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Research Article

Development of dietary fiber enriched chicken nugget using rice bran

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Abstract

The experiment was conducted to investigate the impact of varying levels of rice bran on the sensory attributes and storage qualities of broiler meat nuggets. Three distinct groups were formed for this purpose: T_1 (chicken nuggets without rice bran), T_2 (chicken nuggets with 5% rice bran), and T_3 (chicken nuggets with 10% rice bran). The analysis encompassed parameters assessed at 0, 14, and 28 days, with sensory evaluation conducted on the first day. The proximate composition of the nugget was examined, revealing significant differences in dry matter (DM), crude protein (CP), Ash and crude fiber (CF) percentages ($p<0.05$). T_3 exhibited notably higher DM, ash and CF content, while T_1 showed higher CP. No significant disparities were observed in EE across the treatments. Storage duration significantly influenced DM, CP, ash, and EE content, with an increase noted in DM and CP over time, while ash content decreased. Surface color (CIE L*, a*, b*) measurements of the nugget samples indicated significantly higher lightness in T_1 and lower lightness in T_3, with storage duration also impacting lightness, which decreased with time. Treatment had no effect on pH, but storage duration influenced it, with significantly lower pH observed after 14 days of storage. Biochemical analysis revealed that treatment did not affect free fatty acid value (FFA), peroxide value (POV), or Thiobarbituric acid reactive substances (TBARS), although storage duration influenced POV and TBARS values, which increased over time. During sensory analysis, including overall acceptability, no discernible differences were found among the treatments, suggesting that rice bran incorporation up to 10% in nugget preparation does not compromise consumer acceptance.

Introduction

The poultry industry plays a significant role in advancing agricultural development and mitigating malnutrition among the people of Bangladesh. This industry, accounting for 14% of the total value of livestock output, is experiencing rapid growth. Poultry meat alone contributes to 37% of Bangladesh's total meat production, forming a substantial portion of the nation's animal protein supply, ranging from 22% to 27% (Hamid et al., 2017). Recent shifts in consumer preferences have created a demand for food products that are convenient and easy to prepare. As a response to this, a range of meat products, including breaded and battered items has been developed to offer cost-effective, practical, and ready-to-eat options with appealing sensory attributes (Echeverria et al., 2022). At the same time, there is a growing desire for heal their foods including low-fat foods and functional or nutraceutical foods. According to the national health strategy, each adult need 120g of meat per day. However, the availability is now only 67.17% (Hamid et al., 2017). The amount of meat produced in the country has been increasing over time, but the amount per person is still significantly below the bare minimum. Animal protein is the most important component for human physiology. In Bangladesh, poultry meat is one of the important sources of animal protein. Bangladesh's consumption of poultry meat has increased day-by-day (FAO, 2013). In Bangladesh, desire for meat products is rising along with the consumption of poultry meat. Besides this, the popularity of functional meat products such nuggets, sausages, meatballs, chicken burgers, and others are also growing every day (Bithi et al., 2020; Boby et al., Disha et al., 2020; Khatun et al., 2022). The current tendency has changed how people typically eat simple, easily digested foods, in contrast to former periods when people ate slowly and lavishly. Because of this, the availability of such foods satisfies all of the needs of modern humans. Value-added meat products are steadily gaining in popularity. These goods are inexpensively offered in the market and are easily accessible. The quality and safety of processed meat products are more important to modern customers than their price (Ali et al., 2022; Azad et al., 2021; Hossain et al., 2021, Tushar et al., 2023). Although chicken nuggets/sausages are low in fiber and carbohydrates, they are high in protein and saturated fat. According to (Newman and Newman, 2008), crude fiber is good for the heart, blood pressure, and bones. Fiber is helpful in maintaining a healthy weight as well. Therefore, this research was undertaken to increase the crude fiber level of meat products.

Materials and Methods

Experimental Design

Three different formulations of broiler nuggets were developed (refer to Table 1), consisting of: Broiler meat 0% rice bran (T_1), Broiler meat with 5% rice bran (T_2), and Broiler meat with 10% rice bran (T_3).

Table1: Preparation of chicken nugget

Ingredients (g)/(ml)	Treatments		
	Chicken nugget without Rice bran (T_1)	Chicken nugget with 5% Rice bran (T_2)	Chicken nugget with 10% Rice bran (T_3)
Chicken breast meat	650	600	550
Rice bran	0	50	100
Soybean oil	75	75	75
Skim milk powder	25	25	25
Whole Liquid egg	50	50	50
Bread Crum	25	25	25
Salt	15	15	15
Garlic	10	10	10
Onion	12	12	12
Spices mix	12	12	12
Ice	96	96	96

Broiler nugget preparation

In this experiment, 10 broiler birds were collected from local market near BAU campus. Rice bran & some spices (garlic, ginger, salt) were purchased from local market. The broilers were slaughtered and the breast meat was carefully separated from the dressed broiler. Any visible fat and connective tissue were diligently removed using a knife, and the meat was then cut into small pieces. Next, the broiler meat was ground with the assistance of a meat grinder. This ground meat was combined with various spices, including garlic paste, ginger paste, onion paste, salt, and other ingredients. The meat mixture was divided into three parts, labeled as T_1, T_2, and T_3. T_1 had no bran, while T_2 and T_3 were prepared with 5% and 10% rice bran, respectively. The meat from each mixture was taken and shaped into small round pieces. These small pieces were steamed for duration of 10 minutes. The prepared nuggets were divided into three portions and placed in containers, then stored in a refrigerator at -20°C for a period of 28 days. They were evaluated immediately after processing at 0 day and at intervals of 14th and 28th days following storage.

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 Animal Science 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 analysis

Proximate composition such as dry matter (DM), ether extract (EE), crude protein (CP), crude fiber and Ash were carried out according to the standard methods (AOAC, 1995).

pH measurement

5 g 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 analysis

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

The total nugget samples were divided into three groups. Different sensory attributes were examined at 1-day-old nugget. 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), 6 panelists were screened from 10 potential panelists using basic taste identification test. 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.

The judges evaluated the samples based on the above criterions. Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, smell, juiciness, tenderness, overall acceptability) of nugget using an intensity scale. Sensory qualities of the samples were evaluated after thawing of before cook and after cook using a 5-point scoring method. Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair and 1 for poor. All samples were served in the Petri dishes.

Statistical analysis

The sensory data from different nugget were analyzed 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 biochemical data from different nuggets were analyzed with 3×3 factorial design (where three was different nugget and 3 was 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.

Results and Discussion

Proximate analysis of nugget

The proximate composition of different nuggets was analyzed in table 4 and highly significant differences were found in DM%, CP%, Ash% and CF% among different nuggets as well as among different storage time. The highest DM, Ash and CF content was observed on the 10% rice bran treated nuggets and CP was highest in 0% rice bran treated nuggets. Moreover, DM and Ash were increased and CP was decreased with increase of storage time. Deepak et al. (2018) reported an increase in DM content with the addition of flaxseed, in contrast to the control chicken nugget where no significant difference was observed. Ali et al. (2011) discovered that the addition of rice flour significantly reduced the crude protein content compared to the group without flour.

Table 2: Proximate composition of chicken nugget incorporated with rice bran during different storage time

Parameter (%)	Storage time (Day)	Treatment				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
DM	0	36.44±1.46	37.45±0.80	39.95±0.36	37.95^{b}	**	**	NS
	14	33.57±0.32	35.53±1.38	40.16±0.11	36.42^{c}			
	28	35.69±0.61	40.44±0.55	42.78±0.17	39.63^{a}			
	Mean	35.23^{c}	37.80^{b}	40.96^{a}				
CP	0	16.69±0.19	16.05±0.02	15.81±0.17	16.18^{c}	**	**	NS
	14	19.99±1.80	17.40±0.11	17.13±0.00	18.17^{b}			
	28	21.87±0.34	20.33±0.02	18.99±0.25	20.40^{a}			
	Mean	19.52^{a}	17.93^{b}	17.31^{b}				
Ash	0	2.02±0.09	3.19±0.02	3.53±0.03	2.91^{a}	**	*	NS
	14	2.07±0.01	2.94±0.21	3.29±0.11	2.77^{ab}			
	28	2.07±0.25	2.57±0.05	3.04±0.12	2.56^{b}			
	Mean	2.05^{c}	2.90^{b}	3.29^{a}				
EE	0	9.12±0.59	9.54±0..06	9.04±0.01	9.23^{aa}	NS	**	NS
	14	8.06±0.15	8.29±0.14	7.28±0.14	7.88^{b}			
	28	9.32±0.65	8.96±0.06	8.71±0.16	9.00^{a}			
	Mean	8.84	8.93	8.34				
CF	0	0.15±0.01	0.66±0.06	1.37±0.18	0.72	**	NS	NS
	14	0.11±0.03	0.92±0.08	1.16±0.15	0.73			
	28	0.08±0.04	0.76±0.14	1.40±0.11	0.75			
	Mean	0.11^{c}	0.78^{b}	1.31^{a}				

T1=Chicken nugget without rice bran; T2= Chicken nugget 5% rice bran; T3= Chicken nugget 10% rice b

pH

Table 3 presents the pH values of various treatment groups at different time intervals. The mean values observed across the three treatment groups indicated that there was no significant difference ($p>0.05$) among the treatments. However, the lower pH value was observed in the T3 group (chicken nuggets with 10% rice bran), while the higher pH value was observed in the T2 group (chicken nuggets with 5% rice bran). Similarly, the range of pH values observed over different time intervals ranged from 6.43 to 6.63. The mean values for observations on days 0th, 14th, and 28th indicated significant differences ($p<0.01$) among these three time points. The highest pH value was observed on the 28th day, and the lowest value was observed on the 14th day. Nonetheless, the interaction between treatment and the number of days did not have a significant effect ($p>0.05$) on pH levels. The mean pH values were relatively consistent across all the groups on all days of analysis. This trend aligns with the findings of Sharima-Abdullah et al. (2018), who reported a pH range between 6.52 and 6.70 in chicken nuggets incorporated with chickpea flour and control nuggets, which showed significant differences among the samples.

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

Parameter	Storage time (Day)	Dietary Treatments				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
pH	0	6.65± 0.03	6.54±0.01	6.58±0.05	6.59	NS	**	NS
	14	6.52±0.01	6.35±0.01	6.41±0.05	6.43			
	28	6.60±0.07	6.62±0.06	6.69±0.03	6.63			
	Mean	6.59	6.51	6.56				

T1=Chicken nugget without rice bran; T2= Chicken nugget 5% rice bran; T3= Chicken nugget 10% rice bran; NS, P>0.05; *, P<0.05; **, P<0.01; T=Treatment, D=Day.

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

The observed color scores for lightness in various treatment groups ranged from 58.42 to 68.03. The mean values obtained from these treatments revealed significant differences ($p<0.05$) among them, with the highest score seen in the T_1 group (chicken nuggets without rice bran) and the lowest in the T_3 group (chicken nuggets with 10% rice bran). There were significant differences ($p<0.05$) between the interaction of treatments and the number of days under refrigerated storage. On the other hand, the observed color scores for redness in different treatment groups ranged from 3.05 to 3.73. However, the mean values suggested that there were no significant differences ($p>0.05$) among the three treatments. However, Storage period had no effect on redness value also. The observed color scores for yellowness in different treatment groups ranged from 18.16 to 20.36. However, the mean values suggested that there were no significant differences ($p>0.05$) among the dietary treatments. This finding is similar to Anna, 2011; Hashem et al., 2023 and Das et al., 2022. Singh et al. (2014) observed that the L* value remained relatively consistent across various treatments and storage periods for raw chicken meat when using different natural preservatives.

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

Parameter	Storage time (D)	Dietary Treatments				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T×D
L*	0	78.23±1.28	68.61±2.79	61.62±5.64	69.49^{a}	*	**	*
	14	66.24±3.31	52.02±6.65	54.64±1.61	57.63^{b}			
	28	59.62±4.10	68.87±2.52	59.01±2.36	62.50^{b}			
	Mean	68.03^{a}	63.17^{ab}	58.42^{b}				
a*	0	1.17±0.15	2.47±0.10	3.04±0.40	2.22	NS	NS	NS
	14	4.42±2.65	3.99±1.62	3.73±0.75	4.05			
	28	5.60±2.15	2.69±0.04	2.90±0.55	3.73			
	Mean	3.73	3.05	3.23				
b*	0	16.11±0.26	16.97±0.21	18.15±0.53	17.07	NS	NS	*
	14	17.11±1.81	19.86±2.86	19.90±1.75	18.96			
	28	27.87±5.26	18.95±0.62	16.43±1.93	21.08			
	Mean	20.36	18.59	18.16				

T1=Chicken nugget without rice bran; T2= Chicken nugget 5% rice bran; T3= Chicken nugget 10% rice bran; NS, P>0.05; *, P<0.05; **, P<0.01; T=Treatment, D=Day.

Biochemical properties

Table 5 displays the Free Fatty Acid (FFA) values of different treatment levels over various time intervals. There was no significant difference ($p>0.05$) based on the treatment used. The FFA values increased with the extension of the storage period, with the highest FFA value observed on the 28th day. On the other hand, the range of observed POV values over different time intervals ranged from 1.64 to 1.88. The mean values for observations on days 0th, 14th, and 28th indicated significant differences ($p<0.01$) among these three time points. The highest POV was recorded on the 28th day, while the lowest value was observed on the 0th day of storage. Importantly, the interaction between treatments and the number of days had a significant impact ($p<0.01$) on the peroxide value. The observed TBARS values across different treatment levels ranged from 0.13 to 0.14. The mean values obtained from the different treatment groups indicated highly significant differences ($p>0.05$) among these treatment groups, with the lowest TBARS value in the T_3 group (chicken nugget with 10% rice bran) and the highest in the T_1 group (chicken nugget with 0% rice bran). The TBARS values increased significantly with the extension of the storage period. Baker et al. (2013) found that the content of free fatty acids significantly increased with a longer storage period, which is consistent with the results of my study. Dashti et al. (2015) observed a significant increase in the peroxide value over six months of storage at -20°C in chicken nuggets. This increase was mitigated when thyme essential oil was used instead of synthetic antioxidants in industrially produced nuggets.

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

Parameter	Storage time (Day)	Dietary Treatments				Level of Significance		
		T_1	T_2	T_3	Mean	T	D	T*D
FFA	0	0.01±0.00	0.02±0.00	0.03±0.01	0.02	NS	NS	NS
	14	0.02±0.00	0.02±0.00	0.03±0.01	0.02			
	28	0.02±0.00	0.18±0.15	0.03±0.00	0.08			
	Mean	0.02	0.07	0.03				
POV	0	1.55±0.02	1.54±0.04	1.84±0.17	1.64^{b}	NS	**	**
	14	1.92±0.09	1.60±0.01	1.69±0.02	1.73^{b}			
	28	1.92±0.00	2.09±0.09	1.64±0.01	1.88^{a}			
	Mean	1.79	1.74	1.72				
TBARS	0	0.12±0.00	0.12±0.00	0.12±0.00	0.12^{b}	NS	**	NS
	14	0.12±0.00	0.11±0.00	0.12±0.01	0.12^{b}			
	28	0.17±0.01	0.16±0.02	0.16±0.00	0.16^{a}			
	Mean	0.14	0.13	0.13				

T1=Chicken nugget without rice bran; T2= Chicken nugget 5% rice bran; T3= Chicken nugget 10% rice bran; NS, P>0.05; *, P<0.05; **, P<0.01; T=Treatment, D=Day.

Sensory evaluation

Table shows that there was no significance difference found in Off flavor, Color, Juiciness, Flavor, and Tenderness. However, it is worth noting that the chicken nuggets without rice bran (T_1) exhibited a higher color score, while those with 5% rice bran (T_2) had a lower score, although this difference was not statistically significant ($p>0.05$). The highest flavor rating was assigned to T_1

(chicken nugget without rice bran), while the lowest flavor rating was associated with T_2 (chicken nugget with 5% rice bran). The data derived from various treatments indicated that there were no significant differences ($p>0.05$) observed among the T_1, T_2, and T_3 groups in respect to overall acceptability. In other words, the values for these treatments were statistically similar. Kim et al. (2015) conducted a study in which sensory evaluation revealed no significant difference between chicken nuggets containing wheat fiber and chicken skin and the control sample.

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

Parameters	Dietary treatments			Level of significance
	T_1	T_2	T_3	
Color	4.20±0.01	4.14±0.02	4.18±0.03	NS
Flavor	4.17±0.01	4.12±0.02	4.15±0.01	NS
Off-flavor	1.03±0.01	1.06±0.01	1.04±0.01	NS
Juiciness	4.12±0.03	4.08±0.02	4.11±0.01	NS
Tenderness	4.12±0.02	4.10±0.04	4.11±0.02	NS
Overall acceptability	4.15±0.02	4.13±0.02	4.14±0.01	NS

T_1=Chicken nugget without rice bran; T_2= Chicken nugget 5% rice bran; T_3= Chicken nugget 10% rice bran; NS, P>0.05; *, P<0.05; **, P<0.01; T=Treatment, D=Day.

Conclusion

It might be concluded from this experiment that nuggets incorporated with 10% rice bran could be accepted by the consumers with similar overall acceptability with control.

Conflict of interest

There is no conflict of interest among the authors.

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