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The Effect of the Addition of Oat Flour in Low-Fat Chicken Nuggets

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Abstract

The objective of this study was to develop low-fat chicken nuggets with the inclusion of Oat Flour (OF) and assess the cooking yield, textural properties, sensory properties and proximate composition. Chicken nuggets were prepared with the addition of 0%, 10% and 20% of OF over and above the quantity of meat. The cooking yield was significantly higher in the nuggets containing OF. The increased OF level significantly increased the hardness and adhesiveness; however, the cohesiveness, springiness and resilience significantly decreased with no significant difference between the treatments. No significant difference in the gumminess and chewiness values was noted. The juiciness score increased, whereas the texture and flavor scores and overall acceptability decreased with the increased levels OF inclusion. The increased OF levels resulted in a significant increase in moisture, crude fiber and gross energy and a decrease in the percentage of crude protein and fat. Hence, acceptable dietary fiber-enriched low-fat chicken nuggets can be made with the addition of up to 10% OF over and above the amount of chicken meat.

Keywords: Chicken nugget; Oat flour; Sensory properties; Texture; Proximate composition

Introduction

The consumers' perception towards food intake in today's trend is mainly focused on maintaining good health. People have become more conscious about reduced fat in the diet, balanced protein sources and more importantly the inclusion of recommended levels of dietary fiber sources in the daily diet. However, logically it is not always possible for most people to maintain a healthy and balanced diet, for several practical reasons. Non-vegetarians are more concerned about the consumption of meat and meat products as they are under the misconception that meats are not good for health and will lead to various ailments such as colon cancer, obesity and cardiovascular disorders. However, the AHA Dietary Guidelines [1] recommend that an average 15% of the total energy is met by protein, and the consumption of a diet that contains a variety of foods from all the food categories is healthy. It also recommends fruits and vegetables, fat-free and low-fat dairy products, cereal and grain products, legumes and nuts, fish, poultry, and lean meats in the diet.

Dietary fiber is one of the essential food ingredients vital for human health in various aspects, the benefits of which have been emphasized by many researchers [2,3] and reviewers [4,5]. Potential dietary fiber sources from various cereals, legumes, fruits and vegetables could be used as functional ingredients in meat products by judicious processing methods [6]. Oats has been used in various meat products as a dietary fiber source in different forms [7-9]. Currently, need-based researches are warranted to develop low-fat meat foods with dietary fibers as the functional ingredients.

In India, the per capita consumption of meat per year had increased from 3.7 kg in 1985 to 5.1 kg in 2005 [10]. In India, poultry meat production is fast growing due to the changing food habits in the country where poultry growth, output, and the CAGR per capita consumption of poultry meat increased in the past five years [11]. Higher chicken meat consumption was reported to be in the southern and eastern states [12]. With expanding markets in countries like India, the overall world meat production is expected to grow by 1.7% per year till 2016 [13].

Various researches had been carried out in the processing of chicken nuggets [14-18] which is one of the popular meat products in India. Prinyawiwatkul et al. [19] reported that chicken nuggets with acceptable sensory qualities could be prepared with the incorporation of a mixture of 2.5% fermented cowpeas and 2.5% fermented partially defatted peanuts. Devadason et al. [20] found that corn flour was a better cereal binder in buffalo meat nuggets. Verma et al. [21] suggested that salt substitutes and bottle gourd could be used in developing low-salt, low-fat and high-fibre chicken nuggets without affecting their acceptability. Kumar et al. [22] showed that addition of green banana and soybean hulls flours in chicken nuggets improved their quality and storage stability.

The present work has been taken with a view to fortify the chicken nuggets prepared from broiler meat with oat flour, which is known for its dietary fibre content. The common form of oats available in the local market was used in this study as such as flour in the chicken nuggets where no similar work has been reported previously as the present formulation. Hence, the objective of this study was to optimize the inclusion level of oat flour (OF) in chicken nuggets to fortify the meat with dietary fiber.

Materials and Methods

Formulation and preparation of chicken nuggets

Boneless broiler chicken meat was procured as chunks from the local market and used in the preparation of the product. The meat was trimmed of all visible adipose and connective tissues, minced through an 8-mm plate using a MADO meat mincer and stored at -18 ± 2°C, in low-density polyethylene (LDPE) packs for further use. The meat was used for preparation of the product after partial thawing at 4°C for 12-15 h.

Low-fat chicken nuggets (with 5% fat) were formulated with the

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Ingredients	Treatments*		
	C (g)	O10 (g)	O20 (g)
Meat	1000	1000	1000
Oat flour	-	100	200
Maida	50	-	-
Vegetable oil	25	25	25
Chicken fat	25	25	25
Salt	20	22.5	30
Spice mix	25	38.5	54
Condiment mix	75	115.5	162
Added Water	100	150	200

*C: control (without oats), O10: batter added with oats at 10% level, O20: batter added with oats at 20% level.

Table 1: Formulation for chicken nuggets.

addition of OF at levels of 10% and 20% over and above the quantity of meat and a control without OF was included as shown in Table 1. Commercially available food grade branded oats was purchased from the supermarket, powdered into flour and added to the product. The optimum amount of OF to be added was selected based on earlier studies [23,24]. The remaining non-meat ingredients were then added to the meat in a bowl chopper to make a batter, during which the temperature was maintained below 12°C. Next, one kilogram of batter was filled in a mold box and cooked in moist heat to an internal end point temperature of 80°C. The cooked nuggets were stored at -18°C for further analyses.

Cooking yield

The cooking yield of the nugget was calculated using the following formula: freshly cooked sample weight at room temperature divided by the uncooked sample weight multiplied by 100.

Cooking yield (%)=cooked weight/uncooked weight×100

Texture profile analyses (TPA)

Texture profile analysis was performed using a texture analyzer (Stable Micro System, Model TA.XT 2i/25, UK). Each sample was compressed twice to 80% of the original height [25] using a compression probe (P25). A crosshead speed of 10 mm/s was used. For testing, the frozen samples were heated in a microwave oven, equilibrated to room temperature for 20 mins and cut into uniformly sized cubes of 1"x 1" x 1" dimension. The values were recorded based on the software available in the instrument. Five samples from each treatment were measured and the mean values of the five readings for each texture profile analysis were used for the analyses.

Sensory evaluations

The sensory quality of the nuggets was evaluated in terms of appearance, juiciness, texture, flavor, mouth-coating and overall acceptability based on an 8-point scale by 12 semi-trained panellists, as suggested by Sharma et al. [26]. The sensory panel included the technical staff members from the Department of Meat Science and Technology and the Department of Poultry Science. The panellists evaluated all the attributes in each sample and marked the scales accordingly without any prior idea about the treatments. Sensory evaluation was performed with all the panellists at the same time in the sensory evaluation room. For sensory evaluation, the frozen nuggets were thawed in the chiller for 4 hours, heated in a microwave oven and served to the panellists at room temperature, on white porcelain plates, under natural light.

Proximate analyses

Proximate composition analyses of the nuggets were performed according to AOAC specifications [27]. For each product, the moisture, fat, crude fiber, protein and total ash were determined.

Statistical analysis

Statistical analyses of the data were done using ANOVA technique as per the methods of Snedecor and Cochran [28] on completely randomized design. Average of three replicates was used in calculations. All the statistical analyses were carried out using the statistical analysis software package SPSS, version 15.

Results and Discussion

Cooking yield

The cooking yield of the OF incorporated nuggets was significantly ($P<0.05$) higher than the control (Table 2). However, no significant difference in the cooking yields was observed between the treatments with added OF.

Texture profile analyses

Texture profile analyses results are shown in Table 3. It was observed that the hardness value increased significantly ($P<0.01$), while the springiness value decreased ($P<0.01$) with the increase in the OF level with no significant difference between the treatments, with the added OF. In the present study, with the increased OF levels, the adhesiveness significantly ($P<0.05$) increased, the cohesiveness significantly decreased ($P<0.01$) and the resilience significantly ($P<0.01$) decreased, with no significant difference between the treatments. However, there was no significant difference in the gumminess and chewiness values.

Sensory evaluations

In the sensory evaluation, the overall score for the chicken nuggets

	Treatments[A]		
	C (g)	O10 (g)	O20 (g)
Yield	96.46 ± 0.99[a]	99.85 ± 0.12[b]	99.46 ± 0.68[b]

[a–b] Means in a same row with different letters are significantly different ($p<0.05$)
[A]Same as Table 1

Table 2: Cooking yield of chicken nuggets with/without oat flour.

	Treatments[A]			Significance of treatment effect[##]
	C	O10	O20	
Hardness (g)	1219.59 ± 47.54[a]	1383.80 ± 39.30[a]	1507.28 ± 58.10[b]	**
Adhesiveness	-4.21 ± 0.73[a]	-6.38 ± 0.77[b]	-7.14 ± 0.65[b]	*
Springiness (cm)	0.88 ± 0.01[a]	0.83 ± 0.01[a]	0.75 ± 0.02[b]	**
Cohesiveness (ratio)[1]	0.41 ± 0.01[a]	0.35 ± 0.01[b]	0.32 ± 0.01[c]	**
Gumminess[2]	554.46 ± 13.38	484.33 ± 52.53	543.21 ± 40.30	NS
Chewiness[3]	467.26 ± 10.80	414.02 ± 48.11	399.93 ± 30.40	NS
Resilience[4]	0.12 ± 0.00[a]	0.10 ± 0.00[b]	0.09 ± 0.00[b]	**

[a–c] Means in a same row with different letters are significantly different
[#]Standard error of the mean
[##]Significance of treatment effect: *P <0.05, **P<0.01, NS - Not Significant.
[A] Same as Table 1
[1]Area under second curve/Area under first curve
[2]Hardness × Cohesiveness
[3]Hardness × Springiness × Cohesiveness
[4] Area during the withdrawal of the first compression / Area of the first compression

Table 3: Texture profile analyses of chicken nuggets with/without oat flour (Mean ± SE[#]).

	Treatments[A]			Significance of treatment effect[##]
	C	O10	O20	
Appearance	6.21 ± 0.12	6.50 ± 0.15	6.54 ± 0.18	NS
Juiciness	6.04 ± 0.09[a]	6.25 ± 0.15[ab]	6.45 ± 0.13[b]	*
Texture	6.29 ± 0.20[a]	6.25 ± 0.15[a]	5.54 ± 0.13[b]	**
Flavour	6.66 ± 0.13[a]	5.92 ± 0.17[b]	5.83 ± 0.21[b]	**
Mouth coating	6.13 ± 0.19	6.04 ± 0.25	5.83 ± 0.32	NS
Overall Acceptability	6.42 ± 0.15[a]	6.33 ± 0.14[a]	5.92 ± 0.15[b]	*

[a–b] Means in a same row with different letters are significantly different.
[#]Standard error of the mean
[##]Significance of treatment effect: *P <0.05, **P<0.01, NS - Not Significant
[A] Same as Table 1

Table 4: Sensory evaluation scores of chicken nuggets with/without oat flour (Mean ± SE[#]).

	Treatments[A]			Significance of treatment effect[##]
	C	O10	O20	
Moisture (%)	57.40 ± 1.04[a]	61.17 ± 0.17[b]	62.12 ± 0.85[b]	*
Crude Protein (%)	18.03 ± 0.35[a]	16.94 ± 0.30[ab]	15.79 ± 0.45[b]	*
Crude Fibre (%)	0.76 ± 0.05[a]	1.20 ± 0.08[b]	1.81 ± 0.14[b]	*
Fat (%)	3.02 ± 0.12[a]	2.40 ± 0.12[b]	2.31 ± 0.14[b]	*
Total Ash (%)	1.76 ± 0.31	2.07 ± 0.43	2.08 ± 0.15	NS
Gross Energy (%)	1871 ± 48.43[a]	1880 ± 21.07[a]	2046 ± 49.99[b]	*

[a–b] Means in a same row with different letters are significantly different.
[#]Standard error of the mean
[##]Significance of treatment effect: *P <0.05, NS - Not Significant.
[A] Same as Table 1

Table 5: Proximate composition of chicken nuggets with/without oat flour (Mean ± SE[#]).

with 20% and 10% OF were below and above 6 points, respectively (Table 4), indicating that the latter was not significantly different from the control. The juiciness score increased significantly (P<0.05) with the increase in the level of the OF inclusion. The texture score, however, did not differ when the OF was added up to 10%, although it decreased significantly (P<0.01) at the 20% level. The flavor score decreased significantly (P<0.05) with the inclusion of OF but there was no significant difference between the treatments.

Proximate analyses

The proximate compositions of the nuggets are shown in Table 5. The crude fiber content of the treatments significantly (P<0.05) increased with the level of inclusion of the OF. The crude protein and fat levels decreased significantly with the increased level of the OF. The moisture level increased significantly (P<0.05) in the treatments more than the control.

Discussion

Increase in cooking yield was similar to the reports of by Pinero et al. [24], Dawkins et al. [29] and Talukder and Sharma [30]. This is possibly due to the improved water binding capacity as observed by various researchers [31-33]. The addition of oat fiber to chicken frankfurters increased the processing yields [7] and the inclusion of hydrated oat-meal in the preparation of low-fat sausages retained the product moisture during cooking, with decreased cooking loss [23]. Alvarez and Barbut [34] established that increasing the level of β-Glucan which is the soluble fiber in oats, in cooked meat batters resulted in a significant decrease in cooking losses. Serdaroglu [33] observed no difference in cooking loss between the treatments with oats.

Previously, some researchers observed an increase in the hardness of the emulsion meat products with the inclusion of oats in different forms, in different quantities [7-9], whereas a few reported a decrease in the hardness [23,32,35]. The changes in the hardness values due to the addition of oats had been attributed to the added water content which plays an important role in product hardness [7]. Similarly, in chevon patties with oat bran, the shear force values were found to be lower than the control due to the decrease in cohesion resulting from the increase in the fiber content which was attributed to the good binding capacity of the proteins [29]. Contrary to this, Talukder and Sharma [30] stated that the incorporation of oat bran increased the shear press values of the chicken meat patties.

Yang et al. [23] reported a decrease in the gumminess and chewiness values and no change in the springiness value with the increasing levels of the added hydrated oatmeal and tofu to the pork sausage. With the addition of oat fiber in dry fermented sausages, Garcia et al. [8] observed less adhesiveness and elasticity which was represented by 'springiness' and no changes in the gumminess and chewiness. These variations in the TPA values from the earlier studies may be attributed to the differences in product formulation [36], cooking methods [37,38], processing methods [39], meat from various species [40] and other factors [41].

The sensory scores were in concurrence with the findings of Huang et al. [9]. Similar observations had been recorded by Talukder and Sharma [30] where the overall acceptability scores were lower in the oat bran-added chicken patties. In mutton koftas, the oat flour affected sensory quality of the product up to more than 8% [42]. Juiciness scores increased with OF level as reported by Serdaroglu [33] and Yang et al. [23] due to more moisture retention in the product during cooking. In accordance with our results, Yang et al. [23] demonstrated that acceptable low-fat pork sausages could be made by replacing the pork with hydrated oatmeal, to up to 25%. However, the addition of oatmeal to the pork sausages significantly increased the sensory scores for flavor and tenderness [23]. This may be due to the difference in the formulations and processing methods of the prior studies.

As observed by Dawkins et al. [29] and Huang et al. [9], OF inclusion increased the crude fiber level in the product since the insoluble fiber content of oats is higher than that of meat. In concurrent with the findings of Dawkins et al. [29], Talukder and Sharma [30] and Kerr et al. [35], a decrease in crude protein and fat levels was observed with increase in the levels of OF which may be attributed to the contribution of carbohydrates from OF where the protein and fat content of oats is lower than that of meat. Increase in moisture levels was similar to the findings of Garcia et al. [8]. However, in the chevon patties formulated with oat bran, Dawkins et al. [29] reported a decrease in the moisture with the increased addition of the level of oat bran. Yılmaz and Dağlıoğlu [43] found a decrease in the moisture percentage and an increase in the protein percentage, with an increase in the oat bran addition in the meat balls prepared from veal. These differences in results may be due because the absorption and retention of moisture varies with the type of meat, form of oats and cooking method [30]. Yang et al. [23] stated that the moisture content would not affect either the physical properties or the sensory ratings for sausages with hydrated oatmeal.

The addition of oat flour to the chicken nuggets improved the cooking yield and juiciness of the product. The insoluble fiber percentage increased and fat percent of the nuggets decreased by the addition of the oat flour in the batter. Thus, the inclusion of oat flour is a potential way to develop low-fat emulsion meat products enriched with dietary fiber [44]. However, depending upon the quantity of oat flour added, undesirable changes in the textural and sensory properties

were observed. Although the variation in texture was minimal and the overall sensory acceptability was good after the addition of the 10% oat flour inclusion, at the 20% level it was not so desirable. Hence, this study concluded that acceptable low-fat chicken nuggets can be made in with 10% oat flour, over and above the meat in the formulation.

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