IMPACT OF DIFFERENT PHOSPHATES AND CONCENTRATIONS ON THE QUALITY CHARACTERISTICS OF COOKED SAUSAGE

O. Goemaere, L. Steen, S. Glorieux, K. De Bodt, H. Paelinck and I. Fraeye

KU Leuven Technology Campus Ghent, Leuven Food Science and Nutrition Research Centre (LFoRCe), Research Group for Technology and Quality of Animal Products, Gebroeders De Smetstraat 1 B-9000 Ghent, Belgium

Abstract – Phosphates contribute to several important quality characteristics in meat products. Next to its benefits, it is believed that phosphates also have a negative effect on human health. Therefore it is necessary to optimize the usage of phosphates in meat. The goal of this study is to reveal the most functional phosphate for use in emulsified meat products and to determine its minimum dosage to maintain product quality. This is assessed as structure (rheology) of the dough, emulsion stability, cooking loss, texture (TPA), color and pH.

Results indicated that sodium tetra pyrophosphate is the most promising type of phosphate for sausage production. This is probably due to its strong chelating capacity and pH effect. Furthermore, it was determined that 0.06% P_2O_5, compared to the usual dosages in the industry (0.2% - 0.5%), is sufficient to produce a perfect model cooked sausage.

Key Words – Emulsified meat products, health, sodium tetra pyrophosphate

I. INTRODUCTION

The use of phosphates in the meat industry is widely spread. Phosphate contributes to the solubilisation of the myofibrillar proteins. The functionalized proteins have strong water binding, gelling and emulsifying properties. Therefore a higher cooking yield and product stability can be achieved. In other words, phosphate can be directly linked to several of the most important quality characteristics of emulsified meat products. Texture and structure of the product and thus mouth feel are strongly influenced by the use of phosphate. It is added as E450 (diphosphate), E451 (triphosphate), E452 (polyphosphate) or as mixtures of the former. Nowadays more and more proof has been collected concerning the possible hazardous consequences of the additive on human health. It was already known that phosphates are harmful for kidney patients. Recently Ritz *et al.* [1] proved that phosphate could lead to health problems even for the general population. The results of the investigation were so alarming that in 2013 the European Commission asked the EFSA (European Food Safety Association) to reevaluate the use of phosphate in food products. Final statement will be submitted by 2018. It is possible that in a nearby future the legal maximum dosage of phosphate in meat products will be adjusted. People nowadays are more and more aware of their health. They avoid products with too much fat and salt, nitrite or other E-numbers. Therefore the pressure on the meat companies to develop healthier products is rising. It will be a challenge to reduce or eliminate phosphate completely without losing product quality, but it will be necessary to maintain the consumers demand.

In this study a cooked sausage model was processed with 7 different phosphate fractions: sodium tetra pyrophosphate (TSPP), disodium pyrophosphate (SAPP), sodium tripolyphosphate (STPP), sodium hexametaphosphate (SHMP), monosodium phosphate (MSP), disodium phosphate (DSP) and trisodium phosphate (TSP). Product quality was evaluated as descripted in *'II Materials and Methods'*. Based upon the obtained results the most effective phosphate for use in emulsified meat products was selected, after which its minimum dosage for maintaining product quality could be defined.

II. MATERIALS AND METHODS

A. Production of cooked sausage

The cooked sausages were processed in the pilot plant of the research group 'Technology and Quality of Animal Products' (KU Leuven Technology Campus Ghent).

The products were prepared with the following raw materials: pork shoulder (40 g/100 g), pork back fat (35 g/100 g) and ice (25 g/100 g). The concentration of the salt (1.8 g/100 g) and all the other additives and spices were calculated relative to the total raw materials.

In the first experiment 7 different phosphates (see Introduction) were added to the sausage dough. Each batch (3.5 kg) contained 6 g P_2O_5 (= 0.171%; standard concentration throughout the experiment). The exact weight of each phosphate was calculated depending on the P_2O_5 content of the additives [2].

Phosphate	% P_2O_5 [2]	Amount added (g/3.5 kg)
TSPP	53.38	11.24
SAPP	64.03	9.37
STPP	57.91	10.36
SHMP	69.61	8.62
MSP	45.49	13.19
DSP	39.87	15.05
TSP	19.21	31.23

In the second experiment the amount of P_2O_5 was reduced from 6 g/batch (standard sausage) to respectively 4 g (0.114%), 2 g (0.0571%), 1 g (0.0286%), 0.5 g (0.0142%) and 0.25 g (0.00714%). Also a product without the use of phosphate was processed. The most appropriate phosphate, determined in the first experiment (see 'III Results and discussion'), was used throughout this second part of the research.

The cooked sausage was produced by first pre-chopping the raw meat fraction together with the ice, salt and phosphate in a bowl cutter for 7 min and 30 seconds (Stephancutter UM12, Germany).

In the next step the adipose tissue was added to the cutter together with the remaining spices and additives. The total mass was cut under vacuum for 3 min to obtain a homogenous dough. Temperature didn't exceed 14°C to avoid protein denaturation. This batter was subsequently filled into cans, cooked at 76°C (core temperature 72°C) in a cooking chamber and finally cooled to 4°C to obtain the final product.

B. Rheology

On the raw sausage batter, rheological measurements were performed using an AR2000ex stress controlled rheometer (TA instruments, New Castle, US) equipped with a 40 mm crosshatched parallel plate-plate system. The gap between the plates was set to 1000 µm. Oscillation experiments were conducted at 13°C. The length of the linear viscoelastic region (LVR) was determined by performing a stress sweep between 0.1 and 1000 Pa at 1 Hz.

C. Texture Profile Analysis

The texture of the sausages were evaluated using TPA, as described in the work of Bourne [3]. From each batch 3 cans of sausages were axially penetrated with a depth of 2 cm. A double penetration cycle test was performed using a load cell of 100 N and a cylindrical probe (diameter 6mm) with a speed of 100 mm/min. The following texture parameters were obtained: hardness (results shown), cohesiveness, springiness, gumminess, chewiness, adhesiveness (results not shown).

D. Emulsion stability

The emulsion stability of the cooked sausages was determined based on the procedure described in [4]. The raw sausage dough (30 g) was placed in a pre-weighted centrifuge tube. The sample was heated in a cooking chamber for 30 min at 70°C and centrifuged at 4230 g for 3 min at 25°C. The drip loss, consisting of a mixture of water and fat, was determined. The percentage of total expressible fluid (%TEF) was determined by the following formula:

% TEF = drip loss/sample weight x 100%

D. Cooking loss

Cooking loss was determined by measuring the initial sausage weight and drip loss (jelly and fat separation) after cooking. It was expressed by the following formula:

$$\% \text{ Cooking loss} = \frac{drip\ loss}{initial\ sausage\ weight} \times 100\%$$

E. Statistical analysis

For the statistical analysis of the results on cooked sausages prepared using different phosphates and concentrations, analysis of variance (ANOVA) was performed, followed by a post-hoc Tukey's comparison test to determine the significance of differences (P = 0.05) between treatment means. This was done by SPSS 22 (SPSS Inc., Chicago, IL, USA).

III. RESULTS AND DISCUSSION

A. Use of different phosphates

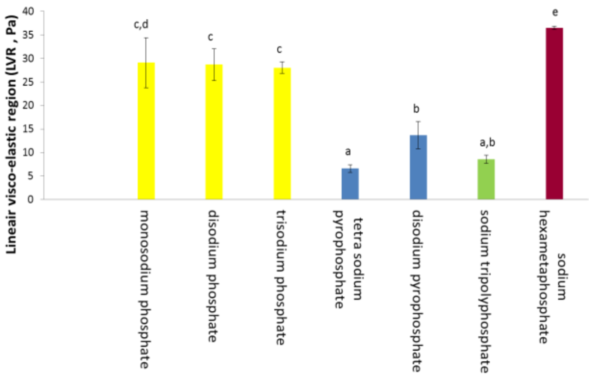

Figure 1. Length of the LVR of the sausage batters made with different phosphates.

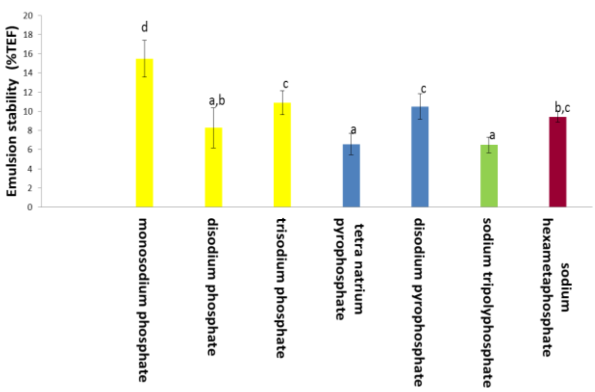

Figure 2. Emulsion stability of sausage batters made with different phosphates.

Based upon the results presented in Figures 1 & 2 it can be concluded that the kind of phosphate plays an important role in the product characteristics.

LVR of the sausage batter can be linked to the strength of its structure [5]. The batch containing TSPP has a significantly lower LVR compared to the other preparations. This is probably due to this phosphate's great potential to sequestrate metal ions such as Ca^{2+}. Binding of phosphates with Ca^{2+} contributes to the separation of actin and myosin after rigor mortis in the meat which possibly leads to a loss of structure of the dough [2]. This is a rather positive effect because it indicates that myosin is released from the actomyosin complex and can therefor act as a natural emulsifier. This hypothesis is supported by the results shown in Figure 2. The batch containing TSPP, next to the one with STPP, has the best emulsion stability (smallest %TEF).

Steen *et al.* [6] obtained similar results when salt was added to ground liver. NaCl caused a significantly shorter LVR of the batter which indicated a more sensitive structure. This effect was explained by the solubilisation of the salt soluble liver proteins, making them available to act as emulsifier.

Furthermore TSPP optimizes water binding due to its pH increasing effect (results not given). The more the pH of the sausage batter is removed from the iso-electrical point of the proteins (pH = 5.1), the greater repulsion forces occur between the proteins actin and myosin. Therefore they start to swell and more water can be bound. This property is strongly pronounced in pyro phosphates [7]. Results concerning the cooking loss (not shown) proved the previous matter. Sausages containing TSPP, next to the ones with STPP, had the best cooking yield.

Based upon the results and conclusions mentioned above, the authors decided to select TSPP as the most promising single phosphate for the manufacture of cooked sausage. This phosphate was used for the second part of the research.

B. Minimum dosage of TSPP to maintain optimal sausage quality

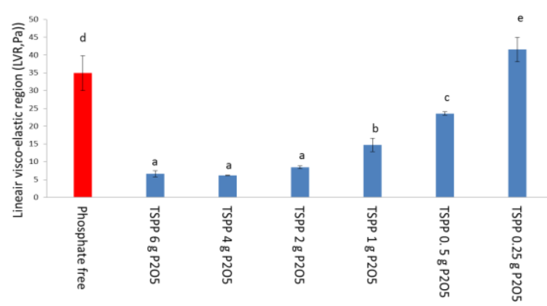

Figure 3. Length of the LVR of the sausage batters made with different TSPP concentrations.

The phosphate free sausage batter shows a great degree of structure (high LVR) compared to the standard production (6 g P_2O_5) (Figure 3). The actomyosin complex remains far more intact due to the absence of TSPP. Figure 3 also reveals that reduction of TSPP from 6 g P_2O_5 to 2 g P_2O_5 per batch has no significant impact on the length of the LVR. Further reduction leads to a significant increase of the LVR. This means that for this cooked sausage recipe, a minimum of 2 g P_2O_5 per batch is needed to maintain the same grade of protein functionalization as the standard (6 g P_2O_5). The difference in dough structure at various P_2O_5 levels was not reflected in the stability nor the texture of the final product. Even the smallest amount of TSPP led to a tremendous decrease in cooking loss (Figure 4 and 5).

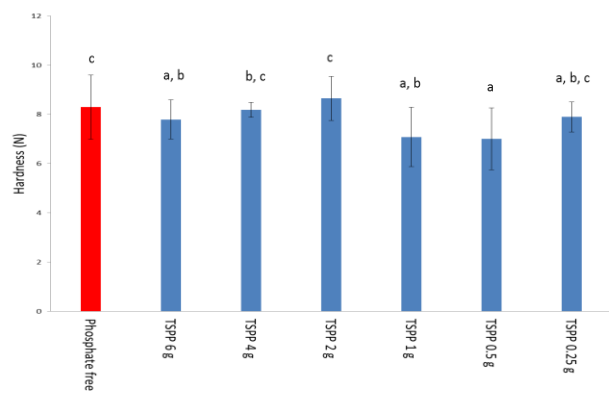

Figure 4. Hardness of the sausages made with different TSPP concentrations.

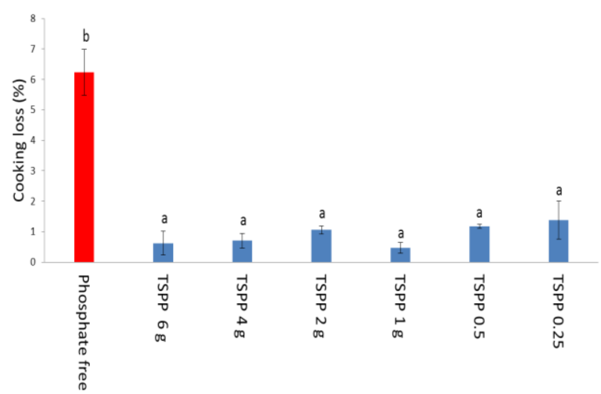

Figure 5. Percentage cooking loss of the sausages made with different TSPP concentrations.

IV. CONCLUSION

Phosphates, especially TSPP, have an important impact on several quality characteristics of cooked sausage (stability, water binding,…). Adding less than 0.0571% P_2O_5 as TSPP leads to smaller protein functionality in the sausage batter. Although not reflected in macroscopic measurements (texture, cooking loss) in the applied model system, this amount of phosphate should be generally applied as a safety barrier to maintain sausage quality. In the industry critical sausage recipes are used more often to decline production costs (e.g. use of more water instead of meat). Therefore a minimum dosage of phosphate (0.0571% P_2O_5 as TSPP) is required to ensure a flawless production.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support from Flanders' FOOD (IWT) and the support from the Flemish meat industry and its suppliers.

REFERENCES

1. Ritz, E., Hahn, K., Ketteler, M., Kuhlmann, M. K., Mann, J. (2012). Phosphate Additives in Food – a Health Risk. Deutsches Ärzteblatt International 109(4): 49 – 55.

2. Bach Son Long, N. H., Gál, R., Buňka, F. (2011). Use of Phosphates in Meat Products. African Journal of Biotechnology 10(86): 19874 – 19882.

3. Bourne, M. (1976). Texture profile analysis. Food Technology 32(7):62 – 66.

4. Hughes, E., Cofrades, S., Troy, D. (1997). Effects of fat level, oat fibre and carrageenan on frankfurters formulated with 5, 12 and 30% fat. Meat Science 45(3):273 – 281.

5. Lippacher, A., Müller, R. H., Mäder, K. (2004). Liquid and semisolid SLN™ dispersions for topical application: rheological characterization. European Journal of Pharmaceutics and Biopharmaceutics 58, 561–567.

6. Steen, L., Fraeye, I., De Mey, E., Goemaere, O., Paelinck, H., Foubert, I. (2014). Effect of Salt and Liver/Fat Ratio on Viscoelastic Properties of Liver Paste and Its Intermediates. Food Bioprocess Technology 7, 496 – 505.

7. Molin, R. A. (1991). Phosphates in Food. Florida, U.S.A.: CRC Press, Inc.