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Development and Evaluation of Quality Characteristics of Meat Nuggets Prepared with Inclusion of *Nelumbo nucifera* Root Powder

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ABSTRACT

Present study was conducted to evaluate the effect of inclusion of *Nelumbo nucifera* powder into formulation of chicken nuggets at four different levels viz. Control (0 % C), 1.5 % (T1), 3.0 % (T2) and 4.5 % (T3). Different quality parameters were evaluated to access the effect of incorporation of *Nelumbo nucifera* powder in fiber-enriched chicken meat emulsion (pH, emulsion stability, moisture, fat), as well as in cooked chicken meat nuggets *viz.* physico-chemical properties, cooking determinants, proximate compositions and sensory quality attributes. Additions of *Nelumbo nucifera* showed higher ($P < 0.05$) pH value in treated groups than control and represent an improvement in significantly ($P < 0.05$) in cooking yield and emulsion stability. *Nelumbo nucifera* root powder added groups showed comparatively lower ($P > 0.05$) in protein, fat and energy values but significantly higher ($P < 0.05$) in ash, fiber,moisture carbohydrate, moisture retention, fat retention and moisture protein ratio than control. Sensory panelist rated significantly higher ($P < 0.05$) score for T2 (3 % *Nelumbo nucifera*) juiciness, texture and overall acceptability than other groups. Results concluded that, *Nelumbo nucifera* at 3.0 % added level have better potential as source of dietary fibers without compromising quality characteristics of meat nuggets and with effecting eating quality of meat nuggets.

HIGHLIGHTS

- *Nelumbo nucifera* root powder contains good quality and quantity of dietary fiber consisting of non-carbohydrate components.
- Fiber-enriched, functional meat nuggets can be prepared by incorporation of 3.0% *Nelumbo nucifera* root powder.

Keywords: Meat nuggets, *Nelumbo nucifera*, proximate composition, sensory attributes

Poultry industry in India is one of the largest and fastest growing sectors ranking third in egg production and sixth in broiler meat production in the world production (DAHD, 2019-20). But due to change in life-style, eating habit, increased purchasing power and urbanization, consumers have shifted to non-vegetarian diets. Poultry meat is free from the social taboo therefore it is quite popular meat and its production is 4.06 MT in India (DAHD, 2019-20). In Indian market major portion of meat is sold in raw/fresh form than processed meat products therefore the processed meat products have huge scope in Indian market. Hence, the development of fresh meat into processed products is need of the hour for better revenue generation for the Indian meat industry. In-general, processed meat products are deficient in fiber and contain high amount of fat, therefore the preparation of meat products with addition of fiber may improve the functional quality of processed meat products.

Meat is nutrient rich products but it is deficient in fiber and vitamin-C. Deficiency of fiber in meat has been associated with enhance in number of diseases such as colon cancer and cardiovascular diseases. Fibers have various health benefits like maintaining bowel integrity,

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decreasing blood cholesterol level, reducing blood sugar level, and act as bulking agent that can help in weight loss by replacing calorie dense food such as fat. Proper intake of fiber in diet can be reducing the risk of cardiovascular diseases, diverticulitis, constipation, irritable colon, colon cancer and diabetes (Mehta *et al.,* 2019). Therefore, various researchers have been proposed to enrichment of meat products with addition of various fiber sources. The addition of the fiber in meat products not only improves the meat product with required nutritional quality but also enhances its techno-functional quality like superior/better water- and oil-holding capacity, cooking yield, emulsion stability and even enhances its oxidative stability of lipid oxidation, when the fiber has optimum amount of phenolic, flavonoid and other antioxidant phyto-active compounds (Verma *et al.,* 2015; Kumar *et al.,* 2021). Daily recommended intake of dietary fiber is 25-40 g per day for an adult.

Lotus (*Nelumbo nucifera*) is found in South-East Asia and grows in aquatic environment. Lotus petal, rhizome and leaf have been used as food ingredients in Indian cuisines. Scientists found that various part of lotus is also comprehensively utilized as a conventional herb medicine (Bangar *et al*., 2022). Lotus rhizome contains various phyto-active compounds like polyphenolic compounds (quercetin, isoquercetin and kaempferol) and oligomeric procyanidines. It also contains good quality and quantity of dietary fiber consisting of non-carbohydrate components (Zhao *et al*., 2014). Furthermore, various researchers reported that its lotoushas various physiological efficacies such as antioxidaive, anti-hypercholesterolemia and anti-inflammatory activities (Yang *et al*., 2016; Lee *et al*., 2015). Few studies have been carried out in meat products reporting that incorporation of lotus rhizome has been enhance the physico-chemical, functional quality, antioxidant and antimicrobial activity of meat products (Talukder *et al*., 2014; Bharti *et al*., 2017; Lee *et al.*, 2012).

Meat products provide most of the desired nutrients for healthy living except dietary fibres. Novel dietary fibre sources are being explored to improve the fibre content in processed meat products. There have been successful efforts to increase the fibre content in meat products by incorporating various sources of dietary fibres in processed meat products such as grape pomace powder (Mainente *et al*., 2019) and inulin powder (Verma *et al*., 2016). Fang *et al*. (2018) utilized sugarcane fibre at 3% level and obtained 3.32% higher cooking yield and better acceptability than control with no dietary fibres.

MATERIALS AND METHODS

Broiler meat

The meat of broiler birds of age approximately 6-8 weeks was procured from local market Meerut, Uttar Pradesh and brought to the meat processing laboratory of the Department of Livestock Products Technology, COVAS, SVPUAT, Meerut. Excessive fat, fascia etc. were removed and potable water was used to clean the carcasses. Water was drained from the carcasses and they were deboned manually. The deboned meat was packed in LDPE bags in the unit pack of 1 Kg and subsequently stored in deep freezer at -18±1ºC till further use. The unit packs were taken out as per requirements and thawed over-night in a refrigerator 4±1ºC for experimental use.

Nelumbo Nucifera (Kamal Kakari)

Root of *Nelumbo Nucifera* (Kamal Kakari) was purchased from local market Modipuram, Meerut. These roots were cleaned with potable water for removal of dirt and dust. After proper draining of water from the roots, they were sliced into approximate uniform cuts of round shape. The slices were further dehydrated in hot-air oven to reduce the moisture content to 8% or below. The dried roots of *Nelumbo Nucifera* pieces were pulverized in a food grinder (Inalsa) to form fine powder. Prepared *Nelumbo Nucifera* root powder was packed in LDPE bag under aerobic packaging condition and stored at refrigerated temperature till further use.

Spice mix. and condiment

Ingredients used for the preparation of spice mix. were purchased from local market, Meerut, U.P. and have been depicted in (Table 1). Before, preparation of spice mix. these ingredients were cleaned carefully and dried in hot air oven at 40±5ºC for 2 h. The ingredients were ground mechanically in a food grinder (Inalsa) and sieved through a fine mesh. The fine powder of various ingredients was blended as per standard formulation and stored in air tight container for subsequent use. Fresh onion, garlic

and ginger were procured from local market Modipuram, Meerut. It was peeled, washed, and minced in a grinder (Inalsa) in the form of homogeneous paste. The onion, garlic and ginger paste were packed separately in LDPE bags and stored at -18±1ºC till further use.

Table 1: Formulation of Spice Mix

Ingredients	Percentage
Coriander (Dhania)	20.50
Cumin seeds (Zeera)	15.50
Aniseed (Soanf)	12.40
Black pepper (Kali Mirch)	12.40
Capsicum (Mirch Powder)	10.50
Caraway seeds (Ajwain)	10.40
Cardamom large (Badi Elaichi)	5.15
Cinnamon (Dalchini)	5.15
Cardamom small (ChhotiElaichi)	2.00
Nutmeg (Jaifal)	2.00
Mace (Javitri)	2.00
Cloves (Laung)	2.00

Chemicals and packaging materials

The salt used was food grade TATA salt (Tata Chemicals Limited, Mumbai), Refined wheat flour and refined oil (Fortune; Adani Wilmar Limited, Gujarat, India) were procured from local market, Meerut, Uttar Pradesh. Good quality of chicken eggs was procured from local market of Modipuram, Meerut. Analytical grade chemicals, ready-made media and standards required in the study were procured from standard firms like Himedia, SRL and CDH etc. Low density polyethylene (LDPE) bags of 200 gauze pouches were purchased from reputed firms for aerobic packaging of meat, meat emulsion and chicken meat nuggets.

Preparation of chicken nuggets

The formulation and processing protocols were standardized on the basis of preliminary trials and available literature. Trimmed and clean chicken meat was taken out from freezer and thawed overnight in refrigerator at 4±1ºC. Thawed meat was cut into small cubes and minced twice using meat mincer through 6 mm plate. *Nelumbo Nucifera* root powder, common salt, vegetable oil, chilled water, refined wheat flour, textured soya flour, whole egg liquid, tri-sodium polyphosphate, nitrite, sugar, spice mixture and condiment mixture were added to weighed meat according to formulation (Table 2). Four treatments of chicken nugget with varying levels of *Nelumbo Nucifera* root powder as source of fiber viz. control (0 %), T-1 (1.5%), T-2 (3.0 %), T-3 (4.5 %). Meat emulsion for chicken meat nuggets was prepared in food mixer (Inalsa). Minced meat was blended and mixed with salt, chilled water, tri-sodium polyphosphate and nitrite for 2 min. followed by addition of refined oil and mixing for another 1.5 min. This was followed by addition of *Nelumbo Nucifera* root powder in treatment group only and was run in the food mixer for blending (1 min), followed by addition of spice mixture, ground textured soya, condiments and mixing again for 1.5 min to get the desired meat batter. The prepared emulsion from each group was filled in aluminum mould which were tapped for the evacuation of air from the filled emulsion. These filed aluminum moulds were subjected to the preheated oven cooking at 180±5 ºC for 40 minutes. The cooked chicken meat nuggets were examined for various physico-chemical attributes (pH, emulsion stability, cooking yield), proximate composition (moisture, protein, fat, ash, fibre carbohydrate and energy) and sensory evaluation (9-point descriptive scale) etc.

Table 2: Formulation of chicken meat nuggets

Ingredients %	Control	T1	T2	T3
Lean meat	71.99	70.49	68.99	67.49
Nelumbo Nucifera root powder	0.0	1.5	3.0	4.5
Oil	8.0	8.0	8.0	8.0
Salt	1.5	1.5	1.5	1.5
Spices	2.0	2.0	2.0	2.0
Condiments	3.0	3.0	3.0	3.0
Chilled water	5.0	5.0	5.0	5.0
Refined wheat flour	3.0	3.0	3.0	3.0
TSPP	0.3	0.3	0.3	0.3
Sugar	0.2	0.2	0.2	0.2
Whole egg liquid	5.0	5.0	5.0	5.0
Sodium Nitrite (ppm)	100	100	100	100
Total (%)	100	100	100	100

C = chicken nuggets without *Nelumbo nucifera* powder (0 %); T1 = chicken nuggets with 1.5 % *Nelumbo nucifera* powder; T2 = chicken nuggets with 3.0 % *Nelumbo nucifera* powder and T3 = chicken nuggets with 4.5 % *Nelumbo nucifera* powder.

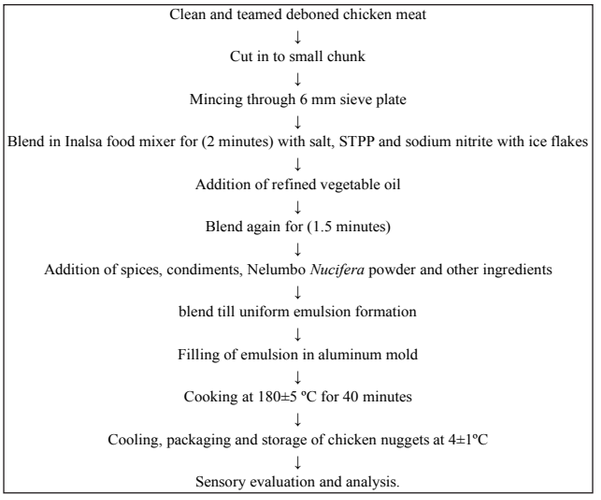

Fig. 1: Flow Diagram showing the preparation of chicken meat nuggets

ANALYTICAL METHODS

pH and Emulsion Stability (%) of nugget

The pH of meat batter and chicken meat nuggets was measured as per the method given by Trout *et al.* (1992) with digital pH meter equipped with a combined glass electrode. Emulsion stability of chicken meat emulsion was estimated by method describe by (Baliga and Madaiach, 1970) and expressed as percentage.

Cooking Yield and cooking loss (%)

For the determination of cooking yield weight of meat emulsion and cooked chicken meat nuggets of each replicate was measured before and after cooking. Cooking yield of chicken meat nuggets was calculated by using following formula and expressed as percentage.

Cooking yield % =

$$\frac{\text{Weight of cooked chicken meat nuggets}}{\text{Weight of raw chicken meat emulsion}} \times 100$$

Total energy value of chicken nuggets was estimated on the basis of 100 g portion using. At water values for protein (4.02 kcal/g), carbohydrate (4 kcal/g) and fat (9 kcal/g). An estimation of the carbohydrate content of chicken nuggets was calculated by using formulae (carbohydrate = 100 – moisture + fat + protien + ash).

Proximate Composition Analysis

Moisture, protein, fat, fiber and ash content of meat nugget was estimated by standard procedure of AOAC, (2000).

Sensory evaluation

A seven-member experienced panel of judges including of teachers and postgraduate students of College of Veterinary and Animal Sciences, Sardar Vallabhbhai Patel University of Agriculture and Technology examined the samples for the sensory parameters such as colour and appearance, texture, flavour, juiciness and overall acceptability using 9-point descriptive scale, where 9 = excellent, 5 = neither like/neither dislike and 1 = extremely poor for meat cooked products. The test samples were offered to the sensory panelists after allotting suitable codes. Samples were warmed prior to serving to the sensory evaluators. The potable water was provided to each panelist for rinsing the buccal cavity between the sample's examination.

STATISTICAL ANALYSIS

The duplicate samples were taken for each parameter and the experiment was repeated three times, total being six observations (n= 2 × 3 = 6) were taken for consistency of the results, except for sensory attributes in which 21 observations (n= 7 × 3 =21) were taken. The data were statistically analyzed using statistical software ('SPSS-22.0' SPSS, Inc, Chicago IL, USA) as per standard methods (Snedecor and Cochran, 1994) for one way analysis of variance using Duncan's Multiple Range Tests and homogeneity tests to test the significance of difference between means. The statistical significance was estimated at 5% level ($P<0.05$) and evaluated with Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Physico-chemical quality of chicken meat emulsion

pH of chicken meat emulsion

The pH of treated chicken meat emulsion increased

significantly (P < 0.05) with incorporation of *Nelumbo nucifera* powder at different concentration (Fig.2a). Highest pH value (6.08) was measured for the T3 and lowest was for the control (5.86). Comparatively higher pH value in treated chicken meat nuggets might be due to the higher pH value of the *Nelumbo nucifera* powder. Bharti *et al*. (2017) also reported that the pH value of the meat emulsion increased with addition of the *Nelumbo nucifera* powder. However, Ham *et al*. (2017) reported that the inclusion of *Nelumbo nucifera* powder did not affect the pH value of meat emulsion.

Emulsion stability (ES) of chicken meat emulsion

Emulsion stability of *Nelumbo nucifera* powder incorporated emulsion and control emulsion varied significantly (P < 0.05) and highest value was recorded for the T3 (92.59) and lowest for the Control (C=83.13). The emulsion stability was higher in *Nelumbo nucifera* powder added meat products than control (Fig.2b). Increase in emulsion stability of the treated groups might be due to water holding capacity and fat retention capacity of fiber present in *Nelumbo nucifera* powder. Fiber has unique properties, it holds water and oil in its matrix and prevent, release of exudate (water and oil) during cooking. These findings were in line with the result reported by Verma *et al*. (2016) for the meat loaves prepared with the addition of fiber. Similarly, other researchers also reported that the addition of fibers from various source also increased emulsion stability (Verma *et al.,* 2015b; Kumar *et al.,* 2021 and conceptualized that the increase in emulsion stability was due to the water binding capacity and fat retention ability of fiber.

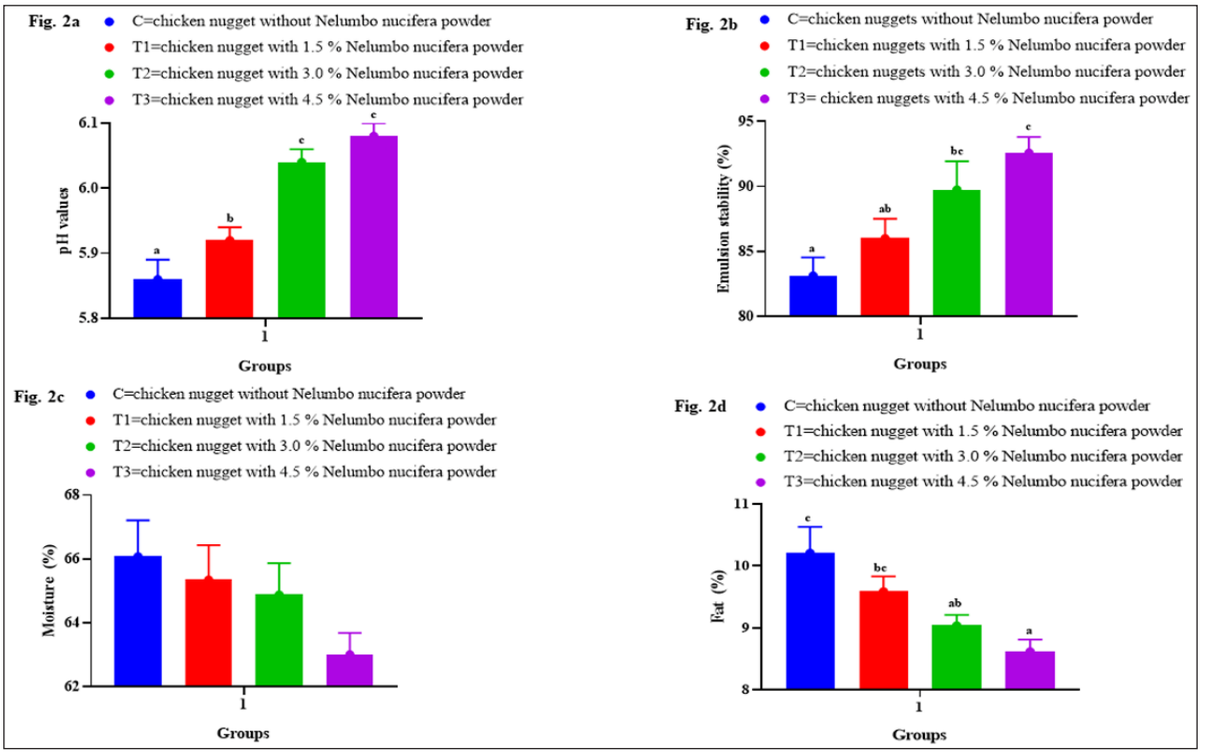

Fig. 2: Effect of addition of *Nelumbo nucifera* powder on meat emulsion parameters of fiber enriched chicken nuggets

Mean values bearing different superscript in a row differ significantly (P < 0.05) n = 6 C = meat emulsion without *Nelumbo nucifera* powder; T1= chicken nuggets with 1.5 % *Nelumbo nucifera* powder; T2 = chicken nuggets with 3.0 % *Nelumbo nucifera* powder and T3 = chicken nuggets with 4.5 % *Nelumbo nucifera* powder.

Moisture and fat in meat emulsion

Non-significant (P > 0.05) decrease in moisture and fat content was observed from control to T3 with increasing level of addition of *Nelumbo nucifera* powder and highest moisture percentage value was recorded for Control (C=66.08 %) and lowest for T3 (63.01 %) Fig. 2c. The lower moisture content in treated groups than control might be due to the lower moisture content in *Nelumbo nucifera* powder. Similarly, highest fat percentage value was recorded for Control (C=10.21 %) and lowest for T3 (8.62%). Fat percentage in *Nelumbo nucifera* powder added groups was slight lower than that of control (Fig.2d). The lower fat percentage in treated groups might be due to the lower fat content in *Nelumbo nucifera* powder than meat. Mukherjee *et al*. (2009) stated that fat content of *nelumbo nucifera* root was 0.11 per cent and similar results were also observed in the study by Sruthi *et al*. (2019) which exhibited that *nelumbo nucifera root* contained about 0.10 percent fat.

Physico-chemical quality of chicken meat nuggets

Cooking yield and cooking loss

Cooking yield was significantly (P < 0.05) higher in treated products as compared to control (Table 3); however, higher cooking yield was recorded for T2 (94.60%) in comparison with T1 (92.55 %) and T3 (92.87 %) and lowest for C (90.31 %). In addition, cooking loss was decreased from control to T2 with increasing level of lotus rhizome (P <0.05) and highest cooking loss was recorded for C (9.69 %) and lowest for T2 (5.40 %). It might be due to higher water-holding capacity and water retention properties attributed to level of inclusion of dietary fiber. It has been well documented that the inclusion of fiber could increase cooking yield of cooked meat product, thereby enhancing the water and fat holding capacity in the matrix of meat batter and reduce the losses of these substances during the cooking (Verma *et al*., 2016; Verma *et al*., 2015a; Kumar *et al.,* 2015). Previous researchers also confirmed that addition of dietary fibre, enhanced the water and fat absorption efficacy which could enhance water-holding capacity and yield of product (Singh *et al.,* 2021). However, Jung *et al*. (2011) reported that cooking yield and moisture/fat retention of pork patty was not influenced by 0.5% lotus rhizome addition.

pH of chicken nuggets

The pH of cooked and treated chicken meat product increased significantly (P < 0.05) with incorporation of *Nelumbo nucifera* powder at different concentration (Table 3). Highest pH value (6.33) was measured for T3 and lowest was for the control (6.07). It might be due to the higher pH value of the *nelumbo nucifera* powder and finding was also supported by Choi *et al*. (2008). for dietary fiber enriched sausage. Slight increase in pH value after cooking might be due to exposure of imidazolium moiety in basic amino acids such as histidine (Choi *et al*., 2008) and release of sulfhydryl groups during cooking (Verma *et al*., 2016). Bharti *et al*. (2017) also reported that the pH value of the meat products increased with increasing level of the *nelumbo nucifera* powder.

Moisture and fiber in chicken nuggets

A significant (P < 0.05) increase in moisture and fiber was observed from control to T3 with incorporation of *Nelumbo nucifera* powder at different concentration in chicken nuggets (Table 3). Lowest moisture percentage value was recorded for Control (C=58.09%) and highest for T3 (62.10%), whereas highest fiber percentage was recorded for T3 (1.55%) and lowest for Control (0.68%). Comparatively higher percentage of moisture and fiber in treated chicken meat nuggets might be due to the increasing level of the *Nelumbo nucifera* powder. The crude fiber content of the treated groups increased significantly (P<0.05) with increase in the level of *Nelumbo nucifera* powder. This might be due to higher crude fiber content in the *Nelumbo nucifera* powder. This finding was supported by study of Verma *et al*. (2016) who reported that with the increase in inulin level in products, its crude fiber content increased proportionally.

Protein in chicken nuggets

Protein content decreased significantly (P < 0.05) from control to T3 with increasing level of addition of *Nelumbo nucifera* powder (Table 3). Highest protein percentage was recorded for Control (C=19.95) and lowest for T3 (17.195). Protein content of all the treated products was lower than control. The decreased in protein content of chicken nuggets might be due to lower protein content in lotus powder than chicken meat. Begum and Punia (2020)

Table 3: Effect of addition of *Nelumbo nucifera* powder on physico-chemical parameters of fiber enriched chicken nuggets

Parameters	C	T1	T2	T3
Cooking yield (%)	90.31±0.74^{a}	92.55±0.80^{ab}	94.60±1.10^{b}	92.87±0.93^{ab}
Cooking loss (%)	9.69±0.74^{b}	7.45±0.80^{ab}	5.40±1.10^{a}	7.14±0.93^{ab}
pH	6.07±0.02^{a}	6.18±0.013^{b}	6.25±0.02^{c}	6.33±0.02^{d}
Moisture (%)	58.09±0.79^{a}	59.72±0.74^{ab}	61.38±0.43^{bc}	62.10±0.71^{c}
Protein (%)	19.95±0.34^{c}	18.71±0.48^{b}	17.68±0.28^{a}	17.195±0.24^{a}
Fat (%)	11.80±0.56^{c}	10.77±0.21^{b}	9.82±0.20^{ab}	9.18±0.18^{a}
Fiber (%)	0.68±0.02^{a}	1.01±0.03^{b}	1.30±0.02^{c}	1.55±0.06^{d}
Ash (%)	2.35±0.06^{a}	2.66±0.06^{b}	2.86±0.04^{c}	2.95±0.06^{c}
Carbohydrate (%)	7.82±0.65	8.15±1.01	8.27±0.53	8.57±0.90
Energy (Kcal/100 gm)	217.63±4.16^{c}	204.74±3.22^{b}	192.49±2.23^{a}	186.02±2.16^{a}
Moisture retention	52.46±0.80^{a}	55.29±1.08^{b}	58.08±0.99^{c}	57.65±0.50^{bc}
Fat retention	83.39±3.84^{a}	88.18±0.79^{ab}	94.41±0.51^{b}	93.08±1.71^{b}
Moisture protein ratio	2.92±0.08^{a}	3.20±0.09^{b}	3.48±0.06^{c}	3.61±0.06^{c}

Mean values bearing different superscript in a row differ significantly ($P < 0.05$) n=6 C=chicken nuggets without *Nelumbo nucifera* powder; T1= chicken nuggets with 1.5 % *Nelumbo nucifera* powder; T2= chicken nuggets with 3.0 % *Nelumbo nucifera* powder and T3= chicken nuggets with 4.5 % *Nelumbo nucifera* powder.

also reported lower protein content in *sev* prepared with addition of *Nelumbo nucifera* powder. Fiber present in *Nelumbo nucifera* powder has inherent property to retain moisture content which is directly proportional to the level of fiber content. This finding was also supported by Lopez-Vargas *et al*. (2014) for meat burger prepared with addition of passion fruit.

Fat and energy of chicken nuggets

A significant ($P < 0.05$) decrease in energy and fat content was observed from control to T3 with increasing level of fiber (Table 3) and highest energy value was recorded for the Control (C=217.63) and lowest for T3 (186.02). In addition, highest fat percentage value was recorded for Control (C=11.80 %) and lowest for the T3 (9.18 %), and lower level of energy in treated group was due to lower percentage of fat, protein and higher moisture contents and this finding was supported by Kumar *et al*. (2015) for finger millet incorporated meat patties. (Verma *et al*., 2016) also reported that the addition of dietary fiber to emulsified meat products has increased its moisture content but decreased fat content due to high water absorption ability of dietary fiber.

Ash and carbohydrate in chicken nuggets

Ash and carbohydrate percentage increased significantly ($P < 0.05$) from control to T3 with incorporation of *Nelumbo nucifera* powder at different concentration in chicken nuggets (Table 3). Lowest ash percentage was recorded for control (C=2.35%) and highest for the T3 (2.95%), while highest carbohydrate percentage was recorded for T3 (8.57%) and lowest for control (7.82%). Saeed *et al*. (2020) reported increase in ash content of biscuit prepared with incorporation of lotus root flour. This finding was also supported by Jung *et al*. (2011) which stated that the addition of 0.5% of lotus rhizome increased ash content of cooked pork patty. Begum and Punia (2020) also reported increased carbohydrate percentage with increase in the level of addition of *nelumbo nucifera* powder in '*sev*'.

Moisture retention and fat retention of chicken nuggets

A significant ($P < 0.05$) increase in moisture retention and fat retention was observed from control (C) to T2, while further increase in fiber level resulted in non-significant ($P > 0.05$) decrease from T2 to T3 (Table 3). Lowest moisture retention percentage value was recorded for control (C=52.46 %) and highest for T2 (58.8 %). Similarly,

as expected lowest fat retention percentage value was recorded for the control (C=83.39 %) and highest for T2 (94.41 %). The higher moisture retention and fat retention in chicken nugget might be due to addition of *Nelumbo nucifera* powder which, contained higher percentage of fiber that entrap the fat and water in its own matrix. This finding was supported by Fernandez-Gines *et al*. (2004) who, stated that addition of dietary fiber to emulsified meat products increased moisture and fat content due to high water absorption ability of dietary fiber. However, Jung *et al*. (2011) stated that moisture and fat retention of pork patty were not influenced by addition of 0.5% lotus rhizome powder it might be due to incorporation of lower level of than our study.

Moisture protein ratio of chicken nuggets

Higher moisture protein ratio was recorded in fiber-treated products when compared to control that increased significantly ($P < 0.05$) with incorporation of *Nelumbo nucifera* powder at different concentration (Table 3). Highest moisture protein ratio (3.61) was measured for T3 and lowest was for control (2.92). The increased in moisture protein ratio in treated products might be due to comparatively high moisture content than control and lower protein content in treated as data depicted in (Table 3). Jung *et al*. (2011) have stated that the addition of lotus rhizome has increased moisture contents but decreased protein contents of cooked pork patty therefore, the ratio of moisture and protein increased in treated products.

Sensory quality of chicken meat nuggets

Colour and appearance as well flavour of the treated products was rated lower than control but it did not differ significantly up to 3.0 % (T2) level of incorporation of *Nelumbo nucifera* powder in chicken nuggets (Fig. 3). However, in T3 (4.4 %) level of incorporation of *Nelumbo nucifera* powder observed significantly ($P < 0.05$)lower scores among all the sample. The decrease in colour and appearance of *Nelumbo nucifera* powder added nuggets might be due to inherent colour and flavour of the *Nelumbo nucifera* powder and at higher concentration these characteristics was more influenced therefore received scores significantly lower than control, T1 and T2. Similar, results were also reported by Bharti *et al*. (2017) for meat products prepared with addition of *Nelumbo nucifera* stem paste at different concentration. Juiciness score of chicken nuggets prepared with addition of *Nelumbo nucifera* powder increased significantly ($P < 0.05$) up to T2 and further increase of addition of *Nelumbo nucifera* powder concentration resulted in significant decrease in juiciness score of T3. Increase in juiciness might be due to optimum water retention and fat holding capacity of fiber present in *Nelumbo nucifera* powder. These observations were similar to the findings of Angiolillo *et al*. (2015) reported for functional meat burgers. A significant ($P < 0.05$) increase in texture was observed from control to T2 with incorporation of *Nelumbo nucifera* powder at different concentration in chicken nuggets (Fig. 3) but further increase in fiber level resulted in significant ($P < 0.05$) decrease from T2 to T3, lowest texture quality was recorded for the T3 (7.29) and highest for the T2 (8.02). Increment in texture value from control to T2 might be due to more water retention and fat retention but it decreased from T2 to T3 due to higher amount of fiber.

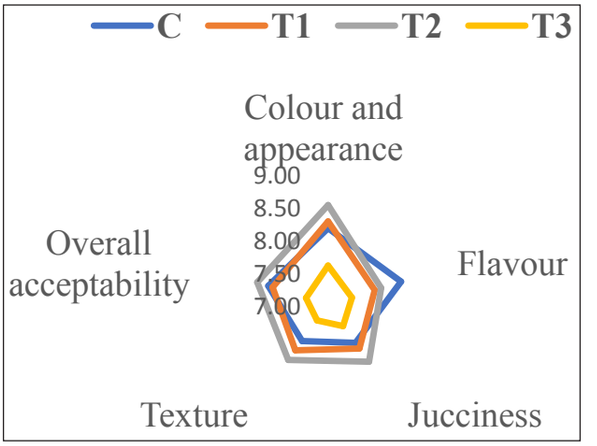

Fig. 3: Sensory attributes of fiber enriched chicken meat nuggets

C = chicken nuggets without *Nelumbo nucifera* powder; T1 = chicken nuggets with 1.5 % *Nelumbo nucifera* powder; T2= chicken nuggets with 3.0 % *Nelumbo nucifera* powder and T3 = chicken nuggets with 4.5 % *Nelumbo nucifera* powder. n = (7×3=21)

At higher level of addition of *Nelumbo nucifera* powder might have altered the binding and stabilizing capabilities of emulsion matrix which might transform the textural attributes of meat products. Overall acceptability increased significantly ($P < 0.05$) from C to T2 with incorporation of *Nelumbo nucifera* powder (Fig. 3) however, further

increase in *Nelumbo nucifera* powder resulted in significant decrease in overall acceptability of T3 (7.36). However, T2 ranked highest for overall acceptability by sensory panel than other groups. Similar, results were also reported by Talukder *et al*. (2014) for restructured meat blocks formulated with addition of lotus stem.

CONCLUSION

Present study proposes that *Nelumbo nucifera* powder had potential as good source of fiber fortification for meat products. Incorporation of *Nelumbo nucifera* was also found to be effective in improvement in emulsion stability, cooking yield and sensory quality. Results on fiber content indicated that selected group (T2) increased 91.17 % of fiber than control and also contain 13.06 % lower energy content. Therefore, *Nelumbo nucifera* had a potential for development of chicken nugget.

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