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Effect of Oat flour on Quality Characteristics of Low-Fat Chicken Sausages

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ABSTRACT

This study was conducted to evaluate the influence of adding oat flour at various levels i.e. 3, 6 and 9 per cent on physico-chemical, proximate, textural and sensory attributes of low-fat chicken sausages as compared to 9 per cent ground nut oil control sausages. Significant (P < 0.05) improvements in cooking yield, emulsion stability, water-holding capacity, pH were noticed and low fat chicken sausages incorporated with 9 per cent oat flour had recorded significantly (P<0.05) highest values compared to control and other level of oat flour extension. Addition of oat flour significantly (P<0.05) increased moisture, fat and crude fibre, moisture and fat retention values compared to control. Because of larger moisture absorption and moisture retention during cooking properties of oat soluble fibre maintains the textural integrity of the sausages without fat addition. Addition of oat flour increased the crude fibre content of low fat chicken sausages. Hardness values are significantly (P<0.05) reduced as the level of oat flour increased due to highest water retention of oat flour added sausages. In sensory attributes i.e. colour, juiciness, tenderness and overall acceptability of low-fat chicken sausages were found to be highest in oat flour added sausages compared to control. From the results obtained in this study, it can be concluded that oat flour can be used successfully as a fat substitute in low-fat chicken sausages without deteriorating the product quality.

Key words: *Low-fat chicken sausages, fat replacers, oat flour, quality characteristics.*

INTRODUCTION

Chicken sausages are popular processed meat products in various parts of the world. Some of the reasons for such wide popularity are their affordable cost, availability in different tastes and longer shelf life. Presently, consumers are very concern about their diet and the food they eat and attention has been diverted toward processed meat products that are lean, low fat and high in protein content. Health concerns about fat utilization and changes in consumer's preferences have led to comprehensive research on low-fat foods (Kumar and Sharma, 2004; Yang et al. 2007). The high contents of saturated fats and cholesterol have been a major problem, resulting in meat products becoming the subject of scrutiny by nutritional, medical, and consumer groups.

Reduction of fat in processed ground meat products presents a number of difficulties in terms of appearance, flavour and texture. Manufacturers have introduced several modifications in an attempt to offset the detrimental effects of reducing the fat level. These modifications include the use of non-meat ingredients that could help to maintain desirable texture and, more importantly enhance the water-holding capacity (Ako 1998). In this regard, carbohydrates and fibre have been successful in improving cooking yield, reducing formulation cost and enhancing texture (Jimenez Colmenero 1996; Keeton 1994). Fibre is one of the most common functional ingredients in food products and has been used as fat replacer, fat reducing agent during frying, volume enhancer, binder, bulking agent and stabilizer (Elena Sánchez-Zapata et al. 2010).

Oats (*Avena sativa* L.) is a typical cereal containing ß-glucans, which have an effect on blood

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cholesterol levels and control of lipoprotein metabolism (Truswell 2002). Oat flour is a potential ingredient for low-fat and fat-free processed meat products. Many of the characteristics of oat fiber such as water absorption could potentially benefit products like fat-free frankfurters and low-fat bologna. For example, improved cooking yields from addition of oat fiber to frankfurters have been reported (Hughes *et al.* 1997). Oat products have also achieved a very positive consumer image because of the health benefits. An inverse dose-response relationship between dietary oat fiber and serum cholesterol concentrations has been reported, giving oat fiber a highly positive consumer perception (Shinnick *et al.* 1990). Because an ideal alternative ingredient for fat in processed meats has yet to be discovered, oat fiber is a good alternative.

The objective of this study was to investigate physico-chemical, proximate and sensory characteristics of low fat chicken sausages extended with different levels of oat flour.

MATERIALS AND METHODS

Basic formula of low fat chicken sausages: The basic formula of low fat chicken sausages are (per cent basis(w/w)): chicken meat at 72, ground nut oil at 9 which is replaced by 3, 6 and 9 per cent of oat flour respectively in treatments, salt at 2, sodium tri polyphosphate at 0.05, sodium nitrite at 0.015, sodium ascorbate at 0.5, sugar at 1, ice flakes at 8, spice mixture at 2 and condiment mixture at 5.

Method of manufacture of low fat chicken sausages: Frozen chicken was thawed at 4±1°C for 16 hours and minced using a 4 mm sieve by a meat mincer (Sirrman, Model TC 12E). The minced meat was placed in a bowl chopper (Scharfen, Mod.No: TC 11, Germany) and various additives i.e salt, sodium tripolyphosphates, sodium nitrite, sodium ascorbate and sugar were added and mixed thoroughly and chopped further for 1 minute. Then ground nut oil, oat flour, spice mix, ice flakes and onion garlic paste were added and chopped again for 1-2 minutes until a good emulsion was formed. After that emulsified sausage mix from each formulation was stuffed into sheep casings of 14 -18 mm diameter with a sausage stuffer (RND, Pune) and the sausages were linked manually with a length of 2-2.5 inches. The prepared sausages were cooked in boiled water at a core temperature of 72°C for 30 minutes. The temperature of sausages was measured by temperature probe. Then cooked sausages were packed in low density polyethylene (LDPE) bags and chilled at 4±1°C in a refrigerator for about 24 hours.

***Estimation of cooking yield*:** The weight of samples was recorded before (raw weight) and after cooking of chicken sausages. Percent cooking yield was determined by calculating weight differences for samples before and after cooking according to Murphy et al. (1975). Cooking Yield (%) = (Weight of cooked product/Weight of raw product) X 100.

***Estimation of emulsion stability*:** Emulsion stability was determined by the procedure of Kondaiah et al. (1985). About 25 g meat emulsion in triplicates was taken in low density polyethylene bags and heated in a thermostatically controlled water bath at 80°C for 20 min. Then the exudate was drained out and dried with tissue paper and the cooked mass was weighed. The percentage of cooked mass was expressed as emulsion stability.

***Estimation of water holding capacity*:** Water-holding capacity (WHC) was determined according to Wardlaw et al. (1973). The 20 g of sample was placed in a centrifuge tube containing 30 ml NaCl (0.6 M) and was stirred with glass rod for 1 minute. The tube was then kept at refrigeration temperature (4±1°C) for 15 min, stirred again and centrifuged at 3000 rpm using refrigerated centrifuge (Sorvall Biofuge Stratos, Thermo electron LED GmbH, D-37520, Osterode, Germany) for 15 min. The supernatant was measured and amount of water retained by samples were expressed as WHC in percentage.

***Estimation of pH*:** The pH of raw and cooked low fat chicken sausages were determined by homogenizing 10 g of sample with 50 ml distilled water with the help of tissue homogenizer (Daihan

Scientifics, WiseMix, HG-15D, Korea) for 1 min. The pH of suspension was recorded by immersing the combined glass electrode of digital pH meter (Thermo Orion, Model 420A+, USA) (Trout et al. 1992) which was calibrated against buffer of pH 4, 7 and 10.

Estimation of proximate composition: The moisture content was determined by hot air oven drying, protein by automatic Kjeldahl method, fat by Soxhlet extraction with petroleum ether and total ash by muffle furnace as described in AOAC (2002). The crude fiber was determined according to the method of Prosky *et al*. (1988).

Estimation of moisture and fat retention: The moisture and fat retention values represent the amount of moisture and fat retained in the cooked product per 100 g of raw sample. These values were calculated according to the following equations as described by El-Magoli *et al*. (1996).

Moisture retention (%): (per cent cooking yield X % moisture in cooked sausage) / 100.

Fat retention (%): (cooked weight X percent fat in cooked sausage) X 100

(raw weight X percent fat in raw sausage)

Estimation of penetrometer value**:** The hardness of the patty was measured in terms of penetration value with the help of cone penetrometer as described by Dixon and Parech (1979).The sausages were placed on the platform of the cone penetrometer (ISI Model, United scientific co. Madras) in such a way that the point of penetration was at least 2.5cm away from the edge of the dish and the platform was so adjusted that the tip of the cone just touched the sample. The cone assembly was allowed to descend in to the sample for exactly 10 sec. The distance through which the cone penetrated in to the sausage products was reflected on the dial of the penetrometer.

Sensory evaluation**:** The sensory panel consist of ten members of postgraduate students and faculty of department of livestock products technology were used to evaluate various sensory attributes like color, flavor, juiciness, tenderness and overall acceptability of the low fat chicken sausages by using a 8 point hedonic scale (Keeton 1983) where 8= extremely good and 1=extremely poor.

The experiment was repeated three times and the data generated for different quality characteristics were compiled and analyzed following the methods of Snedecor and Cochran (1995).

RESULTS AND DISCUSSION

Physico-chemical characteristics**:** The results of various physico-chemical characteristics influenced by different levels of oat flour were presented in Table 1. Cooking yield is the important parameter to predict the behaviour of various additives such as binders and non-meat ingredients during cooking. In present investigation the cooking yield of low fat chicken sausages were significantly ($P<0.05$) affected by addition of different levels of oat flour. Sausages incorporated with 9 percent oat flour had the highest cooking yield followed by 6, 3 and 0 percent. As the incorporation of oat flour was increasing the cooking yield was also found to be increasing

Table 1. Effect of incorporation of oat flour on physico-chemical characteristics of low fat chicken sausages (Mean ± S.E).

Physico-chemical characteristics		Control	Level of oat flour extension (%)		
			3	6	9
Cooking yield (%)		86.48±0.57[a]	89.19±0.13[b]	90.08 ± 0.40[c]	92.34±0.27[d]
Emulsion stability (%)		81.08±0.61[a]	84.86±0.86[b]	87.44±0.51[c]	87.87±0.34[c]
Water-holding capacity (%)	Raw	46.67±0.41[a]	53.89±0.29[b]	56.11±0.47[c]	57.40±0.34[d]
	Cooked	58.84±0.74[a]	63.47±0.14[b]	64.61±0.13[c]	66.94±0.18[d]
pH	Raw	5.84±0.08[a]	5.97±0.12[a]	6.46±0.21[b]	6.64±0.11[c]
	Cooked	6.24±0.13[a]	6.27±0.22[a]	6.58±0.07[b]	6.69±0.20[c]

Note: Mean values bearing same superscript do not differ significantly ($P<0.05$).

indicating higher moisture retention in the products during cooking. The improvement in cooking yield might be due to the ability of oat hydrocolloidal fibres (b-glucan) to create a tridimensional matrix, holding both water and fat in the sausage mix (Giese 1992; Inglett et al. 1994; Warner and Inglett 1997). The results are in agreement with Tornberg *et al.* (1989) in hamburgers and sausages; Trout *et al.* (1992) in low fat ground beef; Suman and Sharma (2003) in low fat ground buffalo meat patties.

The emulsion stability of oat flour treated sausage products were found to be significantly ($P<0.05$) better than the control samples indicating that oil reduction in the sausage formulation does not affect much. The fat loss of the control emulsion was significantly higher than other emulsions containing oat flour. Reports of Vural et al. (2004) and Luruena-Martinez et al. (2004) support the present findings. Earlier works of Fernández-Ginés et al. 2005 and Choi et al. 2007 on addition of various types of dietary fiber to meat products also reported improvement of emulsion stability and rheological properties.

Studies with respect to water-holding capacity (WHC) of both raw and cooked low fat sausages have shown that incorporation of increased level of oat flour significantly ($P<0.05$) increased the WHC values from 46.67 to 57.40 in raw and 58.84 to 66.94 % in cooked sausages. This might be due to higher moisture absorbance capacity of oat flour in meat emulsion. Oat flour can absorb large quantity of water (water absorption 586%) without increasing product viscosity. Rosell et al. (2009) reported that oat fibre had a water binding capacity of 4.79 g water per gram solid compared to 4.15 g water per gram solid by wheat fibre. They concluded that hydration property of fibre depended not only on the shape and particle size but also on the chemical structure of the fibre.

The influence of addition of oat flour on the pH values of low fat chicken sausages was clearly observed in this study. As the level of oat flour increased the corresponding values for pH also increased gradually from 5.84 to 6.64 in raw sausages and 6.24 to 6.69 in cooked sausages. Similar results were obtained by Yilmaz and Daglioglu (2003) in meat balls prepared with 10 % oat bran and Vural *et al.* (2004) who studied the effects of replacing animal fat with inter-esterified vegetable oils and sugar beet fiber on the quality of frankfurters. Choi *et al.* (2008) reported that the addition of rice bran fiber increased the pH value of frankfurters.

Proximate composition: The influences of various levels of oat flour on proximate characteristics of low fat chicken sausages are presented in Table 2. Significant differences ($P < 0.05$) in mean values of moisture, protein, fat, ash and crude fiber contents among the sausage formulations were observed. As expected, raw and cooked sausages formulated with oat flour were significantly ($P< 0.05$) higher in moisture content than the control. This was attributable to highest water absorbable properties of b-glucan in oat flour. Other researchers have shown similar results (Trout *et al.* 1992; Troy et al. 1999; Kumar and Sharma 2004) when using other fat replacers.

The addition of oat flour did not affect the protein content in both raw and cooked sausages. Control sausages had highest protein content than oat flour added sausages. Trout *et al.* (1992) reported significant reduction in protein per cent of low fat beef patties containing oat flour as texture modifying ingredients. The protein percent in emulsified pork meat balls decreased significantly with the incorporation of rice bran at the level of 5 % and above (Choi et al. 2009).

Fat content was significantly ($P < 0.05$) lower on oat flour added chicken sausages compared to that of the control. There was an increase in the fat content of cooked low-fat chicken sausages, that which is consistent with that higher fat retention of the product. Control Low fat chicken sausages recorded significantly highest fat content than flour added sausages are mainly due to addition of ground nut oil which is replaced by oat flour in other formulations.

Total ash content did not significantly (P>0.05) affected by addition of various levels of oat flour in low fat chicken sausages. Addition of different levels of oat flour significantly (P<0.05) affected the crude fiber content of low fat chicken sausages. Control sample have only 0.04 and 0.06 per cent crude fibre in raw and cooked sausages respectively but as the level of oat flour addition significantly increased the crude fiber content upto 4.98 per cent. Increased fibre in meat products may potentially lower the risk for chronic diseases such as heart diseases, cancer and gall stones. Oat flour has a higher amount of soluble dietary fibre known for its hypocholesterolemic effect (Anderson and Chen 1986).

Both moisture and fat retention values significantly (P<0.05) affected by addition of various levels of oat flour in low fat chicken sausages. Increased levels of oat flour increased the moisture and fat retention values and 9 per cent oat flour added sausages had highest moisture and fat retention values than control sausages. Generally fiber rich ingredient addition increased the moisture contents of meat batter thus enhanced moisture retention. This might be due to highest water absorbance capacity of b-glucan. Oat fibre has the ability to retain fat during heating, to result in the lower cooking losses (Giese 1992; Inglett *et al*. 1994; Warner and Inglett 1997). All cereal flours exhibited the same effect on fat retention. Proteins are thought to be excellent fat binders in that they have dual functionality with respect to fat interactions and interfacial film formation (Anderson and Berry 2001; Zayas 1997). In the present research there was a possible connection between increased cooking yield and higher fat retention. Similar to our findings, Anderson and Berry (2001) observed that 10 % fat beef patties extended with pea fibre had higher fat retention and higher cooking yield. However, Trout *et al.* (1992) observed higher cooking yields but no change in fat retention in 5 % fat patties with the use of sugar beet fibre, oat fibre and polydextrose. In addition, increased of fat retention will improve both flavor and texture of this type patty (El-Magoli *et al.* 1996).

***Hardness*:** Factors responsible for textural properties in comminuted meat proteins are degree of extraction of myofibrillar proteins, stromal protein content, degree of comminution and type and levels of non-meat additives. The control sausages had significantly (P<0.05) highest hardness values amongst the sausage samples and the hardness of the sausage samples gradually decreased with the increasing addition of oat flour (Table 2). The penetrometer value in control was

Table 2. Effect of incorporation of oat flour on proximate composition and culinary characteristics of low fat chicken sausages (Mean ± S.E)

Proximate characteristics		Control	Level of oat flour extension (%)		
			3	6	9
Moisture (%)	Raw	65.13±0.12[a]	68.41±0.27[b]	69.61 ± 0.18[c]	71.40±0.20[d]
	Cooked	60.36±0.41[a]	64.37±0.31[b]	66.13 ± 0.27[c]	69.74±0.19[d]
Protein (%)	Raw	18.43±0.34[b]	17.48±0.22[a]	17.13±0.18[a]	17.74±0.41[a]
	Cooked	19.58±0.18[b]	18.31±0.19[a]	18.57 ± 0.11[a]	18.43±0.37[a]
Fat (%)	Raw	13.91±0.34[d]	9.48±0.41[c]	7.46±0.30[b]	3.18±0.18[a]
	Cooked	15.67±0.18[d]	11.84±0.22[c]	9.37±0.11[b]	5.42±0.27[a]
Ash (%)	Raw	2.36±0.12	2.65±0.07	2.78±0.12	2.38±0.12
	Cooked	2.27±0.22	2.68±0.13	2.74±0.34	2.47±0.28
Crude Fibre (%)	Raw	0.04±0.01[a]	1.21±0.11[b]	2.97 ± 0.11[c]	4.14±0.27[d]
	Cooked	0.06±0.03[a]	1.48±0.29[b]	3.43±0.40[c]	4.49±0.34[d]
Moisture retention (%)		57.41±0.39[a]	61.13±0.14[b]	64.23±0.27[c]	69.27±0.38[d]
Fat retention (%)		76.34±0.18[a]	79.03±0.17[b]	82.21±0.31[c]	86.11±0.37[d]
Hardness (mm)		46.14±0.38[d]	39.11±0.29[c]	36.12±0.27[b]	31.21±0.20[a]

Note: Mean values bearing same superscript do not differ significantly (P<0.05).

46.14 and reduced to 31.21 in 9 per cent oat flour added sausages. These results indicate that oat flour is useful in preparing a low fat sausage with softer textural properties. These results are consistent with those reported by other researchers, who demonstrated that the addition of oat bran, soy protein, or starch, improved the textural properties by decreasing product hardness (Dawkins *et al.* 2001). Trout *et al.* (1992) suggested that a decrease in the hardness of sausage by the addition of texture-modifying ingredients, such as soy protein, oat bran, and starch, ie., the ingredient may help absorb and retain moisture. Desmond and Troy (1998) reported that beef burgers containing oat fibre, exhibited decreased hardness values when compared to the low fat control. Troy *et al*. (1999) concluded that blends, in particular involving tapioca starch, oat fibre and whey protein, when formulated together, bind and retain water to produce a more tender meat product, thereby reducing shear forces.

Sensory characteristics: The results obtained in the sensory evaluation of low fat chicken sausages are presented in Table 3. All sensory attributes of low fat chicken sausages were significantly (P<0.05) affected by the various levels of oat flour inclusion. Colour scores gradually increases as the level of oat flour incorporation. Control sausages had significantly highest flavor scores compared to oat flour added chicken sausages. This might be due to decrease in fat level in oat flour added sausages causes in reduction of the flavor intensity. These results are in accordance with Trout *et al.* (1992) and Berry *et al.* (1996) in low fat beef sausages extended with oat bran. Low fat chicken sausages incorporated with 9 per cent oat flour had significantly (P<0.05) highest juiciness and tenderness. As the level of oat flour incorporation increased the juiciness and tenderness scores also increased and this could be attributed to the increased moisture retention of the product during cooking. These findings agree with those of Pszczola (1991) also reported that oat fibre has the ability to retain moisture and prevents meats from drying out when cooked. Warner and Inglett (1997) observed that the use of oat fibre z-trim or z-trim/aotrim- 5 blend to 89% fat-free ground beef increased juiciness compared to the control. In addition, Desmond *et al.* (1998) who found that the oat fibre aided in water retention, produced juicier low-fat beef patties. Chang and Carpenter (1997) reported that the addition of water and oat bran were significant on product tenderness. The overall acceptability scores ranged from 6.58 to 7.31, with maximum acceptability obtained at the 9 % oat flour. All oat flour added sausages had higher overall acceptability scores than the control sausages because of the better juiciness and tenderness scores.

From the above results, it can be concluded that an acceptable low-fat chicken sausage can be made where fat/vegetable oil is replaced with maximum of 9 per cent oat flour without deteriorating the nutritive and textural quality of the product. Oat based meat products have also achieved a very positive consumer image due to the health benefits

Table 3. Effect of incorporation of oat flour on sensory attributes of low fat chicken sausages (Mean ± S.E)

Sensory attributes	Control	Level of oat flour extension (%)		
		3	6	9
Colour	5.91±0.18^a	6.67±0.26^b	7.04±0.24^d	6.84±0.31^c
Flavour	6.84±0.31^b	6.43±0.23^a	6.51±0.12^a	6.54±0.20^a
Juiciness	6.23±0.18^a	6.84±0.29^b	6.79±0.11^b	7.73±0.27^c
Tenderness	6.47±0.25^a	6.97±0.07^b	6.93±0.31^c	7.26±0.14^d
Overall acceptability	6.58±0.19^a	6.74±0.13^b	6.89±0.47^c	7.31±0.11^d

Note: Mean values bearing same superscript do not differ significantly (P<0.05).

that have been associated with the consumption of fibre rich meat products.

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