



Production of value-added broiler nugget enriched with dietary fiber from oat meal

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Abstract

An experiment was conducted to find out the effect of oat meal as a source of dietary fiber to formulate enriched broiler nugget. For this purpose, nuggets were prepared into four different groups such as treatment 1: 10% wheat flour nugget, treatment 2: 20% wheat flour nugget, treatment 3: 10% oat meal nugget and treatment 4: 20% Oat meal nugget. All parameters were analyzed at 0, 15th and 30th days of storage period. The proximate composition of different nuggets batter was analyzed and highly significant differences were found in dry matter (%) and pH. Dry matter was lower, while pH was higher in control nugget (Treatment 1). Significant differences were found in crude protein (%), ether extract (%) among different nuggets, as well as among different storage time. Significantly higher DM (%), Ash (%) and EE (%) was found in broiler meat with 20% oat meal, while higher crude protein (%) were found in broiler meat+10% wheat flour. Crude protein (%) and DM (%) increased, while Ash (%) and EE (%) decreased with increase of storage time. The storage period had significant effect on different biochemical (FFA, POV and TBARS value) and microbial (TVC, TCC and TYMC) tests. In all cases, the values were increased with increase of storage time. The surface color (CIE L^* , a^* , b^*) of nuggets of different treatments at different storage period were measured. No significant differences in b^* value were found among broiler meat nuggets and storage time. On the other hand, different types of nuggets and storage period had a significant effect on L^* and a^* value. Significantly higher a^* value was found in broiler meat with 10% wheat flour (T1). In sensory analysis, no significant differences were found in flavor, off-flavor, juiciness, tenderness and overall acceptability among four types of sausages. It could be concluded that addition of oat meal as a source of dietary fiber did not differ the overall acceptability of broiler meat nuggets compare to broiler meat nuggets with wheat flour.

Keywords: nugget, dietary fiber, oat meal

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Introduction

Poultry is one of the recognized integral components of Agricultural production process. It plays potential role in the national economy being one of the vital components of Agriculture. Animal protein is the most essential element for human physiology. Meat and meat products are widely used in developed and developing countries to meet the consumers demand (Gerber et al., 2009). Meat products are the best sources of minerals, vitamins and complete proteins that are essential for optimal development and growth. As consumers are becoming more health conscious, this is leading to a growing preference for healthier, more nutritious and more functional food products. Nugget is a meat product that is popular worldwide. Though this product has high demand concentrated in western but it also getting more demand in Asia. Nugget is a popular

meat product as it requires less time to prepare and nutritionally more acceptable than other food product. Studies in meat consumption in last decade have shown the health and nutritional value of a product is a major factor in consumer preference (Angulo and Gil, 2007 and Fonseca and Salay, 2008).

Recently, food industry was concerned on using food processing by-products and high fiber plants as sources of dietary fiber to provide high fiber meat products as functional meat products for consumers. However, due to changes in the food habits, lack of moderation and variety in the food consumed many people never get required levels of dietary fiber. Various reports revealed that intake of dietary fiber decrease intestinal disorders, cholesterol level and blood sugar level. Incorporation of dietary fibre from plant sources in meat products would help to reduce the bad

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effects of meat consumption, enhance their nutritional composition and desirability.

Oats are a whole grain food, known scientifically as *Avena sativa*. Oat meal is made by boiling oats in water or milk. The nutrient composition of oats is well balanced. Oats contain large amounts of beta-glucan, a type of soluble sugar. The health benefits of beta-glucan fiber includes: reduced LDL and total cholesterol level, reduced blood sugar, increased feeling of fullness, increased growth of good bacteria in the digestive tract (Anttila et al. 2004). Therefore, the present study was to investigate how the addition of oat meal affects the quality of chicken nugget and to find out appropriate level of oat meal for making chicken nuggets with higher consumer's preference.

Materials and Methods

Experimental Design

Four broiler nugget formulations were developed (Table 1), as follows: 1) Broiler meat with 10% wheat flour 2) Broiler meat with 20% wheat flour 3) Broiler meat with 10% Oat meal 4) Broiler meat with 20% Oat meal.

Broiler nugget preparation

Broiler was purchased from BAU poultry farm and slaughtered. All breast meat was removed from the carcass. 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 meat was grinded with the help of meat grinder. Wheat flour, oat meal, spices and salt were purchased from local market and sodium orthobate was purchased from Dhaka. Oat meal was grinded in a grinding machine. Batters were prepared by mixing all the ingredients in a plastic bowl. Wheat flour and oat meal were added at a level of 10% or 20% (wt/wt). For each batch of batters, ingredients were mixed using a mixer machine. After mixing, nuggets were made by hand, dipped in egg liquid and then giving a coating by *breadcrumbs*. Then the nuggets were cooked in a food steamer for 15 minutes. The prepared nuggets were then packed in food grade poly ethylene bags and stored refrigerated for up to 30 days and assessed immediately after processing (0 day) and at an interval of 15- and 30-days post storage.

Product analysis

Proximate analysis

Moisture, protein, fat and ash of sausages and batters was determined as per the standard

procedures of Association of Official Analytical Chemists (AOAC, 1995).

pH determination

The pH of emulsion and cooked products was determined by blending 10 g of sample with 50 ml of distilled water using an Ultra Turrax T25 tissue homogenizer (Janke and Kunkel, IKA Labortechnik, Staufen, Germany) at 8,000 rpm for 1 min. The pH of the suspension was recorded by dipping combined glass electrode of Elico digital pH meter, Model LI 127 (Elico Limited, Hyderabad, India).

Cooking loss

To determine cooking loss of sausage batter, weighed 5 g sample and wrapped in a heat stable foil paper and kept in water bath at 80°C for 30 minutes. Samples surface are dried and weighed. Cooking loss was calculated as the percentage of the loss weight of the cooked sample (Symeon et al., 2010).

Cooking loss (%) = ((uncooked weight-cooked weight) / uncooked weight) × 100

Color analysis

The surface color (CIE L*, a*, b*) of sausages samples were measured using a Minolta Chromameter (Minolta CR 410, Tokyo, Japan) standardized with a white plate (Y = 93.5, X = 0.3132, y = 0.3198). Five random reading were taken from each type of sausages. The measurements were averaged for each surface and the results were expressed as positive L*(lightness), a*(redness), b*(yellowness).

TBARS, peroxide value (POV) and free fatty acids (FFA)

The amount of malonaldehyde (MDA) was established using a procedure described by Buege and Aust (1978).

TBARS = Abs 530 nm × 7.8 (conversion factor) mg malonaldehyde/kg sausage

FFA value was determined according to Rukunudin et al. (1998). FFA was calculated as shown below:

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

Peroxide value (POV) was determined according to (Sallam et al., 2004). POV was calculated as shown below:

POV (meq / kg) = {(S×N)/W}×1000

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

Microbiological analyses

For microbial assessment total viable count, total coliform count and total yeast-mould count were undertaken. A quantity of 10 g of beef meat sample was aseptically excised from stored stock sample. Each of the stored beef meat samples was thoroughly and uniformly macerated in a mechanical blender using a sterile diluent (0.1% peptone water) as per the recommendation of International Organization for Standardization (ISO, 1995). A quantity of ten (10) grams of the minced meat sample was taken aseptically transferred into a sterile container containing 90 ml of

0.1% peptone water. A homogenized suspension was made in a sterile blender. Thus

1:10 dilution of the samples was obtained. Later on using whirlly mixture machine different serial dilutions ranging from 10² to 10⁶ were prepared according to the instruction of the standard method (ISO, 1995).

$$CFU/gm = (\text{number of colonies} / (\text{volume plated} \times \text{total dilution}))$$

Sensory evaluation

Different sensory attributes were examined at day 1. The nuggets were fry in a fry pan with soybean oil. Each nugget 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). 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. Sensory evaluation was accomplished at 0, 15th and 30th days.

Statistical analysis

The nugget batter data and the sensory evaluation of different nuggets were analyzed using analysis of variance technique with the principles of Completely Randomized Design, while nuggets data during different storage period were analyzed by 4×3 factorial design (where, 4=different nuggets and 3=different storage period) (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

Nugget batter is a mixture of ingredients by which nugget is prepared. The proximate and biochemical composition of nugget batter was shown in table 2.

The data obtained from different nugget batter indicated that there was no significant difference among the treatments in cooking loss (%) (p>0.05). A significant differences were found in pH level of different nugget batter (p<0.05). The higher pH value was observed in chicken meat with 10% wheat flour. However, no significant differences were found among three chicken nugget batter incorporate with 20% wheat flour and 10% and 20% oat meal. Significant difference were found among the treatments in case of DM content (P<0.05). The lowest DM was observed in chicken meat with 10% wheat flour and the highest DM was observed in chicken meat with 20% wheat flour. The value obtained from different nugget batter treatment indicated that there was no significant difference among the treatments (p>0.05). However, the highest value of ash content was observed in nugget batter made from chicken meat with 20% oat meal and lowest ash content was noticed in nugget batter made from chicken meat with 10% oat meal.

Table 1: Composition of different nugget batters

Ingredients	Treatments			
	Broiler nugget + 10% wheat flour	Broiler nugget + 20% wheat flour	Broiler nugget + 10% oat meal	Broiler nugget + 20% oat meal
Breast meat(g)	900	800	900	800
Flour (g)	100	200	100	200
Spices (g)	24	24	24	24
Salt (g)	15	15	15	15
Sodium erthorbate (g)	0.37	0.37	0.37	0.37
Soybean oil (g)	20	20	20	20
Water (ml)	100	100	100	100

Table 2: Proximate composition, cooking loss and pH of chicken nugget batter incorporate with oat meal

Parameters	Treatments (T)				Level of Significance
	Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal	
Cooking Loss (%)	4.57±0.53	2.17±0.77	3.89±0.62	3.10±0.46	Ns
pH	6.25±0.53 ^a	6.18±0.02 ^b	6.15±0.02 ^b	6.14±0.02 ^b	*
Dry matter (%)	28.50±0.70 ^b	35.40±1.54 ^a	30.61±0.35 ^b	34.62±0.80 ^a	*
Ash (%)	2.42±0.44	2.45±0.17	2.20±0.10	2.54±0.12	NS
Crude protein (%)	17.74±0.24	16.19±0.44	17.33±0.18	16.59±0.09	NS
Ether extract (%)	2.15±0.20	1.65±0.35	2.43±0.08	1.78±0.08	NS

*p<0.05; NS: Non-significant; Means with different superscripts within a row differ significantly (p<0.05).

pH of nuggets during different days of interval

The pH of different treatments with days of intervals was shown in Table 3. The mean values observed from four treatment groups indicated that there were no significant (p>0.05) differences among the treatments. However, the higher value was observed in chicken meat with 20% oat meal and the lower value was observed in chicken meat with 10% wheat flour. The range of overall observed of different days of intervals of pH was 6.32 to 6.43. The mean values observed in 0, 15th and 30th days of observation indicated that there were highly significant (p<0.01) differences found among these three days of observation. However, the higher value was observed in 0 day and lower value was observed at 30th day. The interaction between treatment and number of days it was stored does not have a significant difference (p>0.05) on the level of pH. Bhattacharya et al. (2018) conducted a study to know the effect of date palm fruit with the chicken nuggets and found pH values

decreased significantly (p<0.05) with increasing concentration of date palm in chicken nuggets.

Proximate analysis of nuggets during different days of interval

There are four types of chicken nuggets were made for the determination of proximate components. The values of proximate components are shown in table 4.

Result showed that different nuggets have significant (p<0.05) effect and as well as days of interval have significant effect (p<0.01), but their interaction have no significant effect (p>0.05) on DM content. Significantly highest DM (%) was found in nuggets with 20% wheat flour. On the other hand DM content was increased with the increase of storage period. The results agreed with results of Naveena et al. (2008), who have reported an increase in storage period with an increase in the dry matter content of chicken patties incorporated with pomegranate peel extract and pomegranate rind powder extract.

Table 3. pH of chicken nugget batter incorporate with oat meal during different storage time

Parameter	Days of intervals (D)	Treatments (T)				Mean	Level of Significance		
		Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal		T	D	T*D
pH	0	6.40±0.01	6.44±0.01	6.43±0.02	6.45±0.01	6.43 ^a	NS	**	NS
	15	6.36±0.01	6.36±0.02	6.41±0.01	6.39±0.01	6.38 ^b			
	30	6.33±0.02	6.30±0.02	6.30±0.02	6.34±0.02	6.32 ^c			
	Mean	6.36	6.37	6.38	6.39				

**p<0.01; NS: Non-significant; Means with different superscripts within a row differ significantly (p<0.05).

Table 4: Proximate composition of broiler nugget incorporate with oat meal during different storage time

Parameter (%)	Days of intervals (D)	Treatments (T)				Mean	Level of Significance		
		Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal		T	D	T*D
DM	0	33.10±1.08	34.06±1.04	32.82±0.20	34.49±1.31	33.62 ^b			
	15	34.40±1.40	36.84±1.06	33.96±0.10	36.63±1.23	35.46 ^a	*	**	NS
	30	35.72±1.14	38.62±1.34	34.36±1.24	37.69±1.01	36.60 ^a			
	Mean	34.41 ^{bc}	36.51 ^a	33.71 ^c	36.27 ^{ab}				
CP	0	14.36±0.53	13.52±0.49	12.43±0.17	11.82±0.27	13.03 ^c			
	15	15.75±0.35	14.53±0.35	14.62±0.27	14.18±0.35	14.77 ^b	**	**	NS
	30	17.28±0.23	16.37±0.27	16.33±0.18	14.44±0.44	16.10 ^a			
	Mean	15.79 ^a	14.80 ^b	14.46 ^b	13.48 ^c				
Ash	0	2.53±0.27	2.50±0.50	2.83±0.89	2.02±0.04	2.51 ^a			
	15	1.89±0.15	2.11±0.01	2.02±0.04	1.87±0.09	2.02 ^{ab}	NS	*	NS
	30	1.77±0.03	1.59±0.27	1.87±0.09	2.83±0.89	1.82 ^b			
	Mean	2.06	2.07	2.10	2.24				
EE	0	3.45±0.40	2.63±0.13	3.70±0.25	3.30±0.05	3.27 ^a			
	15	2.70±0.07	2.58±0.08	3.28±0.08	2.98±0.08	2.88 ^b	**	**	NS
	30	2.83±0.03	1.93±0.08	3.06±0.05	2.95±0.05	2.69 ^b			
	Mean	2.99 ^b	2.38 ^c	3.34 ^a	3.08 ^{ab}				

*p<0.5; **p<0.01; NS: Non-significant; Means with different superscripts within a row or column differ significantly (p<0.05).DM: dry matter; CP: crude protein; EE: ether extract.

The range of overall observed CP content at different treatments was 13.48 to 15.79%. The mean value observed from different treatment groups indicated that there were highly significant (p<0.01) difference found for CP content. Among four treatment groups, the lowest CP content was observed from nuggets with 20% oat meal and highest was observed from nuggets with 10% wheat flour. The range of overall observed of different days of intervals of CP content was 13.03 to 16.10%. The mean value observed from 0, 15th and 30th days of observation indicated that there were highly significant (p<0.01) differences among these three days of observation. The CP content was increased with the increase storage period. The highest CP content was observed at 30 day and lowest CP content at 0 days. The interaction between treatment and number of days it was stored has no significant difference (p>0.05) on CP content.

Abdullah *et al.* (2018) while conducting an experiment reported that protein content increased significantly in imitation chicken nuggets or ICNs formulated with different percentage of chickpea flour and textured vegetable protein (TVP).Barros *et al.* (2018) conducted an experiment to reformulate chicken nuggets, through the replacement of 0-20% chicken skin by chia flour and found that the protein, lipid and ash contents, oil absorption, weight gain of the coating and cooking yield were not affected by the incorporation of chia flour.

The range of overall observed ash content at different treatments was 2.06 to 2.24%. The mean values observed from four treatment groups indicated that there were no significant (p>0.05) differences of ash content. The range of overall observed of different days of intervals of ash content was 1.82 to 2.51%. The mean values observed from 0, 15th and 30th days of observation indicated that there were significant (p<0.05) differences among these three days of

observation. The ash content was significantly decreased with the increased storage period. The lowest ash content was observed at 30th day and highest ash content at 0 day. Bhattacharya et al. (2007) while conducting an experiment observed that ash content decreased during frozen storage of meat products incorporated with natural herbs. Barros et al. (2018) conducted an experiment to reformulate chicken nuggets, through the replacement of chicken skin by chia flour, and reported that with an increase in the storage period ash content is gradually decreased. The treatments and the interaction between treatment and number of days it was stored did not have a significant difference ($p>0.05$) on ash content.

The range of overall observed EE content at different treatments was 2.38 to 3.34%. Observation from four treatments, the mean values indicated that there were highly significant ($p<0.01$) differences of EE content. Among four treatment groups, the lowest EE content was observed at chicken nuggets with 20% wheat flour group and the highest EE content was observed at chicken nuggets with 10% oat meat group. The range of overall observed of different days of intervals of EE content was 2.69 to 3.27%. The mean values observed from 0, 15th

and 30th days of observation indicated that there were highly significant differences ($p<0.01$) among these three days of observation. The EE content was decreased with the increase storage period. The lowest EE content was observed at 30 day and highest EE content at 0 days. Bhattacharya et al. (2018) conducted a study to know the effect of date palm fruit with the chicken nuggets and reported that with an increase in the storage period EE content is gradually decreased in treatment group. The interaction between treatment and number of days it was stored has no significant difference ($p>0.05$) on EE content.

The instrumental nugget surface color (CIE L^* , a^* , b^*)

The surface color (CIE L^* , a^* , b^*) of chicken nugget 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.

The range of overall observed color score at different treatment for lightness (L^*) was 67.20 to 74.80. The mean values observed from four treatment indicate that there were highly significant difference ($P<0.01$) exist among four treatments.

Table 5: International commission on illumination color measurements (CIE*) of chicken nugget batter incorporate with oat meal during different storage time

Parameter	Days of intervals (D)	Treatments (T)				Mean	Level of Significance		
		Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal		T	D	T*D
L^*	0	73.80±0.56	71.90±3.21	76.77±0.37	71.04±0.43	73.38 ^a			
	15	61.78±0.07	68.99±0.24	72.74±0.09	71.54±0.16	68.76 ^c	**	**	**
	30	66.03±0.24	72.43±0.85	74.88±0.68	68.91±1.07	70.56 ^b			
	Mean	67.20 ^c	71.11 ^b	74.80 ^a	70.50 ^b				
a^*	0	1.60±0.38	1.42±0.36	1.82±0.19	2.26±0.13	1.77 ^b			
	15	4.52±0.19	1.11±0.08	1.76±0.16	1.90±0.13	2.32 ^{ab}	**	*	**
	30	3.14±0.13	1.68±0.34	1.78±0.07	3.16±1.01	2.44 ^a			
	Mean	3.08 ^a	1.40 ^c	1.78 ^c	2.44 ^b				
b^*	0	17.04±2.25	15.67±1.20	15.38±0.70	16.92±0.86	16.25			
	15	19.01±1.09	15.13±0.55	14.50±0.63	16.92±0.89	16.40	NS	NS	NS
	30	19.79±0.62	17.74±1.47	16.57±0.72	19.96±4.00	18.51			
	Mean	18.61	16.18	15.48	17.93				

* $p<0.5$; ** $p<0.01$; NS: Non-significant; Means with different superscripts within a row or column differ significantly ($p<0.05$).

Table 6: Biochemical properties of chicken nugget batter incorporate with oat meal during different storage time

Parameter	Days of intervals (D)	Treatments (T)				Mean	Level of Significance		
		Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal		T	D	T*D
FFA (%)	0	0.45±0.03	0.50±0.03	0.45±0.03	0.47±0.00	0.47 ^c			
	15	0.66±0.03	0.67±0.00	0.65±0.03	0.65±0.03	0.65 ^b			
	30	0.79±0.03	0.76±0.00	0.85±0.03	0.85±0.03	0.81 ^a	NS	**	NS
	Mean	0.63	0.64	0.65	0.65				
POV (meq / kg)	0	1.45±0.03	1.47±0.02	1.49±0.04	1.50±0.02	1.48 ^c			
	15	1.75±0.02	1.79±0.02	1.75±0.02	1.80±0.03	1.77 ^b			
	30	1.92±0.00	1.97±0.02	2.00±0.02	2.00±0.02	1.97 ^a	*	**	NS
	Mean	1.71 ^b	1.74 ^{ab}	1.75 ^{ab}	1.77 ^a				
TBARS (mg malonaldehyde/ kg sample)	0	0.12±0.00	0.13±0.00	0.19±0.00	0.21±0.00	0.16 ^c			
	15	0.19±0.00	0.23±0.00	0.23±0.00	0.32±0.01	0.24 ^b			
	30	0.29±0.00	0.30±0.00	0.30±0.01	0.34±0.00	0.31 ^a	**	**	**
	Mean	0.20 ^d	0.22 ^c	0.24 ^b	0.28 ^a				

*p<0.5; **p<0.01; NS: Non-significant; Means with different superscripts within a row or column differ significantly (p<0.05).FFA: Free fatty acid; POV: Peroxide value; TBARS: Thiobarbituric acid reactive substance

Among the four treatments group highest reading was observed from chicken meat with 10% oat meal and lowest was observed from chicken meat with 10% wheat flour group. Whereas, the range of different days of interval of overall observation of color score for lightness was 68.76 to 73.38. The mean values observed from 0, 15th and 30th days of observation indicated that there were highly significant differences (p<0.01) found among these three days of observation. The higher reading was observed from 0 day and lower reading was observed from 15th day. Again, there was also highly significant difference (p<0.01) exist between the interaction of treatments and number of days (T*D) it was stored under refrigerated condition.

Abdullah *et al.*, (2018) conducted an experiment on the physicochemical properties and consumer preference of imitation chicken nuggets formulated with different percentage of chickpea flour and textured vegetable protein (TVP)

noticed that *L** value vary significantly among different treatment and storage period. Singh *et al.*, (2014) conducted an experiment to study the shelf life evaluation of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste at refrigerated storage (4±1°C). The result shows that *L** value did not vary significantly among different batches.

The range of overall observed color score at different treatment for redness (*a**) was 1.40 to 3.08. The mean values observed from four treatment indicate that there were a highly significant difference (p<0.01) found among four treatments. Of the four treatment group highest reading was observed from chicken meat with 10% wheat flour and lowest color score was observed from chicken meat with 20% wheat flour group. Whereas, the range of different days of interval of overall observation of color score for redness was 1.77 to 2.44. The mean values observed from 0, 15th and 30th days of

observation indicated that there were a significant differences ($p < 0.05$) found among these days of observation. The highest reading was observed from 30th day and lowest from 0 day of storage. The data showed that redness score increased gradually with the increase in storage period. But there was highly significant difference ($p < 0.01$) exist between the interaction of treatments and number of days (T*D) it stored under refrigerated condition. Abdullah *et al.*, (2018) conducted an experiment on nuggets enriched with chickpea flour and textured vegetable protein (TVP) and noticed that a^* value vary significantly among different treatment, storage period and treatment day interaction.

Again, the range of overall observed color score at different treatment for yellowness (b^*) was 15.48 to 18.61. The mean values observed from four treatment indicated that there were no significant difference ($p > 0.05$) found among four treatments. The range of different days of interval of overall observation of color score for yellowness was 16.25 to 18.51. The mean values observed from 0, 15th and 30th days of observation indicated that there were no significant differences ($p > 0.05$) exist among these days of observation. There was no significant difference ($p > 0.05$) found between the interaction of treatments and number of days (T*D) it stored under refrigerated condition. Abdullah *et al.*, (2018) conducted an experiment on the physicochemical properties and consumer preference of imitation chicken nuggets formulated with different percentage of chickpea flour and textured vegetable protein (TVP) noticed that b^* value vary significantly among different treatment and storage period and increases as increases the storage time.

Biochemical properties

The value of Biochemical components were shown in Table 6. The range of overall observed Free Fatty Acid (FFA) value at different treatments was 0.63 to 0.65. No significant differences ($p > 0.05$) were found in Free Fatty Acid value among four treatment groups. The range of overall observed of different days of intervals of FFA was 0.47 to 0.81. The mean values observed in 0, 15th and 30th days of observation indicated that there were highly significant ($p < 0.01$) differences found among these three days of observation. The FFA value was increased with the increased storage period. The highest FFA value was observed at 30th day of observation. Para *et al.* (2017) conducted an experiment to find out effect of clove oil on some quality characteristics and sensory attributes of papaya pulp enriched enrobed chicken nuggets at

refrigerated storage and found that as the days of storage progressed FFA values followed a significant ($p < 0.05$) linear increasing trend which agreed with our result. Banerjee *et al.* (2019) stated that the increase in free fatty acid content of chicken nuggets was insignificant ($P > 0.05$) during the first month of frozen storage. However, FFA values showed significantly ($P < 0.05$) increasing trend with the progressive storage period from 1st to 3rd month in case of all the treatment groups, which might be due to lipolysis.

The range of overall observed Peroxide value (POV-meq/kg) at different treatment levels was 1.71 to 1.77. There was significant differences ($p < 0.05$) were found in peroxide value among four treatments. The POV value was significantly higher in nuggets with 20% oat meal, while it was significantly lower in nuggets with 10% wheat flour. The range of overall observed of different days of intervals of peroxide value was 1.48 to 1.97. The mean values observed at 0, 15th and 30th days of observation indicated that there were highly significant differences ($p < 0.01$) among these observations. During storage, the peroxide value increased in all treatments. The interaction between treatments and their storage time has no significant difference on POV value. Park *et al.* (2016) found the peroxide value for chicken nuggets were 66.03 meq/kg in soybean oil, 71.04 meq/kg in canola oil, 15.48 meq/kg in palm oil, 62.92 meq/kg in lard respectively. Singh *et al.* (2014) reported that peroxide value did not show significant variation on day and different batch group. Kamaruzaman and Babji (2014) reported that peroxide value for all samples chicken nuggets increased throughout 3 months of frozen storage and then start to decrease thereafter.

The range of overall observed TBARS value at different treatment levels was 0.20 to 0.28. The mean values observed from the treatment groups indicated that there were highly significant differences ($p < 0.01$) among four treatment groups. Among the treatments, the lowest TBARS value was observed in nuggets with 10% wheat flour and highest in nuggets with 20% oat meal. The range of overall observed of different days of intervals of TBARS value was 0.16 to 0.31. The mean values observed from 0, 15th and 30th days of observation indicated that there were highly significant differences ($p < 0.01$) found among these three days observation. The interaction between treatments and number of days it is stored has also highly significant differences ($p < 0.01$) on TBARS value. The TBARS values increased significantly ($p < 0.01$) during storage in

all treatments. Bhattacharya *et al.* (2018) observed that the TBARS value did not show significant difference in the treatment group compared to the control which is not similar to the present study. Kamaruzaman and Babji (2014) reported that thiobarbituric acid value for all samples chicken nuggets increased throughout 3 months of frozen storage and then start to decrease thereafter. Para *et al.* (2017) and Akesowan (2016) shows that TBA followed a significant ($p < 0.05$) linear increasing trend in the treatment group and increasing in the storage time.

Microbiological assessment

The present study observed the presence of micro-flora (TVC) and food borne pathogens (Coliform and Yeast-Mold) on control and different treatment groups at different days of intervals and at different treatment levels. After 0 days of observation, four types sample was preserved at -20°C for the observation at 15th and 30th days. The microbiological assessment of different treatment levels with different days of intervals shown in Table 7.

The range of overall observed total coliform count (TCC) from the chicken nugget was 4.37 to 4.46 \log_{10} CFU/g in different treatment groups. The mean values of different treatment indicated that there were a highly significant ($p < 0.01$)

differences in TCC values found among four treatment groups. Of the four treatment groups the total coliform count was highest in the chicken nuggets with 10% wheat flour (4.46 \log_{10} CFU/g) and lowest coliform count was found in chicken nuggets with 10% oat meal (4.37 \log_{10} CFU/g). On the other hand, the range of overall observed of different days of intervals of TCC value was 4.15 to 4.62 \log_{10} CFU/g. The mean values observed from 0, 15th and 30th days of observation indicated that there were highly significant differences ($p < 0.01$) found among these three days of observation. The highest coliform count was found at 30th days of storage while lowest was noticed at 0 days of observation. There was also a highly significant difference ($p < 0.01$) exist between the interaction of treatments and number of days it was stored. Deepak *et al.* (2018) observed a zero coliform count in chicken nuggets incorporated with flaxseed flour. Reddy *et al.* (2017) reported that the overall mean coliform count (\log_{10} cfu/g) increased significantly ($P < 0.05$) with increase in storage period during refrigeration in chicken meat patties. This might be due to the permissive temperature and relative availability of moisture and nutrients for the growth of coliforms bacteria. These results were similar with Szymanczuk *et al.*, (2011) and found that coliform count increased with increasing storage time in refrigerated pork batters.

Table 7: Microbial properties of chicken nugget batter incorporate with oat meal during different storage time

Parameter	Days of intervals (D)	Treatments (T)				Mean	Level of Significance		
		Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal		T	D	T*D
TCC (\log_{10} CFU/g)	0	4.11±0.02	4.17±0.01	4.17±0.02	4.16±0.02	4.15 ^c	**	**	**
	15	4.49±0.01	4.46±0.01	4.45±0.02	4.49±0.01	4.47 ^b			
	30	4.80±0.02	4.60±0.04	4.50±0.04	4.57±0.06	4.62 ^a			
	Mean	4.46 ^a	4.41 ^b	4.37 ^b	4.40 ^b				
TYMC (\log_{10} CFU/g)	0	3.90±0.05	3.99±0.09	4.24±0.04	4.37±0.03	4.12 ^c	NS	**	**
	15	4.81±0.03	4.82±0.03	4.75±0.03	4.50±0.05	4.72 ^b			
	30	5.15±0.01	5.12±0.04	4.89±0.01	4.95±0.09	5.03 ^a			
	Mean	4.62	4.64	4.63	4.60				
TVC (\log_{10} CFU/g)	0	5.80±0.04	5.81±0.11	6.07±0.04	6.08±0.05	5.94 ^c	**	**	**
	15	6.82±0.04	6.33±0.03	6.23±0.03	6.32±0.04	6.42 ^b			
	30	7.09±0.07	6.72±0.14	7.02±0.06	7.09±0.10	6.98 ^a			
	Mean	6.57 ^a	6.29 ^c	6.44 ^b	6.50 ^{ab}				

** $p < 0.01$; NS: Non-significant; Means with different superscripts within a row or column differ significantly ($p < 0.05$). TCC: total coliform count; TYMC: Total Yeast and Mold Counts ; TVC: Total viable count.

Table 8: Sensory properties of chicken nugget batter incorporate with oat meal during different storage time

Parameters	Treatments				Level of Significance
	Broiler meat+10% wheat flour	Broiler meat+20% wheat flour	Broiler meat+10% oat meal	Broiler meat+20% oat meal	
Color	4.68±0.14	4.28±0.07	4.20±0.12	4.40±0.16	Not significant
Flavor	4.90±0.14	4.95±0.14	4.78±0.17	4.73±0.08	Not significant
Off-flavor	1.72±0.05	1.68±0.06	1.67±0.07	1.72±0.04	Not significant
Juiciness	4.75±0.07	4.83±0.10	4.63±0.11	4.60±0.09	Not significant
Tenderness	4.87±0.05	4.87±0.07	4.83±0.06	4.78±0.05	Not significant
Overall acceptability	4.82±0.04	4.82±0.05	4.82±0.05	4.78±0.09	Not significant

The range of overall observed total yeast-mold count (TYMC) from different chicken nugget was 4.60 to 4.64 (\log_{10} CFU/g). The mean values of different treatment indicated that there were no significant differences ($p>0.05$) of TYMC values found among four treatment groups. On the other hand, the range of overall observed of different days of intervals of TYMC value was 4.12 to 5.05 \log_{10} CFU/g. The mean values observed from 0, 15th and 30th days of observation indicated that there were a highly significant differences ($p<0.01$) found among these three days of observation. The highest yeast mold count was found at 30th days while lowest was noticed at 0 days of observation. There was also a highly significant difference ($p<0.01$) exist between the interaction of treatments and number of days it was stored. El-Gammal *et al.* (2018) reported that utilization of loquat seed powder reduced the yeast and mold of nugget samples compared with control sample.

The range of overall observed total viable count (TVC) from the different chicken nugget was 6.29 to 6.57 (\log_{10} CFU/g). The mean values of different treatment indicated that there were a highly significant ($p<0.01$) differences of TVC values among four treatment groups. Of the four treatment groups the total viable count was highest in chicken nuggets with 10% wheat flour (6.57 \log_{10} CFU/g) and lowest viable count was found in chicken nuggets with 20% wheat flour (6.29 \log_{10} CFU/g). The range of overall observed TVC of different days of interval was 5.94 to 6.98 \log_{10} CFU/g. The mean values observed from 0, 15th and 30th days intervals indicated that there were a highly significant differences found among these three days of observation. The highest TVC was found at 30th days while lowest was noticed at 0 days of observation. There was also a highly significant difference ($p<0.01$) exist between the interaction of treatments and number of days it

was stored. El-Gammal *et al.* (2018) utilization of loquat seed powder reduced the total bacterial count of nugget samples compared with control sample. Singh *et al.* (2014), Kumar *et al.* (2011) found the similar result that TVC increases along with the storage day. Reddy *et al.* (2017) reported that the overall mean bacterial count (\log_{10} cfu/g) decreased up to day 6th but significantly ($P<0.05$) increased counts were observed with increase in storage period during refrigeration in chicken meat patties.

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 8.

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 ($p>0.05$).

Abdullah *et al.* (2018) studied the consumer preference of imitation chicken nuggets and shows that percentage of chickpea flour to textured vegetable protein (10:30) was the most preferred by consumers in term of overall acceptance. Barros *et al.* (2018) conducted an experiment and containing 10% chia flour were considered most acceptable by the panelists. However, in our experiment no significant differences were found among the nuggets, therefore it might be concluded that oat meat up to 20% did not affect consumer preferences.

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Conclusion

It could be concluded that oat meal can be successfully use to produce broiler nugget at 10 to 20% level.

Conflict of interest

There is no conflict of interest among the authors to declare.

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