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Optimization of formulation and quality assessment of chicken meat nuggets enriched with *Solanum melongena* L.

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Abstract

The present study aimed to develop fiber-enriched chicken meat nuggets through the incorporation of *Solanum melongena* L. (eggplant) powder at 0% (control), 2%, 4%, and 6% levels by partially replacing lean meat, and to evaluate its impact on quality attributes. The formulated products were analyzed for proximate and chemical composition, colour characteristics, instrumental textural properties, and sensory attributes. Incorporation of eggplant powder in chicken nuggets resulted in a significant ($p < 0.05$) increase in crude fiber content, which rose from 1.21% in the control samples to 6.53% in nuggets containing 6% eggplant powder. A progressive reduction in pH, fat, protein, and moisture content was observed with increasing eggplant powder levels, while ash content showed a significant increase. Instrumental colour analysis indicated decreased lightness and increased redness with higher levels of eggplant powder incorporation. Texture profile analysis revealed significant increases in hardness, chewiness, and gumminess. Sensory evaluation showed that nuggets containing 4% eggplant powder maintained acceptable scores for flavour, texture, and overall acceptability. Results indicated that a 4% inclusion of eggplant powder offers the ideal compromise between nutritional value and sensory quality. Consequently, this study establishes eggplant powder as a promising functional agent for the formulation of fiber-enriched meat products.

Keywords: Eggplant powder, dietary fiber, texture profile, functional meat products

Introduction

In recent years, consumer preferences have increasingly shifted toward foods that not only provide basic nutrition but also deliver additional health benefits. This growing demand has accelerated the development of functional and value-added meat products, particularly those enriched with dietary fiber and bioactive compounds (Trigo *et al.*, 2022) ^[10]. Adequate dietary fiber intake has been strongly associated with improved gastrointestinal health, reduced risk of cardiovascular diseases, enhanced glycaemic control, and the prevention of obesity-related disorders. Despite these well-documented benefits, fiber consumption remains below recommended levels in many populations, largely due to the increased reliance on refined and convenience foods (Weaver *et al.*, 2014) ^[11]. Meat and meat products, including chicken meat nuggets, are widely consumed due to their high-quality protein content, palatability, and convenience (Singh *et al.*, 2021) ^[12]. Among these, chicken meat is particularly valued for its favourable fatty acid profile and higher digestibility compared to red meats. However, conventional meat products are generally low in dietary fiber and, when consumed frequently, may contribute to nutritional imbalance (Mehta *et al.*, 2020) ^[12]. Consequently, the incorporation of plant-based fiber sources into meat products has emerged as an effective strategy to improve the nutritional value while maintaining consumer acceptability (Domínguez *et al.*, 2021) ^[2]. Fiber-rich ingredients can improve water-holding capacity, influence fat distribution, and modify the structural matrix of comminuted meat products (Mehta *et al.*, 2015) ^[4]. Nevertheless, excessive fiber incorporation may adversely affect texture and flavour, highlighting the need for careful optimisation of inclusion levels (Safa *et al.*, 2017) ^[7]. *Solanum melongena* L. (eggplant) possesses considerable potential for use as a functional ingredient in food formulations. Eggplant is recognised for its high dietary fiber content, particularly insoluble fiber, along with appreciable levels of minerals and phenolic compounds such as chlorogenic acid (Kumar *et al.*, 2023) ^[3].

These bioactive constituents contribute to antioxidant activity and have been associated with hypolipidaemic and anti-inflammatory effects (Plazas *et al.*, 2021) [6]. Although recent studies have investigated the incorporation of vegetable powders and fruit by-products as fiber sources in meat products, information regarding the utilisation of eggplant powder in chicken meat nuggets remains limited. Therefore, this study was conducted to develop fiber-

enriched chicken meat nuggets through the incorporation of eggplant powder at varying levels and to evaluate their proximate and chemical composition, colour profile, instrumental textural attributes, and sensory characteristics. The study aimed to identify an optimum level of eggplant powder incorporation that enhances dietary fiber content without compromising product quality or consumer acceptability.

Table 1: Formulation of chicken meat nuggets

Ingredients/Percent	C	T ₁ (2% EPP)	T ₂ (4% EPP)	T ₃ (6% EPP)
Lean chicken meat	69.0	67.0	65.0	63.0
Refined Oil (Soyabean)	7.5	7.5	7.5	7.5
Spices mix	2.5	2.5	2.5	2.5
Salt	1.7	1.7	1.7	1.7
Condiments (Ginger-Garlic)	2.0	2.0	2.0	2.0
Chilled water	8.5	8.5	8.5	8.5
Maida	3.5	3.5	3.5	3.5
Sodium Tripolyphosphate	0.3	0.3	0.3	0.3
Whole Egg liquid	5.0	5.0	5.0	5.0
Sodium Nitrite (ppm)	120	120	120	120
Egg Plant Powder	-	2	4	6

Materials and Methods

Raw materials

Poultry meat (broiler, IBL-80) used in the study was procured from the Directorate of Livestock Farms, Department of COVS, GADVASU, Ludhiana. The birds were slaughtered following standard humane procedures in the departmental slaughterhouse. The broiler carcasses were manually deboned, and all visible connective tissue, fascia, fat, and blood clots were removed. The meat was subsequently packed in transparent low-density polyethylene (LDPE) bags and stored in a deep freezer at -18 ± 1 °C until further use.

Prior to processing, frozen meat was thawed under refrigerated conditions (4 ± 1 °C) and subsequently minced twice using a meat mincer (Kalsi, Ludhiana) fitted with a 6 mm plate to obtain uniform particle size for further experimentation. Other ingredients, including refined soybean oil, spice mix, salt, maida, condiments (ginger-garlic paste), sodium tripolyphosphate, whole liquid egg, and food-grade sodium nitrite, were procured from standard commercial suppliers. All the chemicals and reagents employed for analytical determinations were of analytical grade.

Preparation of eggplant powder

Fresh eggplants were washed, peeled, uniformly sliced, and dried in a hot-air oven at 55-60 °C until a constant weight was attained. The dried slices were ground using a laboratory grinder and sieved through a fine mesh to obtain a uniform powder. The resulting eggplant powder was packed in airtight containers and stored at ambient temperature until further use. The powder was incorporated into nugget formulations at different levels as a dietary fiber source.

Formulation and preparation of chicken meat nuggets

Chicken meat nuggets were formulated according to the ingredient composition presented in Table 1. Four formulations were prepared: a control (C) without eggplant powder and three treatments containing eggplant powder at 2% (T₁), 4% (T₂), and 6% (T₃) levels, respectively. Eggplant powder was incorporated by partially replacing lean meat

content. Minced chicken meat was mixed with salt, sodium tripolyphosphate, and chilled water in a bowl chopper to obtain a uniform batter. Refined oil, spice mix, condiments, maida, whole egg liquid, and sodium nitrite were subsequently added and mixed thoroughly. Eggplant powder was incorporated according to the respective treatment levels, ensuring uniform dispersion. The prepared emulsion was moulded and steam-cooked until an internal temperature of approximately 75 °C was achieved. The cooked nuggets were cooled to room temperature prior to further analysis.

Proximate and chemical composition

The pH of nugget samples was measured using a calibrated digital pH meter after homogenization in distilled water. Proximate composition was determined using standard analytical methods. Moisture, ash, crude fat, and protein contents were determined by the hot-air oven, muffle furnace, Soxhlet extraction, and Kjeldahl methods (N factor = 6.25), respectively, while crude fiber was estimated using standard procedures. All analyses were conducted in six replicates, and results are expressed as mean $\pm$ standard error.

Colour measurement

Instrumental colour parameters of chicken meat nuggets were measured using a CR-400 Chroma Meter (Konica Minolta, Japan). Colour values were expressed as lightness (L*), redness (a*), and yellowness (b*). Measurements were taken at multiple points on the surface of each nugget, and the mean values were calculated for analysis.

Texture profile analysis

Texture profile analysis (TPA) of the cooked meat nuggets was performed using a texture analyser (TMS-PRO, Food Technology Corporation, USA) fitted with a compression probe. The samples were subjected to 2 compression cycles at a fixed deformation level of the material using a constant crosshead speed. Textural characteristics viz. hardness, cohesiveness, springiness, gumminess, chewiness and stringiness were determined from the force-time curves during analysis.

Sensory evaluation

The chicken meat nuggets were evaluated for sensory attributes by a semi-trained panel. Colour and appearance, flavour, texture, taste, and overall acceptability were assessed using an 8-point hedonic scale, where 1 corresponded to “dislike extremely” and 8 to “like extremely.” The nuggets were served warm, coded with random three-digit numbers, and presented to the panellists in a randomised order to minimise bias. Potable water was provided for palate cleansing between sample evaluations.

Statistical analysis

The effects of different levels of eggplant powder incorporation on quality attributes were analyzed using one-way analysis of variance (ANOVA). Differences among treatment means were evaluated using Tukey's post hoc test, and statistical significance was set at $p < 0.05$. Data are expressed as mean $\pm$ standard error ($n = 6$).

Results and Discussion

Proximate and chemical composition

Statistical analysis indicated that the addition of eggplant powder affected numerically ($p < 0.05$) all compositional parameters. The pH rapidly reduced with higher supplementation levels of eggplant powder. The pH decreased from 6.43 in the control treatment to 6.21, 5.97, and 5.18 in nuggets containing 2%, 4%, and 6% eggplant powder, respectively. This reduction in pH may be attributed to the inherently acidic nature of eggplant and the partial replacement of meat proteins with plant material, which alters the product system's buffering capacity (Abdelmaksoud *et al.*, 2025) ^[1]. Similar reductions in pH have been reported in meat products fortified with vegetable powders and fiber-rich plant ingredients (Tobin *et al.*, 2013) ^[9]. Ash content of the chicken meat nuggets increased significantly ($p < 0.05$) with increasing levels of eggplant powder incorporation, indicating a higher mineral contribution from the plant material. The ash content increased from 1.19% in the control to 3.91% in nuggets containing 6% eggplant powder. This increase can be attributed to the mineral-rich nature of eggplant powder and has been similarly reported in meat products enriched with vegetable fibers and plant-based ingredients (Stanišić *et al.*, 2020) ^[8].

The crude fiber content increased significantly ($p < 0.05$) from 1.21% in the control to 2.79%, 4.43%, and 6.53% in nuggets containing 2%, 4%, and 6% eggplant powder, respectively. This significant increase confirms the effectiveness of eggplant powder as a dietary fiber source and demonstrates its suitability for nutritional enhancement of chicken meat nuggets. Similar trends have been documented in fiber-fortified comminuted meat products using vegetable and fruit-derived fiber sources (Trigo *et al.*, 2022) ^[10]. In contrast, fat, protein, and moisture contents decreased significantly ($p < 0.05$) as the level of eggplant powder incorporation increased. The fat content declined from 9.48% in the control samples to 8.87% in nuggets containing 6% eggplant powder. This reduction can be attributed to a dilution effect resulting from the partial replacement of lean meat with a low-fat plant ingredient, as well as to the fat-binding and water-holding capacities of dietary fiber present in eggplant powder. The protein content also showed a significant reduction, decreasing from 19.79% in the control to 17.02% at the highest level of

eggplant powder incorporation, which can be explained by the lower protein content of eggplant powder compared to meat. Moisture content decreased significantly from 64.89% in the control to 61.38% in nuggets containing 6% eggplant powder, possibly due to fiber-induced structural changes and reduced availability of free water within the product matrix. Similar dilution effects and compositional changes have been reported in fiber-enriched meat products (Stanišić *et al.*, 2020) ^[8]. Overall, the results indicate that incorporating eggplant powder significantly increases the dietary fiber and mineral content of chicken meat nuggets while moderately altering other compositional attributes, thereby improving nutritional quality.

Colour characteristics

The incorporation of eggplant powder has a significant effect on the instrumental colour parameters (L^* , a^* , and b^*) of chicken meat nuggets, resulting in a decrease in lightness (L^*) with increasing levels of eggplant powder. The L^* value declined from 51.41 in the control to 48.86 in nuggets containing 6% eggplant powder, indicating a progressive darkening of the product. The observed reduction in lightness may result from natural pigments and phenolic compounds in eggplant powder, which absorb and scatter light, thereby decreasing surface reflectance. Redness (a^*) values increased significantly ($p < 0.05$) with increasing eggplant powder levels, rising from 4.34 in the control to 6.63 in nuggets containing 6% eggplant powder. The increase in redness may be due to interactions between plant pigments and meat proteins, as well as concentration effects resulting from reduced moisture content. In contrast, yellowness (b^*) values showed a significant decreasing trend with increasing eggplant powder incorporation, which may be attributed to masking of native meat colour by darker plant particles. Similar colour changes have been reported in meat products enriched with vegetable powders and plant-based fiber sources (Domínguez *et al.*, 2021) ^[2].

Instrumental textural properties

The influence of eggplant powder incorporation on the instrumental textural attributes of chicken meat nuggets is presented in Figure 1. A significant ($p < 0.05$) increase in hardness, chewiness, and gumminess was observed with increasing levels of eggplant powder incorporation. Hardness increased from 12.04 N in the control to 16.89 N in nuggets containing 6% eggplant powder. This increase may be attributed to the presence of insoluble dietary fiber, which contributes to a denser and more rigid product matrix. Chewiness and gumminess also increased significantly ($p < 0.05$) with increasing eggplant powder levels, indicating greater resistance to mastication. In contrast, cohesiveness, springiness, and stringiness decreased significantly with increasing levels of eggplant powder incorporation. The reduction in cohesiveness and springiness suggests weakening of the meat protein network due to dilution by plant material, while reduced stringiness reflects disruption of the fibrous meat structure. Similar textural trends have been widely reported in fiber-fortified comminuted meat products (Stanišić *et al.*, 2025) ^[8]. Among the treatments, nuggets containing 4% eggplant powder exhibited improved firmness without excessive hardness, indicating a favourable balance between fiber incorporation and textural acceptability.

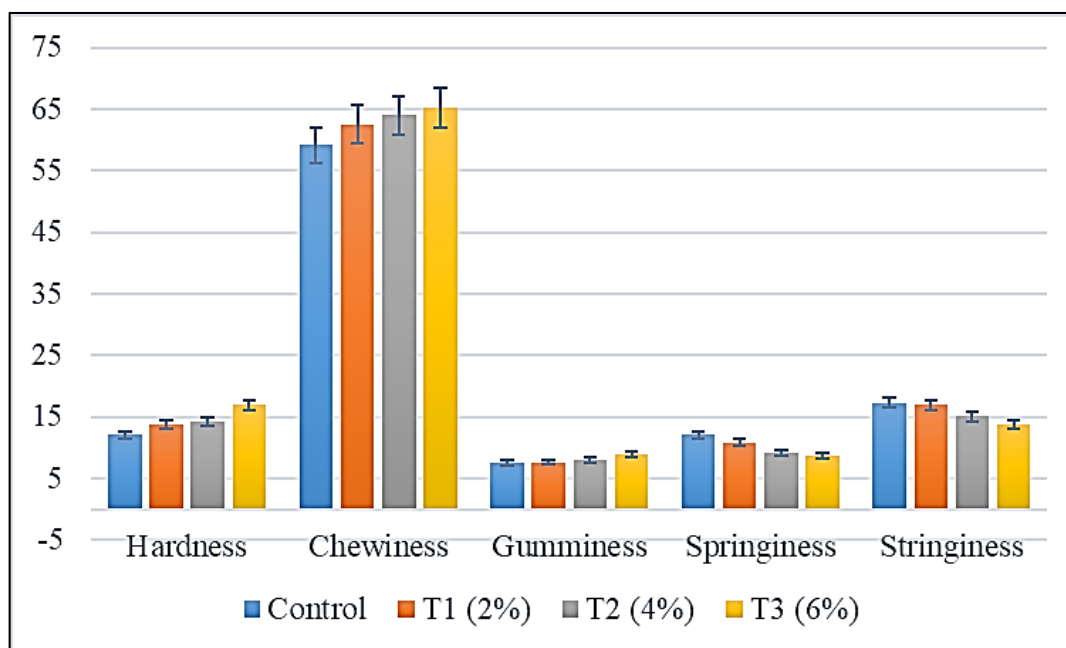


Fig 1: Textural attributes of chicken meat nuggets with different levels of eggplant powder

Sensory Evaluation

Figure 2 shows that sensory scores for colour and appearance, flavour, texture, taste, and overall acceptability of chicken meat nuggets significantly ($p < 0.05$) declined with higher levels of eggplant powder incorporation. The control treatment recorded the highest sensory scores,

followed by nuggets containing 2% and 4% eggplant powder. Nuggets incorporated with 4% eggplant powder maintained acceptable sensory scores for flavour, texture, and overall acceptability, indicating that moderate fiber enrichment did not adversely affect palatability.

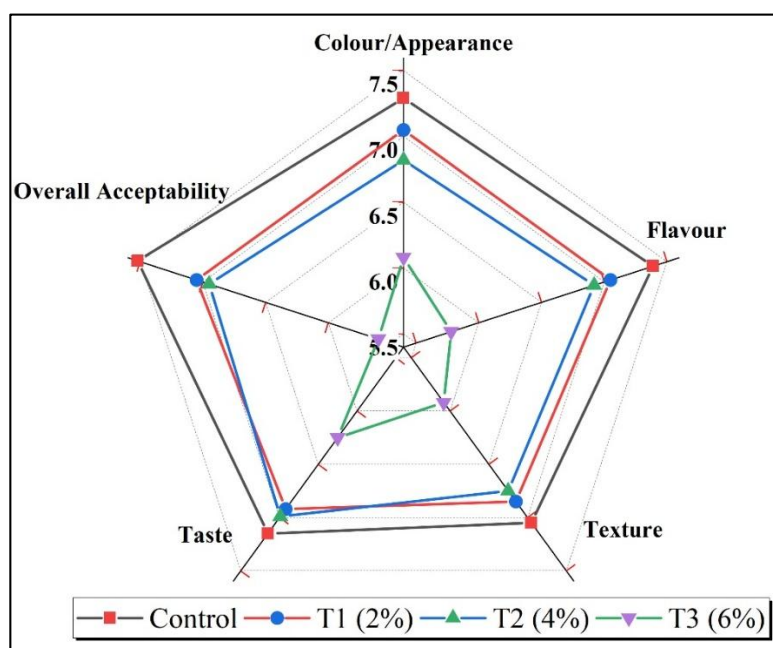


Fig 2: Sensory attributes of chicken meat nuggets with different levels of eggplant powder

However, nuggets containing 6% eggplant powder showed a pronounced decline in sensory scores, particularly for flavour and overall acceptability. This decline may be attributed to excessive plant flavour notes, increased hardness, and darker appearance at higher incorporation levels. Similar observations have been reported in meat products enriched with high levels of dietary fiber (Domínguez *et al.*, 2021) [2]. Based on the combined evaluation of proximate composition, colour, texture, and sensory attributes, the incorporation of eggplant powder at

4% was identified as the optimum level for fiber enrichment of chicken meat nuggets.

Conclusion

The present study demonstrated that eggplant (*Solanum melongena* L.) powder can be effectively used as a dietary fiber source for developing fiber-enriched chicken meat nuggets. Incorporating eggplant powder resulted in a significant ($p < 0.05$) increase in crude fiber content from 1.21% in the control to 6.53% at 6% incorporation, while

also increasing ash content, indicating improved mineral contribution. A progressive decrease in pH (6.43 to 5.18), fat (9.48% to 8.87%), protein (19.79% to 17.02%), and moisture content (64.89% to 61.38%) were observed with increasing levels of eggplant powder.

Instrumental analysis revealed a significant increase in hardness, chewiness, and gumminess. Sensory evaluation showed that nuggets containing 4% eggplant powder maintained acceptable scores for flavor, texture, and overall acceptability, whereas further increasing to 6% resulted in a noticeable decline in sensory quality. Based on the studied assessment of nutritional enhancement, textural properties, and sensory acceptability, incorporation of eggplant powder at 4% was identified as the optimum level for fiber enrichment of chicken meat nuggets. These results indicate that eggplant powder can serve as a functional ingredient to improve the nutritional quality of meat products while maintaining consumer acceptability.

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