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Organoleptic quality of reduced fat turkey sausage using pea fiber or potato starch additives

É. Varga-Visi, B. Toxanbayeva, G. Andrássyné Baka, R. Romvári

Kaposvár University, Faculty of Agricultural and Environmental Sciences
7400 Kaposvár, Guba S. u. 40., Hungary

ABSTRACT

Reduced fat Bologna-type turkey sausages were manufactured and the effects of pea fiber or potato starch based fat replacers on organoleptic characteristics were evaluated. Fat was partially (25, 50 or 75 %) replaced with potato starch or pea fiber resulting 16-17%, 31-33% and 45-50% decrease in gross energy content, respectively. Differences in measured color values were small, being undetectable by assessors. Reduced fat sausages containing medium or high levels of potato starch (3.9%, 5.8%) or high level of pea fiber (1.8%) were perceived less salty than control and scores of saltiness were in line with that of juiciness. Organoleptic properties of sausages with low and medium levels of pea fiber (0.6, 1.2%) and potato starch (1.9%) were similar than that of full fat sausage.

(Keywords: fat replacer, Bologna sausage, turkey, saltiness, juiciness)

INTRODUCTION

Nutritional concern about fat has inspired the production of meat products with lower fat content. Customers are unwilling to compromise on quality originated from the reduction of a compound regarded as unhealthy (*Brewer,* 2012) therefore the development of low fat products should be based on formulations that result in products resembles to the commercial analogues.

Sensory properties of low fat Bolognas were successfully restored with whey protein and tapioca starch (*Lyons et al.*, 1999), carrageenan with pectin gel (*Candogan & Kolsarici* 2003), pea starch or pea fiber (*Pietrasik & Janz*, 2010), or wheat fiber/pig skin mixture (*Choe et al.*, 2013). Most studies on fat-replaced comminuted meat products were conducted on sausages manufactured from pork meat and fat (*Bañón et al.*, 2008; *Berasategi et al.*, 2014; *Choe et al.*, 2013; *Lyons et al.*, 1999; *Keenan et al., 2014*), beef (*Pietrasik & Janz,* 2010) or both (*Bengtsson et al.,* 2011). However, little work has been carried out on low fat products manufactured from poultry (*Beggs et al.,* 1997), therefore the objective of this study was to investigate the effect of potato starch and pea fiber additives on organoleptic properties of low fat Bologna-type sausage made of turkey.

MATERIALS AND METHODS

Manufacture of sausages

Food ingredients as potato starch, pea fiber, salt with nitrite, spice mixture, and casings were obtained from Solvent Inc. (Budapest, Hungary) while vacuum packed turkey breast meat and goose fat were purchased from a local store. The meat was minced following purchase with a 4 mm-hole-size Moulinex Charlotte HV3 type device then sorted into 0.45 kg lots and stored frozen at -20 °C.

Full fat control samples and reduced-fat sausages were processed in a pilot plant at Kaposvár University. In the experimental sausages the ratio of fat was reduced by approximately 25, 50 and 75 % compared to the full fat reference product. Ratios of lean meat, spice mixture and salt were kept constant for each type of sausage (*Table 1*).

Table 1

Composition of ingredients used for processing Bologna-type sausages

Ingredients (w/w)%	Control	Low fat products[1]					
		S1	S2	S3	F1	F2	F3
Turkey meat	58.3	58.3	58.3	58.3	58.3	58.3	58.3
Schredded ice	19.4	19.4	19.4	19.4	19.4	19.4	19.4
Goose fat	19.4	14.6	9.7	4.9	14.6	9.7	4.9
Starch (potato)	-	1.94	3.88	5.83	-	-	-
Water supplement[2]	-	2.91	5.83	8.74	4.27	8.54	12.82
Fibre (pea)	-	-	-	-	0.58	1.17	1.75
Spice mixture[3]	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Salt with nitrite4	1.94	1.94	1.94	1.94	1.94	1.94	1.94

[1]S=potato starch; F=pea fiber; 1=25% of fat was substituted; 2=50% of fat was substituted; 3=75% of fat was substituted.
[2] Water supplement were applied to low fat products in the form of shredded ice.
[3]Bologna sausage type spice mixture contained diphosphate and sodium-iso-ascorbic acid.
[4]Salt with nitrite consisted 0.45±0.05 (w/w) % sodium nitrite.

The manufacture of one set of sausages was carried out on the same day. The weight of each experimental unit including full fat and low fat sausages was 0.77 kg. There were four repetitions of the full set of processing at four different days. On the day of the manufacture the measured ingredients were minced in a Blixer 4 v.v. type silent cutter (Robot couple U.S.A Inc, Ridgeland) for 20 s at 30 s^{-1} then the temperature of the batter was measured and checked, then it was chopped again for 20 s at 30 s^{-1}. Heat-resistant, water impermeable plastic casings with 55 mm diameter were used for stuffing. Heat treatment was accomplished in a 850 C-FRG type instrument (Bayhaand Strackbein GmbH, Arnsberg, Germany) at 78 °C for 2 hours then the sausage batches were cooled in icy water. The temperature of storage was 4 °C. Each assay was conducted on experimental units on the seventh day of storage.

Chemical and organoleptic assays

Proximate analysis was carried out according to the standards of MSZ ISO 1442:2000, MSZ ISO 1443:2002, MSZ ISO 937:2002 and MSZ ISO 936:2000 for moisture, fat, protein and ash content, respectively. An IKA C4000 adiabatic calorimeter (IKA-Werke GmbH & Co. KG, Staufen, Germany) was used to determine the gross energy content of sausages. Instrumental color parameters were determined with a Minolta Chroma Meter CR-300 colorimeter. CIE Lab color values were measured on the freshly cut surfaces of the samples.

Organoleptic assay was accomplished by a semi-trained panel. The members of the panel were familiar with the type of the product being evaluated. Randomly coded 2 mm width slices of 55 mm diameter samples were served on white plates. The number of assessors was 11 for each test. A total of four tasting sessions were conducted. In the first part of the sensory analysis each panelist scored color, odor, consistence, taste and overall acceptability on a five-point hedonic scale (1 = extreme dislike, 5 = like extremely). In the second part of the organoleptic assay assessors evaluated as objectively as possible the next sensory descriptors of the samples: saltiness (1 = saltless, 5 = too salty), juiciness (1 = dry, 5 = juicy) and off flavor (1 = none, 5 = very intensive).

Data analysis

Comparison of treatment means was evaluated with analysis of variance. The effect of treatment was regarded as significant if the null hypothesis on the sameness of averages was rejected at 95% probability. Student-Newman-Keuls post hoc test was used if variances were homogeneous among groups, in the opposite case Tamhane's test was applied. Kruskal-Wallis nonparametric test was used when variables did not follow normal distribution. Calculations were performed by means of commercial statistical software package (IBM SPSS Statistics 20).

RESULTS AND DISCUSSION

Proximate composition, pH and color of Bologna-type sausages

The protein and the fat content of the sausages (*Table 2*) corresponded to the applied formulas (*Table 1*). The effect of individual sausage formulations on ash content was not significant. None of the treatments had any effect on the pH of the product. Control product was processed according to traditional formulations therefore its energy content was similar to that of those products. Application of fat replacers reduced the gross energy content of products with 16-17% at the first level, with 31-33% at the second level and with 45-50% at the third level of fat substitution (*Table 2*). This substantial decrease in gross energy value could be attributed mainly to the decrease in the level of lipids, as the gross energy content of fat replacers, mainly composed of carbohydrates, is significantly lower, than that of the lipids, moreover, some part of lipids was substituted with water supplement.

Table 2

Chemical composition, pH and energy content of Bologna-type sausages[1]

	Control	Low fat products[2]					
		S1	S2	S3	F1	F2	F3
Moisture content (%)	62.9 ±0.10[a]	66.4±0.13[b]	69.4±0.21[d]	72.6±0.24[f]	67.3±0.30[c]	71.5±0.17[e]	75.7±0.31[g]
Crude protein content (%)	14.3 ±0.18	14.3±0.13	14.2±0.13	14.1±0.05	14.1±0.06	14.2±0.06	14.1±0.15
Crude fat content (%)	19.3±0.55[d]	14.6 ±0.47[c]	9.7 ±0.48[b]	5.2±0.12[a]	14.5 ±0.40[c]	9.9 ±0.32[b]	5.3 ±0.14[a]
Crude ash content (%)	3.10±0.08	3.13±0.05	3.13±0.05	3.15±0.05	3.10±0.08	3.20±0.00	3.18±0.05
pH	6.40±0.17	6.42±0.17	6.40±0.17	6.43±0.21	6.43±0.22	6.38±0.17	6.38±0.17
Dietary gross energy (GE) (MJ/kg sample)	11.02±0.11[g]	9.29±0.07[f]	7.63[d]±0.07	6.02[b]±0.05	9.17[e]±0.05	7.35[c]±0.01	5.52[a]±0.09

Means within row with different superscript letters are significantly different (P<0.05).
[1]Values are mean±standard deviation (n=4).
[2]S=potato starch; F=pea fiber; 1=25% of fat was substituted; 2=50% of fat was substituted; 3=75% of fat was substituted.

Color differed very slightly but significantly between formulations (*Table 3*). In this experiment control and experimental products contained the same amount of meat, therefore the levels of meat pigments were at similar levels. Hence, the small variance in color values probably could be attributed to the differences in the ratios of the other constituents like fat and fat replacers. Previous studies reported that changes in fat content exert only minor effect on a* and b* values (*Pietrasik & Janz,* 2010; *Choe et al.,* 2013). Partial replacement of fat with pea fiber, flour or starch did not change these color values remarkably, compared to full fat control (*Pietrasik & Janz,* 2010). The observed degree of difference in present experiment was small and would be considered to be of little practical importance.

Table 3

The color values of high fat and low fat Bologna sausages[1,2]

	L*	a*	b*
Control	78.15 ±0.38^{c}	12.10±0.39^{b}	6.21±0.29^{c}
S1	77.76±0.77^{c}	12.59±0.33^{c}	5.97±0.24^{bc}
S2	76.65±0.51^{b}	12.57±0.63^{bc}	5.84±0.25^{b}
S3	74.71±0.47^{a}	12.57±0.52^{bc}	5.12±0.6^{a}
F1	78.78 ±1.26^{c}	11.54±0.45^{a}	6.43±0.26^{cd}
F2	78.42 ±1.05^{c}	11.46±0.38^{a}	6.68±0.43^{de}
F3	77.70 ±0.97^{c}	11.63±0.61^{ab}	6.95±0.35^{e}

Means within column with different superscript letters are significantly different (P<0.05).
[1]Values are mean±standard deviation (n=16).
[2]S=potato starch; F=pea fiber; 1=25% of fat was substituted; 2=50% of fat was substituted; 3=75% of fat was substituted.

Fat content was reported to be directly proportional to lightness (L*) value (*Choe et al.,* 2013; *Pietrasik & Janz,* 2010), as glossiness is normally provided by fat, therefore smaller lightness values were expected for fat-substituted counterparts compared to full fat control. In this study lightness slightly reduced, compared to control, in sausages containing potato starch, but means did not differ when pea fiber was added as fat substitute (Table 3). The reason for this discrepancy is unclear, but it maybe as a result of the added fiber that can affect the color of meat products interacting with the light scattering properties (*Varnam & Sutherland,* 1995). Similar extent of fat reduction than in present work, from 16% to 10-11% and 5-6%, did not exert significant effect on L* value (*Schmiele et al.,* 2015) using amorphous cellulose fiber (Z-trim ®) as fat replacer. Sausages with pineapple dietary fiber had higher lightness values than control with the highest amount of fat (*Clair Henning et al.,* 2016).

Sensory evaluation of Bologna-type sausages

Regarding color, odor, taste and overall acceptability, no significant differences was found between the control product and its low fat analogues (p≥0.05). Slight differences in instrumental color may have been too subtle for panelists to distinguish. It has been shown previously that significant differences measured in color was not detected by assessors (*Keenan et. al.,* 2014). The average value of the overall score of each sausage was above 3 indicating that all the sausages were more liked than disliked (*Table 4*). Inclusion of pea starch or fiber (*Pietrasik & Janz,* 2010) instead of pork fat, or application of pig skin/wheat fiber mixture (*Choe et al.,* 2013) did not change the means of color, flavor, and overall scores of assessors. Replacement of fat with mixed gels of carrageenan, WPC, and tapioca starch (*Lyons et al.,* 1999) or carrageenan with pectin gel (*Candogan & Kolsarici,* 2003) or potato pulp (*Bengtsson et al.,* 2011) were reported as possess similar characteristic to that of full fat sausages. However, the null hypothesis for the equality of means of consistence was rejected at 95% probability level (p=0.026) (*Table 4*). The consistence of sample with medium level of pea fiber (F2) was evaluated as better than that of control and product with high starch content (S3). Dietary fibers were suggested to compose fiber networks in food products, holding the water within pores, and improve the gel stability unless an interaction occurs between meat protein gel and fibrous structure (*Bengtsson et al.,* 2011).

Table 4

Scores of sensory analysis of high fat and low fat Bologna sausages[1]

	Control	Low fat products[2]					
		S1	S2	S3	F1	F2	F3
Color	4.0±0.96	4.1±1.09	4.4±0.81	4.4±0.90	4.0±1.11	4.0±1.17	4.1±1.04
Odor	3.8±0.94	3.7±1.03	3.8±1.00	4.0±0.95	4.1±0.99	3.8±0.91	3.9±0.90
Consistence	3.8±0.94^{a}	3.9±0.85^{ab}	3.8±0.94^{ab}	3.7±1.07^{a}	4.0±0.84^{ab}	4.3±0.74^{b}	4.1±0.90^{ab}
Taste	3.6±1.15	3.9±0.86	3.8±1.10	4.1±0.90	3.8±0.89	4.1±0.87	4.1±0.86
Overall acceptability	3.7±0.88	3.8±0.83	3.7±0.82	3.9±0.85	3.9±0.74	4.1±0.75	4.1±0.86
Off-flavor	3.3± 1.38^{a}	3.8 ± 1.07^{ab}	3.8 ± 1.21^{ab}	4.2± 1.18^{b}	4.1 ± 0.89^{ab}	4.0± 1.11^{ab}	4.0± 1.18^{ab}
Saltiness	3.6± 0.75^{de}	3.3± 0.55^{cde}	3.1± 0.65^{abc}	2.8± 0.72^{a}	3.4±0.69^{cd}	3.2 ±0.74^{abcd}	3.1±0.66^{abc}
Juiciness	3.7±0.86^{d}	2.8±0.82^{bc}	2.7±0.93^{b}	2.0±0.84^{a}	3.1±0.88^{bcd}	3.2±0.61^{bcd}	3.3±0.86^{cd}

Means within row with different superscript letters are significantly different ($P<0.05$).

[1]Values are mean±standard deviation (n=44)

[2]S=potato starch; F=pea fiber; 1=25% of fat was substituted; 2=50% of fat was substituted; 3=75% of fat was substituted.

Off-flavor was mainly observed in panelist scores when high starch content (S3) was applied (Table 4). The mean value of saltiness was the highest in the case of full fat control samples. The saltiness of low-level fat replaced samples (S1 and F1) did not differ from control, contrarily, samples with high level of fat substitution (S3 and F3) were assessed to less salty. However, the same amount of salt was added to each sample during processing, and the chemical analysis of ash content verified that the ash content of different type of samples was the same. Hence, the variance in organoleptic assessment of saltiness is probably related to the differences in other constituents like fat and water and replacer materials, as meat content also was set to the same level. Fat replaced samples were perceived less salty than full fat samples with the same concentration of added salt. Similarly to this observation, other authors have also reported correlation between high fat content and increased salt perception in meat products. The increase in NaCl content was more noticeable in full fat products than in low fat products (*Matulis et al.,* 1994), moreover, higher fat samples were scored as more salty than lower fat samples with inulin (*Keenan et al.,* 2014). Nevertheless, *Ruusunen and coworkers* (2001) did not find differences in the perceived saltiness of sausages in which fat was replaced with water on an equal weight basis. Moreover, in a study when the temporal changes of flavor was investigated (*Ventanas et al.,* 2010), fat content of sausage was reported as it did not exert a significant effect on the observed maximum intensity of salty taste, although the duration of the decreasing phase of the salty taste was longer in fatty products than in lean ones. These contradictory findings may indicate that background composition is a key factor in the perception of salty taste (*Keenan et al.,* 2014), and besides fat content, the ratio of other constituents, like lean meat, water and fat replacers is important (*Ruusunen et al.,* 2001, 2005). It has been also postulated that meat products, where water is bound weakly, have higher perceived saltiness (*Ruusunen et al.,* 2005). In the present experiment high fat control sausage was juicier than low fat products with starch (Table 4), this may indicate a higher release of watery salt solution during mastication (*Bengtsson et al.,* 2011) that might cause a saltier taste of control than that of high starch containing sample. The means of juiciness for pea fiber enriched sausages were also smaller than that of control, but the differences were not significant. Other studies have also shown that juiciness is concomitant of high fat content (*Tobin et al.*, 2013; *Keenan et al.*, 2014).

Assessors did not find differences between samples regarding taste, while there were significant differences regarding saltiness (Table 4). The reason of this discrepancy is probably that taste assessment is ruled by several factors in a complex process and the advantageous and disadvantageous properties of samples can equate each other. Moreover, in the evaluation of taste, differences between the individuals might be greater than in the assessment of saltiness because the later may be more objective. The standard deviation values of saltiness were smaller, than that of taste (Table 4) verifying this assumption, while the standard deviation of off-flavor was in the same order of magnitude than that of taste referring to the greater individual variance.

CONCLUSIONS

Color, odor, taste and overall acceptability of the manufactured healthier low fat model products proved to be highly similar to the conventional full fat Bologna type turkey sausage. Nevertheless, partial fat replacement using potato starch (3.9%, 5.8%) or pea fiber (1.6%) resulted in significant loss in salty taste. The decreased perception of saltiness is most likely due to the differences in background composition as sausages had the same salt concentration. Changes in saltiness were in line with variation in juiciness. In low fat products with fat replacers, if water and water soluble compounds are bound strongly, their release and therefore the perception of salty taste might be hampered. This effect may be disadvantageous when salt content is reduced parallel with fat content in low fat and low salt Bologna-type sausages, as the assessment of salty taste might be reduced to a greater extent than could be expected based on concentration decrease.

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Corresponding author *(levelezési cím):*

Éva Varga-Visi
Kaposvár University, Faculty of Agricultural and Environmental Sciences
H-7401 Kaposvár, P.O. Box 16.
Tel.: +36-82-505-800, Fax: +36-82-321-749
e-mail: vargane.eva@ke.hu