Meat Research
Vol 4, Issue 2: 1-7, Article 88, April 2024
ISSN: 2790-1971
https://doi.org/10.55002/mr.4.2.88 http://www.bmsa.info/meatresearch

[1]Department of Poultry Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[2]Graduate Training Institute, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[3]Department of Animal Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

***Corresponding Author:**

E-mail: mdshawkatali.ps@bau.edu.bd

Keywords:

Wheat bran
Chicken meat
Sausage
Overall acceptability

Article Info:

Received: 23 March 2024
Accepted: 21 April 2024
Published online: 30 April 2024

Research Article

Development of dietary fiber enriched chicken sausage using wheat bran

M Shanaullah[1], M Habib[2], MA Hashem[3], MAK Azad[3], MS Ali[1]*

Abstract

The study was conducted to evaluate the effect of wheat bran on the sensory, physicochemical, and biochemical properties of chicken sausages. For this purpose, sausages were prepared into 4 different groups. Such as: control- broiler breast meat sausage without wheat bran, broiler breast meat sausage with the addition of 5% wheat bran, broiler breast meat sausage with the addition of 10% wheat bran, broiler breast meat sausage with the addition of 15% wheat bran. All parameters were analyzed at 0, 14 and 28 days of storage period. The surface color (CIE L*, a*, b*) of sausage samples were measured using a colorimetric meter at different storage period. The proximate composition, pH and cooking loss of different sausage batter were analyzed and significant differences were found in DM%, CF%, CP%, Ash%, EE%, and pH. The DM and CF% were significantly lower, while CP% was higher in control sausage batter. Highly significant ($p<0.01$) differences were found in DM, CP, CF, and Ash % in broiler breast meat sausages. DM, CF, and Ash% were significantly lower and CP% was higher in control sausage. Both CP and CF content were increased, but Ash and Fat content decreased with the increase of storage time. The storage period has significant effect ($p<0.01$) on different biochemical (POV and TBARS value) tests. POV and TBARS were increased with increasing the storage period. Lightness (L*) value showed significant ($p<0.05$) differences among different treatments and different storage period. Significantly ($p<0.05$) lower lightness and yellowness were found in broiler breast meat sausage without wheat bran. Again, redness and yellowness were decreased with increasing the storage period. In sensory analysis, flavor and overall acceptability were significantly higher in broiler breast meat sausages with 5% wheat bran ($p<0.05$). Taken together it may conclude that wheat bran at 5% level might be incorporated in broiler breast meat sausages with higher overall acceptability.

Introduction

During the recent few years, consumers are very much conscious towards healthy food. Now they are more conscious of calories, fat and cholesterol than consumers of twenty year ago and want a wide variety of nutritious and convenient food products (Akter et al., 2022; Das et al., 2022; Hashem et al., 2022 and 2023). Especially the children of this era do not like to take fiber content in their meal. On the contrary, they would like to take meat in their meal especially chicken meat due to its tenderness but there has a problem that chicken meat has the insufficiency of fiber content, which is very important element for better gut development (Mia et al., 2023; Rahman et al., 2022; Sajib et al., 2023; Slavin et al., 2013). Dietary fiber is one of the components, which can be incorporated in meat as it is lacking of fiber. The raw materials (meat) used to prepare all meat products come from livestock enterprises. Meat products with added value are gaining in popularity. Consumers today are worried about the safety and quality of processed meat products. To satisfy customer demand, meat and meat products are widely used in both developed and developing nations (Gerber et al., 2009). The development of meat and meat products with physiological properties to support healthy lifestyles and lower the risk of disease has received a lot of attention in recent years. Value-added meat products are gaining popularity due to their quality and safety, with chicken sausage offering health benefits like high protein and saturated fat, but less carbohydrate and fiber (Newman et al., 2008; Ali et al., 2022; Boby et al., 2021; Hossain et al., 2021; Jahan et al., 2018; Khatun et al., 2022). Fiber is crucial for maintaining a healthy weight, and cereal by-products like wheat bran and rice bran can be added to chicken sausage 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-Aal et al., 2011). So, it may fulfill all nutritional demand. Many works have been done on sausages, but limited work has been done on sausage prepared with wheat bran. These studies have shown that wheat bran may have a beneficial effect on the prevention of disease including some cancers (colorectal cancer), type 2 diabetes, CVD, obesity, and some gastrointestinal diseases, including diverticular disease, constipation and irritable bowel syndrome (IBS) (Fardet, 2010). Keeping above points in view, this study was conducted to develop fiber-enriched chicken sausages using wheat bran and study the effect of fiber incorporation on quality attributes of fresh and refrigerated stored chicken sausages.

Materials and Methods

Experimental Design

Four sausages formulation were developed (Table 1), as follow: broiler breast meat sausage without wheat bran, broiler breast meat sausage with 5% wheat bran, broiler breast meat sausage with 10% wheat bran, broiler breast meat sausage with 15% wheat bran.

Sausage Preparation

All visible fat and connective tissue were trimmed off as far as possible with the help of knife and the meat was cut into small pieces. Chicken breast meat was grinded with the help of meat grinder. The grinded meat was then mixed with some spices i.e., Chili powder, turmeric powder, condiments, oil, STPP. Minced meat was chopped in bowl chopper along with salt, Sodium tripolyphosphate. The meat was divided into 4 parts- T_1, T_2, T_3 and T_4 were then compounded with wheat bran at 0%, 5%, 10% and 15%respectively. Meat from each mixture then taken and were wrapped with small square pieces of plastic as a casing in to candy like structure. Both ends were then tied with thread check the entry of water as possible and were then placed in to boiling water for cooking. These procedures were made for three times to prepare sample to analyze the first one as fresh basis. The temperature in bowl chopper was kept low by adding water in the form of slushed ice intermittently throughout the process. Basic sausage formulations for all treatments were shown on Table 1. The prepared sausages were then packed in poly ethylene bags and stored refrigerated for up to 28 days and assessed immediately after processing (0 day) and at an interval of 14- and 28-days post storage

Table 1. Ingredient Composition of different sausage batter incorporated with wheat bran

Sl. No.	Ingredients	Treatment			
		T_1	T_2	T_3	T_4
1.	Chicken breast meat	750	700	650	600
2.	Wheat bran	0	50	100	150
3.	Refined oil	50	50	50	50
4.	Corn starch	41	41	41	41
5.	Salt	20	20	20	20
6.	Garlic	10	10	10	10
7.	Onion	12	12	12	12
8.	Spice's mix	12	12	12	12
9.	STTP	5	5	5	5
10.	Ice	100	100	100	100
Total		**1000**	**1000**	**1000**	**1000**

T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat+15% wheat bran

Proximate analysis

Moisture, protein, fiber, fat, ash of sausages and batters was determined as per the standard procedures of Association of Official Analytical Chemists (AOAC, 1995).

pH determination

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.

Cooking loss

To determine cooking loss, weighed 5±1 g sample, wrapped in a heat stable foil paper, and kept in water bath at 75°C for 30 minutes. Sample's surface is dried and weighed. Cooking loss was calculated as the percentage of the loss weight of the cooked sample (Ali et al., 2011). Cook loss was calculated after draining the drip coming from the cooked sausage as follows:

$$\text{Cooking loss (\%)} = \frac{w2 - w3}{w2} \times 100$$

Where, w2 = Sausage weight before cooking w3 = Sausage weight after cooking.

Color analysis

The surface color (CIE *L**, *a**, *b**) of chicken nugget samples was measured using a Minolta Chroma Meter (Minolta CR 410, Tokyo, Japan) standardized with a white plate (Y =93.5, X = 0.3132, y = 0.3198).

Biochemical analysis

There were three types of Biochemical properties analysis. These were Free Fatty Acid (FFA), Peroxide Value (POV) and Thiobarbituric Acid value (TBARS). Three types of analysis were discussed below.

Free Fatty Acid (%) analysis
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 2-thiobarbituric acid (TBA) method described by Schmedes and Holmer (1989).

TBARS = Abs 532 nm × 7.8 (conversion factor) mg malonaldehyde/kg sausage

Sensory evaluation

The total sausage samples were divided into four groups. Different sensory attributes were examined at 1-day old sausage. A trained panel of 6-honorable judges at Bangladesh Agricultural University evaluated each sausage sample. Recruitment, selection and training of panelist were performed according to sensory evaluation procedure (AMSA, 1995), 6 panelists were screened from 10 potential panelist 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. Sensory evaluation was carried out in individual booths under controlled conditions of light, temperature and humidity. Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, smell, juiciness, tenderness, overall acceptability) of sausages using an intensity scale. Sensory qualities of the samples were evaluated after cook on day one.

Statistical analysis

The proximate and bio-chemical data from sausage batter and the sensory data from different sausages 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 sausages were analyzed with 3×3 factorial design (where 3 is different sausages 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.

Results and Discussion

Proximate, pH, and cooking loss of sausage batter

The proximate composition, cooking loss and pH of broiler meat sausage batters incorporate with wheat bran are shown in Table 2. The proximate composition of different sausages was analyzed and highly significant differences were found in DM (%), EE (%), CP (%) and CF (%). Significantly higher DM (%), EE (%), CF (%) were found in T_4, while CP (%) was significantly higher in T_1. significant differences were found in pH. Significant differences were found in pH. Significantly higher pH was found in T_1. No significant differences were found in cooking loss (%) and Ash (%) among the treatments. Yang et al. (2009) found that ash and fat content of sausage batters deceased, while pH of sausage batters increased with addition of cereal flours.

Table 2. Proximate composition, cooking loss and pH of different sausage batter incorporated with wheat bran

Parameters	Treatments				Level of significance
	T_1	T_2	T_3	T_4	
Cooking loss (%)	6.60±0.49	4.80±1.03	2.88±0.29	2.97±0.89	NS
pH	6.39^{a}±0.02	6.37^{ab}±0.00	6.36^{b}±0.00	6.35^{b}±0.01	*
Dry matter (%)	30.29^{c}±1.23	31.69^{bc}±1.06	33.61^{b}±0.05	40.27^{a}±0.12	**
Ash (%)	3.11±0.04	3.20±0.01	3.45±0.09	3.52±0.25	NS
CF (%)	0^{d}±0.00	0.36^{c}±0.04	0.70^{b}±0.02	0.88^{a}±0.02	**
EE (%)	3.45^{d}±0.10	3.98^{c}±0.08	4.53^{b}±0.08	4.98^{a}±0.08	**
Crude protein (%)	23.08^{a}±0.03	21.73^{b}±0.16	19.98^{c}±0.08	19.51^{d}±0.08	**

**p<0.01 means significant different at 1% level; *p<0.05 means significant different at 5% level; NS= Non-significant, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

Proximate analysis of sausage

The value of proximate components was shown in Table 3. The proximate composition of different sausages was analyzed and highly significant differences were found in DM (%), Ash (%), CP (%) and CF (%) among the treatments. Significantly higher DM (%), Ash (%), and CF (%) were found in T_4, while CP (%) was significantly higher in T_1. No significant differences were found in EE (%) among the treatments. Storage period had highly significant on Ash (%), CP (%), EE (%) and CF (%). CP (%) content is increased with increase of storage period but Ash (%), EE (%) and CF (%) content is decreased with increase of storage period. Haque et al. (2024) found that nugget incorporated with rice bran tends to increase DM (%), Ash (%) and CF (%), while decrease CP (%). On the other hand, storage period tends to increase DM and CP content and decrease ash content. Nahid et al. (2024) found that wheat bran incorporated chicken nugget tends to increase Ash (%) and CF (%) and decrease CP (%).

Table 3. Proximate composition of broiler meat sausages incorporates with wheat bran during different storage time

Parameter (%)	Storage time (D)	Treatment					Level of Significance		
		T_1	T_2	T_3	T_4	Mean	T	D	T*D
Dry matter	0	26.99±0.34	28.48±1.19	32.87±1.03	33.60±0.91	30.22	**	NS	NS
	14	27.11±1.00	28.01±0.04	32.38±1.26	34.34±0.03	30.58			
	28	27.94±0.43	30.14±0.08	32.26±0.82	34.48±0.04	31.36			
	Mean	27.34^{d}	28.88^{c}	32.50^{b}	34.14^{a}				
Ash	0	2.23±0.15	2.34±0.20	2.50±0.08	2.56±0.12	2.40^{a}	**	**	NS
	14	1.79±0.08	2.08±1.00	2.19±0.02	2.25±0.08	2.08^{b}			
	28	1.68±0.01	1.96±0.06	1.71±0.03	2.01±0.05	1.84^{c}			
	Mean	1.90^{b}	2.12^{a}	2.13^{a}	2.27^{a}				
Crude fiber	0	0	0.35±0.03	0.57±0.01	0.79±0.03	0.43^{a}	**	**	NS
	14	0	0.32±0.02	0.53±0.01	0.71±0.03	0.39^{b}			
	28	0	0.28±0.01	0.45±0.05	0.55±0.01	0.33^{c}			
	Mean	0.00^{d}	0.32^{c}	0.52^{b}	0.70^{a}				
Ether extract	0	3.39±0.10	3.38±0.18	3.28±0.18	3.38±0.11	3.35^{a}	NS	**	NS
	14	2.35±0.25	2.85±0.08	3.10±0.20	3.15±0.07	2.86^{b}			
	28	2.07±0.45	2.25±0.18	2.49±0.18	2.68±0.23	2.37^{c}			
	Mean	2.60	2.82	2.95	3.07				
Crude protein	0	23.10±0.06	20.57±0.09	18.66±0.07	17.34±0.18	19.92^{c}	**	**	NS
	14	23.26±0.07	20.61±0.13	19.38±0.24	18.08±0.16	20.33^{b}			
	28	23.47±0.11	21.75±1.01	19.68±0.37	19.06±0.08	20.99^{a}			
	Mean	23.27^{a}	20.98^{b}	19.24^{c}	18.16^{d}				

**p<0.01 means significant different at 1% level; *p<0.05 means significant different at 5% level; NS= Non-significant, T = Treatment, D = Day, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

pH of sausage

The pH of different treatments with days of intervals is shown in Table 4. The mean values observed from four treatments indicate that there were no significant differences among the treatments. The mean values observed in 0, 14 and 28 days of observation indicates that there were highly significant differences found among the three days of observation. Increasing the storage period pH increased in different sausages and higher pH found at 28 days of storage period. McCarthy et al. (2001) and Carpenter et al. (2007) 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.

Table 4. pH of different sausage batter incorporated with wheat bran

Parameter	Storage time (D)	Treatments					Level of Significance		
		T_1	T_2	T_3	T_4	Mean	T	D	T*D
pH	0	6.49±0.01	6.53±0.02	6.50±0.00	6.49±0.01	6.50^{b}	NS	**	**
	14	6.42±0.03	6.52±0.00	6.53±0.01	6.55±0.01	6.50^{b}			
	28	6.77±0.11	6.59±0.02	6.66±0.03	6.60±0.01	6.65^{a}			
	Mean	6.56	6.54	6.56	6.54				

**p<0.01 means significant different at 1% level; NS= Non-significant, T = Treatment, D = Day, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

Instrumental surface color (CIE *L**, *a**, *b**) of sausage

The surface color (CIE *L**, *a**, *b**) of sausages samples were measured using a Minolta Chroma meter (Minolta CR 410, Tokyo, Japan) standardized with a white plate (Y=93.5, X = 0.3132, y = 0.3198) shown in Table 5.

Lightness (*L**)

The mean values observed from four treatment indicates that there was a significant difference (P<0.05) exist among four treatments. Of the four- treatment group highest reading was observed from broiler breast meat sausage with 5%wheat bran (T_2) and lowest was observed from broiler breast meat sausage without wheat bran group. The mean values observed from 0, 14th and 28th days of observation indicates there were highly significant differences (p<0.01) among these days of observation. The higher reading was observed from 14th day and lower reading was observed from 28th day. There was a significant difference (p>0.05) exist between the interaction of treatments and number of days it was stored under refrigerated condition. Singh et al. (2014) while conducted an experiment on the shelf-life evaluation of raw chicken meat by using different natural preservatives noticed that *L** value did not vary significantly among different treatment and storage period. Nahid et al. (2024) found increasing storage period L* value increased in wheat bran incorporated chicken nuggets. Haque et al. (2024) found decreasing L value with increasing rice bran level and storage period in chicken nugget.

Table 5. International commission on illumination color measurements (CIE*) of broiler meat sausages incorporate with wheat bran at different storage time

Parameter	Storage time (D)	Treatments					Level of Significance		
		T_1	T_2	T_3	T_4	Mean	T	D	T × D
*L**	0	33.08±2.75	42.39±6.29	48.20±6.76	45.95±1.76	42.41^{b}	*	**	*
	14	52.17±5.60	68.99±2.39	57.20±1.76	62.49±1.70	60.21^{a}			
	28	45.84±0.04	48.50±1.92	37.21±2.11	41.50±3.20	43.26^{b}			
	Mean	43.70^{b}	53.29^{a}	47.54^{ab}	49.98^{ab}				
*a**	0	2.92±0.23	2.86±0.41	2.87±0.11	2.89±0.08	2.89^{a}	NS	**	NS
	14	0.93±0.13	1.32±0.24	1.65±0.08	1.44±0.18	1.33^{b}			
	28	1.22±0.18	1.13±0.06	1.38±0.15	1.39±0.11	1.28^{b}			
	Mean	1.69	1.77	1.97	1.91				
*b**	0	13.36±0.32	14.96±0.73	15.92±1.34	14.75±0.30	14.75^{a}	*	**	NS
	14	11.45±0.82	14.70±1.07	14.27±0.84	15.54±0.54	13.99^{a}			
	28	10.36±0.32	9.63±1.23	9.62±0.13	11.63±0.28	10.31^{b}			
	Mean	11.72^{b}	13.10^{a}	13.27^{a}	13.97^{a}				

**p<0.01 means significant different at 1% level; *p<0.05 means significant different at 5% level; NS = Non-significant, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

Redness (*a**)

The mean values observed from four treatment indicates there no significant difference (p<0.05) found among three treatments. Of the four- treatment group highest reading was observed from broiler breast meat sausage with 5% wheat bran (T_2) and lowest color score was observed from broiler breast meat sausage without wheat bran (T_1) group. The mean values observed from 0, 14th and 28th days of observation indicates there were highly significant differences (p>0.01) found among these days of observation. The highest reading was observed from 0th day and lowest from 28th day. The data shows that redness score decreased gradually with the increase in storage period. But there was no significant difference (p>0.05) exist between the interaction of treatments and number of days it stored under refrigerated condition. Singh et al. (2014) while conducted an experiment on the shelf- life evaluation of raw chicken meat by using different natural preservatives reported that redness (a*) value increases significantly with the increase in storage period.

Yellowness (*b**)

The mean values observed from four treatment indicates that there was a significant difference (p<0.05) found among three treatments. Of the three treatments highest score was observed from broiler breast meat sausage with 15% wheat bran (T_4) and lowest color score was observed from broiler breast meat sausages without wheat bran (T_1) group. The mean values observed from 0, 14th and 28th days of observation indicates there were highly significant differences (p>0.01) exist among these days of observation. The highest color score was observed from 0th day and lowest from 28th day. The data shows that yellowness score is increased with the decrease in storage time. But there was no significant difference (p>0.05) found between the interaction of treatments and number of days it stored under refrigerated condition. Yilmaz (2004) investigated the effects of rice bran addition on color and quality characteristics of low-fat meatballs reported that, L* value (lightness) and b* value (yellowness) tends to increase with the increase in storage period. Gradual changes in appearance and color scores of sausages stored at refrigeration conditions (-20ºC) might be due to pigment and lipid oxidation resulting in non-enzymatic browning between lipids and amino acids. Anna et al. (2011) observed a decreased color test scores during storage resulted from the denaturation of proteins, particularly the myofibrillar protein that affects gel formation. In our experiment, we did not find any significant effect of b* value during 30 days storage period.

Biochemical properties

Peroxide Value (POV-meq/kg)

Peroxide value (POV-meq/kg) of different treatment levels with the days of intervals shown in Table 6. The mean values observed from different treatment groups indicates that there were highly significant differences (p<0.01) found among the treatment groups. Of the four treatments, the highest POV value was observed from T4(broiler breast meat sausage with 15% wheat bran) and lowest was observed from T1 (broiler breast meat sausage without wheat bran). The mean values observed at 0, 14thand 28th days of observation indicates that there was a significant difference (p<0.05) found among these three days observations. The highest value was observed at 28^{th} day and lowest value was observed at 0 day of storage. Moreover, the interaction between treatments and number of days has no significant difference (p>0.05) on the level of peroxide value. Sallam et al. (2004) observed significant increase in peroxide value during storage of chicken sausages. The increase in peroxide value in garlic treated sausages was found to be lower as compared to control.

Thiobarbituric Acid Value (TBARS)

The TBARS values of different treatment levels with days of intervals shown in Table 6. The mean values observed from different treatment groups indicates that there were highly significant differences (p<0.01) found among the treatment groups. Of the four treatments, the highest TBARS value was observed from T4 (broiler breast meat sausage with 15% wheat bran) and lowest was observed from T1 (broiler breast meat sausage without wheat bran). The mean values observed from 0, 14th and 28th days of observation indicates that there were highly significant differences (p<0.01) exist among these three days observation. the highest TBARS value was observed from 28^{th} day and lowest was observed from 0 day. The interaction between treatment and number of days it was stored has no significant difference (p>0.0) on the level of TBARS. The TBARS values increased significantly with increasing the storage period. Yadav et al. (2018) found a significant decrease in TBARS value of control and fiber enriched sausage with an increase in storage period. Devatkal et al. (2008) observed that the TBARS

value increased during the refrigerated storage in cooked goat meat patties added with different plant extract.

Table 6. Biochemical properties of broiler meat sausages incorporate with wheat bran during different storage time

Parameter	Storage time(d)	Treatments					Level of Significance		
		T_1	T_2	T_3	T_4	Mean	T	D	T × D
POV (meq/kg)	0	1.93±0.00	1.70±0.03	1.75±0.02	1.69±0.02	1.64^{b}	**	*	NS
	14	2.04±0.04	1.85±0.02	1.85±0.02	1.84±0.04	1.64^{b}			
	28	2.05±0.05	1.93±0.00	1.97±0.04	1.87±0.04	1.70^{a}			
	Mean	1.36^{d}	1.60^{c}	1.74^{b}	1.93^{a}				
TBARS (malonaldehyde/ kg sample)	28	0.15±0.01	0.14±0.00	0.16±0.01	0.16±0.01	0.15^{c}	**	**	NS
	14	0.17±0.01	0.16±0.00	0.18±0.01	0.20±0.01	0.17^{b}			
	0	0.19±0.01	0.20±0.01	0.20±0.00	0.22±0.01	0.20^{a}			
	Mean	0.17^{c}	0.17^{c}	0.18^{b}	0.19^{a}				

**p<0.01 means significant different at 1% level; *p<0.05 means significant different at 5% level; NS= Non-significant, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

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 gearing) for the purpose of evaluating consumer products. The sensory analysis was done at 1-day old sausages. The effects of wheat bran on the sensory properties of chicken sausages were shown in Table 7. The data obtained from different treatment indicated that there was significant difference among the treatments in flavor,and overall acceptability among the chicken sausages from sensory evaluation ($p > 0.05$). Miller et al. (1980) reported that the lower flavor scores may be related to the increased malonaldehyde formation due to oxidation of fat, which has detrimental effect on the flavor and firmness of the product. Ravindranath et al. (1988) studied quantitative and qualitative characteristics of products prepared from buffalo meat and pork, and reported that addition of phosphates improved the sensory scores for color, flavor, tenderness, juiciness and overall acceptability of patties.

Table 7. Sensory properties of cooked broiler sausages manufactured from broiler meat incorporate with wheat bran

Parameters	Different Treatments				Level of significance
	T_1	T_2	T_3	T_4	
Color	3.83±0.09	4.07±0.09	4.03±0.07	4.07±0.03	NS
Flavor	4.10^{a}±0.06	4.17^{a}±0.09	3.90^{c}±0.06	3.83^{c}±0.03	*
Off-flavor	1.20±0.06	1.13±0.09	1.20±0.06	1.13±0.03	NS
Juiciness	4.10±0.06	4.13±0.03	3.93±0.15	3.90±0.11	NS
Tenderness	4.00±0.06	4.00±0.10	4.03±0.03	4.03±0.09	NS
Overall acceptability	3.90^{ab}±0.31	4.13^{a}±0.07	3.57^{b}±0.09	3.47^{b}±0.07	*

*p<0.05 means significant different at 5% level; NS= Non-significant, T_1 = Broiler breast meat without wheat bran, T_2 = Broiler breast meat + 5% wheat bran, T_3 = Broiler breast meat + 10% wheat bran, T_4 = Broiler breast meat + 15% wheat bran

Conclusions

It might be concluded that addition of wheat bran at 5% level increased the overall acceptability of broiler breast meat sausage to that of broiler breast meat sausage.

Conflicts of interest

There are no Conflicts of interest among the authors.

Acknowledgements

The authors are highly appreciated to the Bangladesh Agricultural University Research System (BAURES) for funding this research.

References

Abdel A, ESM, Hucl P, Miller SS, Patterson CA, Gray D. 2011. Microstructure and nutrient composition of hairless canary seed and its potential as a blending flour for food use. Food Chemistry, 125: 410-416.

Akter R, Hossain MA, Khan M, Rahman MM, Azad MAK, Hashem MA. 2022. Formulation of value-added chicken meatballs by addition of Centella leaf (Centella asiatica) extracts. Meat Research, 2: 2, Article No. 18.

Ali MS, Rahman MM, Habib M, Kabir MH, Hashem MA, Azad MAK, Rahman MM. 2022. Quality of spent hen sausages incorporated with bee honey. Meat Research, 2: 1, Article 9.

Ali MS, Kim GD, Seo HW, Jung EY, Kim BW, Yang HS, Joo ST. 2011. Possibility of Making Low-fat Sausages from Duck Meat with Addition of Rice Flour. Asian-Australasian Journal of Animal Science, 24: 421-428.

AMSA. 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Chicago III American Meat Science Association and Nutritional Livestock and Meat Board. Analytical Chemists International, Maryland, USA.

Anna A. 2011. Shelf life of boiled restructured buffalo meat rolls in refrigerated storage under vacuum packaging condition. Journal of Applied Animal Research, 43: 318-323.

AOAC. 1995. Official method of analysis of the Association of Official Analytical Chemists 17th edition. Association of Official Analytical Chemists, 7: 65-68.

Baker IA, Alkass JE, Saleh HH. 2013. Reduction of Oxidative Rancidity and Microbial Activities of the Karadi Lamb Patties in Freezing Storage Using Natural Antioxidant Extracts of Rosemary and Ginger. International Journal of Agricultural and Food Research, 2: 31-42.

Boby F, Hossain MA, Hossain MM, Rahman MM, Azad MAK, Hashem MA. 2021. Effect of long coriander leaf (Eryngium foetidum) extract as a natural antioxidant on chicken meatballs during at freezing temperature. SAARC Journal of Agriculture, 19(2): 271-283.

Carpenter R, Grady MNO, Callaghan YCO, O'Brien NM, Kerry JP. 2007. Evaluation of the antioxidant potential of grape seed and bearberry

extracts in raw and cooked pork. Meat Science, 76:604-610.
Das A, Hashem MA, Azad MAK, Rahman MM. 2022. Edible oil marination in broiler meat for short term preservation. Meat Research, 2: 3, Article 22.
Devatkal S, Mendiratta SK, Anjaneyulu ASR. 2008. Effect of calcium lactate on the quality and shelf life of restructured pork rolls. Journal of Meat Science, 1: 1-6.
Fardet A. 2010. New hypotheses for the health protective mechanisms of whole-grain cereals: what is beyond fibre? Nutrition Resarch Reviews, 23:65–134
Gerber N, Scheeder MRL, Wenk C. 2009. The influence of cooking and fat trimming on the actual nutrient intake from meat. Meat Science, 81: 148- 154.
Haque ME, Mollah MBR, Habib M, Hashem MA, Azad MAK, Ali MS. 2024. Development of dietary fiber enriched chicken nugget using rice bran. Meat Research, 4:82.
Hashem MA, Rahman MF, Mustari A, Goswami PK, Hasan MM, Rahman MM. 2023. Predict the quality and safety of chicken sausage through computer vision technology. Meat Research, 3: 1, Article 47.
Hashem MA, Morshed MM, Khan M, Rahman MM, Al Noman MA, Mustari A, Goswami PK. 2022. Prediction of chicken meatball quality through NIR spectroscopy and multivariate analysis. Meat Research, 2: 5, Article No. 34.
Hossain MS, Rokib M, Habib M, Kabir MH, Hashem MA, Azad MAK, Rahman MM, Ali MS. 2021. Quality of spent hen sausages incorporated with fresh ginger extract. Meat Research, 1: 1, Article 4.
Jahan I, Haque MA, Hashem MA, Rima FJ, Akhter S, Hossain, MA. 2018. Formulation of value-added beef meatballs with pomegranate (Punica granatum) extract as a source of natural antioxidant. Journal of Meat Science and Technology, 6(1): 12-18.
Khatun MM, Hossain MA, Ali MS, Rahman MM, Azad MAK, Hashem MA. 2022. Formulation of value-added chicken nuggets using carrot and ginger as a source of dietary fiber and natural antioxidant. SAARC J. Agric., 20 (1): 185-196.
McCarthy TL, Kerry JP, Kerry JF, Lynch PB, Buckley DJ. 2001. Evaluation of the antioxidant potential of natural food/plant extracts as compared with synthetic antioxidants and vitamin E in raw and cooked pork patties. Meat Science, 57: 45-52.
Mia N, Rahman MM, Hashem MA. 2023. Effect of heat stress on meat quality: A review. Meat Research. 3 (6): Article No. 73.
Miller AJ, Ockerman SA, Palumbe SA. 1980. Effect of frozen storage on functionality of meat for processing. Journal of Food Science, 50**:** 531-534
Modi VK, Mahendrakar NS, Narasimha Rao D, Sachindra NM. 2003. Quality of buffalo meat burger containing legume flours as binders. Meat Science**,** 66: 143-149.
Nahid MZA, Habib M, Mollah MBR, Hashem MA, Azad MAK, Ali MS. 2024. Development of dietary fiber enriched chicken nugget using wheat bran. Meat Research, 4:84.
Rahman MA, Hossain MA, Rahman MM, Ali MS, Hossain MM, Hashem MA. 2022. Growth performance and meat quality of rice fed broiler and native chicken genotypes in Bangladesh. Meat Research, 2: 3, Article 23.
Ravindranath G, Varadarajulu P, Reddy KS 1988. A study on certain quantitative and qualitative characteristics of products prepared from buffalo meat and pork. Indian Journal of Meat Science 1**:** 67-78.
Rukunudin IH, White PJ, Bern CJ, Bailey TB. 1998. A modified method for determining free fatty acids from small soybean oil sample sizes. Journal of the American Oil Chemists' Society.75: 563-568.
Sajib MMR, Obidullah M, Dutta A, Ghosh E, Nahar S, Hassin BM, Rahman MM, Ferdaus AJM. 2023. Body conformation, morphometry and meat yield characteristics of different genotypes of chicken. Meat Research. 3 (5): Article No. 68.
Sallam KI, Ishioroshi M, Samejima K. 2004. Antioxidants and antimicrobial effects of garlic in chicken sausage. Lebensmittel Wissenschaft and Technology, 37**:** 849–855.
SAS. 2009. User's Guide: Statistics, Version 9.1. SAS Institute Inc., Cary, NC.
Schmedes A, Holmer G. 1989. A new thiobarbituric acid (TBA) method for determination of free malonaldehyde (MDA) and hydroperoxides selectivity as a measure of lipid peroxidation. Journal of American Oil Chemistry Society, 66:813–817.
Singh P, Sahoo J, Chatli MK, Biswas AK. 2014. Shelf-life evaluation of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste as natural preservatives at refrigerated storage (4±1°C). International Food Research Journal, 21: 1363-1373.
Yang HS, Ali MS, Jeong JY, Moon SH, Hwang YH, Park GB, Joo ST. 2009. Properties of duck meat sausages supplemented with cereal flours. Poultry Science, 88: 1452-1458.
Yılmaz I. 2004. Effects of rye bran addition on fatty acid composition and quality characteristics of low-fat meatballs. Meat Science, 67: 245-249.