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Research Article

Development of dietary fiber enriched chicken nugget using wheat bran

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Abstract

An experiment was conducted to find out the effect of different levels of wheat bran on the sensory, oxidative stability, physicochemical properties in different storage period of broiler meat nugget. For this purpose, nuggets were prepared in 3 different groups. They were T_1 (chicken nugget incorporated with 0% wheat bran), T_2 (chicken nugget incorporated with 5% wheat bran), T_3 (chicken nugget incorporated with 10% wheat bran). All parameters were analyzed at 0^{th}, 14^{th} and 28^{th} days. The sensory evaluation was evaluated at day one. The proximate composition of different nuggets was analyzed and highly significant differences were found in CP (%) and CF (%). Significantly, higher CF (%), Ash (%) were found in T_3, while CP (%) was significantly higher in T_1. No significant differences were found in EE (%) and DM (%) among the treatments. Storage period had highly significant on CP only. CP (%) content is increased with increase of storage period. The surface color (CIE L*, a*, b*) of nugget samples were measured. Significantly, the highest lightness value was found in T_1 and lowest value was found in T_3. Storage period had an effect on lightness value also. Increasing the storage value lightness decreased. Treatment had no effect on pH, but storage period had effect on pH. Significantly, lower pH was found in 14^{th} days of storage period. During biochemical analysis, it was found that treatment had no effect on free fatty acid value (FFA) and per-oxide value (POV) but had effect on Thiobarbituric acid reactive substances (TBARS). However, storage period had effect on FFA, POV and TBARS value. Increasing the storage period FFA, POV and TBARS values increased. During sensory analysis, all parameters including overall acceptability did not differ among the treatments concluded that wheat bran up to 10% could be used in nugget preparation with no change in consumer acceptance.

Introduction

Chicken nuggets are immensely popular, especially among children and young adults. They are a staple in fast food menus and are widely available in grocery stores, making them a convenient and accessible food choice for many people. These are easy to eat, requiring minimal preparation and utensils. Their bite-sized nature makes them ideal for on-the-go consumption, making them a convenient option for busy individuals and families. Chicken nuggets are typically made from chicken meat, which is a good source of protein. While the nutritional value can vary depending on the ingredients and preparation method, chicken nuggets can contribute to meeting daily protein requirement (Khatun et al., 2022). Chicken nuggets have evolved over the years to include a wide range of flavors, coatings, and dipping sauces. This constant innovation keeps them relevant and appealing to different tastes and preferences. The popularity of functional meat products like nuggets, sausages, and meatballs in Bangladesh is increasing due to urbanization, family breakdown, quality, convenience, working women, and rising per capita income (Akter et al., 2022; Bithi et al., 2020; Boby et al., 2021; Disha et al., 2020; Hossain et al., 2021). These foods fulfill modern human needs and cater to the changing lifestyles of middle-income individuals, making them widely used in both developed and developing countries (Gerber et al., 2009). Nugget, a popular meat product in developed countries, is gaining popularity due to its quick preparation time and high nutritional value. (Angulo and Gil, 2007; Fonseca and Salay, 2008). Nugget is the best sources of a complete protein, fats, essential amino acids, minerals and vitamins that are essential for optimal development and growth (Verbeke et al., 2010). Consumers are becoming more health conscious and this is leading to a growing preference for healthier, more nutritious and more functional food products. For chicken nugget, much attention has focused on its chemical composition and physical component as well as attractive appearance (Tushar et al., 2023; Rahman et al., 2023). Value-added meat products are gaining popularity due to their quality and safety, with chicken nuggets offering health benefits like high protein and saturated fat, but less carbohydrate and fiber (Newman and Newman, 2008). Fiber is crucial for maintaining a healthy weight, and cereal by-products like wheat bran and rice bran can be added to chicken nuggets to increase fiber content. Wheat bran is popular in Bangladesh due to its health benefits, including dietary fiber, vitamins and minerals, and its versatility in meal preparation. It also contains high amount of crude protein (Abdel et al., 2011)). Therefore, it may fulfill all nutritional demand. Many researches have been done on nuggets, but limited work has been done on nugget prepared with wheat bran to increase the content of fiber.

Materials and method

Experimental Design

Three broiler nugget formulations were developed (Table 1), as follows: 1) Broiler meat with 0% wheat bran 2) Broiler meat with 5% wheat bran 3) Broiler meat with 10% wheat bran.

Broiler nugget preparation

Breast was separated from dressed broiler. All visible fat and connective tissue were trimmed off as far as possible with the help of knife and the sample was cut into small pieces. Broiler meat was ground with the help of a meat grinder. The ground meat was then mixed with some spices i.e. garlic pest, ginger pest, onion pest, salt etc. The meat was divided into 3 parts T_1, T_2, and T_3 respectively. T_1, T_2 & T_3 were compounded with 0%, 5% and 10% wheat bran respectively. Meat from each mixture then was taken and shaped with small round pieces. The small pieces were steamed for 10 minutes. A basic nugget formulation for all treatments were shown in Table (1). The prepared nuggets were divided into 3 parts & kept in boxes and stored in refrigerator (-20°C) for up to 30 days and assessed immediately after processing (0 day) and at interval of 14^{th} & 28^{th} day post storage.

Table 1: Preparation of chicken nugget

Ingredients	Chicken nugget with 0% Wheat Bran (T_1)	Chicken nugget with 5% Wheat Barn (T_2)	Chicken nugget with 10% Wheat Bran (T_3)
Meat	650	600	550
Wheat bran	0	50	100
Wheat flour	30	30	30
Salt	15	15	15
Cold water	96	96	96
Soybean oil	75	75	75
Skim milk powder	25	25	25
Whole liquid egg	50	50	50
Bread crumbs	25	25	25
Garlic	10	10	10
Onion	12	12	12
Spices mix	12	12	12
Total	1000	1000	1000

Product analysis

The surface color (CIEL*, a*, b*) of nugget

The surface color (CIE L*, a*, b*) of chicken nugget samples was measured at the department of Food Science and Technology using a Minolta Chroma Meter (Minolta CR 410, Tokyo, Japan) standardized with a white plate (Y =93.5, X = 0.3132, y = 0.3198). Three random readings were taken from each nugget sample.

Proximate composition of prepared nugget

Proximate composition such as dry matter (DM), ether extract (EE), crude protein (CP), crude fiber (CF) and ash were carried out according to the standard methods (AOAC, 1995). All determinations were done in duplicate and the mean value was reported.

pH measurement

Five gram of nugget sample was taken in a blender jar and 25ml-distilled water was added. The mixer was blended at high speed for 1 min. pH value of sample was measured using a digital pH meter (model 210, HANNA instruments microprocessor pH meter). The homogenate was prepared by blending 5 g of meat with 25ml distilled water.

Biochemical properties

There were three types of Biochemical properties analysis were done. These were Free Fatty Acid (FFA), Peroxide Value (POV) and Thiobarbituric acid reactive substances (TBARS). Free fatty acid value was determined according to Rukunudin et al. (1998).

FFA (%) = (ml titration × Normality of KOH × 28.2) / g of sample

Peroxide value of the nugget samples was determined according to AOAC (1995).

POV was calculated as shown below:

POV %= {(A-B) ×N×1000}/S

Where, B= reading of blank in ml, A= reading of sample ml, S=weight of oil sample, N= normality of $Na_2S_2O_3$

Lipid oxidation was assessed in triplicate using the Thiobarbituric acid reactive substances (TBARS) method described by Schmedes and Holmer (1989).

TBARS=Abs 532 nm× 7.8 (conversion factor) mg malonaddehyde/kg nugget

Sensory evaluation

Different sensory attributes were examined at day 1. The nuggets were fry in a fry pan with soybean oil. A trained panel of 6-honorable judges at Bangladesh Agricultural University evaluated each nugget sample. Recruitment, selection and training of panelist were performed according to sensory evaluation procedure (AMSA, 1995). The sensory questionnaires measured intensity on a 5-point balanced semantic scale (weak to strong) for the following attributes color, smell, tenderness, juiciness and overall acceptability. Sensory evaluation was carried out in individual booths under controlled conditions of light, temperature and humidity. Sensory qualities of the samples were evaluated after thawing of before cook and after cook using a 5-point scoring method.

Statistical analysis

The proximate and bio-chemical data from nugget batter and the sensory data from different nugget were analyzed where applicable, using analysis of variance technique by a computer using SAS statistical package program in accordance with the principles of Completely Randomized Design (SAS, 2009). DMRT was done to compare variations among treatments where ANOVA showed significant differences. While the proximate, physicochemical and microbial data from different nuggets were analyzed with 3×3 factorial design (where 3 is different nugget and 3 is different storage period) with the principles of Completely Randomized Design (SAS, 2009). DMRT was done to compare variations among treatment means and storage period means where ANOVA showed significant differences.

Result and Discussion

Proximate composition of different nuggets

The proximate composition of different nuggets was analyzed and highly significant differences were found in CP (%) and CF (%) (Table 2). Significantly, higher CF (%), Ash (%) were found in T_3, while CP (%) was significantly higher in T_1. No significant differences were found in EE (%) and DM (%) among the treatments. Storage period had highly significant on CP only. The CP (%) content is increased with increase of storage period.

Table 2. Proximate composition of chicken nugget containing wheat bran during different storage time

Parameter (%)	Storage time (Day)	Dietary treatment				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
DM	0	36.44±1.64	33.91±3.91	37.67±3.75	36.01	NS	NS	NS
	14	33.58±0.32	37.01±1.97	40.14±0.11	36.91			
	28	35.69±0.61	39.69±1.00	41.53±0.49	38.97			
	Mean	35.23	36.87	39.78				
CP	0	16.69±0.19	15.02±0.60	14.00±0.55	15.24^{c}	**	**	NS
	14	19.99±1.80	16.28±0.44	14.90±0.62	17.05^{b}			
	28	21.87±0.34	18.56±0.34	18.06±0.42	19.49^{a}			
	Mean	19.52^{a}	16.62^{b}	15.65^{b}				
Ash	0	2.02±0.09	2.46±0.08	2.89±0.06	2.46	**	NS	NS
	14	2.07±0.01	2.23±0.04	2.75±0.13	2.35			
	28	2.07±0.25	2.26±0.02	2.40±0.04	2.24			
	Mean	2.05^{c}	2.31^{b}	2.68^{a}				
EE	0	9.12±0.59	8.88±0.71	8.55±0.47	8.85	NS	NS	NS
	14	8.06±0.15	7.76±0.19	9.02±0.03	8.29			
	28	9.33±0.65	7.33±0.15	7.90±0.22	8.19			
	Mean	8.84	7.99	8.49				
CF	0	0.15±0.01	0.34±0.02	.48±0.07	0.32	**	NS	NS
	14	0.11±0.03	0.31±0.21	0.65±0.03	0.36			
	28	0.08±0.04	0.37±0.13	0.69±0.09	0.38			
	Mean	0.11^{c}	0.34^{b}	0.60^{a}				

T_1 = Chicken meat+0% wheat bran; T_2 = Chicken meat+5% wheat bran; T_3 = Chicken meat +10% wheat bran; NS, P>0.05; **, P<0.01;

Table 3. pH of chicken nugget containing wheat bran during different storage time

Parame-ter	Storage time (Day)	Dietary treatment				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
pH	0	6.65±0.04	6.55±0.02	6.59±0.02	6.60^{b}	NS	**	**
	14	6.52±0.01	6.44±0.03	6.47±0.03	6.48^{c}			
	28	6.59±0.07	6.78±0.03	6.72±0.02	6.70^{a}			
	Mean	6.59	6.59	6.59				

T_1= Chicken meat +0% wheat bran; T_2 = Chicken meat+5% wheat bran; T_3 = Chicken meat +10% wheat bran; NS, P>0.05; **, P<0.01;

pH

The pH of different treatments with days of intervals is demonstrated in Table 3. The mean values observed from three treatment groups indicated that no significant differences were found among the treatments. The pH range of overall observed during different days of storage intervals of pH was 6.48 to 6.70. The mean values observed in 0, 14th and 28th days of observation indicated that there were highly significant ($p<0.01$) differences among these three days of observation. However, the maximum value was observed at 28th day and minimum value was observed at 14th day. The interaction between treatment and number of days had also highly significant effect ($p<0.01$) on the level of pH. The mean pH was not similar in all the groups on all the days of analysis. McCarthy et al., (2001) reported no difference in the pH of control and test antioxidants like grape seed, bearberry and rosemary extracts incorporated raw and cooked pork meat products. Sharima

et al. (2018) reported that the range of pH value was between 6.52 to 6.70 in chicken nugget incorporated with chickpea flour and control nugget and showed significant difference among the samples.

The surface color (CIEL*, a*, b*) of nugget

The surface color (CIE L*, a*, b*) of chicken nugget samples was measured at the department of Food Science and Technology using a Minolta Chroma Meter (Minolta CR 410, Tokyo, Japan) standardized with a white plate (Y =93.5, X = 0.3132, y = 0.3198). The surface colors of nuggets are presented in Table 4. Storage period had highly significant effect on lightness values. With the increasing of the storage time lightness values were decreased. The range of overall observed color score at different treatment for lightness was 65.64 to 68.03. The mean values observed from three treatments indicated that there were no significant differences (P>0.05) among the treatments. Although no significant differences were found, higher reading was observed from T_1 group (chicken nugget with 0% wheat bran) and lower value was recorded from T_3 group. Whereas, the range of different days of interval of overall observation of color score for lightness was 61.56 to 71.93. The mean values of 0, 14^{th} and 28^{th} days of observation indicated that there were highly significant differences ($p<0.01$) among these days of observation. Higher reading was observed from 0 day and lower reading was observed from 28^{th} day. No Significant differences ($p>0.05$) existed between the interaction of treatments and number of days it was stored under refrigerated condition. Singh et al., (2014) noticed that L* value did not vary significantly among different treatments and storage period of raw chicken meat by using different natural preservatives.

Dhingra et al. (2012) reported that L* value significantly varied in chicken nugget incorporated with hydrated wheat bran and control. The range of overall observed color score at different treatment for redness was 1.77 to 3.73. From the mean values, it had been observed that there was no significant difference ($p>0.05$) among three treatments. Although no significant differences were found, among them higher reading was observed in T_1 group and lower color score was observed in T_2 group. Whereas, the range of different days of interval of overall observation of color score for redness was 1.84 to 3.38. The mean values of 0, 14^{th} and 28^{th} days of observation indicated that there were no significant differences ($p>0.05$) among these days of observation. Although no significant differences were found, higher value was observed from 14^{th} day and lower from 0 day. The data showed that redness score increased gradually with the increase in storage period. But there were no significant differences ($p>0.05$) between the interaction of treatments and number of days it stored under refrigerated condition. Singh et al., (2014) when conducted an experiment on the shelf life evaluation of raw chicken meat by using different natural preservatives reported that redness (a*) value increased significantly with the increase in storage period. Dhingra et al., (2012) reported that a* value significantly increased in chicken nugget incorporated with hydrated wheat bran compared to the control nugget. The range of overall observed color score at different treatment for yellowness was 15.71 to 20.36. The mean values indicated that there were no significant differences ($p>0.05$) among the dietary treatments. Although no significant differences were found, higher score was observed from T_1 and lower color score was observed from T_2 group. Whereas, the range of different days of interval of overall observation of color score for yellowness was 16.94 to 19.99. The mean values of 0, 14^{th} and 28^{th} days of observation indicated that there were no significant differences ($p>0.05$) exist among these days of observation. Although no significant differences were found, higher color score was observed at 28^{th} day and lower in 0 day. However, there were significant differences ($p<0.05$) between the interaction of treatments and number of days it stored under refrigerated condition. Anna (2011) observed a decreased color test scores during storage resulting from the denaturation of proteins, particularly the myofibril protein that affects gel formation. Dhingra et al. (2012) reported that b* value significantly increased in chicken nugget incorporated with hydrated wheat bran compare to control nugget.

Table 4. International commission on illumination color measurements (CIE*) of chicken nugget containing wheat bran during different storage time

Para meter	Storage time (Day)	Dietary Treatments				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
L*	0	78.23±1.28	69.94±3.42	67.64±0.57	71.93[a]	NS	**	NS
	14	66.24±3.31	72.25±1.16	65.27±5.25	67.92[a]			
	28	59.62±4.10	61.05±4.26	64.02±5.25	61.56[b]			
	Mean	68.03	67.75	65.64				
a*	0	1.16±0.15	1.83±0.12	2.54±0.38	1.84	NS	NS	NS
	14	4.42±2.65	1.75±0.09	3.97±0.059	3.38			
	28	5.60±0.2.15	1.73±0.50	2.13±0.40	3.15			
	Mean	3.73	1.77	2.88				
b*	0	16.11±.26	15.37±1.20	19.46±2.30	16.98	NS	NS	*
	14	17.11±1.81	16.56±0.12	19.78±2.63	17.82			
	28	27.87±5.26	15.20±0.93	16.89±1.46	19.99			
	Mean	20.36	15.71	18.71				

T_1= Chicken meat +0% wheat bran; T_2 = Chicken meat +5% wheat bran; T_3 = Chicken meat +10% wheat bran; NS, P>0.05; *, P<0.05; **, P<0.01

Biochemical properties

Table showed the Free Fatty Acid value of different treatment levels with days of intervals. The range of overall observed FFA value at different treatments was 0.0 to 0.02. Treatment had no significant difference ($p>0.05$) on FFA value. On the other hand, overall observed in different days of intervals of FFA was ranged 0.01 to 0.02. The mean values observed in 0, 14^{th} and 28^{th} days of observation indicated that there were significant ($p<0.05$) differences among these three days of observation. The FFA value was increased with increasing storage period. The highest FFA value was observed at 28^{th} days of observation. The interaction between treatment and number of days had no significant difference ($p>0.05$) on the level of FFA. Modi et al. (2004) reported that the FFA value gradually increased in fresh and smoked meat nuggets as 3.9 and 3.7

respectively during 6 months of frozen storage. Baker et al., (2013) reported that free fatty acids content was significantly increased with increasing storage period which was similar to findings of this study.

Peroxide value (POV-meq/kg) of different treatment levels with the days of intervals is shown in Table 5. The mean values observed from three treatment groups indicated that there were no significant differences ($p>0.05$) among the dietary treatments. The range of overall observed values of different days of intervals was 1.57 to 2.05. The mean values observed at 0, 14th and 28th days of observation indicated that there were highly significant differences ($p<0.01$) among these three days of observations. Higher value was found at 28th and lowest value was observed at 0 day of storage. The interaction between treatments and number of days had a significant difference ($p<0.05$) on the level of peroxide value. Other studies have also reported an increasing peroxide value over storage time in products with or without antioxidants. However, antioxidant treatments generally can minimize the peroxide value in the food sample during storage compared with the control. Dashti et al. (2015) observed significant increase in peroxide value throughout 6 months at -20ºC storage of chicken nugget. The increase was found in peroxide value in a proper use of thyme essential oil in industrially produced nuggets instead of synthetic antioxidant. Das et al. (2008) reported a significant increase in peroxide value of the meat samples during refrigerated storage.

Table 5 stated the TBARS values of different treatment levels with days of intervals. The range of overall observed TBARS value at different treatment levels was 0.14 to 0.15. The mean values observed from different treatment groups indicated that there were significant differences ($p<0.05$) among the treatment groups. Higher TBARS value was observed from T_2 (chicken nugget with 5% wheat bran) and lower was observed from T_1 and T_3. The overall observed in different days of intervals of TBARS value was ranged 0.13 to 0.17. The mean values observed from 0, 14Th and 28th and days of observation indicated that there were highly significant differences ($p<0.01$) exist among these three days of observation. However, the highest TBARS value was observed at 28th day and values were observed same at 0 and 28th. The interaction between treatment and number of days it was stored had no significant difference on the level of TBARS. The TBARS values increased significantly with increasing the storage period. Deepak et al. (2018) found no significant differences in TBARS value of control and flaxseed flour enriched nuggets with an increase in storage period. The TBARS value was decreased with the increased of flaxseed concentration.

Table 5. Biochemical properties of chicken nugget containing wheat bran during different storage time

Parameter	Storage time (Day)	Dietary treatment				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
FFA	0	0.01±0.00	0.01±0.00	0.02±0.01	0.01^{b}	NS	*	NS
	14	0.02±0.00	0.02±0.01	0.02±0.00	0.02^{a}			
	28	0.02±0.00	0.02±0.00	0.02±0.01	0.02^{a}			
	Mean	0.02	0.02	0.00				
POV	0	1.55±0.02	1.59±0.02	1.59±0.02	1.57^{c}	NS	**	*
	14	1.92±0.09	2.00±0.02	1.62±0.01	1.85^{b}			
	28	1.92±0.09	2.09±0.09	2.14±0.03	2.05^{a}			
	Mean	1.79	1.89	1.78				
TBARS	0	0.12±0.00	0.14±0.01	0.12±0.00	0.13^{b}	*	**	NS
	14	0.12±0.00	0.13±0.01	0.13±0.01	0.13^{b}			
	28	0.17±0.01	0.18±0.01	0.17±0.01	0.17^{a}			
	Mean	0.14^{b}	0.15^{a}	0.14^{b}				

T_1= Chicken meat +0% wheat bran; T_2 = Chicken meat+5% wheat bran; T_3 = Chicken meat +10% wheat bran; NS, P>0.05; *, P<0.05; **, P<0.01

Sensory evaluation

Sensory evaluation is a scientific discipline that applies principles of experimental design and statistical analysis to the use of human senses (sight, smell, taste, touch and hearing) for the purpose of evaluating consumer products. The sensory analysis was done at day 1 old nuggets. The effects of sensory evaluation were shown in Table 6. The data obtained from different treatment indicated that there was no significant difference among the treatments in color, flavor, off-flavor, juiciness, tenderness and overall acceptability among the chicken nuggets from sensory evaluation ($p > 0.05$)

Table 6. Sensory properties of chicken nugget containing wheat bran during different storage time

Parameters	Dietary treatments			Level of Significance
	T_1	T_2	T_3	
Color	4.20±0.01	4.17±0.01	4.19±0.01	NS
Flavor	4.17 ±0.01	4.15 ±0.01	4.15 ±0.01	NS
Off-flavor	1.04 ±0.01	1.06 ±0.01	1.04 ±0.01	NS
Juiciness	4.13 ±0.03	4.09 ±0.02	4.12 ±0.01	NS
Tenderness	4.12 ±0.02	4.11 ±0.03	4.11 ±0.02	NS
Overall acceptability	4.15 ±0.02	4.13 ±0.02	4.13 ±0.01	NS

Conclusion

It can be concluded that wheat bran up to 10% can be used in nugget preparation with no change in consumer acceptance.

Conflict of interest

There is no conflict of interest among the authors.

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