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Quality Characteristics of Functional Pork Sausages Incorporated with Oat Bran Powder

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ABSTRACT

Sausages were developed by replacing lean meat with oat bran (OB) at 3%, 6%, and 9% levels. pH, cooking yield, instrumental textural profile and sensory properties of treated sausages were evaluated. Different levels of dietary fiber source with very good sensory acceptability were compared with control. Overall acceptability of 6 per cent fibre (oat bran) incorporated sausages were comparable with control. The moisture level of all treatment sausages dropped significantly (P<0.05). Protein content of oat bran incorporated sausages decreased, but the ash content increased significantly. Emulsion stability and cooking yield were significantly higher in 6 and 9 per cent treated sausages, while crude fibre content was significantly higher in all treatment groups.

Key words: Oat bran, Powder, Functional, Pork sausages, Quality

INTRODUCTION

Emulsion-based pork products can be used as carrier matrices for functional products, and dietary fibres can be added to the food production process to provide health advantages in specific illnesses. Concurrently, dietary fibres are commonly employed in meat products to increase functional features like water binding, gelling potential, and textural enhancement. Plant components may also provide essential nutritional opportunities with the addition of soluble fiber.

Oat is a remarkable cereal grain with the ability to produce EFSA-approved health claims on soluble fiber (β-glucan) conferring health benefits to consumers like maintaining and lowering blood cholesterol, improving blood glucose balance, increasing faecal bulk, and lowering the risk of heart and vascular diseases (Smulders et al. 2018); while also providing excellent physical functioning to the end product in which they have been incorporated (Ahmad et al. 2012). Oat has immense potential for development into functional foods and food additives as it is the only cereal listed as a healthy food by the World Health Organization. Efforts have been made to improve food quality and health benefits by using whole grain oats or other ingredients. Kosova et al. (2020) and Turrini et al. (2019) have published several reviews on oat, including analytical methods, processing effects, and health benefits of specific nutrients. The utilization rate of oat bran was improved recently in the food industry as a source of dietary fiber in various food products and meat products.

Meat and meat products are naturally poor in soluble fiber and highly susceptible to deterioration, due to oxidation reactions of meat lipids and proteins, as well as microbial propagation owing to the presence of unsaturated fatty acids, high moisture, and nutritional density (Kumar et al. 2013; Kumar et al. 2015).

MATERIALS AND METHODS

Preparation of oat bran powder

Oat bran was purchased from Bagrrys India Limited; these were brought to the laboratory. The oat bran was dried in a vacuum oven (PromarksVac Co Ltd, Taiwan) at 60ºC till constant weight. To obtain the fine powder, the dried bran was crushed in a mixer-grinder and sieved through a stainless steel sieve of 50-60 mesh size. The dried oat bran powder was put in a plastic jar and kept refrigerated until usage.

Preparation of the pork sausages

Lean pork was obtained by humanely slaughtering 2 castrated Large White Yorkshire pigs (ages 9 months and 80-90 kg) in the livestock products technology department slaughterhouse as per the established technique. The cleaned and dressed carcass was taken to the experimental lab and immediately cooled to (4±1°C) for 12-18 hours before manual deboning. The deboned chunks, which were free of skin, external fascia, fat, and connective tissue, were collected and preserved separately in low-density polyethylene (LDPE) bags at (-18±1°C). The required amount of frozen meat was then taken out of the freezer and defrosted overnight in the refrigerator. The meat was cut into smaller chunks and minced twice in a meat mincer (MADO Eskimo Mew 714, Spain) for further study. Based on several preliminary trials, three different levels of oat bran powder viz. 3% and 6% 9% and control were prepared. Four groups of pork emulsions control (C) and treatments T1, T2, and T3 were prepared by replacing lean meat in the formulation. The minced pork with salt, nitrite, and phosphates was Chopped in a bowl chopper (Model: TC11, Scharfen, Germany) for 50 seconds followed by the addition of ice flakes and further chopping for 80 seconds. Ground pork fat was slowly added and further chopping was done for 120-130 seconds. The remaining ingredients such as spice mix, condiments, whole egg liquid, and refined wheat flour were added and chopped for 60 seconds (Table 1).

The emulsion was appropriately stuffed into hydraulic sausage filler and filled into goat casings that had been previously prepared. The sausages were then cooked for 20 minutes in a preheated hot air oven at 180°C, with frequent flipping after 10 minutes to provide consistent heating and colour production. Before being evaluated for quality attributes, the cooked sausages were allowed to cool to room temperature.

Table 1. Formulations of high-fibre pork sausages

Ingredients %	**Control (C)**	**T1**	**T2**	**T3**
Minced Pork	70	67	64	61
Oat bran powder	-	03	06	09
Vegetable oil	5.0	5.0	5.0	5.0
Fat	5.0	5.0	5.0	5.0
Ice flakes	8.0	8.0	8.0	8.0
Egg liquid	2.0	2.0	2.0	2.0
Salt	1.60	1.60	1.60	1.60
Polyphosphates	0.20	0.20	0.20	0.20
Condiments	3.0	3.0	3.0	3.0
Spices	2.0	2.0	2.0	2.0
Refined wheat flour	3.0	3.0	3.0	3.0
Sodium nitrite	120 ppm	120 ppm	120 ppm	120 ppm
Sugar	0.20	0.20	0.20	0.20

Physico-Chemical Parameters

pH

A digital pH meter (SAB 5000, LABINDIA, Mumbai) with a glass electrode was used to determine the pH of pork emulsion and pork sausages (n=6) (Trout et al. 1989). Ten grams of sausages were homogenized for one minute in a homogenizer with 50 ml distilled water (T-25D S22 digital ultra-TURRAX Germany). The pH was measured using a combination glass electrode immersed in the suspension

Emulsion stability

In a thermostatically controlled water bath (Model: NSW 125)., 20 grams of pork meat emulsion were placed in 150 gauge LDPE bags (size 11 ×10 cm) and heated to 80±1°C for 20 minutes. The cookout fluid (fat, water-soluble particles) was drained from the bags, and the weight of the cooked mass was recorded. The cooked emulsion was weighed and the percentage was calculated (Baliga and Madaiach, 1970).

Cooking yield

Before and after cooking, the weight of each product was recorded. A formula was used to compute the cooking yield, which was then expressed as a percentage.

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked product}}{\text{Weight of raw pork emulsion}} \times 100$$

Instrumental texture profile analysis

Instrumental texture profile analysis (TPA) was performed using a texture analyzer (TMS-PRO, Food Technology Corporation, USA). With a load cell of 2500 N, a sample size of 1.0cm ×1.0cm ×1.0cm was subjected to a double compression cycle at pre-test speed (30mm/sec), post-test speed (100 mm/sec), and test speed (100mm/sec).

Sensory Evaluation

A panel of seven experts comprised of faculty and post-graduate students from Guru Angad Dev Veterinary And Animal Sciences University's College of Veterinary Science, Ludhiana evaluated the samples for colour, texture, flavour, juiciness, and overall acceptability using a 9 – point descriptive scale where 9=extremely favorable and 1=extremely disagreeable Keeton,1983. The sausages sample were warmed in a microwave oven for 20 seconds before being served to the sensory panelists. After each sample, potable water was offered to rinse the palate.

Statistical analysis

The significance level was calculated using a 95% confidence level (Myers and Montgomery 2016). Standard statistical methods were used to analyze the data using IBM SPSS Statistics-20.0 software from the United States (Snedecor and Cochran 1994). For each parameter, duplicate samples were drawn and reproduced three times (n=6). A panel of seven judges conducted sensory evaluations, with a total of 21 observations (n=21). Duncan's multiple range test was used to analyze the statistical significance at the 5% level ($p<0.05$). The outcomes were revealed in the form of Mean± S.E.

RESULTS AND DISCUSSION

The physicochemical properties of pork sausages with varying percentages of oat bran content are presented in Table 2. The mean pH of the pork sausage with 9% oat bran incorporation was significantly ($P<0.05$) lower than the control, the product pH ranges from 5.86 to 5.95. The highest pH values (5.95) were of control and the lowest value was of T3; there was a decreasing trend in product pH value with a subsequent increase in the level of oat bran incorporation. Yilmaz and Daglioglu (2003) reported similar pH values upon the incorporation of oat bran in meatballs. Similar results have been reported by Malav et al. (2015) and Kumar et al. (2016) on the addition of cabbage powder as a source of fiber in mutton patties and oat bran and wheat bran in chicken meat biscuits respectively. Mehta et al. (2015) additionally reported that the pH of the product is heavily influenced by the pH of the fibre source used.

The cooking yield and emulsion stability both showed an upward trend with increasing oat bran content in the product. The emulsion stability of all oat bran incorporated treatment products was significantly ($P<0.05$) greater than the control products, but it was comparable among the treatment products. The cooking yield increased significantly ($P<0.05$) with an increasing level of inclusion of oat bran in treatment products. Choi et al. (2007) reported an increase in emulsion stability and cooking yield with the addition of rice bran to meat batters. Moller et al. (2011) found similar results in pork sausage using carrot fibre.

Table 2. Effect of incorporation of oat bran on physicochemical properties and texture profile of pork sausages (Mean ±S.E)*

Parameters	Physico-chemical properties			
	Control	T1 (3% OB)	T2 (6% OB)	T3 (9% OB)
pH	5.95±0.024[a]	5.92±0.014[b]	5.89±0.025[c]	5.86±0.018[d]
Emulsion stability	93.69±1.05[b]	95.09±1.02[a]	95.68±1.17[a]	95.98±0.75[a]
Cooking yield (%)	91.49±0.53[d]	93.59±0.48[c]	94.40±0.21[b]	95.79±0.56[a]
Texture Profile Analysis				
Hardness (N/cm²)	31.42±0.18[d]	32.35±0.11[c]	33.60±0.16[b]	35.50±0.19[a]
Stringiness (mm)	19.86±0.14[c]	20.15±0.15[c]	20.64±0.17[b]	20.99±0.14[a]
Springiness (cm/mm)	11.39±0.07[c]	11.65±0.09[b]	11.69±0.15[b]	12.71±0.13[a]
Gumminess (N/cm²)	6.80±0.08[d]	7.21±0.07[c]	7.57±0.06[b]	7.95±0.04[a]
Chewiness (N/cm)	40.69±0.32[d]	41.71±0.39[c]	42.79±0.27[b]	43.85±0.31[a]
Resilience (ratio)	0.83±0.06[a]	0.63±0.03[b]	0.65±0.06[bc]	0.69±0.01[c]

*Mean ±S.E. with different superscripts differ significantly (P<0.05) column wise. n=6; C= Control; T1= 3% oat bran; T2= 6% oat bran; T3= 9 % oat bran.

These findings are also consistent with Talukder and Sharma (2010) who observe that adding oat bran to meat patties reduces cooking loss, possibly due to the existence of ß glucan, which is hydrophilic and hence binds free water. Yasarlar et al. (2007) also reported a decreased weight loss during cooking after incorporating different types of bran (rye, wheat, corn, and oat) into Turkish meatballs. A similar increase in emulsion stability and cooking yield value in meat products was reported by Kumar et al. (2015) in chevon patties incorporated with finger millet flour with high fibre content, Singh et al. (2015) in meat cutlets incorporated with carrot and broccoli powder, Kumar et al. (2013) in emu nuggets incorporated with broccoli powder.

Textural profile analysis

Analysis of the texture profiles of control and treatment pork sausages enriched with three different levels i.e. 3%, 6%, and 9% was carried out (Table 2). According to Lu et al. (2013) food textural properties are defined as a set of physical properties derived from the food's structural element, which are typically perceived through the sense of touch, and are related to the deformation, disintegration, and flow of food when subjected to a force, and are measured objectively using mass, time, and distance functions.

Control sausages had a substantially lower hardness and chewiness value (P<0.05) than all of the treatment products. The hardness value of pork sausages increased significantly (P<0.05) when increasing amounts of oat bran were added with T3 having the highest hardness values. This could be due to the formation of a high-quality gel matrix and better water-binding capabilities of treated oat-rich products. Yilmaz and Daglioglu (2003) also revealed that the use of oat bran increased the toughness of the meatballs. Our results accord with Yadav et al. (2018) who reported similar effects after incorporating wheat bran and carrot pomace in chicken sausages. In addition, Luisa et al. (2006) found that using inulin, wheat fibre, and oat fibre (3.5% and 7%) as fat substitutes in sausage increases hardness when compared to untreated.

The chewiness of the control samples was substantially higher than the chewiness of the treatment samples (P<0.05). According to Barretto et al. (2015), chewing fiber-rich meals requires more energy. Additionally, texture hardness influences chewiness, so chewiness increases with an increase in texture hardness (Huang et al. 2011).

Gumminess and chewiness are secondary texture profile parameters, as gumminess is influenced by hardness and cohesiveness scores, while chewiness is influenced by gumminess and springiness scores. Gumminess was significantly (P<0.05) higher in the treatment products than in control this could be related to changes in the fiber contents and other prominent variables in the developed products. In addition, Saricoban et al. (2009) concluded that adding wheat bran to cooked beef patties raised hardness and gumminess while decreased springiness and cohesiveness without affecting adhesiveness.

Springiness was observed to be considerably higher in treatment items than in control products (P<0.05). T3 had the greatest value (20.99) while the control had the lowest value (19.86). The springiness of the product may be related to superior emulsion formulation and the gel-like structure formed by oat bran. The mean springiness of the treated products differs substantially (P<0.05), which could be attributed to the inclusion of more soluble fiber, which generates a gel-like texture and improves the sausages' elasticity, increasing the labour require to chew the sample. This is in line with Steenblock et al. (2001) who indicated that the highest springiness values were found in the highest level of oat bran used (3%), and chewiness was generally increased by oat bran. Resilience was also shown to be considerably lower (P<0.05) in treated items than in control products.

Sensory evaluation

The sensory score is significant in determining the consumer acceptability of a product (Table 3). The sensory scores for all the attributes of oat bran incorporated pork sausages varied significantly (P<0.05). As the amount of oat bran in the product increases, the colour and appearance scores decline significantly and T3 had the lowest value. The lower appearance score for T3 could be attributed to an increase in the lightness of the product with the higher level of incorporation of oat bran in the product. Further, it could also be attributed to the innate light colour of the oat bran. The appearance score for T1 and T2 was comparable with the control.

T3 received the lowest score for flavour and the highest score for control from the sensory panelist. However, the flavour scores of control, T1 and T2 were comparable with each other. Significant (P<0.05) reduction in flavour score of T3 might be due to the replacement of pork at a higher level (9%) with high fibre oat bran.

The data showed that incorporation of oat bran in treatment sausages decreased the juiciness scores. A significant (P<0.05) decline in juiciness scores was noticed in T3 at the 9% level. This could be attributed to an increase in oat bran content, which masks the pork's juiciness. Chang and Carpenter (1997) also reported a decrease in juiciness score in frankfurters with the addition of oat bran.

The texture score decreased as the percentage of oat bran in treatment items increased. The T3 showed a significant (P<0.05) lower texture score among all the control and treatment products. The results for the texture scores are also reflected in the hardness value, where T3 had the highest hardness value. Chang and Carpenter (1997) found that wheat and oat bran frankfurters had greater shear press values. Mansour and Khalil (1997) also reported an increase in the hardness of beef burgers containing wheat fiber.

Similar effects of the addition of dietary fibre sources were observed by Kim et al. (2010). Similarly, with increasing quantities of rice bran and psyllium husk. Mehta et al. (2013) found a drop in sensory ratings of chicken rolls and patties. Yilmaz (2004) also discovered that the sensory qualities of the rye bran-added meatballs differed significantly.

The overall acceptability scores of pork sausages were highest for the control, followed by T1, T2, and the lowest score was observed for T3. The product's overall acceptability scores for T1 and T2 were equivalent to the control product, while the score in T3 was significantly (P<0.05) lower. As a result, the 6% level of oat bran integration in pork sausages was chosen for further research based on physicochemical, textural, and sensory qualities

CONCLUSION

The inclusion of dried oat bran in treatment products resulted in higher cooking yield emulsion stability. The pH of the treatments made with dried oat bran powder was higher than the control products. Although the texture features of 3 and 6 percent dry oat bran powder included treatments seemed to be similar to the control, were found significantly higher. Pork sausages with 3 and 6 per cent dried oat bran powder had overall palatability similar to control pork sausages, according to sensory evaluation. It may thus be useful for commercial uses in the meat sector, and the usage of dried oat bran is cost-effective.

Table 3. Effect of incorporation of oat bran on sensory evaluation of pork sausages (Mean ±S.E)*

Parameters	Sensory evaluation			
	Control	T1 (3% OB)	T2 (6% OB)	T3 (9% OB)
Appearance	7.35 ± 0.07^{a}	7.32 ± 0.05^{a}	7.25 ± 0.05^{a}	6.98 ± 0.04^{b}
Flavour	7.31 ± 0.05^{a}	7.25 ± 0.06^{a}	7.19 ± 0.08^{a}	7.02 ± 0.04^{b}
Juiciness	7.23 ± 0.05^{a}	7.20 ± 0.05^{a}	7.12 ± 0.07^{a}	6.75 ± 0.08^{b}
Texture	7.40 ± 0.07^{a}	7.38 ± 0.08^{a}	7.28 ± 0.06^{a}	6.79 ± 0.07^{b}
Overall Acceptability	7.30 ± 0.05^{a}	7.27 ± 0.07^{a}	7.20 ± 0.06^{a}	6.73 ± 0.07^{b}

(Mean ±S.E)* n= 21 Means with different superscripts differ significantly (P < 0.05) in a row.

COMPETING INTERESTS

The authors do not have any competing interests among themselves or others related to this research work.

ETHICS STATEMENT

Not applicable

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