J., Bewig, M., Islam, R., Renartz, M., & Hildebrandt, G. (2011). Verbraucher wünscht Klarheit und Ehrlichkeit. Zusammengefügter Rohschinken - Verbrauchertäuschung oder mehr? Fleischwirtschaft 91: 44-48.
2. Boles, J. A. (2011). Use of Cold-Set Binders in Meat Systems. In J. P. K. Kerry, J. F. (Ed.), Processed meats: Improving safety, nutrition and quality (pp. 270-298). Oxford, Cambridge, Philadelphia, New Delhi: Woodhead Publishing.
3. Kaufmann, A., Köppel, R., & Widmer, M. (2012). Determination of microbial transglutaminase in meat and meat products. Food Additives & Contaminants 29: 1364-1373.
4. Andrés-Bello, A., Barreto-Palacios, V., García-Segovia, P., Mir-Bel, J., & Martínez-Monzó, J. (2013). Effect of pH on Color and Texture of Food Products. Food Engineering Reviews 5: 158-170.
5. ISO 6887-1 (1999). Microbiology of food and animal feeding stuffs - Preparation of test samples, initial suspension and decimal dilutions for microbiological examination - Part 1: General rules for the preparation of the initial suspension and decimal dilutions. International Organization for Standardization, Geneva, Switzerland.
6. ASU L 07.00-60. (2007). Bestimmung des Nitrat- und/oder Nitritgehaltes in Fleischerzeugnissen nach enzymatischer Reduktion von Nitrat zu Nitrit; Spektralphotometrisches Verfahren. Berlin: Beuth-Verlag.
7. ISO 2917 (1999). Meat and meat products - Measurement of pH - Reference method. International Organization for Standardization, Geneva, Switzerland.
8. Hamm, R. (1972). Kolloidchemie des Fleisches. Berlin: Paul Parey.
9. Ngapo, T. M., Wilkinson, B. H. P., & Chong, R. (1996). 1,5-glucono-δ-lactone-induced gelation of myofibrillar protein at chilled temperatures. Meat Science 42: 3-13.