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EFFECT OF PARTIAL FAT SUBSTITUTION WITH DIETARY FIBER ON SENSORY ATTRIBUTES OF FINELY COMMINUTED SAUSAGES. PART II. POTATO FIBER AND BRAN PREPARATION*

Barbara Szczepaniak[1], Elżbieta Piotrowska[2], Włodzimierz Dolata[2]

[1]Department of Human Nutrition Technology, [2]Institute of Meat Technology;
August Cieszkowski Agricultural University of Poznań, Poznań

Key words: finely comminuted sausages, potato fiber and bran preparation, reduced fat content, texture, profile analysis, consumer examination

The aim of the study was to assess the effect of varying amounts of potato fiber and bran preparation on the quality of finely comminuted thick wiener type sausages. In sausage batters 7.5% and 10% fine fat were successively replaced with rehydrated (1:5) fiber preparations. Proximate analyses were conducted to determine the basic chemical composition of sausages (contents of water, fat and protein) and their texture was measured instrumentally. Model products were also subjected to a detailed sensory analysis, determining the intensity of 16 selected quality attributes using profile analysis. Moreover, consumer desirability was also established for the analysed sausages. In sausages with fat substituted with dietary fiber their fat content decreased significantly (from 25% in the control sausage to approx. 17% in sausages with a 10% fiber content). In comparison to the control sausages a statistically significant reduction was shown for all the instrumentally analysed texture parameters, especially in sausages with fat substituted with bran preparation. These results were confirmed in profile analysis. A decrease was found for binding, hardness and springiness, whereas watery feel of experimental sausages was found to increase. In sausages containing 10% potato fiber the perceptibility of meaty taste was reduced, while sausages with bran preparation were characterised by an enhanced intensity of fatty taste.

Fat substitution with potato fiber, especially with bran preparation, resulted in a decreased consumer desirability of experimental sausages as a consequence of inferior texture of these sausages.

INTRODUCTION

At present overweight and obesity are major health problems in many countries, including Poland [Ziemlański, 1998]. To prevent an increase in obesity, technologists are constantly working on developing food with a reduced fat content, in which the high energy component is replaced with different types of fat substitutes. In Poland the reduction of calorie content of meat products, the consumption of which is very high, is going to be of great importance. At present low-fat processed meat products or ones with a reduced fat content are not produced on a mass scale, since these meat products are not easy to produce [Matuszewska, 1997; Piotrowska *et al.,* 2005; Duda, 1998; Zaborowska & Bilska, 2001; Adamczak *et al*., 2001]. Fat has a considerable effect on rheological attributes, primarily on an appropriate sensory profile of products [Dolata *et al.,* 2004; Tyszkiewicz, 1993; Piotrowska *et al.,* 2003]. There are data available in literature on the application of preparations of fiber, natural or modified starch, carrageenan and different types of protein as fat substitutes. All these substitutes make it possible to increase rehydration of processed meat products and, at the same time, thanks to their texture-forming properties exhibit consistency and mouthfeel as traditional processed meats [Piotrowska *et al.,* 2003; Bilska *et al.*, 2002; Tyszkiewicz *et al*., 1997; Solheim & Ellekjaer, 1993; Dolata *et al.,* 2002; Baranowska *et al*., 2003; Pietrasik, 1998]. It is essential to develop a possibly maximum reduction in the amount of fat added to foodstuffs. However, this procedure may not deteriorate sensory attributes of products, which have to be fully acceptable for consumers [Matuszewska, 1997; Szczepaniak *et al*., 2005; Solheim, 1992]. Fat substitutes applied with an increasing frequency in meat processing include different types of fiber preparations. One of them is potato fiber. It has very good water binding and fat emulsifying properties, it reduces losses during smoking and scalding and improves product texture [Information materials of Avebe, 1997]. Moreover, a bran preparation produced in a processing plant in Kruszwica as a dietary foodstuff may be used as a fat substitute. However, it contains only 20% fiber, with carbohydrates amounting to 41%, respectively.

Thus the aim of this study was to assess the effect of varying amounts of potato fiber and bran preparation, replacing a portion of fat in finely comminuted sausages, on individual quality attributes and consumer acceptance of these processed meat products.

MATERIAL AND METHODS

Experimental material consisted of finely comminuted thick frankfurter type sausages produced in a semi-commer-

Author's address for correspondence: dr Barbara Szczepaniak, Department of Human Nutrition Technology, August Cieszkowski Agricultural University of Poznań, ul. Wojska Polskiego 31, 60-624 Poznań, Poland; tel.: (48 61) 848 73 31; fax: (48 61) 848 72 54; e-mail: elutka50@poczta.onet.pl.

cial scale. The control sausage consisted of 48.0% fine pork class III, 20.8% fine fat trimmed from ham, 2.2% curing mixture, spices and water, amounting to 29.0% weight of meat and fat material. In experimental sausages a portion of fat was replaced successively with rehydrated (1:5) potato fiber (PASELI FP) and experimentally applied bran preparation produced at a processing plant in Kruszwica. Both types of fiber were introduced to sausage batter to replace 7.5% and 10% removed fat. Meat and fat, after being ground using mesh size of 3 mm, were cured for 24 h at 2–4°C. Next these raw materials were chopped for 10 min adding successively meat, water with ice and spices, and fat. After 2 min 2/3 of fiber were added to the cutter, while the remaining 1/3 was added after 8-min comminution. The produced batter with the maximum temperature of 12°C was stuffed into natural casings 28–30 mm in diameter, and next they were sooted, hot smoked and scalded in a smoking and scalding chamber at a temperature of 70°C. After cooling, the final products were placed in a cooler at 4–6°C. Samples for analyses were collected after 24 h cold storage.

Proximate chemical composition was analysed in the produced sausages: *i.e.* contents of water [PN-73/A-82110], protein [PN-75/A-04018] and fat [PN-73/A-82111].

Texture of sausages was analysed using an Instron 1140 universal testing machine. Samples were compressed twice to 50% of their original height (the TPA test) and shear was tested with a Warner-Bratzler knife. Samples with a diameter of 2.5×10^{-2} m and height of 2×10^{-2} m were used in compression tests. Head velocity during TPA was 5×10^{-2}m/min. From the graph of the general texture profile its parameters were determined according to Bourne [1986]. They were maximum compressive force at the first compression (hardness 1 (N)) and maximum force of the second compression (hardness 2 (N)), cohesiveness (cohesion) and elasticity (mm). Maximum shear force (N) and shear work (J) were determined while samples were cut with a Warner-Bratzler knife [Voisey & Hansen, 1967]. Knife velocity was 0.5 m/min.

Sensory analysis of sausages included quality assessment conducted using a quantitative descriptive analysis (QDA), *i.e.* profile analysis [PN–ISO 11035, 1996; Baryłko-Pikielna, 1995; Matuszewska *et. al.*, 1997] and a simultaneous semi-consumer analysis. A trained 8-person panel participated in the profile analysis, while 40 individuals took part in the consumer analysis. All examinations were carried out in a sensory laboratory meeting the requirements of the respective standard [PN-ISO 8589, 1996]. First 16 individual notes were selected, characterising colour, texture, aroma and taste of the assessed sausages. Moreover, appropriate anchoring points were established. For intensity and uniformity of colour they were “pale” and “pink”, and “non-uniform” and “uniform”. Texture included four notes: binding – “poor” and “strong”, hardness – “soft” and “hard”, water feel – “considerable” and “slight”, and springiness – “low” and “high”. Sausage aroma was characterised by three attributes: fatty, meaty and extrinsic. Taste was determined by seven descriptors: fatty, meaty, salty, sour, bitter, spicy and burning. Anchoring points for taste and aroma attributes were identical: “undetectable” and “intensive”. After several preliminary analyses to establish the range of intensity of selected attributes, profile analysis was carried out itself.

The intensity of each of the attributes was assessed using a 100-mm unstructured graphic scale with the boundary denotations given above, with samples being analysed each time in two independent replications. Each result constituted a mean from 48 replications (8 panel members × 2 sessions × 3 production series).

Consumer examination of experimental sausages, conducted at the same time, consisted in the determination of the degree of their desirability. In this examination a 100-mm graphic scales was also used, with boundary markings: ”I don’t like it at all” – “I like it very much”.

Sausages were examined when hot after being heated in water until the temperature inside the link reached 70°C. The prepared samples with a unit weight of approx. 100 g in the profile analysis and approx. 70 g in the consumer examination, after being coded, were given to panel members in a random order. Wheat bread and tea with no sugar added were used to neutralize taste.

Results were transformed into numerical values by measuring the distance from the left end of the scale to the point marked by panel members. Means calculated for each of the 16 assessed attributes were used to prepare polar diagrams. A comparison of the created sensory profiles of the analysed sausages made it possible to determine the variation in sensory attributes depending on the amounts of both analysed fiber types in experimental sausages.

Statistical analysis concerning the chemical composition and texture of experimental sausages was carried out using a two way analysis of variance (ANOVA) at the level of significance $\alpha = 0.05$. In contrast, the effect of the type and amount of fiber introduced to sausage batter on the sensory quality of final products was interpreted using a multivariate analysis of data in the principal component analysis (PCA). This facilitated a comprehensive evaluation of similarities and differences between produced sensory profiles of individual sausages and thus a precise determination of the effect of introduced fiber on changes in the intensity of the quality notes analysed.

A comparison of this precise qualitative and quantitative characteristic of the analysed finely comminuted sausages with the results of their consumer examination made it possible to define quality attributes of final products, both positive and negative, having a decisive effect on consumer desirability of final processed meat products [Matuszewska *et. al.*, 1998].

RESULTS AND DISCUSSION

Results concerning the basic chemical composition of experimental sausages are presented in Table 1. Sausages with varying levels of fat replacement using the analysed fibers exhibited its statistically lower content in comparison

TABLE 1. Proximate chemical composition of model sausages (g/100 g).

Parameter	Control sample	Potato fibre		Bran preparation	
		7.5%	10%	7.5%	10%
Water	62.97[a]	68.16[b]	69.68[b]	67.83[b]	68.04[b]
Fat	25.08[a]	18.77[b]	16.62[c]	19.91[b]	17.24[c]
Protein	10.07[a]	10.10[a]	9.95[a]	10.07[a]	10.02[a]

[a, b, c] – means with different letters in rows differ statistically significantly at $p<0.05$.

to the control sausage. The amount of fat decreased from 25% in the control sausage to approx. 17% in the product with a 10% fat substitution. Moreover, significant differences were found in fat content between sausages containing 7.5% and 10% dietary fiber. Protein content in all sausage variants did not differ statistically significantly, amounting to approx. 10%, which was consistent with the requirements of the respective Polish Standard [PN-A-82007, 1996]. The amount of water was observed to increase in produced sausages along with the increase in the amount of fat replacement applied. It resulted from the introduction of additional amounts of water required to rehydrate fiber in experimental sausage batters.

Results of profile analysis of sausages with fat replaced by potato fiber are presented in Figure 1. Fat substitution using this type of fiber affected first of all the variation in texture attributes. An increased content of fiber in the formulation caused a directly proportional reduction of binding, hardness and springiness and an increase in moisture content of experimental sausages. The intensity of the pink colour was reduced as well. Moreover, a 10% addition of potato fiber resulted in a lowered detectability of meaty taste in comparison to the other sausages. The intensity of the other notes practically did not differ from their intensity in the reference sausage.

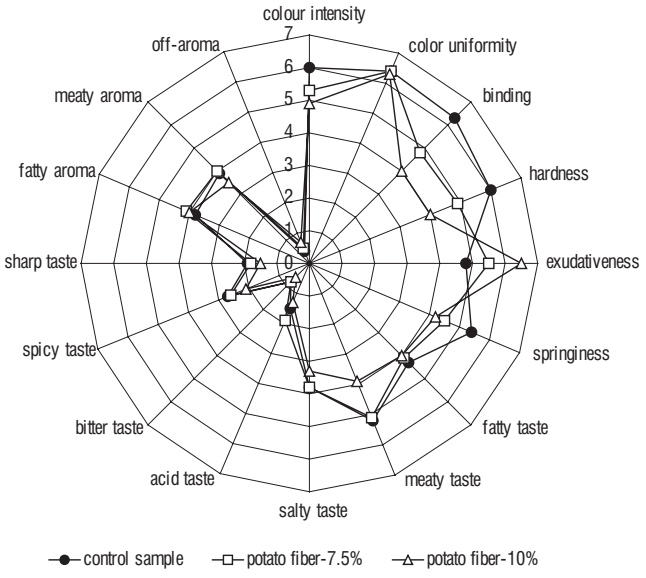


FIGURE 1. Profile descriptive analysis of sausages with fat replaced with potato fiber.

Sensory profiles of experimental sausages with fat substitution using bran preparation are presented in Figure 2. The application of this preparation, to an even larger extent than in the case of potato fiber, resulted in a deterioration of rheological properties of experimental sausages. This was especially evident at a 10% fat substitution with this preparation. First of all hardness of this product was considerably lowered. A higher content of fiber caused also a much worse binding, increased watery feel and a deteriorated springiness of sausages. The analysis of taste and aroma attributes in comparison to the control showed only an increased intensity

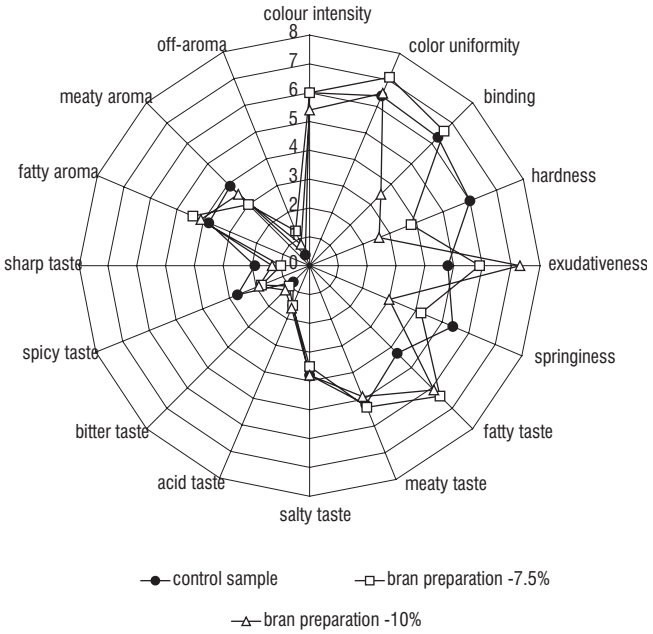
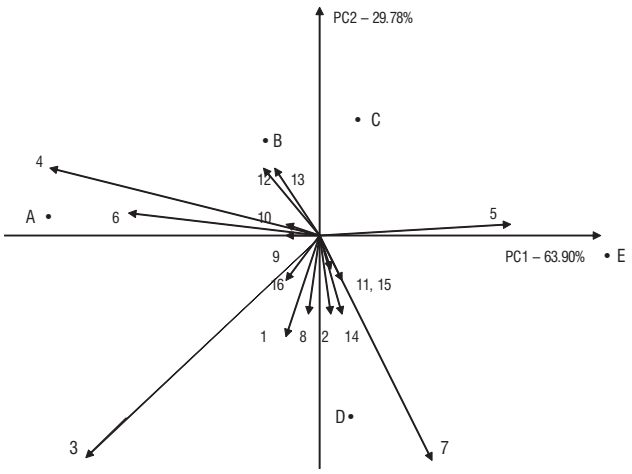


FIGURE 2. Profile descriptive analysis of sausages with fat replaced with bran preparation.

of fatty taste in the sample with the introduced bran preparation. The other quality attributes showed similar intensity.

Figure 3 presents PCA for profile analysis results of five variants of experimental sausages with varying fat substitutions using potato fiber and bran preparation. Analysis of principal components covering 94% total variation confirmed a significant quality variation of the analysed processed meat products characterising attributes playing a



A – Control sausage; B – Sausage with 7.5% potato fiber; C – Sausage with 10% potato fiber; D – Sausage with 7.5% bran preparation; E – Sausage with 10% bran preparation.

Parameters for characterization of sausage quality: 1 – colour intensity, 2 – colour uniformity, 3 – binding, 4 – hardness, 5 – exudativeness, 6 – springiness, 7 – fatty taste, 8 – meaty taste, 9 – salt taste, 10 – acid taste, 11 – bitter taste, 12 – sharp taste, 13 – spicy taste, 14 – off-aroma, 15 – fatty aroma, 16 – meaty aroma.

FIGURE 3. Principal Component Analysis (PCA) projection of sensory profiling results of fine comminuted sausages.

key role in the shown variation. The investigated sausages formed distinctly separate clusters found along the first principal component. This indicated a dominant effect of the type of applied fat substitute on product quality. It needs to be mentioned that the quality of sausages both with potato fiber and bran preparation considerably differed from that of the control. This difference was especially large when using bran preparation. A tangible deterioration of sausage quality was observed along with an increasing amount of fiber introduced, especially in the case of bran preparation. Attributes having a decisive effect on the variation in the quality of the samples analysed were in this case properties connected with sausage texture, such as hardness (attribute 4), springiness (attribute 6), binding (attribute 3), watery feel (attribute 5), as well as fatty taste (attribute 7). This was indicated by the length of plotted vectors. The other attributes of taste, aroma and colour had a slight effect on the variation of samples, as it was manifested by small lengths of vectors. The worst binding was observed for sausages with a 10% fat substitution using both potato fiber and bran preparation. In the latter sausages fatty taste was also clearly detectable. Samples with a bigger addition of both these types of fiber were also characterised by a higher moisture content.

Results of a simultaneous consumer examination of the produced variants of sausages are presented in Figure 4. None of the sausages with a reduced fat content received higher scores than those of the control. In contrast, it was found that sausages in which fat was replaced with potato fiber or bran preparation, especially in the amount of 10%, were characterised by a much lower desirability than the control. This resulted from a deterioration of attributes characterising texture of these sausages, which as it turned out was significant for the panel members. Consumers preferred sausages with good binding, appropriate hardness and low moisture content. A too high intensity of fatty taste in finely comminuted sausages was not found acceptable by consumers.

The disadvantageous effect of potato fiber on the texture of finely comminuted sausages was also reported in a study by Dolata *et al.* [2002, 2004].

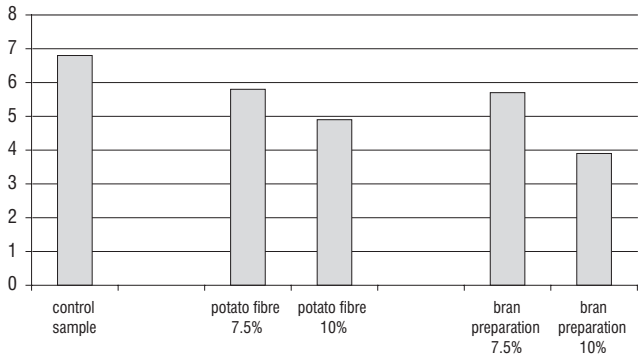


FIGURE 4. Consumer acceptance of sausages with a lowered fat content (points).

Table 2 presents mean values of attributes characterising sausage texture obtained using an Instron 1140 testing machine. On the basis of these data a statistically significant effect was found for fat substitution with fiber on all the analysed texture parameters in comparison to the control. Primarily shear force, hardness II and cohesiveness of sausages were significantly reduced along with an increase in the amount of potato fiber and bran preparation introduced to sausage batter. These results were reflected both in the conducted profile analysis and in the consumer examination.

TABLE 2. Mean values of parameters characterising texture of sausages.

Parameter	Control sample	With potato fiber		With bran preparation	
		7.5%	10%	7.5%	10%
Shear force (N)	3.47[a]	3.12[b]	2.61[c]	3.08[b]	2.29[c]
Shear work (J)	0.100[a]	0.087[b]	0.080[b]	0.085[b]	0.076[b]
Hardness 1 (N)	26.75[a]	23.45[b]	20.09[b]	22.84[b]	18.73[b]
Hardness 2 (N)	22.95[a]	19.23[b]	15.55[c]	18.48[b]	14.32[c]
Cohesion	0.62[a]	0.56[b]	0.51[b]	0.57[b]	0.49[c]
Elasticity (mm)	7.27[a]	6.75[b]	6.32[b]	6.61[b]	6.35[b]

[a, b, c] – means with different letters in rows differ statistically significantly at $p<0.05$.

CONCLUSIONS

1. A 10% fat substitution with potato fiber in finely comminuted sausages of the thick wiener type reduced fat content in these sausages by approx. 32% in comparison to the control sausage.

2. The content of potato fiber in the raw material composition of sausages resulted in reduced binding, hardness and springiness, increased watery feel of products and a deterioration of the detectability of meaty taste. The application of bran preparation to an even higher degree resulted in a deterioration of texture attributes and at the same time increased the intensity of fatty taste.

3. The range of qualitative changes, connected first of all with attributes determining the texture of sausages with fat substitution, especially using a bran preparation, was large enough to result in a reduction of consumer desirability of these products.

4. In sausages with fat replaced with potato fiber, and especially with bran preparation, all the instrumentally analysed texture parameters were found to decrease, which was detectable in sensory analysis.

5. Bran preparation should not be used as a fat substitute due to the evident deterioration of texture attributes of finely comminuted sausages of the thick wiener type. Fat substitution with potato fiber should not exceed 7%.

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WPŁYW CZĘŚCIOWEJ WYMIANY TŁUSZCZU BŁONNIKIEM POKARMOWYM NA CECHY SENSORYCZNE WĘDLIN DROBNO ROZDROBNIONYCH. CZĘŚĆ II. BŁONNIK ZIEMNIACZANY I PREPARAT OTRĘBOWY

Barbara Szczepaniak[1], Włodzimierz Dolata[2], Elżbieta Piotrowska[2]

[1]Katedra Technologii Żywienia Człowieka, [2]Instytut Technologii Mięsa; Akademii Rolniczej im. A. Cieszkowskiego, Poznań

Celem pracy była ocena wpływu zróżnicowanej ilości błonnika ziemniaczanego i preparatu otrębowego, na jakość wędlin drobno rozdrobnionych typu parówkowa. W farszach wędlinowych wymieniano kolejno 7,5% oraz 10% tłuszczu drobnego uwodnionymi (1:5) preparatami błonnika. Przeprowadzono badania podstawowego składu chemicznego wędlin (zawartość wody, tłuszczu i białka) oraz wykonano instrumentalne pomiary ich tekstury. Modelowe wyroby poddano także kompleksowej analizie sensorycznej, określając metodą profilową intensywność wybranych 16 not jakościowych. Wyznaczono również stopień pożądalności konsumenckiej analizowanych wędlin. W wędlinach z wymianą tłuszczu błonnikiem pokarmowym zmniejszyła się istotnie zawartość tłuszczu (z 25% w wędlinie kontrolnej do około 17% w wędlinach z 10% zawartością błonnika). Wykazano statystycznie istotne zmniejszenie, w porównaniu z wędliną kontrolną, wszystkich badanych instrumentalnie parametrów tekstury, szczególnie w kiełbasach z wymianą tłuszczu preparatem otrębowym (tab. 2). Wyniki te zostały potwierdzone w analizie profilowej (rys. 1 i 2). Stwierdzono mianowicie zmniejszenie związania, twardości i sprężystości oraz zwiększenie wodnistości wędlin doświadczalnych. W wyrobach zawierających 10% błonnika ziemniaczanego została obniżona wyczuwalność smaku mięsnego, natomiast wędliny z preparatem otrębowym charakteryzowały się zwiększoną intensywnością smaku tłuszczowego. Wymiana tłuszczu błonnikiem ziemniaczanym, a szczególnie preparatem otrębowym, spowodowała obniżenie stopnia pożądalności konsumenckiej wędlin doświadczalnych, co było wynikiem gorszej tekstury tych wędlin.