PE9.18 Differently Heat Treated Carrot and Potato Pulp Used in Low-Fat Sausage 112.00

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Abstract — The increase of incidence of diet-related diseases promotes an interest for developing foods with a low caloric value and high in health-promoting additives such as dietary fiber. To increase the consumption of such products, there is a need for understanding of how the dietary fiber affects the texture of the food product. Therefore carrot and potato pulp, after different heat treatments, have been studied when used as a replacement of fat in sausages, where the water/protein ratio, starch and fiber content were set constants. Process losses, the hardness of the cooked sausages along with the sensory profile have been investigated. Potato pulp sausages were preferred by the sensory panel compared to the other sausages. These sausages had also the highest process losses and hardness. The heat treatments had only minor effects on the sensory attributes; however, heat treatment had a significant influence on hardness and process loss of the sausages, in such a way that the samples heated with high temperature and long times, which favors solubilization of pectin (ß-elimination), had the lowest hardness and process loss.

Index Terms—Carrot and potato pulp suspensions, low-fat sausage, heat treatment.

I. INTRODUCTION

THERE is a constant increase of people diagnosed with the metabolic syndrome, including diseases such as obesity, diabetes, and cardiovascular diseases. To fight these diseases, an addition of dietary fiber in the daily diet might play an important role since it would contribute to a higher daily intake of dietary fibers and a lower caloric content in the food by replacing the standard ingredients, such as fat, with dietary fibers [1]. Dietary fibers (DF) are components of the cell wall consisting of pectin, cellulose, hemicelluloses and lignin [2].

Pectin is a dietary fiber with a backbone of galacturonic acid and its methyl ester. Pectins are usually classified according to the degree of methylation, where above 50 % methylation is considered a high methoxy pectin [3]. The entire food market is today stimulated by a need to develop new, healthy products, but one area where this is especially interesting is the protein-rich product group [4], since many of these products, e.g. sausages and hamburgers, contain a great deal of fat and is naturally low in DF.

There have been studies carried out where different DF have been added to these meat systems in order to reduce the fat content such as cauliflower [5] and oat fiber [6], however, without finding the cause of the change in texture on DF addition. To produce a sausage with the desired processing and texture properties, the final product should consist of a firm and elastic network, keeping the water in the structure. In a previous study [7] a high proportion of soluble pectin in fiber suspensions showed increased elastic properties. Changes in the pectin structure by heating can be achieved by various methods, e.g. activating PME and ß-elimination. ß-elimination functions, at elevated temperatures, by splitting off a proton from a galacturonic acid sub-unit, inducing a double bond within the unit, and thereby breaking the pectin chain [8]. This reaction is favored at galacturonic acid units with methyl groups. Optimum temperature to obtain maximal ß-elimination ranges around 80° C to 110° C, depending on the pH in the solution [9].

Pectin methyl esterase (PME) is an enzyme that is present in most vegetables and fruits. The enzyme has its maximum activity around 50-70°C, and it acts by cutting off methyl groups from the polygalactoronic acid-chains. The PME reaction makes it possible for the pectin to form a calcium-pectin network by binding calcium-ions to the free carboxylic ends [10]. When pectin is heated to the optimum temperature for PME activity, followed by an increase in temperature to activate ß-elimination, the rate of ß-elimination is diminished.

This is due to the lower amount of methyl groups available after PME activity [11]. It is our intention to study how added fibers of different origin affect the texture, measured by texture analyzer and sensory analysis, of low-fat sausages. The influence of different heat treatments of the fiber sources in order to change the pectin structure within the fiber is also investigated.

II. MATERIALS AND METHODS

FIBER PREPARATION Carrot (Magnihill AB, Sweden) and potato pulp (Potex, Lyckeby Stärkelsen, Sweden) were used as dietary fibre sources. The carrot was washed and sliced in cubes of 10x10x10 mm and then frozen without any heat treatment until use. The potato samples were washed and frozen potato pulp, reminiscence from starch manufacturing, i.e. most of the potato starch was removed. Cubes of carrot were defrosted, cut to smaller pieces in an Electrolux food processor, and mixed with water to obtain a fiber suspension with proportions of fiber and half the water in the recipe (Table 1).

Table 1. Recipe of the reference sausage and the sausages with added carrot and potato pulp fiber

Ingredients	Ref	Carrot	Potato pulp
Water/ice	46.18 g	33.25 g	36.2 g
Meat[1]	47.25 g	38.7 g	49.4 g
Spices and additives[2]	2.27 g	2.27 g	2.27 g
Potato starch	4 g	3.75 g	4 g
Fiber addition	-	21.8 g	8.4 g
Total amount	100.0 g	100.0 g	100.0 g

[1] 60 % pork and 40 % beef
[2] Black pepper (0.1 g), nitrite salt (0.72 g), vacuum salt (1.28 g), ascorbic acid (0.02 g), polyphosphate (0.15 g)

The mixture was put in a Fasett blender to obtain a puree. The potato pulp was put directly in the Fasett blender together with half the water from the recipe. A. Heat treatments Four different heat treatments of the two fiber sources were prepared according to Table 2.

Table 2. Heat treatments of the carrot and potato pulp fiber suspensions

Heat treatment	Heating pad	Water bath	Reaction
h0	90-95°C, 5 min	-	Stop the PME activity
h1	Up to 85°C	85°C, 2 hours	Stop the PME activity and initiate the ß-elimination.
h2	-	65°C, 40 min + 90°C, 5 min	PME activity followed by a stop in PME activity
h3	-	65°C, 40 min + 85°C, 2 hours	PME activity followed by ß-elimination

$$a = Wi - \frac{Wf * (100 - PL)}{100} \quad [\%] \qquad (1)$$

$$b = PL - a \quad [\%] \qquad (2)$$

The h0 treatment has a minimal heat treatment in order to stop enzymatic reactions. The samples are also heat treated to favor ß-elimination (h1), activate PME (h2), and to both activate PME and thereafter favor ß-elimination (h3).

SAUSAGE PREPARATION

The sausages were prepared according to the recipe in Table 1. For each of the recipes of sausages with potato pulp and carrot additives four sausages were made with the four different heat treatments (Table 2). A reference sausage was prepared with the same content of starch, 4 % (w/w), and a water/protein ratio as the other sausages (7.9) in order to only have the addition of different fiber matrices (0.6 %) as a variable for sausage texture. In total, nine different types of sausages in duplicate were made. The fat content in the cooked sausage was 2 %. The dry ingredients, half the meat and half the water/fiber suspension were mixed in a Braun food processor for one minute. The rest of the water (as ice) and meat was then added and mixing continued for an additional 4 minutes. The batter was left to rest for 1.5 hours at refrigerated temperatures, stuffed in plastic tubes (Φ = 3.7 cm) and, after a total resting time of 2.5 hours, cooked in a water bath to a center temperature of 75ºC.

SAUSAGE ANALYSIS

All the analyses were made in duplicate if not stated otherwise.

A. Water, fat and total process loss Process loss (PL) was calculated by measuring the difference in weight before and after cooking of the sausages. To measure the water loss a sample of 5 g each of the meat batter and the sausages were dried at 102° C over the night. The dried samples were then weighed, and the loss of water could be calculated (equation 1). By subtracting the value for water loss from the process loss, the fat loss could be calculated (equation 2). (2) where a is the water loss, Wi the water content of the batter, Wf the water content of the cooked sausage, and b the fat loss.

B. Frying loss The frying loss was measured by frying pieces of sausage, cut by a knife with two blades, with the distance of 1 cm, in a pan pre-heated to 174° C, for 2 minutes on each side to a center temperature of around 72-73° C. Their weight was measured before and after frying, in triplicate.

C. Texture analysis The texture was evaluated using an Instron Universal Testing Machine, measuring maximum hardness during compression (30%, speed 1 mm/s) of 10 mm3 cubes of the sausages. Measurements were performed in triplicate.

D.Sensory evalution A sensory evaluation was carried out with an untrained panel of 34 participants at 6 different occasions. In every occasion 16 participants evaluated the sausages. The sausages were cut to samples of 1 cm thickness, and fried in a pan of 174° C for 2 minutes on each side, and left to cool to room temperature before being served. The panel evaluated appearance/ color, crumbliness, compactness, juiciness, meat-taste intensity, off-flavor and total impression of the sausages on a scale from 1 to 9. The tests were carried out in individual booths.

E. Statistics All results were analyzed statistically using Principal Component Analysis (PCA) from the Unscrambler software (Camo, version 9.0), and Analysis of Variance (ANOVA) in General linear model with fiber and heat treatment as variables as well as one-way ANOVA and Pearson correlation of the variables (Minitab, version 14) with a significance level of $p<0.05$.

III. RESULTS AND DISCUSSION

The texture and the different losses of the sausages are presented in Table 3. In general the fat losses are rather small (0.05-0.5 %) and no significant difference between the group of samples with different additive (carrot, potato pulp and no additive) is achieved. Neither the type of fiber nor the heat treatment has any significant influence on the water losses.

Table 3. Properties of the sausage with added fiber (carrot and potato pulp) heat treated in different manners, and without added fiber (ref)

Sample	Heat treat-ment	Water loss (%)	Fat loss (%)	Process loss (%)	Frying loss (%)	Hardness (N)
Carrot						
	h0	3.4	0.3	3.7	19	524
	h1	2.7	0.2	2.9	22	543
	h2	2.5	0.05	2.5	21	451
	h3	3.1	0.5	3.6	21	517
Potato pulp	h0	4.2	0.3	4.5	19	1105
	h1	2.7	0.2	2.9	15	926
	h2	3.2	0.3	3.5	17	830
	h3	5.1	0.3	5.4	17	1031
Ref						
	-	2.6	0.4	3.0	15	594

However, for both the hardness of the samples and the frying loss, the type of additive have a significant influence ($p<0.001$), where the carrot sausages generally have higher frying loss than the other samples, while the potato pulp sausages have a significantly harder texture. Since all the samples have the same water/protein ratio, starch content and, for the carrot and potato pulp samples, the same fiber content, the difference in texture mainly arises from the variation fiber composition and/or the fiber microstructure [7]. Using ANOVA heat treatment has a significant influence on hardness and process loss ($p<0.001$). The short heat treated sample (h0) has the highest hardness and process losses, while the β-elimination favored sample (h1) has the lowest (see Table 2 for heat treatments).

The network in h1 sample can probably withhold more of the water inside the sausage compared to the h0 sample, since in the h1 sample more pectin is released from the insoluble cell wall matrix by the β-elimination (results not shown). Thereby can the soluble pectin stabilize more water in the continuous phase of the meat batter and this is probably the reason for the lower process loss and softer sausages. However, when PME had a chance to operate on the fiber suspensions, only a minor decrease in hardness compared to h0 is seen. The same is seen for the combined PME/β-elimination heat treatment (h3), where the action of β-elimination probably is hindered by the PME activity.

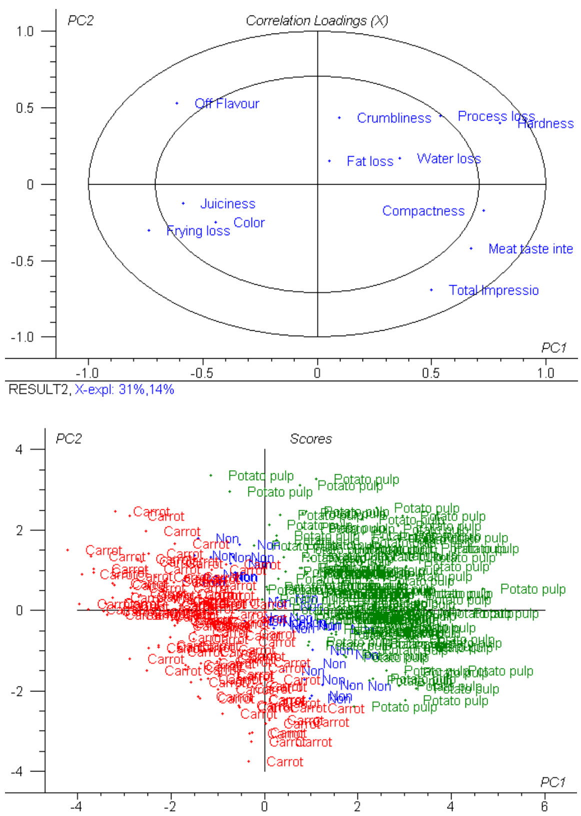

Figure 1: Principal Component Analysis (PCA)-plot of sensory and process data: 45 % explained variance in the first two PCs. A) Loading plot containing the variables used in the analysis and B) Scores plot with the additive highlighted (carrot, potato pulp and no additive) and the different groups are circled.

The sensory results together with the previously discussed parameters are presented in relation to each other in a PCA plot (Figure 1) with an explained variance of 45 % for the first two principal components. Since the degree of explanation is rather low, the PCA can only indicate possible relationships, which will be verified by ANOVA. In the loading plot (Figure 1a) an inverse relation ship can be seen between frying loss and process loss as well as hardness. This is probably due to the fact that if more water is lost during the cooking of the sausages, a more compact and hard structure is created ($p<0.05$ in Pearson correlation). Moreover, for those sausages that lose less water during cooking, more water is still available to be lost during frying. After summing up all the losses, during both cooking and frying, sausages with carrot additive lose in general more water/fat than the other two type of sausages. For the sensory descriptors two dimensions can be seen (Figure 1a).

In the first one, a high juiciness and color score is found when there is a low perceived compactness in the sausage (Pearson correlation $p<0.001$). The carrot sausages have higher color scores ($p<0.001$), since orange pieces were still visible in the cooked sausage. Potato pulp sausages is perceived as less juicy and more compact than the other two type of sausages ($p<0.001$), possibly since the potato pulp lose more water during cooking than the other sausages (Table 3). The heat treatments have no significant effect on the sensory properties of the sausages. In the other sensory dimensions, off-flavor is negatively correlated to meat taste and total impression (Pearson correlation $p<0.001$). For these sensory attributes type of added fiber has a significant influence ($p<0.001$). The carrot sausages experienced most off-flavor, whereas the potato pulp sausages are preferred by the sensory panel, even better than the sausage without added fiber (Figure 1b). This is probably due to the fact that the potato pulp sausages have the strongest perceived meat taste intensity. However, none of the heat treatments significantly affected these variables.

IV. CONCLUSION

Addition of carrot and potato pulp in a low-fat sausage changed the properties, especially the perceived texture. Sausages containing potato pulp had a higher process loss during the cooking of the sausage batter, which rendered a more compact and hard sausage compared to the sausage without additives and with added carrot. Pre-heat treatment of the fiber suspensions where β-elimination of the pectin is favored rendered a sausage with lower process losses and thereby lower hardness. The opposite was seen for the short heat treated samples. The potato pulp sausages were preferred by the sensory panel compared to the other sausages, since they had a lower off-flavor and higher meat taste intensity.

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