THE EFFECT OF ADDING RYE BRAN, OAT BRAN AND BARLEY FIBRE IN LOW-FAT SAUSAGES AND MEATBALLS

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Abstract – The aim of this study was to investigate the effect of adding rye bran, oat bran and barley fibre on the physicochemical and sensory properties of low-fat sausages and meatballs. The water/protein ratio, the total amount of starch and the dietary fibre content of the batters were set constant. Frying losses and the firmness of the sausages and meatballs were measured and a hedonic sensory test was performed.
The sausages with added oat bran were preferred by the sensory panel. These sausages also had lower frying losses and higher values for the firmness compared to the others. The barley fibre had a very low value of the firmness and was the least preferred. Oat bran had the ability to form a gel during the heating of the sausages, while rye bran and barley fibre didn't. Adding cereal materials to low-fat meatballs did not improve the texture or the water-holding capacity during frying. The sensory panel did not however prefer the references over the meatballs with cereal additive. A strong gel in the sausage is very important to obtain good texture, high water-holding capacity and sensory acceptance. This is not as important in meatballs.

Key Words – cereal dietary fibre, low-fat sausages and meatballs, physicochemical properties, sensory evaluation

I. INTRODUCTION

There is a continuous demand for new, healthy products. Decreased fat content of food items are requested along with a higher amount of dietary fibre (DF).

Sausage and meatballs are two common meat products, which normally contain a high amount of fat. The sausages are more comminuted and have a higher salt content than the meatballs and therefore a gel of a strong meat protein-network will be created. This protein-network is dominating the texture and sensory properties of the sausage [1]. Meatballs on the other hand are a mixture of the minced meat and the other ingredients, with a more particulate appearance and the protein network is not as dominating concerning the water- and fat holding ability [2-3].

Previous studies have been made to evaluate the effects of adding DF-rich cereal materials into meat products with a reduced fat content, some examples being oat fibre, barley β-glucan and wheat fibres [4-6]. Different cereal materials are however rarely compared in the same study and moreover different types of low-fat meat products are not often evaluated together. Therefore the cause of the change of important properties, such as the texture, when adding DF to low-fat meat products is not yet well understood.

The intention of this study was to evaluate if fibre-rich cereal materials could be incorporated in low-fat sausages and meatballs and to thereby improve the understanding of how texture and other properties are affected by the addition of DF. The effect of the addition of DF-rich cereal materials were studied concerning the water-holding capacity, texture and sensory properties. A comparison between the different cereal materials as well as the effect on sausages versus meatballs was performed.

II. MATERIALS AND METHODS

Meat and cereal sources

Oat bran and rye bran (Lantmännen, Sweden) as well as barley fibre (Lyckeby Stärkelsen, Sweden) were used as cereal additives. The DF composition of the cereal materials have previously been characterized [7]. Rye bran, oat bran and barley fibre had DF contents of 36, 18 and 63 % respectively. Rye bran consists mainly of insoluble arabinoxylans and cellulose, while barley fibre has 22% soluble β-glucans. Oat bran has 10% total β-glucan of which one third is soluble. Low fat pork

(4.3% fat) and low- and high fat beef (3.4 and 17.7% fat) provided by Ugglarps AB, Sweden, were used. The high fat meats were used for references with high fat and high starch content (Ref 1). References were also made with low fat and high starch content (Ref 2) and low fat and low starch content (Ref 3).

Sausage preparation

The sausages were prepared according to the recipes given in table 1. The following central parameters were kept constant when the recipes were designed:

- Water/protein ratio of 7.9 and a salt content of 2 %
- 3.2 or 6.5 % total starch
- 1% total DF in the sausages with added cereal fibre.

The dry ingredients, including the cereals, half the meat and half the water were mixed in a food processor (Braun, Germany) for 1 min.

Table 1. Recipes of the sausages and meatballs (gram of ingredient per 100 gram batter).

Ingredients	Ref 1	Ref 2	Ref 3	Oat bran	Barley fibre	Rye bran
Sausages						
Water/ice	41.1	43.9	46.2	44.7	45.5	45.2
Meat[1]	48.4	45.6	47.3	45.8	46.7	46.4
Spices and additives[2]	2.57	2.57	2.57	2.57	2.57	2.57
Potato starch	8.0	8.0	4.0	1.0	3.6	2.9
Cereal additive	-	-	-	6.0	1.7	2.9
Soluble DF[4]	-	-	-	0.31	0.39	0.08
Meatballs						
Water	17.9	24.7	27.6	26.5	27.1	26.9
Meat[3]	51.3	44.5	46.7	45.3	46.3	46.0
Onion	11.6	11.6	11.6	11.6	11.6	11.6
Potato chips	9.2	9.2	9.2	9.2	9.2	9.2
Potato starch	8.7	8.7	3.6	1.5	3.4	2.8
Salt	1.3	1.3	1.3	1.3	1.3	1.3
White pepper	0.1	0.1	0.1	0.1	0.1	0.1
Cereal additive	-	-	-	4.3	1.3	2.1
Soluble DF[4]	-	-	-	0.22	0.31	0.06

[1] 60% pork and 40 % low- or high-fat beef
[2] Black pepper (0.1 g), nitrite salt (0.72 g), vacuum salt (1.28 g), ascorbic acid (0.02 g), and polyphosphate (0.15 g), liquid smoke (0.3 g)
[3] Low- or high-fat beef
[4] Amount of soluble DF added by the cereal additive

The rest of the water (as ice) and meat were then added and mixing continued for an additional 4 min. The temperature of the meat batter was kept below 12 °C. The batter of 1 kg was left to rest for 30 min in a refrigerator, and 50-60 g of the batter was then packed into plastic tubes with lids (Ø = 3.7 cm). The sausages were boiled in a water bath to a centre temperature of 75 °C, which took approximately 40 min. The starting temperature of the water bath was 55 °C and it was continuously increased with steps of 5 °C to be at least 5 °C higher than the centre temperature of the sausage.

Meatball preparation

The meatballs were prepared according to the recipes given in table 1. These central parameters were kept constant in the preparations of the meatball batters:

- Water/protein ratio of 7.4 and a salt content of 1.3 %
- 4.0 or 8.1 % total starch
- 1% of total DF in the meatballs with added cereal fibre.

The meat and the dry ingredients were mixed at low speed in a food processor (Braun, Germany) for 1 minute. The water was added and mixing continued for additional 2 minutes. For the last 15 seconds, the speed was increased to the highest possible. The batter of 500 g was left for 30 min in a refrigerator, before round meatballs of 15 g were made. 15 meatballs were deep-fat fried in a sunflower oil bath of 160 °C until the centre of the meatballs had reached a temperature of 80 °C, which took approximately 150 s. The meatballs were cooled to room temperature on a piece of paper, in order to remove the external oil, before being weighed. All meatballs were stored in a freezer at -20 °C until the sensory evaluation and texture measurements were performed.

Process and frying loss

Process loss of the sausages was calculated by measuring the difference in weight before and after boiling of the sausages. The frying loss of the sausages were determined by frying 1 cm thick slices in a pan at 175 °C for 2 min on each side, and then left to cool to room temperature. The frying loss of the meatballs was determined

by the difference of weight before and after the deep-fat frying. Process and frying losses were calculated as percentage of the initial weight.

Texture analysis

Texture measurements were performed on cooked sausages and fried meatballs using a Texture Analyser, TA-XT2*i* (Stable Micro Systems, Godalming, England) equipped with a 5 kg load cell and a cylindrical probe with a diameter of 35 mm. The firmness (N) was measured as the maximum force needed to compress a 10 mm^3 cube of sample by 50% at a speed of 1 mm/s. Three replicates were made for each recipe.

Sensory evaluation

Sensory evaluation was performed on the fried sausages and meatballs. An untrained panel of 16 participants evaluated the sausages on four occasions and the meatballs on another four sessions. The participants evaluated 5 or 6 samples on each session. The sausages were fried as described earlier before being served. The meatballs were served in halves at room temperature. The panel evaluated colour, crumbliness, compactness, juiciness, meat-taste intensity, off-flavour and total impression of the sausages and meatballs on a scale from 1 to 9.

Rheology of cereal additives in sausages

To be able to compare the contribution of the added cereals to the texture of the sausages, they were mixed together with potato starch and water in the same proportions as in the sausage recipes but without meat and heated in the same manner as when cooking the sausages. The heated cups were stored in a fridge over night and then analysed at room temperature by an oscillatory stress sweep between 0.1 and 100 Pa at 1 Hz (StressTech, Reologica AB, Sweden), using a bob and cup geometry.

Statistical analysis

Data was analysed using students t-test, pair wise comparison (Microsoft Office Excel 2003). Significant differences between samples were detected when the level of probability was 5% ($P \leq 0.5$) for all the comparisons.

III. RESULTS AND DISCUSSION

Results of the process- and frying losses as well as texture measurements and some of the sensory properties are shown in table 2. The sensory panel preferred sausages with oat bran. Oat bran also had the ability to keep more water and had both a higher value of firmness as well as compactness, analysed by the sensory panel, compared to barley fibre and rye bran. Oat bran is the only sample that improves the frying loss compared to that reference which has the same amount of fat and starch as for the fibre added sausages (Ref 3). The process loss is very low for all samples, but it can be seen that the oat bran sample is the only cereal sample that does not increase the loss compared to the references. Sausages with barley fibre had a very low value of firmness and was least preferred by the sensory panel.

When studying the rheological properties of the additives in figure 1 it can be seen that oat bran together with potato starch forms a strong gel with a high elastic modulus (G´), much higher than the viscous modulus (G´´).

Table 2. Losses, firmness and sensory evaluation

	Ref 1	Ref 2	Ref 3	Oat bran	Barley fibre	Rye bran
Sausages						
Process loss (%)	1.2^{c}	0.7^{a}	1.1^{c}	0.9^{b}	3.8^{d}	2.8^{d}
Frying loss (%)	8.2^{a}	10.8^{b}	13.2^{c}	10.9^{b}	19.6^{d}	22.8^{e}
Firmness (N)	12.2^{b}	11.8^{bc}	12.6^{bc}	11.0^{c}	4.6^{a}	7.4^{a}
Compactness	5.8^{c}	5.2^{b}	4.6^{b}	4.9^{b}	3.5^{a}	5.0^{b}
Crumbliness	5.4^{b}	4.1^{a}	4.4^{a}	3.8^{a}	4.5^{ab}	5.3^{b}
Total impression	5.5^{bd}	5.8^{bc}	5.8^{ace}	6.1^{ce}	4.6^{a}	4.9^{ad}
Meatballs						
Frying loss (%)	17.6^{a}	18.5^{ab}	24.3^{b}	21.8^{a}	21.6^{ab}	27.7^{ab}
Firmness (N)	16.0^{b}	15.7^{b}	5.2^{a}	3.4^{c}	4.3^{ac}	3.9^{ac}
Compactness	7.3^{c}	6.8^{c}	3.6^{ab}	3.3^{a}	3.3^{a}	4.1^{b}
Crumbliness	6.1^{c}	5.3^{bc}	5.2^{bd}	3.0^{a}	4.7^{bd}	5.4^{cd}
Juiciness	3.4^{a}	5.4^{b}	7.5^{c}	5.5^{b}	7.1^{c}	6.0^{b}

Different superscript letters in the same row indicate a significant difference ($p<0.05$)

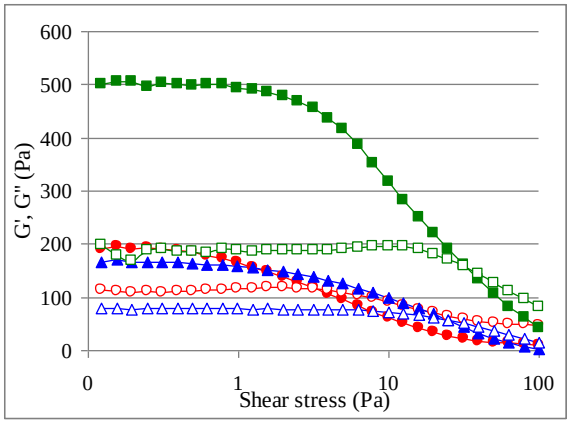

Figure 1. Rheological properties of the cereal additives, where the filled symbols are G´ and the non-filled ones are G´´. □ - oat bran + potato, ○ - barley fibre + potato, Δ - oat bran

Also oat bran without potato starch creates a gel with a G´ almost as high as the barley fibre together with potato starch. The barley on its own did not create a gel and neither did the rye with or without the potato starch. The ability of the fibre to form a firm gel is evidently important to improve/sustain the properties of the sausages on fibre addition. The water-holding capacity of the sausages during frying followed the same order as the ability of the cereal additive to form a gel.

The total amount of starch (cereal and potato) is kept constant. The ratios of potato starch/cereal starch will however differ, since different amount of cereal material is added. The swelling capacity of potato starch is much higher for potato starch than for the cereal starches. Even if the amount of potato starch is much lower for the oat sausages, the ability to form a gel and lower the frying losses is higher, which imply that the amount of potato starch is not the dominating reason for the change of the properties of these sausages.

The meatballs have higher frying losses compared to the sausages. All low-fat and low-starch meatballs have a lower value of the firmness than the references 1 and 2. This result was seen in both the texture measurements and the sensory evaluation. The amount of potato starch is dominating the result of the texture of the meatballs and is more important here than in the sausages. There was also an increase in the perceived juiciness, which was especially high when the barley fibre was added. The oat bran meat balls on the other hand, were perceived with a much lower crumbliness compared to the rest of the meatballs.

IV. CONCLUSION

Oat bran was the best additive due to its gelling ability on heating. Since a strong gel is more important in sausages than in meatballs, the effect was more pronounced in the former product.

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