Quality characteristics of low fat chicken nuggets: effect of salt substitute blend and pea hull flour

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Revised: 20 August 2013 / Accepted: 18 November 2013 / Published online: 27 November 2013
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Abstract Effect of salt substitution (Treat I) and added pea hull flour (PHF) at 8 (Treat-II), 10 (Treat-III) and 12 % (Treat-IV) levels on the quality of low fat chicken nuggets (Control) was investigated. Replacement of NaCl significantly affected ($P < 0.05$) emulsion and product pH, emulsion stability, cooking yield, ash content while PHF had additional effect on moisture and protein. Dietary fibre content in the product significantly ($P < 0.05$) increased at each level of PHF. The colour parameters remained similar to control due to salt replacement while added PHF decreased their values. Textural properties were lower ($P < 0.05$) in the treated products. Addition of PHF significantly ($P < 0.05$) decreased cholesterol and glycolipids contents at 8 % and 12 % levels, respectively. Sensory evaluation exhibited that 40 % NaCl can efficiently be replaced and 8 % PHF can be incorporated as a source of fibre in low fat chicken nuggets without significant effect on various attributes.

Keywords Physicochemical properties · Texture profile analysis · Pea hull flour · Chicken nuggets

Introduction

Today's consumers are increasingly interested in their personal health, and expect the foods they eat to be safe and healthful besides tasty and appealing. Regarding consumers' health, numerous reports have linked consumption of saturated fat,

excess salt and calories with the incidence of coronary heart diseases, hypertension and obesity (Jiménez-Colmenero et al. 2001). This has led to demand for the functional meat products consisting of less saturated fat and salt as a preventive measure. In order to fulfill their demand, development of various low fat meat products such as sausages (Grigelmo-Miguel et al. 1999; Muguerza et al. 2002), meatballs (Yilmaz 2004; Serdaroğlu et al. 2005) and low salt meat products, like low sodium ground meat patties (Ruusunen et al. 2005) and low sodium frankfurter (Jiménez-Colmenero et al. 2005) have been previously attempted.

The long term consumption of meat and meat products has been associated with colon cancer, obesity and cardiovascular diseases (Tarrant 1998; Larsson and Wolk 2006). Lack of dietary fibre in the meat and meat products has been mainly implicated for such problems. Dietary fibre in foods is known to reduce the risk of cancer, obesity, cardiovascular diseases and several other disorders (Eastwood 1992). Epidemiological data also reveal that a diet high in fibre generally promotes a healthier life style (Kritchevsky 2000) and fibre intake can be viewed as a marker of healthy diet. Dietary fibre is a key ingredient greatly used nowadays while developing nutritionally designed foods due to its significance in health promotion (Puupponen-Pimia et al. 2002) and technological impact. Some workers have made endeavour to incorporate dietary fibre, especially in some emulsion type meat products (Claus and Hunt 1991; Cofrades et al. 1995; Grigelmo-Miguel et al. 1999; Talukder and Sharma 2010; Kumar et al. 2011).

In recent years, legumes (peas, soybeans and other beans) have been investigated regarding their potential use in development of functional foods as they provide energy, dietary fibre, proteins, vitamins and minerals required for human health (Serdaroğlu et al. 2005). Their inclusion in the daily diet has many physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease and colon cancer (Tharanathan and Mahadevamma

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2003). Pea hull, a legume by-product, is very rich in fibre, which is mainly insoluble in nature (Serena and Knudsen 2007) and can be incorporated in the various food items including meat and meat products. However, use of pea hull flour (PHF) as a source of dietary fibre in meat products is yet to be explored. In this view, the present study was undertaken to partially replace common salt content of pre-standardized low fat chicken nuggets with salt substitute blend and to enrich them with dietary fibre through incorporation of PHF and observe their effects on the quality characteristics of products.

Materials and methods

Sample preparation

Dressed chicken were procured from Central Avian Research Institute, Izatnagar. These were packed in clean low density polyethylene (LDPE) bags and promptly brought to the laboratory of Livestock Products Technology Division. Chicken were deboned carefully and packaged in LDPE bags. They were stored overnight at 4 ± 1 °C and then kept frozen at -18 °C till further use. Other additives used were sodium chloride, salt substitute blend, sodium hexametaphosphate, sodium nitrite, liquid egg white, refined sunflower oil, condiments (onion and garlic paste), carrageenan, sodium alginate, PHF, refined wheat flour and spice mix. Pea hull flour was prepared by grinding of clean dried pea hulls to the consistency of flour.

Study profile

In the study 40 % of common salt of pre-standardized low fat chicken nuggets (Control) was replaced by the salt substitute blend to get low salt, low fat chicken nugget (Treat I). In the resultant product, PHF of known composition was incorporated as a source of dietary fibre at three different levels i.e. 8 (Treat II), 10 (Treat III) and 12 % (Treat IV). All the four treated products were compared for various physicochemical, colour, textural, lipid profile and sensory properties against control which is a pre-standardized low fat chicken nugget with 2 % common salt.

Processing of chicken nuggets

Chicken meat was partially thawed overnight, cut into small cubes and double minced in a mincer (Electrolux, Model-9152). Meat emulsion was prepared in a bowl chopper (Seydelmann K20, Ras, Germany). In a pre-weighed quantity of minced chicken meat, salt/salt substitute blends, sodium hexametaphosphate, and sodium nitrite were added and chopped for about 2–3 min with simultaneous addition of ice flakes. After adding liquid egg white and chopping again

for 1 min refined sunflower oil was slowly incorporated while chopping till it completely dispersed in the batter. Condiment paste, carrageenan, sodium alginate, pea hull flour, refined wheat flour and dry spice mix were added (Table 1). Chopping was continued till uniform dispersion of all the ingredients and desired consistency of the emulsion was achieved. Weighed quantity (360 g) of emulsion was taken and filled in stainless steel mould. Mould was covered with lid and tied with thread and steam cooked for 35 min to achieve product internal temperature of about 85 °C. Chicken meat blocks so obtained were sliced and cut into pieces to get nuggets. The products were packed in LDPE and analyzed for the following parameters:

pH determination

The pH of emulsion and cooked products was determined by blending 10 g of sample with 50 ml of distilled water using an Ultra Turrax T 25 tissue homogenizer (Janke and Kunkel, IKA Labortechnik, Staufen, Germany) at 8,000 rpm for 1 min. The pH of the suspension was recorded by dipping combined glass electrode of Elico digital pH meter, Model LI 127 (Elico Limited, Hyderabad, India).

Emulsion stability and product yield

Emulsion stability (ES) was determined as per method described by Townsend et al. (1968) with some modifications. About 25 g emulsion samples were placed in polyethylene bags and heated at 80 °C in a thermostatically controlled water bath for 20 min. After draining out the exudate, the cooked mass was cooled, weighed and the yield was expressed as emulsion stability percent. Product yield was determined by

Table 1 Product formulation for the different chicken nuggets

Ingredients	Control	Treat I	Treat II	Treat III	Treat IV
Lean meat (%)	74.65	74.19	69.19	66.69	64.19
Sodium chloride (%)	2.0	1.2	1.2	1.2	1.2
Potassium chloride (%)	–	0.2	0.2	0.2	0.2
Citric acid (%)	–	0.03	0.03	0.03	0.03
Tartaric acid (%)	–	0.03	0.03	0.03	0.03
Sucrose (%)	–	1	1	1	1
Pea hull flour (%)	–	–	8	10	12

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

The following ingredients were also added to all samples: 0.5 % sodium hexametaphosphate, 150 ppm sodium nitrite, 6.5 % ice flakes, 1.5 % liquid egg white, 7 % refined sunflower oil, 3 % condiment mix, 0.75 % carrageenan, 0.1 % sodium alginate, 2 % spice mix and 2 % refined wheat flour

measuring weight of meat blocks for each treatment and calculating the ratio of cooked weight to raw weight and expressed as a percentage.

Proximate composition and dietary fibre

Moisture, protein, fat, ash and dietary fibre contents of the PHF and products were determined as per the standard procedures of Association of Official Analytical Chemists (AOAC 1995).

Instrumental colour

The colour of cooked chicken nuggets was compared using a Lovibond Tintometer (Model F; UK). Samples from two different nuggets of each treatment were taken in the sample holder and secured against the viewing aperture. The sample colour was matched by adjusting red (a) and yellow (b) units, while keeping the blue units fixed at 2. The corresponding colour units were recorded. The hue and chroma (saturation) values were determined using the formula, $(\tan^{-1} b/a)$ and $(a^2 + b^2)^{1/2}$, respectively, where, a, is the red unit, b the yellow unit.

Texture profile analysis

The textural properties of nuggets were evaluated using the texturometer (Stable Micro System Model TA.XT 2i/25, U.K.) at Post Harvest Technology, Central Avian Research Institute, Izatnagar. Texture profile analysis (Bourne 1978) was performed using central cores of two pieces of each sample (1.5 cm^3) which were compressed twice to 60 % of the original height. A crosshead speed of 3 mm/s was used applying 0.15 N load cell and 75 mm compression platen probe (P75).

Lipid profile

The fat content of the samples were extracted according to Folch et al. (1957) and total lipids were determined gravimetrically. The different components of lipids, including total phospholipids, glycolipids and free fatty acids (FFA) were measured by standard procedures as described by Marinetti (1962), Roughan and Batt (1968) and Koniecko (1979), respectively, whereas total glycerides were indirectly calculated by subtracting all these from total lipid values. Total cholesterol content in the lipid extracts was determined according to procedure described by Sabir et al. (2003) using Liberman-Burchard reagent. The developed colour complex was measured by reading the optical density at 640 nm in a spectrophotometer (Elico, Scanning minispec SL 117) and expressed as mg per g of product.

Sensory characteristics

Sensory evaluation method using an 8 point descriptive scale (Keeton 1983) was followed, where 8 = excellent; 1 = extremely poor. The sensory panel consisted of ten trained scientists and post graduate students of the division. Three digit coded samples were served to the panelists in random order. The panelists were explained about the nature of experiments without disclosing the identity of samples and were asked to rate their preference on 8 point descriptive scale on the sensory evaluation proforma for different traits. Samples were warmed using microwave oven for 1 min. Water was provided to rinse mouth between the samples. The panelists judged the samples for general appearance, flavour, texture, saltiness, juiciness and overall acceptability.

Statistical analysis

The statistical design of the study was 5(treatment)×3(replication) randomized block design. All chemical and physical determinations were in triplicate. There were ten sensory determinations for each treatment—replication combination. Data were subjected to one way analysis of variance. Duncan's multiple range tests and critical difference were determined at the 5 % significance level (Snedecor and Cochran 1994).

Results and discussion

Chemical characteristics of PHF

The amount of moisture, protein, fat and ash in the pea hull flour were found to be 5.13 %, 7.5 %, 1.48 % and 2.77 %, respectively. One of the important findings was the amount of dietary fibre in pea hull flour. It was found that PHF is a rich source of dietary fibre and composed of 10.99 % soluble dietary fibre, 70.02 % insoluble dietary fibre and 81.01 % total dietary fibre. The present finding proves healthier nature of PHF and paves the way for its use as bioactive ingredients in meat products to improve the health status of consumers. The soluble dietary fibre (SDF) is generally associated with a potential prebiotic character and usually considered a significant factor in the prevention of cardiovascular disease. However, insoluble dietary fibre (IDF) is frequently related to an increase in faecal bulk and a reduction in gastrointestinal transit time (Chandalia et al. 2000; Bosaeus 2004; Gray 2006).

Emulsion and product pH

Emulsion and product pH values for different treatments were significantly lower ($P < 0.05$) than the corresponding control nuggets. However incorporation of PHF in low salt, low fat emulsion and products increased the pH values (Table 2).

Table 2 Effect of salt substitution and pea hull flour on the physicochemical characteristics of low fat chicken nuggets

Parameters	Control	Treat I	Treat II	Treat III	Treat IV
Emulsion pH	5.89±0.02 ^a	5.66±0.02 ^c	5.72±0.02 ^b	5.74±0.01 ^b	5.75±0.02 ^b
Nuggets pH	6.03±0.01 ^a	5.78±0.04 ^c	5.83±0.01 ^{bc}	5.84±0.02 ^{bc}	5.86±0.01 ^b
Emulsion stability (%)	95.74±0.44 ^a	93.30±0.20 ^b	93.49±0.19 ^b	92.97±0.29 ^{bc}	92.16±0.47 ^c
Product yield (%)	96.44±0.17 ^a	95.07±0.18 ^c	95.83±0.26 ^{ab}	95.42±0.27 ^{bc}	95.33±0.17 ^{bc}
Moisture (%)	64.51±0.13 ^a	63.99±0.20 ^a	62.13±0.45 ^b	61.61±0.37 ^{bc}	61.10±0.24 ^c
Protein (%)	17.16±0.43 ^a	16.91±0.60 ^a	15.08±0.60 ^b	14.42±0.49 ^b	13.95±0.08 ^b
Fat (%)	9.05±0.07	9.16±0.07	9.18±0.14	9.23±0.10	8.96±0.18
Ash (%)	3.36±0.04 ^a	2.77±0.07 ^b	2.79±0.03 ^b	2.75±0.04 ^b	2.68±0.04 ^b
Total dietary fibre (%)	0.87±0.04 ^d	0.88±0.03 ^d	5.33±0.06 ^c	6.15±0.06 ^b	6.90±0.06 ^a

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

$n=6$

Mean values with different superscript letters in the same row differ significantly ($P<0.05$)

Lower pH values for treat I might be due to presence of food grade citric and tartaric acids in the salt blend. Increase in pH values of products with PHF could be attributed to dilution of acidity in meat batter and products by almost neutral pea hull flour. This was in agreement with the results observed by Yilmaz (2004) in low fat meatballs incorporated with rye bran. According to Talukder and Sharma (2010), addition of wheat and oat brans in chicken meat emulsion increased pH value with significant effect at 15 % level.

Emulsion stability and product yield

The emulsion stability of all the treatments was significantly ($P<0.05$) lower in comparison with control and it was further decreased significantly as the levels of PHF increased (Table 2). Amount of extracted meat proteins are most vital in the processing of emulsion based meat product since their active participation in the water binding and emulsification of fat particles thus formation of stable meat batter. This extraction is achieved through formation of high ionic strength salt solution, mainly by sodium chloride. Stability of meat batter could have been further worsening by the replacement of meat proteins by pea hull flour. Sodium chloride solubilises meat proteins, and this increases the number of locations in the polypeptide chains capable of interacting during heating. The result is a stable, elastic and rigid protein gel matrix with good water and fat binding properties (Carballo et al. 1995). A decrease in gel strength of frankfurter batters was observed as the salt content decreased (Whiting 1984). The decrease in sodium chloride level caused marked increase in cooking loss in ground beef patties (Ruusunen et al. 2005). The cooking loss and total fluid release was significantly higher in low sodium frankfurter containing transglutaminase, KCl, sodium caseinate and dietary fibre as salt replacers (Jiménez-Colmenero et al. 2005). Salt replacement in low fat chicken nuggets significantly ($P<0.05$)

decreased the product yield. Incorporation of PHF in low salt, low fat meat products improved the yield and greatest improvement was observed at 8 % PHF level, where products yield was comparable to control nuggets. Sofos (1986) indicated that one of the functions of NaCl in meat products is to extract myofibrillar proteins, which contributes to meat particle binding, fat emulsification, water-holding capacity and thus reduces cook losses and improves quality and texture. Hsu and Sun (2006) reported significant increase in cooking yield of *Kung-wans* at higher salt levels. Claus and Hunt (1991) showed that addition of 3.5 % oat and sugar beet fibers increased cooking losses in low fat (10 %) bolognas, while cooking losses were not affected by addition of 3.5 % pea fibre or wheat starch. Verma et al. (1984) reported increase in cooking loss with increased level of substitution of chickpea flour in pork, beef, and mutton sausages.

Proximate composition and dietary fibre

Moisture percent in treatment I was statistically similar ($P>0.05$) to control product. However treatments with PHF had significantly ($P<0.05$) lower moisture content and value further decreased with the higher levels of PHF (Table 2). It could be due to less protein extraction leading to poor water binding (Somboonpanyakul et al. 2007) as well as reduced capacity of PHF to retain the water while cooking. Gordon and Barbut (1992) reported that increasing NaCl from 1.5 to 2.5 g/100 g resulted in a higher protein extraction in chicken meat batter. A linear decrement in water binding capacity of low sodium ground meat patties was reported with decreasing levels of sodium chloride (Ruusunen et al. 2005). A decrease in moisture percent of low fat ground beef patties (Troutt et al. 1992) and low fat dry fermented sausages (Mendoza et al. 2001) containing texture modifying ingredients and inulin, respectively has been observed. Other workers also observed similar

Table 3 Effect of salt substitution and pea hull flour on the colour characteristics of low fat chicken nuggets

Parameters	Control	Treat I	Treat II	Treat III	Treat IV
Red	2.83±0.05 ^a	2.82±0.05 ^a	2.80±0.05 ^a	2.65±0.04 ^b	2.58±0.06 ^b
Yellow	3.20±0.06 ^a	3.18±0.06 ^a	3.13±0.08 ^{ab}	3.05±0.15 ^{ab}	2.90±0.06 ^b
Hue	50.76±1.61 ^{ab}	45.64±1.41 ^b	51.44±1.80 ^{ab}	50.30±2.56 ^{ab}	52.06±2.08 ^a
Chroma	4.28±0.04 ^a	4.30±0.07 ^a	4.20±0.07 ^{ab}	4.05±0.11 ^b	3.76±0.05 ^c

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

n=6

Mean values with different superscript letters in the same row differ significantly ($P<0.05$)

results in meatballs added with various brans (Yilmaz and Daglioglu 2003; Yilmaz 2004; Huang et al. 2005).

Percent protein remained unchanged due to salt replacement while addition of PHF in low salt, low fat meat products significantly ($P<0.05$) decreased protein percent. In the present study pea hull flour was incorporated in the formulations by replacing lean meat and this could be the main reason for lower protein contents in treatments having PHF. The protein percent of low fat beef patties containing polydextrose and oat flour as texture modifying ingredients was significantly decreased (Troutt et al. 1992). Similar result was also observed by Huang et al. (2005) in emulsified pork meatballs incorporated with rice bran at the level of 5 % and above. Amount of fat in the control and treatment products did not differ significantly. The percent ash in the control was significantly ($P<0.05$) higher in relation to the treatment products. However, the differences in the ash percent among treatments were non-significant. Mendoza et al. (2001) obtained similar result in low fat dry fermented sausages incorporated with inulin as a fat substitute. There was significant decrease in ash content of low sodium frankfurter with transglutaminase, potassium chloride, sodium caseinate and dietary fibre as salt replacer (Jiménez-Colmenero et al. 2005). The treatments with PHF had significantly ($P<0.05$) higher dietary fibre content than control and low salt, low fat chicken nuggets and which

increased with the increasing levels of PHF. As we have seen previously that almost 81 % of pea hull flour is composed of dietary fibre, its addition in low salt, low fat chicken nuggets enriched their fibre content, thus further enhanced their functional and health characteristics. According to De Almeida Costa et al. (2006) raw pea contained about 10.4 % crude fibre. In general, legumes are sources of complex carbohydrates, protein and dietary fibre, having significant amounts of vitamins and minerals, and high energetic value (Morrow 1991; Nielsen 1991; Tharanathan and Mahadevamma 2003).

Instrumental colour

The redness values of treat I and II were comparable to control (Table 3). However incorporation of PHF in low salt, low fat product at 10 % and 12 % levels significantly ($P<0.05$) decreased redness value. Yellowness value was also affected by added PHF and significant effect was noticed at 12 % level. Colour of meat products could be affected by the amount of lean meat, water, fat and non-meat ingredients. Lower redness value of the products with PHF at higher levels could be attributed to overall reduction in the amount of meat pigments. Dzudie et al. (2002) demonstrated that supplementing beef sausages with common bean flour significantly increased lightness and yellowness while reducing redness. Incorporation of

Table 4 Effect of salt substitution and pea hull flour on the texture profile analysis of low fat chicken nuggets

Parameters	Control	Treat I	Treat II	Treat III	Treat IV
Hardness (N/cm ²)	61.73±2.09 ^a	49.57±0.85 ^b	41.72±1.07 ^c	37.76±1.31 ^d	35.76±0.19 ^d
Adhesiveness (Ns)	−0.06±0.02 ^b	0.02±0.02 ^a	−0.04±0.04 ^{ab}	−0.04±0.02 ^{ab}	−0.03±0.02 ^{ab}
Springiness (cm)	0.81±0.01	0.82±0.01	0.83±0.02	0.83±0.01	0.82±0.01
Cohesiveness (ratio)	0.41±0.00 ^c	0.36±0.01 ^d	0.50±0.01 ^a	0.49±0.01 ^a	0.45±0.01 ^b
Gumminess (N/cm ²)	25.34±0.61 ^a	17.94±0.63 ^c	20.72±0.58 ^b	18.47±0.55 ^c	16.15±0.37 ^d
Chewiness (N/cm)	20.56±0.40 ^a	14.69±0.56 ^c	17.24±0.45 ^b	15.30±0.53 ^c	13.16±0.25 ^d

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

n=6

Mean values with different superscript letters in the same row differ significantly ($P<0.05$)

Table 5 Effect of salt substitution and pea hull flour on the fatty acid profile of low fat chicken nuggets

Parameters	Control	Treat I	Treat II	Treat III	Treat IV
Total phospholipids (mg/g)	6.81±0.24	6.80±0.24	6.52±0.18	6.47±0.18	6.36±0.11
Total cholesterol (mg/g)	1.05±0.01 ^a	1.05±0.01 ^a	0.83±0.01 ^b	0.76±0.01 ^b	0.75±0.01 ^b
Total glycolipids (mg/g)	0.09±0.01 ^a	0.09±0.01 ^a	0.09±0.00 ^a	0.08±0.00 ^{ab}	0.07±0.01 ^b
Total lipid (mg/g)	70.17±2.18	70.17±2.01	68.50±1.02	66.50±1.67	66.17±1.17
Free fatty acids (mg/g)	0.99±0.04	0.99±0.04	0.95±0.02	0.93±0.02	0.92±0.02
Total glyceroids (mg/g)	61.23±2.17	61.06±1.93	58.34±1.23	58.01±1.84	57.84±1.79

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

n = 6

Mean values with different superscript letters in the same row differ significantly ($P < 0.05$)

green banana and soybean hulls flours as well as their combinations significantly decreased the redness value of chicken nuggets (Kumar et al. 2011). Products hue value was significantly ($P < 0.05$) affected by salt replacement, however value was improved due to pea hull flour addition. The chroma index of the products showed trend similar to the redness value.

Texture profile analysis

The evaluation of textural parameters revealed a significantly ($P < 0.05$) lower hardness value for low salt, low fat chicken nuggets in relation to control and the value was further decreased by addition of pea hull flour (Table 4). The higher hardness value in control could have been attributed to higher common salt content helping in extraction of more salt-soluble protein from the muscle tissues that involve in formation of stable protein matrix and firm three dimensional networks (Hsu and Sun 2006). An increase in product hardness with increase in salt and fat content was observed (Matulis et al. 1995). A significantly lower hardness value for the low salt, low fat meat products with PHF could be the outcome of weak emulsion formation due to interruption in the formation of uniform and stable meat matrix as well as less protein content.

A decrease in the hardness value was observed in low fat, high dietary fibre frankfurters and low fat dry fermented sausages incorporated with peach dietary fibre suspension and cereals, respectively (Grigelmo-Miguel et al. 1999; Garcia et al. 2002). However, some workers obtained opposite results in the emulsified pork meatballs added with rice bran (Huang et al. 2005) and chicken nuggets with green banana and soybean hulls flours (Kumar et al. 2011).

Salt replacement significantly ($P < 0.05$) improved the product's adhesiveness but the value was decreased when PHF was incorporated in low salt, low fat meat product. The springiness values between control and treatments did not differ significantly ($P > 0.05$). Low salt, low fat meat product had significantly ($P < 0.05$) lower cohesiveness value than the corresponding control. Incorporation of PHF in low salt, low fat meat products significantly ($P < 0.05$) increased the cohesiveness value at lower level while value was gradually decreased with the higher levels. This result concurs with findings of Garcia et al. (2002) who reported a higher cohesiveness value for low fat dry fermented sausages incorporated with wheat and oat. Gumminess and chewiness values were significantly ($P < 0.05$) affected due salt replacement. Incorporation of PHF in low salt, low fat chicken nuggets at 8 %

Table 6 Effect of salt substitution and pea hull flour on the sensory characteristics of low fat chicken nuggets

Parameters	Control	Treat I	Treat II	Treat III	Treat IV
Appearance	7.37±0.05 ^a	7.27±0.05 ^{ab}	7.20±0.04 ^b	7.00±0.05 ^c	6.82±0.07 ^d
Flavour	7.15±0.05 ^a	7.12±0.05 ^a	7.00±0.06 ^{ab}	6.87±0.07 ^{bc}	6.73±0.07 ^c
Texture	7.30±0.04 ^a	7.22±0.04 ^a	7.02±0.06 ^b	6.80±0.08 ^c	6.63±0.10 ^c
Saltiness	7.07±0.07	7.03±0.02	7.08±0.06	7.05±0.05	6.95±0.06
Juiciness	7.22±0.05 ^a	7.18±0.04 ^a	6.97±0.07 ^b	6.72±0.08 ^c	6.47±0.10 ^d
Overall acceptability	7.20±0.05 ^a	7.18±0.04 ^a	7.02±0.07 ^a	6.82±0.07 ^b	6.58±0.09 ^c

Control: low fat chicken nuggets; Treat I: low fat low salt chicken nuggets; Treat II: low fat low salt chicken nuggets with 8 % PHF; Treat III: low fat low salt chicken nuggets with 10 % PHF; Treat IV: low fat low salt chicken nuggets with 12 % PHF

n = 30

Mean values with different superscript letters in the same row differ significantly ($P < 0.05$)

level significantly ($P < 0.05$) improved these values but negatively affected at higher levels. Gumminess and chewiness are the secondary parameters and their value reflects the behavior of component parameters. The results of this study were opposite to the findings observed by Garcia et al. (2002) in low fat dry fermented sausages incorporated with wheat and oat. The chewiness value of frankfurter was significantly decreased by replacement of sodium chloride with transglutaminase, potassium chloride, sodium caseinate and dietary fibre (Jiménez-Colmenero et al. 2005).

Fatty acid profile

It was noticed that mere salt replacement did not have any significant effects on fatty acid profile of chicken nuggets (Table 5). Addition of PHF in low salt, low fat chicken nuggets significantly decreased the total cholesterol and total glycolipids at 8 % and 12 % levels, respectively. This could be mainly due to the replacement of meat, thus also meat fat by added PHF in their formulation.

Sensory characteristics

Results of sensory evaluation revealed non-significant ($P > 0.05$) differences in the various scores due to salt replacement (Table 6). Pea hull flour at 8 % level significantly ($P < 0.05$) affected the appearance, texture and juiciness scores while flavour and overall acceptability scores remained statistically similar ($P > 0.05$) to control and treatment I. However, PHF at higher level significantly decreased various sensory attributes except saltiness. The presence of dark grains of pea hull flour on the surface of products might have affected general appearance at higher level. A decrease in the flavour scores of treatments at higher levels of pea hull flour could be attributed to dilution of meaty flavour in the products. The lower juiciness with higher levels of PHF might be due to graininess perceived by sensory panelists (Claus and Hunt 1991) and lower moisture percent in the product. A significantly lower appearance, flavour, texture and juiciness at higher level of PHF are supposed to be responsible for their lower overall acceptability.

Conclusions

Various physicochemical, colour values, lipid profile, textural and sensory properties of the products are affected by salt substitution and PHF addition. Lipid profile and sensory characteristics were not affected by 40 % sodium chloride substitution. Incorporation of PHF in low salt, low fat product significantly increased dietary fibre content. Addition of PHF even at 8 % level is able to decrease the cholesterol content of the product. Sensory properties of low salt, low fat product

with 8 % PHF were almost similar to control. Hence, it is concluded that low salt, low fat and high fibre functional chicken nuggets can be developed by replacing sodium chloride with salt substitute blend and incorporation of 8 % pea hull flour without affecting any sensory attributes significantly.

Acknowledgments We wish to thank Head, Division of Post Harvest Technology, CARI, Izatnagar for providing facilities to evaluate texture analysis of products. The authors also gratefully acknowledge Indian Veterinary Research Institute (IVRI), Izatnagar, for providing Ph.D. research grant in the form of Institute fellowship to the first author.

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