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ARTICLE

Effect of Dietary Fiber Enrichment and Different Cooking Methods on Quality of Chicken Nuggets

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Abstract

The effect of dietary fiber enrichment (wheat bran) and cooking methods (oven, steam and microwave) on functional and physico-chemical properties of raw nuggets formulation as well as nutritional, color and textural properties of chicken nuggets were analyzed in this study. Among different cooking methods used for nuggets preparation, steam cooked nuggets had significantly ($p<0.05$) higher water holding capacity (56.65%), cooking yield (97.16%) and total dietary fiber content (4.32%) in comparison to oven and microwave cooked nuggets. The effect of cooking methods and wheat bran incorporation was also noticed on textural properties of the nuggets. Hardness, firmness and toughness values of oven and steam cooked nuggets were significantly ($p<0.05$) higher than microwave cooked nuggets. Among nuggets prepared by different cooking methods, cohesiveness of microwave cooked nuggets was found to be significantly ($p<0.05$) highest, whereas, oven cooked nuggets had significantly ($p<0.05$) highest gumminess and chewiness values. Steam cooked nuggets were found to be better among all nuggets due to their higher cooking yield and dietary fiber content.

Keywords chicken nuggets, dietary fiber, cooking methods, physico-chemical properties

Introduction

With the advent of time, the meat products are also evolving to meet out the demands of health conscious consumers. Meat is a rich source of essential nutrients in our diet but it is deficient in dietary fiber content. High consumption of diet deficient in dietary fiber is being linked with several chronic health problems (WHO/FAO, 2003). Dietary fiber has established a positive effect on human health and has some beneficial functions which adds bulk to the diet, attracts water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose, lowers total and LDL (low density lipoprotein) cholesterol, regulates blood pressure, speeds the passage of foods through the digestive system, adds bulk to stool, balances intestinal pH and stimulates intestinal fermentation production of short chain fatty acids (Dhingra *et al.,* 2012).The potential of dietary fiber as satiety agent and a contributor to weight management have been also examined (Sharma *et al.,* 2008). The recommended daily allowance of 30-40 g total dietary fiber per day is desirable (Nayak *et al.,* 2000) and National Academy of Sciences (USA) also recommended the daily intake of 30-38 g and 21-26 g dietary fiber for men and women, respectively.

Several researchers used wheat, corn, rice, oat and rye bran in cooked meat

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products as dietary fiber sources (Choi *et al.,* 2011; Talukder and Sharma, 2010; Yadav *et al.,* 2016; Yadav and Malik, 2016; Yılmaz, 2004). Wheat bran is a byproduct from milling industry and it contains 11.58% crude fiber, 48.69% total dietary fiber, 46.59% insoluble dietary fiber and 2.10% soluble dietary fiber (Yadav and Malik, 2016). The utilization of cereal by products from agro industry in meat products has the potential of imparting health benefits to consumers and reduces the overall cost of production. Cereal brans contribute towards dietary fiber content in meat products and act as a functional ingredient as stabilizer, fat replacer, binder, volume enhancer in emulsion based meat products (Alesson-Carbonell *et al.,* 2005a; Alesson-Carbonell *et al.,* 2005b; Borderias *et al.,* 2005; Fernandez-Lopez *et al.,* 2008; Hu *et al.,* 2009; Hur *et al.,* 2009; Kumar *et al.,* 2011; Sendra *et al.,* 2008). Dietary fibers influence the color, texture, pH sensory and nutritional quality of processed meat products. Several studies have been reported for dietary fiber enrichment from cereal brans in chicken sausages (Yadav *et al.,* 2016), chicken patties (Talukder and Sharma, 2010), pork sausages (Khate, 2007), meat balls (Yasarlar *et al.,* 2007; Yılmaz, 2004; Yılmaz, 2005), chicken nuggets (Yadav and Malik, 2016), beef patties (Saricoban *et al.,* 2009).

Generally, dry and moist cooking methods have been used for processed meat products. Microwave cooking is also being used frequently in processed meat products preparation. The cooking techniques have influence on quality characteristics of meat products. Therefore, this study was carried out to analyze the effect of dietary fiber enrichment and cooking methods on various quality parameters of chicken nuggets.

Materials and Methods

Wheat bran

Wheat bran was procured from local flour mill. Microwave stabilization of bran was done as per method developed by Ramezanzadeh *et al.* (2000) in a commercial microwave oven (Samsung, model C103FL) operating at 2450 MHz and 900 W. The moisture content of bran was adjusted to 21% as the lower moisture content of bran was not suitable for microwave heating and leads to burning of bran. 100 g bran at a time was placed in a microwave safe bag and exposed to heating for 3 min. The temperature of the heated bran reached 109°C. The bran was removed from the oven and cooled to 25ºC. Then grinded in an electrical grinder, passed through 1 mm sieve, packed in an air tight container and stored in a freezer (-18°C) for further use. The moisture, protein, fat, ash and crude fiber content of wheat bran was 9.51, 14.32, 3.11, 4.66 and 11.66%, respectively.

Broiler chicken

Broiler chicken of 6-7 wk age reared under similar feeding and management were slaughtered and dressed as per the standard procedure in slaughter house of Department of Livestock Products Technology, Lala Lajpat Rai University of Veterinary and Animal Sciences. Carcasses were washed thoroughly; breast and leg cuts were separated. Both the cuts were deboned manually after trimming of visible fat and connective tissue. Deboned meat from both the cuts was mixed in equal proportion and stored in a freezer (-18°C) for further use. The moisture, protein, fat and ash content of chicken meat were 73.58, 19.47, 4.05 and 1.95%, respectively.

Nuggets preparation

Deboned meat was minced in an electrical mincer (MADO Primus, model MEW 613, Germany) by 4 mm plate. Previously optimized three different formulations, aimed for dietary fiber enrichment by incorporation of wheat bran (Table 1), were used to prepare nuggets by oven, steam and microwave cooking methods (Pathera *et al*., 2017). Minced meat, common salt, sodium tripolyphosphate, sodium nitrite, chilled water, spice mix, condiment paste, refined wheat flour, egg albumen, fat (groundnut oil) and wheat bran were mixed in a bowl chopper (Stadler Corporation, India) to prepare emulsion. Emulsions were prepared separately as per formulation for oven,

Table 1. Formulation for dietary fiber enriched chicken nuggets

Ingredients	F-ON	F-SN	F-MN
Minced meat (g)	100.0	100.0	100.0
Common salt (g)	2.5	2.5	2.5
Sodium nitrite (mg)	20.0	20.0	20.0
Sodium tripolyphosphate (mg)	400.0	400.0	400.0
Spice mix (g)	3.0	3.0	3.0
Condiments paste (g)	4.0	4.0	4.0
Refined wheat flour (g)	3.0	3.0	3.0
Chilled water (g)	12.0	12.0	12.0
Egg albumen (g)	12.85	10.12	8.99
Fat (g)	10.21	8.46	8.60
Wheat bran (g)	10.58	12.51	8.26

F-ON: raw formulation for oven cooking of nuggets, F-SN: raw formulation for steam cooking of nuggets, F-MN: raw formulation for microwave cooking nuggets.

steam and microwave cooking. Equal weight of emulsion was stuffed in rectangular moulds of same size and was cooked by oven (in a preheated electrical oven of Ditz Electricals Ltd, India, at 165°C temperature for 35 min), steam (in a closed container at sim flame for 30 min) and microwave oven (Samsung, model C103FL, at 2450 MHz and 900 W) for 5 min (Pathera *et al.,* 2016). Cooked products were cooled to room temperature. Nuggets were prepared by slicing cooked emulsion to 3 × 3 × 3 cm size and evaluated for various parameters.

Functional properties

Emulsion stability

Emulsion stability was determined using the method of Baliga and Madaiah (1970). Meat emulsion (20 g) was taken in polyethylene bag and was placed in a thermostatically controlled water bath at 80±1ºC for 20 min. After that the bag was removed from water bath, cut open and the cook out fluid (fat, water and water soluble solids) was drained. The cooked emulsion mass was weighed and expressed in percentage.

Water holding capacity

Water holding capacity (WHC) was estimated as per the method prescribed by Wardlaw *et al.* (1973). In a 100 mL polycarbonate centrifuge bottle, finely minced sample (20 g) was taken and then 30 mL of 0.6 M NaCl solution was added to it, mixed with glass rod and stirred for 2 min on a mechanical shaker. After holding for 15 min at 4ºC in order to allow the effect of salt to reach equilibrium, the meat slurry was again stirred for 1 min on a shaker and immediately centrifuged at 5000 rpm for 10 min at -9ºC in a centrifuge (Eltek refrigerated centrifuge, model MP 400 R). The supernatant volume was measured and difference between the added and decanted solution was expressed as percentage of the initial weight of sample.

Cooking yield

Cooking yield was measured by the difference in the weight of cooked product and initial raw weight by using formula, cooking yield (%) = [Weight after cooking/ initial weigh] ×100.

Physico-chemical properties

Proximate analysis

Moisture, protein, fat, ash and crude fiber were measured according to AOAC (1995). Moisture was determined by drying chopped sample at 105±5ºC to constant weight. Protein was analyzed as per the Kjeldahl method by using Kelplus apparatus (Pelican Equipments, India). Fat was determined by the Soxhlet method. Extraction of the sample was done with petroleum ether in Socsplus extraction apparatus (Pelican Equipments, India). Ash content was determined by incineration in a muffle furnace at 550±5ºC for 2 h. Crude fiber estimation was done with Fibraplus apparatus (Pelican Equipments, India). The carbohydrate content was calculated by using formula, Carbohydrates % = 100 - (moisture % + ash % + protein % + fat % + crude fiber %).

pH

The pH was determined according to method of Trout *et al.* (1992) by using pH meter (CyberScan pH 510, Thermo Fisher Scientific Inc.). Ten gram sample was homogenized with 50 mL distilled water by using IKA T10 Basic Ultra Turrax homogenizer. The pH was recorded by dipping the electrodes of pH meter directly in the suspension.

Nutritional properties

Total dietary fiber

Total dietary fiber (TDF) was estimated by combination of enzymatic and gravimetric method (AOAC, 1997) by using TDF assay kit (Sigma-Aldrich Inc.). Dried and fat-free samples were gelatinized with heat stable α-amylase and then enzymatically digested with protease and amyloglucosidase to remove the protein and starch present in the sample. Ethanol was added to precipitate the soluble dietary fiber. The residue was then filtered and washed with ethanol and acetone. After drying, the residue was weighed. Half of the samples were analyzed for protein and others were ashed. Total dietary fiber was the weight of the residue less the weight of the protein and ash.

Cholesterol

Cholesterol-extraction of fat from samples were carried out according to the method of Angelo *et al.* (1987) with slight modifications and for estimation of cholesterol, spectrophotometric method by Zak (1957) was followed. Blank and standard solutions were run simultaneously along with samples and absorbance was measured at 560 nm. From standard graph, amount of cholesterol present in fat sample was calculated which was later converted to mg/100 g sample.

Color analysis

Color was measured using a Konica Minolta chroma meter CR-400 (Konica Minolta Sensing, Inc., Japan) with 8 mm aperture and D65 illuminant. The instrument was calibrated with a white standard plate. Nuggets of 3 × 3 × 3 cm size were evaluated for color at room temperature. Color scores were expressed as CIE Lab i.e., L* (lightness), a* (redness) and b* (yellowness).

Textural properties

The texture profile analysis was performed at room temperature as per the procedure outlined by Bourne (1978) using TA*HD* Plus Texture Analyser (Stable Micro Systems, England). Cubic samples of 15 × 15 × 15 mm size were compressed to 50% of their original height. A time interval of 5 s was allowed between two compression cycles. Force time deformation curves were obtained with a 50 kg load cell applied at a cross-head speed of 2 mm/s. Textural attributes such as hardness (N), springiness, cohesiveness, gumminess (N) and chewiness (N) were analyzed.

Firmness (N) and toughness (N.sec) were measured by cutting cubic samples of 15 × 15 × 15 mm size by Warner Bratzler cutting blade having rectangular notch. Force time cutting curves were obtained with a 50 kg load cell applied at a cross-head speed of 2 mm/s. The maximum force required to cut the sample was taken as an index of firmness and the toughness was taken as the total positive area under the curve.

Statistical analysis

Statistical analysis of the data obtained from 6 replicates was done by ANOVA. Duncan's multiple range test at 5% significance level was applied to find out significant differences in mean (Snedecor and Cochran, 1989) and results were expressed as mean ± standard deviation.

Results and Discussion

Physico-chemical and functional properties of raw chicken nuggets formulation

Raw chicken nugget formulation for microwave oven cooking had significantly (p<0.05) higher moisture content in comparison to formulation for oven cooking as shown in Table 2. Moisture content of steam cooked nuggets formulation was statistically comparable with both, oven cooked nuggets and microwave cooked nuggets formulation. Different ingredients like dietary fiber, fat and albumen affect the moisture content of meat products. Difference in quantity of ingredients used, affected the composition of meat formulations. Higher moisture content (p<0.05) in F-MN in comparison to F-ON might be due to low level of wheat bran (8.26 g) and fat (8.60 g) in optimized formulation for MN in comparison to formulation of ON. Lower amount of wheat bran and fat resulted in lower total solid content in F-MN which contributed to quantitative increase in moisture content. Choi *et al.* (2014) reported that moisture content of reduced-fat frankfurters increased significantly with decrease in back fat levels from 30% to 10%. The increase in moisture content was attributed to replacement of fat with water in low fat frankfurters. Addition of dietary fiber sources like brans has been reported to decrease the moisture content of meat products. Yılmaz (2005) reported a decrease in moisture content of low fat meat balls with increasing level of wheat bran from 5% to 20%. Similar decrease in moisture content of products after addition of cereal bran has also been reported by Yasarlar *et al.* (2007). Huang *et al.* (2011) studied the effect of wheat fiber, oat fiber and inulin on properties of Chinese-style sausages and observed the similar results. No significant (p<0.05) difference was noticed in protein content between formulations for different cooking methods. F-ON showed significantly higher fat content in comparison to F-SN and F-MN. This was due to higher fat content in formulation of oven cooked nuggets. F-MN showed significantly (p<0.05) lower crude fiber and

Table 2. Physico-chemical and functional properties of raw chicken nuggets formulations

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	pH	ES (%)	WHC (%)
F-ON	61.64±0.89^b	16.24±0.47^a	10.51±0.38^a	2.94±0.24^{ab}	1.15±0.15^a	7.52±0.69^a	6.05±0.06^a	96.75±1.13^a	53.46±1.86^b
F-SN	62.55±0.77^{ab}	16.05±0.76^a	9.27±0.33^b	2.87±0.18^b	1.34±0.20^a	7.93±0.57^a	6.12±0.05^a	97.28±1.41^a	56.65±1.51^a
F-MN	63.58±1.02^a	16.32±0.36^a	9.48±0.44^b	3.19±0.21^a	0.95±0.13^b	6.48±0.45^b	5.96±0.07^b	96.37±1.10^a	51.77±1.59^b

F-ON: raw formulation for oven cooked nuggets, F-SN: raw formulation for steam cooked nuggets, F-MN: raw formulation for microwave oven cooked nuggets, ES: emulsion stability, WHC: water holding capacity.
Data values were expressed as means±SD (n=6).
Means with different superscripts within a column for a particular parameter differ significantly (p<0.05).

carbohydrate content than F-SN and F-ON formulations. This might be due to comparatively less quantity of wheat bran in F-MN in comparison to F-ON and F-SN which contributed to lower crude fiber and carbohydrate content in F-MN. Increase in bran level proportionately increases crude fiber content. Huang *et al.* (2011) also reported the increase in crude fiber content with added dietary fiber sources in Chinese-style sausages. The results indicate that amount and type of ingredients used in developing raw formulations for meat products influence their composition.

pH of F-ON and F-SN was significantly ($p<0.05$) higher than F-MN. Water holding capacity (WHC) of F-SN was significantly ($p<0.05$) higher than F-ON and F-MN (Table 2). WHC was positively enhanced by higher wheat bran incorporation in F-SN than F-ON and F-MN. Dietary fibers have good water and fat binding properties (Cofrades *et al.*, 2000) which contribute to increase in WHC. Besbes *et al.* (2008) suggested that the addition of dietary fibers from pea and wheat improved the water binding capacity of beef burgers. No significant difference was noticed in emulsion stability between the formulations.

Physico-chemical and nutritional properties of cooked chicken nuggets

Moisture content of steam cooked nuggets was significantly ($p<0.05$) higher than oven and microwave cooked nuggets (Table 3). As discussed earlier, raw chicken nugget formulation for microwave nuggets had highest ($p<0.05$) moisture content among raw nugget formulations. But moisture content of microwave cooked nuggets decreased significantly ($p<0.05$) on cooking in comparison to steam cooked nuggets indicating a remarkable effect of steam cooking in retention of moisture. Meat is in direct contact with heat during oven and microwave cooking, which results in increased rate of moisture evaporation from the product resulting in a decrease in moisture content. On the other hand, cooking takes place in the presence of moisture/steam during steam cooking, which slows down the rate of water loss from the product resulting in more retention of moisture. Cholan *et al.* (2011) had also reported significantly ($p<0.05$) higher moisture content in chicken patties cooked by moist cooking method in comparison to other cooking methods. Ngadi *et al.* (2009) showed a significant effect on moisture loss due to microwave pre-treatment in chicken nuggets. There was a significant ($p<0.05$) difference in protein and fat content of nuggets (Table 3). Microwave cooked nuggets had significantly ($p<0.05$) highest protein content than ON and SN. Steam cooked nuggets had significantly ($p<0.05$) lowest protein content among all the nuggets. Fat content of ON was significantly ($p<0.05$) highest, followed by MN and SN which had significantly ($p<0.05$) lowest fat content. Water evaporation, melting of fats and loss of soluble proteins during cooking affected the composition of meat products. Higher moisture content in SN resulted in a quantitative decrease in protein and fat content resulting in significantly ($p<0.05$) lowest protein and fat content. Raw formulation for oven cooked nuggets (F-ON) had significantly ($p<0.05$) highest fat content which was maintained in cooked product (ON) also. Cholan *et al.* (2011) also reported significantly ($p<0.05$) lower protein content in steam cooked chicken patties in comparison to microwave and oven cooked chicken patties. No significant ($p<0.05$) difference was noticed in ash content of nuggets. Crude fiber and carbohydrate contents of SN were statistically similar to ON but significantly ($p<0.05$) higher than MN. This was due to higher level of wheat bran in formulation for SN which contributed to significantly ($p<0.05$) higher crude fiber and carbohydrate content in steam cooked nuggets. The pH of treatment SN was significantly ($p<0.05$) higher than treatments ON and MN. It was also noticed that pH of nuggets was also higher than their respective raw formulation. The results indicate that cooking influences the pH of meat products. Similar increase in pH on cooking was also reported by Babu *et al.* (1994) in chicken meat who suggested that increased salt concentration and change in the net charge of protein due to

Table 3. Physico-chemical and nutritional properties of cooked chicken nuggets

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	pH	CY (%)	TDF (%)	Cholesterol (mg/100g)
ON	58.79±0.77^{b}	17.45±0.40^{b}	11.29±0.36^{a}	3.16±0.26^{a}	1.24±0.15^{ab}	8.08±0.57^{ab}	6.36±0.05^{b}	92.83±0.80^{b}	3.84±0.29^{b}	61.23±3.34^{b}
SN	61.04±0.90^{a}	16.30±0.37^{c}	9.64±0.35^{c}	2.98±0.19^{a}	1.40±0.21^{a}	8.64±0.64^{a}	6.44±0.07^{a}	97.16±0.92^{a}	4.32±0.32^{a}	59.46±3.87^{b}
MN	59.16±0.86^{b}	18.31±0.40^{a}	10.68±0.49^{b}	3.23±0.23^{a}	1.07±0.14^{b}	7.55±0.62^{b}	6.28±0.06^{b}	88.57±1.10^{c}	3.36±0.20^{c}	67.75±3.45^{a}

ON: oven cooked nuggets, SN: steam cooked nuggets, MN: microwave oven cooked nuggets, CY: cooking yield, TDF: total dietary fiber.
Data values were expressed as means±SD (n=6).
Means with different superscripts within a column for a particular parameter differ significantly ($p<0.05$).

denaturation might be responsible for pH increase. As discussed earlier, no significant (p<0.05) difference was noticed in emulsion stability among chicken nugget formulations optimized for different cooking methods. However, a significant (p<0.05) difference in cooking yield was noticed in nuggets prepared by different cooking methods indicating their influence on yield. Steam cooked nuggets had significantly (p<0.05) higher cooking yield than oven and microwave cooked nuggets (Table 3). MN had significantly (p<0.05) lowest cooking yield. The cooking loss depends on the mass transfer process during cooking and thermal techniques also influenced the difference in water loss during cooking (Cheng and Sun, 2008).

Higher cooking yield of SN was due to more retention of moisture in SN in comparison to ON and MN as discussed earlier. The results were agreed with Cholan *et al.* (2011) who reported highest cooking yield in steam cooked chicken patties. Moreover, higher WHC of F-SN due to its higher fiber content had also contributed to significantly highest cooking yield in steam cooked nuggets. Dietary fibers increase cooking yield due to their water and fat binding properties (Cofrades *et al.,* 2000).

Total dietary fiber content of oven, steam and microwave cooked nuggets were significantly (p<0.05) different and highest TDF content was observed in steam cooked nuggets. The difference in TDF content was due to the different level of wheat bran incorporation in optimized formulations for nuggets. Highest level of wheat bran was optimized for SN formulation and lowest for MN formulation, and the clear effect of quantity incorporated was observed on TDF content. SN and MN had TDF content 4.32±0.32% and 3.36±0.20%, respectively. Verma *et al.* (2010) reported increase in the fiber content in formulation of low-salt and low-fat chicken nuggets when apple pulp added at a level of 8-10 g/100 g. Yadav *et al.* (2016) also reported similar increase in total dietary fiber content in chicken sausage enriched with bran and pomace. Cholesterol content of ON and SN was significantly lower than that of microwave cooked nuggets. This was due to the comparative more non meat ingredients in raw ON and SN formulations in comparison to MN formulation.

Color and textural properties of chicken nuggets

Lightness (L*) and redness (a*) values of nuggets were not affected by difference in ingredients and cooking methods. However, yellowness (b*) value of SN was significantly (p<0.05) higher than ON and MN (Table 4). This might be due to higher bran level in SN. Cereal brans contain different pigments which influence the color of meat products. Yasarlar *et al.* (2007) and Yadav *et al.* (2016) reported change in lightness, redness and yellowness values of meat products after incorporation of different cereal bran.

Texture profile analysis of nuggets showed that hardness values of oven and steam cooked nuggets were significantly (p<0.05) higher than microwave cooked nuggets (Table 4). Significantly (p<0.05) highest cohesiveness was found in MN and lowest in SN. There was no significant (p<0.05) difference in springiness values of nuggets. The difference in hardness and cohesiveness of nuggets was due to difference in methods of cooking and level of wheat bran. ON and SN formulation had higher wheat bran than MN formulation. Addition of bran influences the hardness and cohesiveness of meat products. Yadav *et al.* (2016) reported increased values for hardness and decreased values for cohesiveness as a function of level of bran and pomace incorporation in chicken sausage. Garcia *et al.* (2002) reported similar results for hardness in dry fermented sausage by addition of wheat and oat fiber. Gumminess and chewiness of nuggets were significantly (p<0.05) different and highest values were observed in oven cooked nuggets. Gumminess and chewiness are secondary parameters and their values depend on hardness, cohesiveness and springiness values. Higher gumminess and chewiness of ON nuggets were due to their higher hardness values. Firmness and toughness of ON and SN were significantly (p<0.05) higher than microwave cooked nuggets. Several authors also supported the results who reported higher firm-

Table 4. Color and textural properties of chicken nuggets

	Color properties			Textural properties						
	L*	a*	b*	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)	Firmness (N)	Toughness (N.sec)
ON	43.85±3.12[a]	6.48±0.49[a]	12.60±0.54[b]	50.63±3.36[a]	0.81±0.01[a]	0.55±0.03[b]	27.82±1.49[a]	22.62±1.15[a]	12.82±1.07[a]	81.60±3.25[a]
SN	45.49±2.22[a]	6.60±0.32[a]	13.62±0.78[a]	47.73±2.90[a]	0.81±0.02[a]	0.45±0.02[c]	21.31±0.84[c]	17.14±0.88[c]	12.37±0.97[a]	80.51±3.83[a]
MN	46.08±2.70[a]	6.20±0.54[a]	12.68±0.66[b]	42.02±3.64[b]	0.84±0.04[a]	0.60±0.03[a]	25.25±1.63[b]	21.07±1.33[b]	10.25±0.74[b]	72.86±3.16[b]

ON: oven cooked nuggets, SN: steam cooked nuggets, MN: microwave oven cooked nuggets.
Data values were expressed as means±SD (n=6).
Means with different superscripts within a column for a particular parameter differ significantly (p<0.05).

ness and toughness due to added fiber sources in meat products (Huang *et al.,* 2005; Jung and Joo, 2013; Talukder and Sharma, 2010; Yasarlar *et al.,* 2007; Yılmaz, 2005; Yılmaz and Daglioglu, 2003).

Conclusion

Dietary fiber enriched chicken nuggets were prepared using different cooking methods and steam cooked nuggets resulted in higher cooking yield and dietary fiber content. Nutritional and textural properties of the all nuggets were acceptable for quality description of nuggets with enhanced dietary fiber content. 100 g serving of chicken nuggets per day would meet $1/6^{th}$ to $1/8^{th}$ of RDA for dietary fiber. Dietary fiber enriched ready to eat chicken nuggets can be a healthy option towards daily requirement for dietary fiber in non-vegetarian diet.

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References

1. Alesson-Carbonell, L., Fernandez-Lopez, J., Perez-Alvarez, J. A., and Kuri, V. (2005a) Characteristics of beef burger as influenced by various types of lemon albedo. *Innov. Food Sci. Emerg. Technol.* **6,** 247-255.
2. Alesson-Carbonell, L., Fernandez-Lopez, J., Perez-Alvarez, J. A., and Kuri, V. (2005b) Functional and sensory effects of fiber-rich ingredient on breakfast fresh sausages manufacture. *Food Sci. Technol. Int.* **11,** 89-97.
3. Angelo, A. J. St., Vercellotti, J. R., Legendre, M. G., Vinnett, C. H., Kuan, J. W., James. C. Jr., and Dupuy, H. P. (1987) Chemical instrument analyses of warmed over flavour in beef. *J. Food Sci.* **52,** 1163-1168.
4. AOAC. (1995) Official Methods of Analysis, 16th edition, Association of Official Analytical Chemists, Washington, DC.
5. AOAC. (1997) Official Methods of Analysis, 16th Edition, Volume II, Section 45.4.07, Method 985.29.
6. Babu, N. P., Kowale, B. N., Rao, V. K., and Bist, G. S. (1994) Effect of cooking and storage on lipid oxidation and development of cholesterol oxides in chicken meat. *Ind. J. Poult. Sci.* **29,** 254.
7. Baliga, B. R. and Madaiah, N. (1970) Quality of sausage emulsion prepared from mutton. *J. Food Sci.* **35,** 383-385.
8. Besbes, S., Attia, H., Deroanne, C., Makni, S., and Blecker, C. (2008) Partial replacement of meat by pea fiber: Effect on the chemical composition, cooking characteristics and sensory properties of beef burgers. *J. Food Qual*. **31,** 480-489.
9. Borderias, A. J., Sanchez-Alonso, I., and Perez-Mateos, A. (2005) New applications of fibers in foods: Addition of fishery products. *Trends Food Sci. Technol.* **16,** 458-465.
10. Bourne, M. C. (1978) Texture profile analysis. *Food Technol*. **33,** 62-66, 72.
11. Cheng, Q. and Sun, D. W. (2008) Factors affecting the water holding capacity of red meat products: A review of recent research advances. *Crit. Rev. Food Sci. Nutr.* **48,** 137-159.
12. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., Jeong, J. Y., and Kim, C. J. (2011) Effects of rice bran fibre on heat induced gel prepared with pork salt soluble meat proteins in model system. *Meat Sci*. **88,** 59-66.
13. Choi, Y. S., Kim, H. W., Hwang, K. E., Song, D. H., Choi, J. H., Lee, M. A., Chung, H. J., and Kim, C. J. (2014) Physicochemical properties and sensory characteristics of reduced-fat frankfurters with pork back fat replaced by dietary fiber extracted from makgeolli lees. *Meat Sci*. **96,** 892-900.
14. Cholan, P., Rao, V. K., Karthikeyan, B., Sreenivasamoorthy, P. R., and Cytyarasan, S. (2011) Effect of different cooking methods on physicochemical, organoleptic and microbiological quality of chicken patties. *Ind. J. Poult. Sci.* **46,** 206-210.
15. Cofrades, S., Guerra, M. A., Carballo, J., Fernandez-Martin, F., and Jimenez-Colmenero, F. (2000) Plasma protein and soy fiber content effect on bologna sausage properties as influenced by fat level. *J. Food Sci.* **65,** 281-287.
16. Dhingra, D., Michael, M., Rajput, H., and Patil, R. T. (2012) Dietary fibre in foods: A review. *J. Food Sci. Technol.* **49,** 255-266.
17. Fernandez-Lopez, J., Sendra, E., Sayas-Barbera, E., Navarro, C., and Perez Alvarez, J. A. (2008) Physico-chemical and microbiological profiles of "Salchichon" (Spanish dry-fermented sausage) enriched with orange fiber. *Meat Sci*. **80,** 410-417.
18. Garcia, M. L., Dominguez, R., Garlvez, M. D., Casas, C., and Sergas, M. D. (2002) Utilization of cereal and fruit fibers in low-fat dry fermented sausage. *Meat Sci*. **60,** 227-236.
19. Hu, G., Huang, S., Cao, S., and Ma, Z. (2009) Effect of enrichment with hemicellulose from rice bran on chemical and functional properties of bread. *Food Chem.* **115,** 839-842.
20. Huang, S. C., Shiau, C. Y., Liu, T. E., Chu, C. L., and Hwang, D. F. (2005) Effects of rice bran on sensory and physico-chemical properties of emulsified pork meatballs. *Meat Sci*. **70,** 613-619.
21. Huang, S. C., Tsai, Y. F., and Chen, C. M. (2011) Effects of wheat fiber, oat fiber and inulin on sensory and physico-chemical properties of Chinese-style sausages. *Asian Aust. J. Anim. Sci.* **24,** 875-880.
22. Hur, S. J., Lim, B. O., Park, G. B., and Joo, S. T. (2009) Effect of various fiber additions on lipid digestion during *in vitro* digestion of beef patties. *J. Food Sci.* **74,** 653-657.
23. Jung, E. and Joo, N. (2013) Roselle (*Hibiscus sabdariffa L.*) and soybean oil effects on quality characteristics of pork patties studied by response surface methodology. *Meat Sci*. **94,** 391-401.

24. Khate, K. (2007) Development of designer pork sausages with low salt and fat. Ph.D. thesis, submitted to Deemed University, IVRI, Izatnagar, UP, India.
25. Kumar, V., Biswas, A. K., Chatli, M. K., and Sahoo, J. (2011) Effect of banana and soybean hull flours on vacuum-packaged chicken nuggets during refrigeration storage. *Int. J. Food Sci. Technol.* **46,** 122-129.
26. Nayak, S. K., Pattnaik, P., and Mohanty, A. K. (2000) Dietary fiber, a low-calorie dairy adjunct. *Indian Food Ind.* **19,** 268-274.
27. Ngadi, M. O., Wang, Y., Adedeji, A. A., and Raghavan, G. S. V. (2009) Effect of microwave pretreatment on mass transfer during deep-fat frying of chicken nugget. *LWT-Food Sci. Technol.* **42,** 438-440.
28. Pathera, A. K., Riar, C. S., Yadav, S., Sharma, D. P., Yadav, Y. S., and Kumar, M. (2017) Optimization of dietary fiber enriched chicken nuggets for different cooking methods. *Food Measure*. DOI:10.1007/s11694-017-9517-2
29. Pathera, A. K., Riar, C. S., Yadav, S., and Singh, P. K. (2016) Effect of cooking methods on lipid oxidation, microbiological and sensory quality of chicken nuggets under refrigerated storage. *Cogent Food Agric*. **2,** 1232472.
30. Ramezanzadeh, F. M., Rao, R. M., Prinyawiwatkul, W., Marshall, W. E., and Windhauser, M. (2000) Effects of microwave heat, packaging, and storage temperature on fatty acid and proximate compositions in rice bran. *J. Agric. Food Chem.* **48,** 464-467.
31. Sarıcoban, C., Yılmaz, M. T., and Karakaya, M. (2009) Response surface methodology study on the optimisation of effects of fat, wheat bran and salt on chemical, textural and sensory properties of patties. *Meat Sci*. **83,** 610-619.
32. Sendra, E., Fayos, P., Lario, Y., Fernandez-Lopez, J., Sayas-Barbera, E., and Perez-Alvarez, J. A. (2008) Incorporation of citrus fibers in fermented milk containing probiotic bacteria. *Food Microbiol.* **25,** 13-21.
33. Sharma, A., Yadav, B. S., and Ritika. (2008) Resistant starch: Physiological roles and food applications. *Food Rev. Int.* **24,** 193-234.
34. Snedecor, G. W. and Cochran, W. G. (1989) Statistical methods. 8th Edn, The Iowa State University Press, Ames, Iowa.
35. Talukder, S. and Sharma, D. P. (2010) Development of dietary fiber rich chicken meat patties using wheat and oat bran. *J. Food Sci. Technol.* **47,** 224-229.
36. Trout, E. S., Hunt, M. C., Johson, D. E. Clans, J. R., Castner, C. L., and Kroff, D. H. (1992) Characteristics of low fat ground beef containing texture modifying ingredients. *J. Food Sci.* **57,** 19-24.
37. Verma, A. K., Sharma, B. D., and Banerjee, R. (2010) Effect of sodium chloride replacement and apple pulp inclusion on the physico-chemical, textural and sensory properties of low fat chicken nuggets. *LWT-Food Sci. Technol.* **43,** 715-719.
38. Wardlaw, F. B., McCaskill, L. H., and Acton, J. C. (1973) Effect of post mortem muscle changes in poultry meat loaf properties. *J. Food Sci.* **38,** 421-424.
39. WHO/FAO. (2003) Diet, nutrition and prevention of chronic diseases. Geneva, Switzerland, WHO Technical report series 916.
40. Yadav, S. and Malik, A. (2016) Study on development of dietary fiber enriched designer meat products. Ministry of Food Processing Industries, Govt. of India, New Delhi, F.No.56/MFPI/R&D/2011.
41. Yadav, S., Malik, A., Pathera, A., Islam, R., and Sharma, D. (2016) Development of dietary fiber enriched chicken sausages by incorporating corn bran, dried apple pomace and dried tomato pomace. *Nutr. Food Sci.* **46,** 16-29.
42. Yasarlar, E. E., Daglioglu, O., and Yılmaz, I. (2007) Effect of cereal bran addition on chemical composition, cooking characteristics and sensory properties of Turkish meat balls. *Asian J. Chem.* **19,** 2353-2361.
43. Yılmaz, I. (2004) Effect of rye bran addition on fatty acid composition and quality characteristics of low fat meatballs. *Meat Sci*. **67,** 245-249.
44. Yılmaz, I. (2005) Physicochemical and sensory characteristics of low fat meatballs with added wheat bran. *J. Food Eng.* **69,** 369-373.
45. Yılmaz, I. and Daglioglu, O. (2003) The effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meat balls. *Meat Sci*. **65,** 819-823.
46. Zak, B. (1957) Simple rapid microtechnic for serum total cholesterol. *Am. J. Clin. Pathol.* **27,** 583-588.