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Effects of Elephant Foot Yam (*Amorphophallus peoniifolius*) Flour on Proximate Compositions and Sensory Attributes of Duck Meat Nugget Under Refrigerated Storage

Sk Md Sadique Anwar[1], Gopal Patra[1*], Souvik Dhara[2], A. Das[1] and A.K. Das[3]

[1]West Bengal University of Animal and Fishery Sciences, 68, K.B. Sarani, Kolkata-37, West Bengal, INDIA
[2]Assam Agricultural University, Khanapara, Guwahati, Assam, INDIA
[3]Eastern Regional Station, ICAR-IVRI, 68, K.B. Sarani, Kolkata-37, West Bengal, INDIA

**Corresponding author: G Patra; E-mail: lptgopal81@gmail.com*

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ABSTRACT

The present study was conducted with an objective to improve the quality of duct meat nugget incorporated with elephant foot yam (EFY) flour at 2.5% (T_1) and 5.0% (T_2) and different quality parameters were studied as compared to control (without any EFY) on the day of processing. The moisture and protein contents of duck meat nuggets were significantly ($P<0.01$) different between the groups. The control product showed significantly ($P<0.01$) lowest and T_2 showed highest protein content. The treated groups did not show any significant variation in fat and total ash contents of duck meat nuggets. Dietary fibre content of T_2 was significantly ($P>0.05$) higher among the treatment groups. Total phenolic values of T_1 and T_2 were significantly ($P>0.05$) higher than control. There was a significant ($P<0.01$) effect of test ingredients on pH values of duck meat nuggets. The TBARS value of T_2 was significantly lower than T_1 and control. The treatment groups (T_2 and T_1) showed significantly ($p<0.01$) lower total plate counts (TPC) as compared to control. Except appearance, other sensory attributes were significantly higher ($P<0.01$) in EFY incorporated duck meat nuggets compared to control. T_2 T_1 and showed highest score of overall acceptability as compared to control. The results concluded that incorporation of 2.5 % and 5.0% elephant foot yam flour improved the total protein content, dietary fibre content, physicochemical, microbiological qualities up to 12 days of refrigerated storage and but the nuggets were sensorially accepted and were on the border line of acceptance up to 9 days of refrigerated storage.

HIGHLIGHTS

- Incorporation at 2.5% and 5.0% elephant foot yam improved the sensory attributes of duck meat nuggets.
- Incorporation at 2.5% and 5.0% elephant foot yam improved the physicochemical and microbiological qualities of duck meat nuggets.

Keywords: Elephant foot yam, duck meat nugget, meat quality, dietary fibre

Ducks occupy second place to chickens for the production of meat and eggs in our country in the poultry sector. They are mainly reared for laying purpose. Spent and culled ducks are presented in market after 3-4 laying year. Such duck meat intended for human consumption has less juiciness, more toughness, less palatability which are the hidden reasons for unacceptance of duck meat by consumer, though there is no significant decline in its nutritive value with increase in age (De, 2001). Comminuted, emulsion type, value added meat products can be prepared from this *Desi* duck meat to increase their acceptability.

Meat is a rich source of essential nutrients in our diet but it is deficient in dietary fiber content. High consumption of

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diet deficient in dietary fiber is being linked with several chronic health problems (FAO, 2003). Functional meat products can be developed by various strategies like reduction of fat, saturated fatty acids, salt and nitrite as well as by the incorporation of functional ingredients like antioxidants, dietary fibers etc. (Barros *et al*., 2018).

Elephant foot yam (EFY) is one of the major tuber crops produced in tropical and subtropical zones. Elephant foot yam is a popular tuber crop in Eastern India especially, West Bengal. Elephant yam (*Amorphophallus* spp.) belongs to Araceae family and its common names are Elephant yam, Elephant bread, Elephant foot yam, Suran, Sweet yam, Jimikand. Average composition of EFY- Dry matter 21.13%; starch 11.83%; fat 0.31%; protein 1.46%; carbohydrates 0.97%; and crude fibre 1.48% (Peetabas *et al*., 2015). It is rich in nutrients like minerals (Ca, K, P, Zn), vitamins (A, B1, B2) and contains starch as a major energy source. The EFY is a concentrated source of dietary fiber (approximately 1.48%) and has good potential for its use in meat products. However, information on dietary fibre from EFY flour in meat food system is not studied. Considering the above facts, the present study was conducted with an objective to improve the quality of duct meat nugget incorporated with elephant foot yam (EFY) flour at 2.5% (T1) and 5.0% (T2) and different quality parameters were studied under refrigerated storage condition as compared to control (without any EFY) nuggets.

MATERIALS AND METHODS

Location of experiment

The study was carried out at the Department of livestock Products Technology of West Bengal University of Animal and Fishery science Kolkata-37. During the course of study, the help of other Department's Laboratories was also taken within the faculty of Veterinary and Animal Sciences, Kolkata.

Plant material

Raw material like elephant foot yam was collected from the local market of Howrah in fresh condition. After purchasing this was kept in sunlight for drying to prepare powder. Raw elephant foot yam was cleaned and washed with water to remove any external soil and dust and then processed. The corm was peeled with stainless steel knife. The corm was sliced using hand slicer. The slices were dipped immediately in 0.1% potassium metabisulphite solution to prevent enzymatic browning and kept for 5 minutes. After that, it was blanched at 100 °C for 5 minutes in boiling water. Then, the slices were dehydrated (osmotic and convective); and finally ground to make fine flour.

Duck meat

Indian *Desi* ducks (2.5 to 3 kg of live weight) were purchased from new market, Kolkata. Scientific slaughter and dressing were carried out in the department of Livestock Products Technology as per the standard procedure. After dressing, the carcasses were manually deboned as per the method of Staff and Darrow (1983) and then minced through 4 mm plate in a mechanical mincer. The minced meat was broadly divided in to three groups (250 gm each). One group was taken as control © and other two (T_1 and T_2) were mixed with different concentration of elephant foot yam flour (2.5% and 5.0% respectively) to prepared the duck meat nuggets.

Condiments

Onion and garlic were used as condiments. The external covering of onion and garlic were peeled off and cut into small bits. Onion and garlic were blended in 3:1 ratio using electric grinder with suitable blade to make into fine paste.

Spice mixture

All the spice ingredients were cleaned to remove extraneous matter, dried in hot air oven at 60ºC for $2^1/_2$ hour and then ground in a grinder using proportionate quantity to obtain dry spices mix for preparation of nuggets. The spice mixture consisted of Aniseed (Soanf) 10%, Black pepper (Kali mirch) 7%, Chilli (Mirch powder) 12%, Caraway seed (Ajwain) 10%, Cardamom (Badielaichi) 5%, Cinnamon (Dalchini) 5%, Cloves (Laung) 2%, Coriander powder (Dhania) 14%, Cumin seeds (Zeera) 15%, Dried ginger (Sunth) 15% and Turmeric (Haldi) 5%.

Preparations of nuggets

One kg formulation was made for each treatment. Control formulation consisted of duck meat 70%, refined mustard oil 10%, ice flakes 10%, salt 1.6%, tripolyphosphate 0.3%,

sugar 0.3%, dry spices powder 1.8%, condiments (4 parts onion and 1part garlic) 3%, refined wheat flour 0.3%. Sodium nitrite at 150 ppm was also added to the above formulations. In treated formulations (T_1 and T_2), elephant foot yam powder (2.5% and 5%) were incorporated respectively by replacing an equal amount duck meat in the control formulation. Minced duck meat, salt, sodium tripolyphosphate and sodium nitrite were added and chopped for about 1–2 min. After addition of ice flakes, it was chopped again for 2 min. Elephant foot yam powder were added for uniform dispersion in the meat system and chopping was continued for another 1–2 min. Refined mustard oil was slowly added while chopping for proper dispersion. Condiment paste, dry spice powder and refined wheat flour were added and chopping continued until a uniform dispersion of all ingredients and the desired emulsion consistency was obtained. Final temperature of the meat emulsion was 10–12 °C. Meat emulsion (~250 g) was placed into three different stainless steelmoulds (18 × 12 × 4 cm), packed compactly and covered. The emulsion filled moulds from all the treatments were clipped and cooked in a steam oven at atmospheric pressure for 35 min. The temperature of the steam oven during cooking was over 100 °C. The meat blocks were cooled to room temperature, chilled overnight at 4 ± 1 °C and cut into slices to prepare the duck meat nuggets.

Proximate composition evaluation

The proximate compositions of the duck meat nuggets were determined by the standard procedure of AOAC (1995). The moisture was determined by weight loss after 16 hours drying in a hot air over at 105ºC. The crude protein content of sample was determined by the standard Kjeldahl method. The fat content was determined in moisture free samples by an ether extraction procedure and extracted for 8-10 h with petroleum ether (B.P. 60-80ºC) in Soxhlet apparatus. The total ash was determined by weight loss after drying in muffle furnace at 600ºC for 3 hours. The dietary fibre was estimated by acid hydrolysis method (Weende method) as described by Van Soest and McQueen, 1973.

Physico-chemical analysis

The cooking yields were calculated and expressed as percentage by weight of cooked meat block/ weight of raw meat block × 100 each sample.

The pH values of the duck meat nugget samples were determined by the method of Trout (1992), using digital pH meter (Systronics μ pH system 361). The thiobarbituric acid (TBA) values the of the duck meat nugget samples were measured according to the method described by Witte et al. (1970) with slight modification. The absorbances at 532 nm were observed in a UV-Vis spectrophotometer (Perkin Emler Lambda 25) and reported as TBA value (mg/kg sample) for each sample. Total phenolic contents (TPC) of duck meat nuggets were determined by using the Folin–Ciocalteu assay (Chan *et al.,* 2010). The absorbances at 765 nm were read by a spectrophotometer (Thermo Spectronic model 4001/4, USA). The results were expressed as milligram gallic acid equivalents per 100 ml of infusion (mg GAE/100 ml).

The Expressible water of meat balls were determined by the method of (Jauregui *et al.* 1981) with little modification. About 5 g of meat ball sample was placed on 2 layers of Whatman no. 1 filter paper. The sample was placed in a 50 ml centrifuge tube and centrifuged for 15 minutes at 1500 g using a centrifuge (Remi, India). Soon after centrifuging, the sample was reweighed and the % of expressible water was calculated by the formula:

Expressible water (%) = Initial weight (g) – Final weight (g)/ Initial weight (g) × 100

The samples were analyzed in duplicates and the average value was noted for each sample.

Microbiological examination

Total plate counts of the duck meat nugget samples were determined by the APHA (1984) method using plate count agar. Briefly, 1ml of appropriate dilution of sample was transferred aseptically to sterile petri plates in duplicate. The plates were then poured with 10-15 ml melted plate count agar medium at 45 °C. After solidification the petri-plates were incubated at 37°C for 24- 48 hours. The colonies were counted by using a colony counter. The average number of colonies was multiplied with dilution factor to obtain total count as colony forming unit (CFU) per gram of meat sample. This count was then converted to total plate count of log CFU/g of sample.

Sensory evaluation

Sensory attributes of the chicken nuggets were assessed organoleptically using 8 point Hedonic scale score card described by American Meat Science Association (AMSA, 1995) with the help of seven semi-trained taste panelists of the Department of Livestock Products Technology, W.B.U.A.F.S., Kolkata. The nuggets were shallow fried in oil and served warm to the panelists with code numbers. The coded samples were tested for sensory scores in duplicates and this experiment was repeated thrice. The average of the individual scores was taken as the score for the particular attribute.

Statistical analysis

The analysis was carried out using statistical software SPSS (version 16.0) for analysis of variance (ANOVA). The significantly affected means were separated by Duncan's multiple range test (Duncan, 1955).

RESULTS

Proximate composition

The proximate compositions of duck meat nugget in different treatment groups are depicted in Table 1. The moisture and protein contents of duck meat nuggets were significantly ($P<0.01$) different between the groups. The control product showed significantly ($P<0.01$) lowest and T_2 showed highest protein content. The treated groups did not show any significant variation in fat and total ash contents of duck meat nuggets. Dietary fibre content of T_2 was significantly ($P>0.05$) higher among the treatment groups. The moisture percentage of treatment with 2.5% elephant foot yam powder was recorded as 54.31%, which was found to be lowest compared to other groups.

Physico-chemical analysis

Cooking yield of the duck meat nuggets were 89.31, 92.85 and 93.99 in control, T_1 and T_2 respectively on the day of processing (Table 2). The mean±SE values for total phenolic content (mg GAE/100 ml) were 0.049±0.022, 0.131±0.003 and 0.102±0.002 respectively for control, T_1 and T_2 on the day of processing. The Expressible Water (%) for control, T_1 and T_2 were 3.03±0.093, 2.00±0.037 and 1.89±0.029 respectively on the day of processing (Table 2).

The values of other physico-chemical parameters of duck meat nuggets incorporated with elephant foot yam powder under refrigerated storage are presented in Table 2.

The pH values of control, T_1 and T_2 were 6.20, 6.09 and 6.13 respectively on the day of processing. A gradual declining trend in the pH values of the control and treatments were observed throughout the storage period. The lowest pH was observed in the control nuggets with a value 6.06±0.080 at the end of storage study. The Mean TBARS values (mg/kg) were 0.15±0.008, 0.16±0.008 and 0.16±0.008 respectively for control, T_1 and T_2 on the 0 day.

Microbiological examination

The microbiological quality of duck meat nugget in different treatment groups are given in Table 2. The mean±SE Total Plate Count (TPC) values were 3.03±0.093, 2.00±0.037 and 1.89±0.029 respectively for control, T_1 and T_2.

Sensory evaluation

The sensory attributes (appearance, flavor, juiciness, texture, saltiness, and overall acceptability) of different level of EFY incorporated duck meat nuggets is presented in Table 3. The analysis of variance showed except appearance, other sensory attributes of the duck meat nuggets showed significant difference ($P<0.01$) between the groups. The multiple range test revealed that EFY (both 2.5 and 5.0%) incorporated duck meat nuggets had significantly higher score of texture and saltiness compared to control group (0% EFY). However, 5.0% EFY incorporated duck meat nuggets had significantly highest score of overall acceptance compared to rest of the groups (C and T_1).

DISCUSSION

Proximate composition evaluation

The moisture percentage of treatment with 2.5% elephant foot yam powder was recorded as 54.31%, which was found to be lowest compared to other groups. This could be due the loss of water/moisture, temporarily bound by the dietary fibres during cooking. Dietary fibres used in the present study constitute mainly insoluble dietary

Table 1: Effects of different levels of EFY flour on proximate composition of duck meat nuggets (Mean ±SE)

Parameters	C (Control)	T_1 (EFY-2.5%)	T_2 (EFY-5.0%)	Level of significance
Moisture content (%)	61.84 ± 0.019^{c}	56.18 ± 0.032^{a}	58.07 ± 0.020^{b}	**
Protein (%)	17.03 ± 0.251^{a}	18.75 ± 0.599^{ab}	20.42 ± 0.171^{b}	**
Fat (%)	11.64±0.328	11.66±0.328	11.67±0.328	NS
Ash (%)	2.06±0.087	2.07±0.086	2.07±0.086	NS
Total dietary fibre (%)	32.91±0.446	33.18±0.223	33.33±0.223	NS

Means bearing different superscript (a, b, c) in within a row differ significantly (**P<0.01; NS- Non-significant).

Table 2: Effects of different levels of EFY flour on Physcio-chemical qualities of duck meat nuggets (Mean±SE*) on the day of processing

Parameters	C (Control)	T1 (EFY-2.5%)	T2 (EFY-5.0%)	P-value
Cooking Yield (%)	89.31 ± 0.095^{a}	92.85 ± 0.092^{b}	93.99 ± 0.159^{b}	0.000
Total Phenolic Content (mg GAE/100ml)	0.049 ± 0.022^{a}	0.131 ± 0.003^{c}	0.102 ± 0.002^{b}	0.000
Expressible Water (%)	41.21 ± 0.011^{a}	49.41 ± 0.004^{b}	50.81 ± 0.009^{b}	0.000

Means bearing different superscript (a, b, c) in within a row differ (p<0.05) significantly.

Table 3: Effects of different levels of EFY flour on Physcio-chemical and microbiological qualities of duck meat nuggets (Mean ±SE)

	Days				
	Day 0	**Day 3**	**Day 6**	**Day 9**	**Day 12**
pH					
Control	6.20 ± 0.016^{aA}	6.17 ± 0.016^{aAB}	6.13 ± 0.008^{aB}	6.09 ± 0.039^{aBC}	6.06 ± 0.080^{aC}
T_1	6.09 ± 0.035^{bA}	6.08 ± 0.015^{bA}	6.06 ± 0.019^{bAB}	6.04 ± 0.032^{bB}	6.02 ± 0.108^{bBC}
T_2	6.10 ± 0.036^{bA}	6.09 ± 0.026^{bA}	6.07 ± 0.012^{bA}	6.05 ± 0.022^{bBC}	6.02 ± 0.020^{bC}
TBARS Value					
Control	0.15 ± 0.008^{aE}	0.31 ± 0.002^{aD}	0.64 ± 0.006^{aC}	0.95 ± 0.02^{aB}	1.27 ± 0.010^{aA}
T_1	0.15 ± 0.004^{aE}	0.26 ± 0.008^{bD}	0.48 ± 0.004^{bC}	0.72 ± 0.002^{bcB}	0.86 ± 0.010^{bA}
T_2	0.14 ± 0.002^{aE}	0.22 ± 0.006^{bD}	0.40 ± 0.008^{cC}	0.68 ± 0.004^{cB}	0.78 ± 0.006^{cA}
TPC					
Control	2.03 ± 0.093^{aE}	3.34 ± 0.067^{aD}	4.08 ± 0.073^{aC}	5.08 ± 0.073^{aB}	5.45 ± 0.119^{aA}
T_1	2.02 ± 0.037^{aE}	2.54 ± 0.149^{bD}	3.68 ± 0.149^{bcC}	4.55 ± 0.059^{bcB}	4.91 ± 0.059^{bcA}
T_2	2.00 ± 0.029^{aE}	2.48 ± 0.031^{cD}	3.59 ± 0.029^{cC}	4.46 ± 0.065^{cB}	4.82 ± 0.065^{cA}

Means bearing different superscript in a row (A-E) and in a column (a-c) differ (p<0.05) significantly.

fibre which could not have retained moisture content during cooking. Das *et al.* (2015) reported that addition of antioxidant dietary fiber (*bael* pulp residue) in goat meat nuggets did not influence moisture content. But in the present study, differences in moisture content between control and treatment duck nuggets might be difference in water absorption and holding capacity of dietary fiber used. The effect of 2.5% and 5% elephant foot yam powder on protein content of duck meat nuggets was found to be highly significant (P<0.01). Similar result was found by

Table 4: Effects of different levels of EFY flour on sensory attributes of duck meat nuggets (Mean ±SE)

	Days			
	Day 0	**Day 3**	**Day 6**	**Day 9**
Colour				
Control	7.11±0.02^{Ca}	7.08±0.014^{Ac}	7.00±0.02^{Bc}	6.77±0.03^{Ce}
T_1	7.20±0.01^{baA}	7.15±0.012^{bB}	7.09±0.01^{aB}	6.92±0.03^{bB}
T_2	7.24±0.02^{cA}	7.20±0.01^{aA}	7.13±0.01^{aA}	7.09±0.02^{aA}
Flavor				
Control	7.27±0.01^{bA}	7.12±0.01^{cC}	7.08±0.02^{cB}	6.97±0.03^{cB}
T_1	7.28±0.02^{bA}	7.21±0.01^{bB}	7.18±0.01^{bA}	7.06±0.02^{abA}
T_2	7.334±0.02^{aB}	7.30±0.01^{aA}	7.22±0.01^{aA}	7.09±0.014^{aA}
Juiciness				
Control	7.30±0.014^{aA}	7.19±0.013^{aA}	7.10±0.02^{aBC}	6.91±0.02^{aC}
T_1	7.26±0.01^{aA}	7.18±0.03^{aA}	7.08±0.01^{aAB}	6.93±0.02^{aB}
T_2	7.29±0.02^{aA}	7.19±0.02^{aA}	7.12±0.01^{aC}	6.95±0.03^{aA}
Texture				
Control	7.20±0.02^{aA}	7.16±0.024^{aA}	6.96±0.03^{bB}	6.71±0.03^{cC}
T_1	7.20±0.02^{aA}	7.16±0.02^{aA}	7.00±0.03^{bB}	6.84±0.04^{bC}
T_2	7.21±0.02^{aA}	7.20±0.02^{aA}	7.11±0.02^{aB}	7.00±0.03^{aC}
Overall Acceptability				
Control	7.09±0.02^{bA}	6.95±0.03^{bB}	6.82±0.03^{bC}	6.66±0.04^{bD}
T_1	7.12±0.02^{bA}	7.00±0.03^{bB}	6.78±0.03^{bC}	6.52±0.03^{cD}
T_2	7.13±0.02^{abA}	7.01±0.02^{bB}	6.94±0.02^{aC}	6.76±0.03^{bD}

Means bearing different superscript in a row (A-D) and in a column (a-c) differ ($p<0.05$) significantly.

Ulu (2004) in cooked meatball by addition of soya protein isolate. In present study the fat percentage in the nugget in different treatment did not varied significantly ($P>0.05$). The ash and dietary fibre content in the duck meat nugget also had no significant difference among various treatment groups. Jindal and Bawa (1988) reported that ash content of cooked sausages increased with increase in soy flour level upto 30%. Dietary fiber content was highest in 5% elephant foot yam powder treated duck meat nugget which was 33.33% (DM basis) while it was lowest in control which was observed as 32.91% (DM basis). Higher content of dietary fiber in treated duck meat nuggets was due to higher dietary fiber content of elephant foot yam powder. Das *et al.* (2016) reported that incorporation of *bael* pulp residue in the formulation significantly increased ($P<0.05$) the total dietary fiber and total phenolic content.

Physico-chemical analysis

The cooking yields in this study were higher than those of the spent-duck sausages studied by Bhattacharyya *et al.* (2007). Although that study reported yields of 83-85%, the age of the animal will influence the properties of the final product. However, the results of this study are almost identical to those reported by Garcia-Garcia and Totosaus (2007) who found that the cooking yield of low-sodium sausages formulated with locust bean gum, potato starch and k-carrageenan was within the range of 96.86-97.00%. There was no significant difference in pH among various treatment groups. Similarly, 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. Significant difference ($P<0.01$) was observed in total phenolic content of duck meat nugget between the groups. Similarly, Verma *et al.* (2013) also reported that incorporation of guava powder in meat products formulation significantly increased the phenolics content of final products than control. No significant difference was

observed in value of TBARS of duck meat nugget between different groups. However, EFY flour treated groups (T1 and T_2) showed lower values of TBARS compared to control. Recently, Das *et al.* (2015) observed that the *bael* pulp residue was effective in preventing increased TBARS number of precooked goat meat patties during storage. The expressible water (%) of the duck meat nugget had significant ($p<0.01$) difference among various groups. The results also revealed that group T_2 had significantly ($p<0.01$) highest expressible water (%) as compared to T_1 and control. The values of expressible water (%) in this study were higher than those of the spent-duck sausages studied by Bhattacharyya *et al*. (2007). Although that study reported that the water holding capacity ranged from 43-45%, the age of the animal will influence the properties of the final product.

Microbiological examination

Present observation (as given in Table 2) revealed that EFY flour treated groups (T_1 and T_2) had lower Total Plate Count (TPC) compared to control group. This might be due to presence of large amount of poly-phenolic compound which causes irreversible damage to bacterial cytoplasmic membrane and check the microbial growth. They also inhibit bacterial growth and protease activity by damaging the cell wall and cytoplasm causing rapid structural destruction (Shimamura *et al.* 2016).

Sensory evaluation

In the present study 5.0% EFY incorporated duck meat nuggets showed highest score of overall appearance. It was also noticeable that the treated groups (both T_1 and T_2) had significantly higher score of sensory attributes compared to control group. These findings indicated that incorporation of elephant foot yam into the duck meat nuggets had significant effects on the sensory attributes. The juiciness in the nuggets of control group had significantly higher compared to EFY incorporated groups (T_1 and T_2). This result might be due to lower moisture content of the treated groups. Higher texture of the treated groups may be due to presence of fibre in the EFY. Similarly, Jebin *et al*. (2012) demonstrated that incorporation of 7% glutinous rice flour significantly increased the overall acceptance of duck meat salamis. However, Reddy *et al.* (2017) reported that incorporation of 9% oat flour significantly increased the juiciness, flavor, tenderness and overall acceptability of mutton nuggets. Sathu *et al.* (2017) recommended 4.0% of oat bran incorporation into the chicken nuggets without deteriorating the nutritive and sensory qualities.

CONCLUSION

The results revealed that elephant foot yam (EFY) flour can be incorporated into the duck meat nuggets without deteriorating the proximate composition, physico-chemical properties, microbial qualities and sensory attributes of the duck meat nuggets. However, 5.0% EFY flour significantly improved the total protein content and overall acceptance of the duck meat nuggets.

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