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Research Article

Development of dietary fiber enriched sausage using rice bran

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Abstract

The study was conducted to evaluate the effect of de oiled rice bran as a source of dietary fiber on the sensory, physicochemical and biochemical properties of chicken sausages. For this purpose, sausages were prepared into 4 different groups. They were as follows: control; broiler breast meat sausage without rice bran, broiler breast meat sausage with 5% rice bran, broiler breast meat sausage with 10% rice bran, broiler breast meat sausage with 15% rice bran. All parameters were analyzed at 0, 14th and 28th days of storage period. The surface color (CIE L*, a*, b*) of sausages samples were measured using a Minolta Chroma meter at different storage period. DM, Ash, Crude fiber, EE and pH showed significantly different among the different sausage batters. All the parameters except pH was significantly lower in control group compare to different rice bran sausage batter group. During the analysis of sausages, all proximate parameters were significantly different among different sausage treatment groups. DM, Ash and EE contents were significantly higher in rice bran groups compare to control, while CP content and pH were significantly higher in control group. DM and CP% increased, while EE% and pH decreased with increasing the storage period. The lightness (L*) value was higher, while redness (a*) and yellowness (b*) values were lower in control sausage compare to rice bran group sausages. Free fatty acid, TBARS were significantly lower in control group compare to rice bran sausages group. Peroxide value and TBARS value increased with increasing the storage period. In sensory analysis, significantly lower color, off-flavor, juiciness and tenderness were found in broiler breast meat sausage without rice bran. Although color, off- flavor, juiciness and tenderness were not varied during sensory evaluation, flavor and overall acceptability significantly differ among the four treatments. Sensory evaluation indicated higher acceptability of sausage with 5% rice bran incorporated group compare to other rice bran incorporated sausage group.

Introduction

Meat and meat products are naturally enriched nutritionally with protein, fat, minerals and vitamins and is conventionally an essential part of the diet (Azad et al., 2022; Cosgrove et al., 2005; Tushar et al., 2023). The eating habits of present-day health- conscious consumer had a dramatic and progressive shift toward foods including meat products with decreased levels of fat, salt, cholesterol and caloric content as well as enriched with dietary fiber (Yang et al. 2009). Meat and meat products are widely used in developed and developing countries to meet the consumers demand (Gerber et al., 2009; Hossain et al., 2021; Khatun et al., 2022; Akter et al., 2022). In recent years, much attention has been paid to develop meat and meat products with physiological functions to promote health conditions and prevent the risk of diseases. Oxidation of lipid and auto-oxidation are one of the major causes of quality deterioration and reduction of shelf life of meat products. This may produce changes in meat quality parameters such as color, flavor, odor, texture and even nutritional value (Fernandez et al. 1997; Hashem et al., 2022 and 2023). The challenge for meat industry is product with food safety issues and low-cost production. Sausage is a ground meat variously seasoned and cooked that mixed with different types of binders like moida, oats, corn flour, jellying powder and spices. It is processed comminuted meat which can be classified as restructured meat and is very popular among some countries within the Asian region and certain European countries. It can be prepared using beef, chicken, and pork meat and the one that is very popular and widely found in the market is chicken sausage.

Health-conscious consumers demand low level of fat and higher dietary fiber in meat products. Considering the value of meat, different types of meat products are available in the market to meet consumers need. Among those meat products, Chicken sausages are considered as very popular and highly consumed in many countries because it has no religious restrictions and it also found to be a good source of polyunsaturated fatty acid (PUFA) compared to beef sausage (Khaksar et al., 2010; Das et al., 2022; Sadakuzzaman et al., 2023). Meat is specifically valuable as a source of omega-3 fatty acids, vitamin B12, protein and highly bio- available iron (Bender, 1992). However, meat and meat products are considered harmful for health due to their high saturated fatty acid and cholesterol content. Moreover, meat and its products intrinsically lack dietary fiber which is not favorable for a healthy diet.

There are two types of dietary fiber; soluble and insoluble dietary fibers. Rice, wheat, rye and most other grains are mainly composed of insoluble fibers (Southgate et al., 1978). Rice bran is the best-

known source of insoluble dietary fiber and are very available in Bangladesh. Previously called as roughage, insoluble dietary fibers also increase insulin sensitivity, fecal bulk and the excretion of bile acids and decrease intestinal transit time (laxative effect) (Perry and Ying, 2016). Very fewer studies have been reported on the utilization of rice bran for the development of meat products. Therefore, the present study was carried out to develop fiber enriched chicken sausage with incorporation of rice bran as natural fiber source. The present study was undertaken to find out the effect of rice bran on the quality properties of low-fat chicken sausages.

Materials and Methods

Experimental Design

Four sausages formulation were developed (Table 1), as follow: broiler breast meat sausage without rice bran (T_1), broiler breast meat sausage with 5% rice bran (T_2), broiler breast meat sausage with 10% rice bran (T_3), broiler breast meat sausage with 15% rice bran (T_4).

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 rice 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 polyethylene bags and stored at -18ºC for up to 28 days and assessed immediately after processing (0 day) and at an interval of 14- and 28-days post storage.

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.

Table 1. Composition of sausage batter

Ingredients (g)	Treatment			
	T_1	T_2	T_3	T_4
Chicken breast meat	700	650	600	550
Rice bran	0	50	100	150
Soybean oil	100	100	100	100
Corn starch	30	30	30	30
Salt	20	20	20	20
Garlic	10	10	10	10
Onion	12	12	12	12
Spices mix	12	12	12	12
Ice	116	116	116	116
Total	1000	1000	1000	1000

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

Cooking loss

To determine cooking loss, weighed 5±1 g sample and 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, w_2= Sausage weight before cooking w_3= 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. Each sausage sample was evaluated by a trained panel of 6-honorable judges at Bangladesh Agricultural University. 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 composition, pH, and cooking loss of sausage batter

The proximate composition, cooking loss and pH of broiler meat sausage batter incorporate with rice bran was shown in the following Table 2. The proximate composition of different sausages was analyzed and highly significant differences were found in DM (%), Ash (%) and CF (%). Significantly higher DM (%), Ash (%) and CF (%) were found in T_4. Significant differences were found in pH. Significantly higher pH was found in T_1. No significant differences were found in cooking loss (%), CP (%) and EE (%) 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 broiler meat sausage batters incorporate with rice bran

Parameters	Treatments				Level of significance
	T_1	T_2	T_3	T_4	
Cooking loss (%)	5.25±0.70	5.50±0.60	5.23±0.51	5.54±0.87	NS
pH	6.44^{a}±0.02	6.39^{b}±0.01	6.37^{b}±0.05	6.37^{b}±0.00	**
Dry matter (%)	29.74^{d}±0.17	32.53^{c}±0.25	33.86^{b}±0.04	34.59^{a}±0.03	**
Ash (%)	3.39^{d}±0.09	3.50^{c}±0.00	3.82^{b}±0.02	4.04^{a}±0.025	**
CF (%)	0^{d}±0.00	0.57^{c}±0.01	1.07^{b}±0.03	1.41^{a}±0.05	**
Ether extract (%)	4.55±0.15	4.70±0.25	5.15±0.10	5.23±0.05	NS
Crude protein (%)	16.26±0.31	16.22±0.26	15.56±0.40	15.09±0.03	NS

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

pH of sausages

The pH of different sausages with days of intervals is shown in Table 3. The mean values observed from sausage groups indicate that there were highly significant ($p<0.01$) differences among the sausages. The higher value was observed in T_1 (Broiler breast meat without rice bran) and the lower value was observed in T_3 (Broiler breast meat+10% rice bran). The mean values observed in 0, 14^{th} and 28^{th} days of observation indicates that there were a highly significant ($p<0.01$) differences found among these three days of observation. The higher value was observed at 0 day and lower value was observed at 28^{th} day. 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 3. pH of broiler meat sausages incorporates with rice 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
pH	0	6.54±0.01	6.50±0.01	6.47±0.01	6.47±0.01	6.49^{a}	**	**	NS
	14	6.50±0.00	6.47±0.01	6.43±0.01	6.44±0.00	6.45^{b}			
	28	6.47±0.01	6.46±0.00	6.40±0.01	6.40±0.00	6.44^{c}			
	Mean	6.50^{a}	6.47^{b}	6.43^{c}	6.44^{c}				

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

Proximate composition of sausage

The value of proximate components was shown in Table 4. The proximate composition of different sausages was analyzed and highly significant differences were found in DM (%), Ash (%), EE (%), CP (%) and CF (%) among the treatments. Significantly higher DM (%), Ash (%), EE (%), and CF (%) were found in T_4, while CP (%) was significantly higher in T_1. Storage period had highly significant on DM (%), Ash (%), EE (%), CP (%) and CF (%). The DM, CF and CP (%) content were increased with increase of storage period but Ash (%), and EE (%) 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 4. Proximate composition of broiler meat sausages incorporates with rice bran during different storage time

Parameter	Storage time (D)	Treatments					Level of Significance		
		T1	T2	T3	T4	Mean	T	D	T*D
DM (%)	0	28.02±0.14	31.34±0.29	32.93±0.51	33.82±0.43	31.52^{c}	**	**	NS
	14	29.75±0.57	32.79±0.32	34.17±0.36	35.23±0.38	32.99^{b}			
	28	32.90±0.60	35.58±0.12	37.11±0.07	39.70±0.10	36.32^{a}			
	Mean	30.22^{d}	33.24^{c}	34.73^{b}	36.25^{a}				
Ash (%)	0	2.86±0.01	3.06±0.01	3.64±0.04	3.74±0.01	3.32^{a}	**	**	NS
	14	2.77±0.04	2.94±0.06	3.43±0.05	3.70±0.19	3.21^{b}			
	28	2.67±0.04	2.87±0.01	3.30±0.03	3.68±0.06	3.13^{b}			
	Mean	2.77^{d}	2.96^{c}	3.46^{b}	3.70^{a}				
CF (%)	0	0	0.56±0.00	1.10±0.02	1.44±0.06	0.78^{b}	**	**	NS
	14	0	0.59±0.01	1.18±0.04	1.52±0.08	0.82^{ab}			
	28	0	0.71±0.01	1.26±0.06	1.54±0.02	0.88^{a}			
	Mean	0.00^{d}	0.62^{c}	1.18^{b}	1.50^{a}				
FAT (%)	0	6.23±0.18	6.40±0.10	6.20±0.20	6.35±0.35	6.29^{a}	**	**	NS
	14	6.00±0.15	5.88±0.08	6.10±0.10	6.16±0.10	6.03^{b}			
	28	4.88±0.13	5.45±0.15	5.65±0.15	6.08±0.03	5.51^{c}			
	Mean	5.70^{b}	5.91^{ab}	5.98^{ab}	6.20^{a}				
CP (%)	0	19.58±0.10	18.06±0.39	16.39±0.24	14.18±0.30	17.05^{c}	**	**	NS
	14	21.53±0.18	20.35±0.22	19.69±0.09	18.60±1.10	20.04^{b}			
	28	22.54±0.66	21.97±0.09	19.91±0.66	19.52±0.09	20.98^{a}			
	Mean	21.21^{a}	20.12^{b}	18.66^{c}	17.43^{d}				

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

Lightness (*L**)

The mean values observed from four treatment indicates that there was highly significant difference ($p<0.01$) exist among four treatments. Of the four treatments group highest reading was observed from broiler breast meat without rice bran (T_1) and lowest was observed from broiler breast meat sausage 15% rice bran (T_4) group. The mean values observed from 0, 14th and 28th days of observation indicates there were a highly significant differences ($p<0.01$) among these days of observation. The higher reading was observed from 0 day and lower reading was observed from 28th day. However, there was also highly significant difference ($p<0.01$) exist between the interaction of treatments and number of days it was stored under refrigerated condition. Haque et al. (2024) found similar results with decreasing L value with increasing rice bran level and storage period in chicken nugget.

Redness (*a**)

The mean values observed from four treatment indicates there were highly significant difference ($p<0.01$) found among four treatments. Of the four treatments group highest reading was observed from broiler breast meat sausage with 15% rice bran (T_4) and lowest color score was observed from broiler breast meat sausage without rice bran (T_1) group. The mean values observed from 0, 14th and 28th days of observation indicates there were no significant differences ($p>0.05$) found among these days of observation. The highest reading was observed from 28th day and lowest from 0 day. The data shows that redness score increased gradually with the increase in storage period. 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 increase significantly with the increase in storage period.

Yellowness (*b**)

The mean values observed from four treatments indicates that there was highly significant difference ($p<0.01$) found among three treatments. Of the four treatments. Highest score was observed from broiler breast meat sausage with 15% rice bran (T_4) and lowest color score was observed from broiler breast meat sausages without rice 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 0 day and lowest from 28th day. The data shows that yellowness score is decreased with the increase in storage time. Yilmaz (2004) investigated the effects of rice bran addition on color and quality characteristics of low-fat meatballs reported that, b* value (yellowness) tends to increase with the increase in storage period. 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 28 days storage period.

Table 5. International commission on illumination color measurements (CIE*) of broiler meat sausages incorporate with rice 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	60.18±2.44	59.42±4.65	58.70±1.83	56.00±3.47	58.57^{a}	**	**	NS
	14	57.96±0.54	57.62±2.84	53.67±3.43	50.33±0.56	54.90^{a}			
	28	57.84±1.30	54.93±1.17	47.80±0.58	42.45±4.38	50.75^{b}			
	Mean	58.66^{a}	57.32^{ab}	53.39^{bc}	49.59^{c}				
*a**	0	1.77±0.50	1.97±0.14	2.50±0.09	3.12±0.26	2.34	**	NS	NS
	14	1.81±0.47	2.22±0.25	3.61±0.32	3.35±3.47	2.75			
	28	1.28±0.17	2.47±0.04	2.95±0.09	2.86±0.56	2.39			
	Mean	1.62^{c}	2.22^{b}	3.02^{a}	3.11^{a}				
*b**	0	11.93±0.42	15.07±0.23	16.90±1.37	18.34±1.40	15.56^{a}	**	**	NS
	14	11.23±0.43	14.20±0.27	15.23±0.89	16.54±0.39	14.30^{a}			
	28	10.69±1.13	12.00±1.51	12.83±0.36	14.62±0.69	12.54^{b}			
	Mean	11.28^{c}	13.76^{b}	14.99^{b}	16.50^{a}				

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

Biochemical properties

Free fatty acid (FFA)

The Free Fatty Acid value of different treatment levels with days of intervals shown in Table 6. The range of overall observed FFA value at different treatment levels was 0.28 to 0.56. The mean values observed from different treatment groups indicates that there were a highly significant differences (p<0.01) found among the treatment groups. Of the four treatments, the highest POV value was observed in T3(broiler breast meat sausage with 10% rice bran) and also in T_4 (broiler breast meat sausage with 15% rice bran) and lowest was observed from T_1 (broiler breast meat sausage without rice bran). On the other hand, the range of overall observed of different days of intervals of FFA was similar and it was 0.46. The mean values observed in 0, 14th and 28th days of observation indicates there was no significant (p>0.05) differences among these three days of observation. Thus, the interaction between treatment and number of days it was stored does not have a significant difference (p > 0.05) on the level of FFA. Modi et al. (2004) reported that the FFA value gradually increase 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 increasing storage period significantly rise in free fatty acids content which is similar to my findings.

Peroxide Value (POV-meq/kg)

Peroxide value (POV-meq/kg) of different treatment levels with the days of intervals shown in Table 6. The range of overall observed POV value at different treatment levels was 1.36 to 1.93. The mean values observed from different treatment groups indicates that there were a highly significant differences (p < 0.01) found among the treatment groups. Among the four treatments, the highest POV value was observed from T_4 (broiler breast meat sausage with 15% rice bran) and lowest was observed from T_1 (broiler breast meat sausage without rice bran). The range of overall observed of different days of intervals of peroxide value was 1.64 to 1.70. The mean values observed at 0, 14th and 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 28th day and lowest value was observed at 0 day of storage. And the interaction between treatments and number of days has no 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. 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.

Table 6. Biochemical properties of broiler meat sausages incorporate with rice 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
FFA (%)	0	0.28±0.00	0.42±0.14	0.56±0.00	0.56±0.00	0.46	**	NS	NS
	14	0.28±0.00	0.42±0.14	0.56±0.00	0.56±0.00	0.46			
	28	0.28±0.00	0.42±0.14	0.56±0.00	0.56±0.00	0.46			
	Mean	0.28^{c}	0.42^{b}	0.56^{a}	0.56^{a}				
POV (meq/kg)	0	1.39±0.02	1.56±0.04	1.69±0.01	1.90±0.03	1.64^{b}	**	*	NS
	14	1.33±0.03	1.60±0.02	1.73±0.01	1.89±0.02	1.64^{b}			
	28	1.37±0.01	1.79±0.08	1.79±0.08	2.00±0.03	1.70^{a}			
	Mean	1.36^{d}	1.60^{c}	1.74^{b}	1.93^{a}				
TBARS (malonaldehyde/ kg sample)	0	0.14±0.00	0.14±0.00	0.15±0.00	0.12±0.00	0.15^{c}	**	**	NS
	14	0.18±0.01	0.16±0.01	0.21±0.00	0.25±0.00	0.18^{b}			
	28	0.19±0.00	0.17±0.00	0.23±0.00	0.26±0.00	0.20^{a}			
	Mean	0.17^{b}	0.17^{b}	0.19^{a}	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 = Treatment, D = Day, T_1 = Broiler breast meat without rice bran, T_2 = Broiler breast meat + 5% rice bran, T_3 = Broiler breast meat + 10% rice bran, T_4 = Broiler breast meat + 15% rice bran

Thiobarbituric Acid Value (TBARS)

The TBARS values of different treatment levels with days of intervals shown in Table 6. The range of overall observed TBARS value at different treatment levels was 0.17 to 0.19. The mean values observed from different treatment groups indicates that there were highly significant differences ($p<0.01$) found among the treatment groups. Among the four treatments, the highest TBARS value was observed from T_3 (broiler breast meat sausage with 10% rice bran) and also in T_4 (broiler breast meat sausage with 15% rice bran) and lowest was observed from T_1 (broiler breast meat sausage without rice bran) and also in T_2 (broiler breast meat sausage with 5% rice bran) The range of overall observed of different days of intervals of TBARS value was 0.15 to 0.20. 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 value was observed at 28th day and lowest value was observed at 0 day of storage. The interaction between treatment and number of days it was stored has no significant difference ($p>0.05$) 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 7. Sensory properties of cooked broiler sausages manufactured from broiler meat incorporate with rice bran

Parameters	Different Treatments				Level of significance
	T_1	T_2	T_3	T_4	
Color	3.93±0.08	4.03±0.12	4.07±0.09	4.10±0.06	NS
Flavor	4.20^{a}±0.06	4.20^{a}±0.12	3.90^{b}±0.06	3.87^{b}±0.07	*
Off-flavor	1.23±0.03	1.17±0.09	1.23±0.03	1.27±0.03	NS
Juiciness	4.13±0.03	4.17±0.03	3.97±0.12	3.93±0.09	NS
Tenderness	4.03±0.07	4.03±0.12	4.07±0.03	4.07±0.09	NS
Overall acceptability	4.43^{b}±0.03	4.60^{a}±0.06	4.33^{b}±0.03	4.17^{c}±0.03	**

**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 rice bran, T_2 = Broiler breast meat + 5% rice bran, T_3 = Broiler breast meat + 10% rice bran, T_4 = Broiler breast meat + 15% rice 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 rice bran on the sensory properties of chicken sausages were shown in Table 7. The data obtained from different treatment indicated that there was highly significant difference among the treatments in overall acceptability among the chicken sausages from sensory evaluation ($p > 0.01$). 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.

Conclusions

It might be concluded that addition of rice 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.

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