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Development and quality evaluation of functional chicken cutlets enriched with pumpkin and chia seed powders

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Abstract

To remain competitive with other segments of the food industry, the meat sector must prioritize the development of innovative value-added products enriched with nutraceutical ingredients. This study aimed to develop functional chicken meat cutlets by incorporating pumpkin seed powder and chia seed powder and to evaluate their sensory and nutritional characteristics. Three formulations were prepared: a control, a pumpkin seed powder-incorporated treatment and a chia seed powder-incorporated treatment. The cutlets were prepared using optimized formulations containing 5% pumpkin seed powder (T1) and 3% chia seed powder (T2) and were evaluated for sensory quality using an 8-point descriptive scale, along with proximate composition analysis. Significant differences ($p < 0.05$) were observed among the treatments. Cutlets containing pumpkin seed powder showed better scores for appearance, flavour, taste and overall acceptability. In contrast, chia seed-incorporated samples exhibited improved juiciness, crispiness and higher moisture retention. Nutritional analysis indicated increased protein and fat content in pumpkin seed-treated samples, whereas chia seed incorporation resulted in higher dietary fibre and lower fat content. The findings indicate that the inclusion of pumpkin and chia seed powders enhances the nutritional value and functional properties of chicken meat cutlets. Pumpkin seed powder contributed more to sensory improvement, while chia seed powder was effective in enhancing moisture retention and fibre content. This approach offers a promising strategy for developing healthier, value-added meat products.

Keywords: Functional meat products, chicken cutlet, pumpkin and chia seeds, proximate composition, sensory attributes

Introduction

In recent years, greater emphasis on health, nutrition and functional foods has strongly influenced consumers to adopt healthier eating habits. Meat and meat-based products remain an important component of the diet, as they are rich in high-quality protein, essential amino acids, and readily absorbable micronutrients that aid in satiety, appetite control and weight management. At the same time, the rising demand for healthier, value-added meat products has prompted researchers to investigate the use of natural, plant-derived ingredients with functional properties to enhance both the nutritional quality and overall acceptability of meat products. Chicken cutlet is a popular comminuted meat product prepared from minced chicken blended with wheat flour, spices, condiments and other non-meat ingredients. The mixture is moulded into uniform portions, coated with batter and bread crumbs and fried to achieve a desirable texture and flavour. As a ready-to-eat convenience food, it has gained wide consumer acceptance alongside similar products such as nuggets and patties, particularly in response to changing lifestyles and dietary patterns. Moreover, cutlets serve as an effective means of value addition in the poultry industry due to their palatability and high energy content (Singh *et al.*, 2016; Kumar *et al.*, 2017) [28, 13].

Fernández-Ginés *et al.* (2005) [7] demonstrated that improving meat products can be achieved by incorporating natural antioxidants, dietary fibre, and vegetable oils and by reducing fat and

cholesterol content. In line with this approach, the addition of plant-derived functional ingredients has become an important strategy for enhancing the nutritional profile, improving resistance to oxidative deterioration, and prolonging the shelf life of meat products, while meeting the growing demand for healthier food options. In addition to formulation strategies, processing techniques such as enrobing contribute significantly to product quality. Enrobing involves coating food products with batter-based materials, which not only enhances sensory characteristics but also forms a protective barrier that reduces moisture loss and lipid oxidation by limiting exposure to gases, water vapour, and solutes (Wu *et al.*, 2000; Garg and Mendiratta, 2006) [30, 9]. This technique thereby supports the development of value-added meat products with improved stability and keeping quality.

Pumpkin seeds are nutritionally rich and serve as an excellent source of protein, iron, manganese, magnesium, zinc, potassium, polyunsaturated fatty acids (PUFA), γ -tocopherol, and carotenoids (Syed *et al.*, 2019) [29]. The bioactive compounds present in pumpkin seeds exhibit diverse pharmacological activities such as anthelmintic, antidiabetic, antidepressant, antioxidant, antitumor, and cytoprotective effects and they may also help in managing microbial infections, hepatic disorders, and prostate-related conditions (Kalogropoulos *et al.*, 2013 and Dotto and Chacha, 2020) [11, 6]. Regular consumption of pumpkin seeds has been reported to be safe without adverse health effects (Maheshwari *et al.*, 2015) [14]. Additionally, pumpkin seeds are gaining popularity in the snack food industry as a healthier alternative to conventional fried snacks, supported by increasing awareness of sustainable agriculture and functional foods (Devi *et al.*, 2018) [5]. Studies have further demonstrated that incorporation of pumpkin seed powder into meat products can improve nutritional quality and storage stability, although higher levels may negatively influence sensory attributes due to reduced fat content (de Melo *et al.*, 2024; Rani *et al.*, 2024) [4, 23].

Chia seeds (*Salvia hispanica* L.) are characterized by a unique chemical composition and high nutritional value, providing approximately 486 kcal per 100 g. They contain substantial amounts of fat (30-33%), particularly omega-3 fatty acids, protein (15-25%), carbohydrates (26-41%) and dietary fiber (18-30%), along with vitamins (A, E, C, B-complex) and essential minerals such as calcium, phosphorus, potassium and magnesium (Muñoz *et al.*, 2012) [16]. Chia seeds are also rich in polyphenolic compounds, including phenolic acids and flavonoids such as quercetin, kaempferol, chlorogenic acid, rosmarinic acid, and caffeic acid, which contribute to their strong antioxidant activity (Motyka *et al.*, 2023) [15]. These bioactive constituents are associated with anti-inflammatory, antioxidant, and hypotensive effects, as well as improved carbohydrate metabolism, modulation of intestinal microbiota, weight management, and reduced risk of metabolic disorders. Recent evidence also suggests their potential role in preventing kidney stone formation and offering neuroprotective and hepatoprotective benefits (Motyka *et al.*, 2023) [15]. Recognized as a “novel food” by the European Food Safety Authority in 2009, chia seeds are considered safe for human consumption (Bresson *et al.*, 2009) [2].

The incorporation of pumpkin seed powder and chia seed powder into chicken cutlets was explored as a novel approach in this study. These seed powders were utilized for the first time in the formulation of chicken cutlets with the aim of developing a functional meat product. The objective was to enhance the functional attributes of the cutlets by improving

their nutritional profile, extending shelf life and reducing oxidative deterioration.

Materials and Methods

The experiments were conducted at the Department of Livestock Products Technology (Meat Science), Veterinary College and Research Institute, Namakkal, Tamil Nadu Veterinary and Animal Sciences University, India, from January to July 2025. Broiler chickens were humanely slaughtered and dressed according to the standard protocols followed in the Department of Livestock Products Technology (Meat Science), VCRI, Namakkal. After deboning, the meat was packed in LDPE material and stored at -18 ± 2 °C for future use. Pumpkin and chia seeds were procured from the local market in Namakkal, India. The seeds were dried in a hot air oven at 50-55 °C for 8 hours, ground into a fine powder, packed in polythene bags, and stored at -18 ± 2 °C for future use.

Preparation of Chicken Cutlets

The frozen, deboned chicken meat was cut into small pieces and minced using a mechanical meat mincer (Junior MEW 510, MAD0, Germany) fitted with an 8 mm plate and then used for the preparation of cutlets. Potatoes were boiled, peeled and mashed to obtain a smooth and uniform consistency. The minced meat, mashed potatoes and other non-meat ingredients were thoroughly blended in a meat homogenizer for 2-3 minutes to ensure uniform mixing. The resulting mixture was then portioned and shaped into standardized cutlet forms. Several preliminary trials were conducted to determine the optimum levels of pumpkin and chia seed incorporation for the development of functional chicken meat cutlets. The standardized formulations of the control and treated cutlets are presented in Table 1.

Table 1: Formulation of Functional Chicken Meat Cutlets Incorporated with Pumpkin and Chia Seed Powders

Ingredients (%)	Control	T1 (Pumpkin seeds powder @ 5%)	T2 (Chia seeds powder @ 5%)
Minced meat	100	100	100
Potato	70	70	70
Ginger Garlic paste	3	3	3
Masala powder	5	5	5
Maida	4	4	4
Pepper	2	2	2
Salt	1.8	1.8	1.8
Enrobing			
Maida	10	10	10
Whole Egg Liquid	1	1 (no.)	1
Bread crumbs	30	25	27
Pumpkin seeds	0	5	0
Chia seeds	0	0	3

Enrobing and Cooking Process

Initially, the cutlets were lightly coated with refined wheat flour (maida) as a pre-dusting step. This was followed by battering, in which the pre-dusted cutlets were dipped in whole egg liquid to enhance coating adhesion. Subsequently, breading was carried out by coating the cutlets with bread crumbs incorporated with pumpkin seed powder or chia seed powder, depending on the treatment group. The enrobed cutlets were then deep-fried in hot oil at an appropriate frying temperature until a uniform golden-brown color was obtained. After cooking, the cutlets were cooled to room temperature and packaged in LDPE under aerobic conditions and stored at 4 ± 1 °C for further analysis.

Analysis of functional chicken meat Cutlets

The developed chicken cutlets were evaluated for sensory attributes and proximate composition to assess their acceptability and nutritional characteristics.

Sensory Evaluation

A sensory panel consisting of semi trained panelist and experienced faculty members from the Department of Livestock Products Technology, Namakkal evaluated the developed chicken cutlets for standard sensory attributes. The assessment was performed using an eight-point descriptive scale, where a score of 8 indicated excellent quality and 1 indicated extremely poor quality. The parameters evaluated included color and appearance, flavor, taste, juiciness, crispiness and overall acceptability. Prior to evaluation, the samples were coded and ensured uniform serving conditions. Water was provided to the panelists to rinse their mouths between samples, ensuring accurate and unbiased sensory judgment.

Proximate Composition

The proximate composition of developed chicken cutlets was determined as per the methods recommended by AOAC (2016) [21]. The crude protein content was determined by the Kjeldahl method and the crude fat content was determined by the Soxhlet method. The total ash content was determined by ashing the samples overnight at 550°C. Moisture content was determined by drying the samples overnight at 105 °C.

Statistical Analysis

The obtained data were statistically analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Differences among treatment means were evaluated using Tukey's post hoc test and statistical significance was determined at the 5% level ($p < 0.05$).

Results and discussion

Sensory quality

The sensory evaluation of functional chicken meat cutlets revealed significant ($p < 0.05$) differences among the control and treatment groups for all attributes studied, including appearance, flavour, taste, juiciness, crispiness and overall acceptability (Table 2). The appearance scores ranged from 7.38 to 7.60, with the pumpkin seed-incorporated cutlets (T1) recording the highest score (7.60 ± 0.01), followed by the control (7.50 ± 0.04), while chia seed treatment (T2) showed comparatively lower scores (7.38 ± 0.00). The improved appearance in T1 may be attributed to better color development and surface characteristics imparted by pumpkin seed components, whereas chia seeds may have slightly altered the visual appeal. This finding is in line with Öztürk and Turhan (2020) [18], who reported enhanced color and appearance in beef meatballs incorporated with pumpkin seed flour. Similarly, Serdaroğlu *et al.* (2017) [26] observed that pumpkin-based ingredients positively influenced product appearance, although excessive incorporation could negatively affect sensory quality.

In terms of flavour, T1 (7.25 ± 0.00) scored significantly higher than the control (7.10 ± 0.00) and T2 (7.00 ± 0.00). The enhancement in flavour in pumpkin seed-treated cutlets could be due to the presence of natural oils and bioactive compounds that contribute to desirable flavor notes. Conversely, the slightly lower score in T2 might be related to the mild nutty taste of chia seeds, which may not fully align with traditional consumer expectations. The taste attribute

followed a similar trend, with T1 (7.35 ± 0.00) scoring the highest, indicating better palatability compared to T2 (7.22 ± 0.02) and control (7.10 ± 0.00). This suggests that pumpkin seed incorporation positively influenced the overall taste profile, possibly due to improved fat mimetic properties and flavor enhancement. The improvement in flavour and taste in T1 can be explained by the presence of bioactive compounds, essential fatty acids, and natural antioxidants in pumpkin seeds, which contribute to desirable flavour development. The fat-mimetic properties of pumpkin seed powder may also enhance mouthfeel and palatability. Comparable results were reported by Rani *et al.* (2021) [22], who found that optimized incorporation of pumpkin and chia seed powders improved flavour and overall sensory acceptability of chicken meat nuggets. In contrast, the slightly lower flavour scores in T2 might be due to the mild, characteristic flavour of chia seeds, which may not fully complement traditional meat product profiles.

Table 2: Sensory Attributes of functional chicken meat cutlets incorporated with pumpkin and chia seed powders

Sensory Attributes	Control	T1 (Pumpkin Seed)	T2 (Chia Seed)
Appearance	7.50 ± 0.04^b	7.60 ± 0.01^c	7.38 ± 0.00^a
Flavour	7.10 ± 0.00^b	7.25 ± 0.00^a	7.00 ± 0.00^c
Taste	7.10 ± 0.00^c	7.35 ± 0.00^a	7.22 ± 0.02^b
Juiciness	7.18 ± 0.00^b	7.34 ± 0.04^a	7.40 ± 0.06^a
Crispiness	7.11 ± 0.00^b	7.25 ± 0.00^a	7.25 ± 0.00^a
Overall Acceptability	7.16 ± 0.01^c	7.35 ± 0.02^a	7.22 ± 0.04^b

For juiciness, both T1 (7.34 ± 0.04) and T2 (7.40 ± 0.06) exhibited significantly higher scores compared to the control (7.18 ± 0.00). The increased juiciness in treated samples could be attributed to the water-binding capacity and lipid content of both pumpkin and chia seeds, which help retain moisture during cooking. The significantly higher juiciness observed in both T1 and T2 treatments can be attributed to the high water-binding capacity and fiber content of the incorporated seed powders. Chia seeds, in particular, are known for their exceptional hydration properties due to mucilage formation, which helps retain moisture during cooking. This observation is strongly supported by Hanifah *et al.* (2021) [10], who reported improved moisture retention and juiciness in chicken sausages containing chia seed powder. Additionally, Rani *et al.* (2024) [23] demonstrated that both pumpkin and chia seed powders enhanced water-holding capacity and reduced moisture loss in chicken nuggets, contributing to improved juiciness and texture.

The crispiness scores were also higher in treated groups (7.25 ± 0.00 for both T1 and T2) compared to the control (7.11 ± 0.00). The enhancement in crispiness of treated samples may be linked to the structural interaction between seed powders and the coating system during enrobing and frying. The incorporation of seed particles in bread crumbs likely contributed to a more rigid and uniform crust formation, resulting in improved textural properties. Similar improvements in texture and coating characteristics have been reported by Rani *et al.* (2024) [23] in fiber-enriched chicken nuggets.

The overall acceptability scores indicated that T1 (7.35 ± 0.02) was the most preferred, followed by T2 (7.22 ± 0.04) and the control (7.16 ± 0.01). The higher acceptability of pumpkin seed-incorporated cutlets reflects a balanced improvement in sensory attributes without compromising product quality. Although chia seed incorporation improved

certain attributes such as juiciness and crispiness, its overall acceptability was slightly lower than T1, possibly due to subtle differences in flavour and appearance. Furthermore, the incorporation of pumpkin seed powder may have contributed to improved oxidative stability and color retention, as reported by Gadekar *et al.* (2025) [8], who highlighted the role of pumpkin seed as a natural preservative enhancing lipid stability in meat matrix. This could indirectly influence sensory attributes such as flavour and overall acceptability during storage.

Proximate Composition

The proximate composition of pumpkin seed and chia seed incorporated functional chicken meat cutlets revealed significant ($p < 0.05$) differences among the control and treatment groups (Table 3). The results of the present study clearly demonstrate that incorporation of pumpkin seed powder (T1) and chia seed powder (T2) significantly enhanced the proximate composition of functional chicken meat cutlets. The observed variations in moisture, protein, fat, fiber, ash and energy values can be attributed to the distinct compositional and functional characteristics of these plant-based ingredients.

Table 3: Proximate Composition of Functional Chicken Meat Cutlets Incorporated with Pumpkin and Chia Seed Powders

Parameter	Control	T1 (Pumpkin Seed 5%)	T2 (Chia Seed 3%)
Moisture (%)	50.11±0.02 ^b	49.65±0.02 ^a	56.94±0.01 ^c
Crude Protein (%)	14.13±0.50 ^a	17.82±0.00 ^c	15.65±0.04 ^b
Crude Fat (%)	11.93±0.00 ^b	14.17±2.66 ^c	9.30±1.01 ^a
Crude Fiber (%)	1.58±0.02 ^a	2.10±0.06 ^b	2.19±0.00 ^c
Total Ash (%)	2.49±0.10 ^a	2.65±0.08 ^b	2.84±0.04 ^c
Total Energy (kcal/kg)	2363±20.22 ^a	3268±15.00 ^c	2798±18.00 ^b

The moisture content was significantly higher in T2 ($56.94 \pm 0.01\%$) compared to the control ($50.11 \pm 0.02\%$) and T1 ($49.65 \pm 0.02\%$). The increased moisture in the chia seed-treated samples may be due to the high water absorption and retention capacity of chia seeds. The significantly higher moisture content observed in chia seed-treated cutlets (T2) may be due to the exceptional water-holding capacity of chia seeds, which form a gel-like structure when hydrated. This finding is consistent with Coorey *et al.* (2012) [3], who reported strong gelling and water-binding properties of chia flour. Similarly, Hanifah *et al.* (2021) [10] observed increased moisture retention in chia-incorporated chicken sausages, which contributed to improved product texture and juiciness. The crude protein content was significantly higher in T1 ($17.82 \pm 0.00\%$), followed by T2 ($15.65 \pm 0.04\%$) and the control ($14.13 \pm 0.50\%$). This indicates that incorporation of pumpkin seed powder contributed to an increase in protein content of the product. The increase in crude protein content, particularly in pumpkin seed-incorporated samples (T1), can be attributed to the high protein content of pumpkin seeds. This is in agreement with the findings of Saraswathi *et al.* (2018) [25], who reported enhanced protein levels in products fortified with pumpkin seed powder. Likewise, Rani *et al.* (2021) [22] observed improved protein content in chicken nuggets incorporated with pumpkin and chia seed powders, confirming their potential as protein-enriching functional ingredients.

The crude fat content showed a significant increase in T1 ($14.17 \pm 2.66\%$) compared to the control ($11.93 \pm 0.00\%$),

while T2 ($9.30 \pm 1.01\%$) recorded the lowest fat content. This suggests that chia seed incorporation may help in reducing fat levels, whereas pumpkin seeds, being rich in oil, increased the fat content. The variation in crude fat content, with higher values in T1 and lower values in T2, reflects the inherent lipid composition of the seeds used. Pumpkin seeds are rich in natural oils, leading to increased fat and energy content, as also reported by Öztürk and Turhan (2020) [18] in pumpkin seed-enriched meat products. In contrast, chia seed incorporation resulted in reduced fat content, which aligns with the findings of Pintado *et al.* (2015) [19], who demonstrated that chia-based formulations could reduce fat and overall caloric value in meat products due to their fat-replacing ability.

The crude fiber content was significantly higher in both treatment groups, with T2 ($2.19 \pm 0.00\%$) showing the highest value, followed by T1 ($2.10 \pm 0.06\%$) and the control ($1.58 \pm 0.02\%$). This reflects the high dietary fiber content of both pumpkin and chia seeds. The significantly higher crude fiber content in both treatment groups confirms the effectiveness of pumpkin and chia seeds as excellent sources of dietary fiber. Zargar *et al.* (2014) [31] also reported increased fiber content in pumpkin-incorporated meat products, while Romankiewicz *et al.* (2017) [24] highlighted improved fiber levels in chia-enriched food products. Enhanced dietary fiber not only improves nutritional quality but also contributes to better water retention and texture.

The total ash content was also significantly higher in T2 ($2.84 \pm 0.04\%$) and T1 ($2.65 \pm 0.08\%$) compared to the control ($2.49 \pm 0.10\%$), indicating enhanced mineral content due to seed incorporation. The increase in total ash content in treated samples indicates a higher mineral content, which can be attributed to the rich mineral composition of both pumpkin and chia seeds. Similar observations were reported by Pintado *et al.* (2018) [20], who noted increased mineral content in meat products formulated with chia-based ingredients. Nduko *et al.* (2018) [17] also reported improved ash content in chia-fortified food products, supporting the present findings.

The total energy value was highest in T1 (3268 ± 15.00 kcal/kg), followed by T2 (2798 ± 18.00 kcal/kg) and the control (2363 ± 20.22 kcal/kg). The higher energy content in T1 can be attributed to increased fat and protein levels. The higher energy value observed in pumpkin seed-treated cutlets (T1) may be due to increased fat and protein content, whereas chia-treated samples (T2) showed moderate energy levels due to lower fat content. These findings are in agreement with previous studies (Öztürk & Turhan, 2020; Pintado *et al.*, 2015) [18, 19], which reported similar trends in energy variation depending on ingredient composition.

Overall, the results demonstrate that incorporation of pumpkin and chia seed powders significantly improved the nutritional profile of chicken meat cutlets by increasing protein, fiber, and mineral content, while chia seed addition contributed to higher moisture retention and lower fat content. In addition to nutritional improvements, pumpkin seed incorporation may also contribute to enhanced oxidative stability and shelf life, as reported by Gadekar *et al.* (2025) [8], who highlighted the role of pumpkin seeds as natural preservatives in meat systems. Furthermore, Rani *et al.* (2024) [23] demonstrated that both pumpkin and chia seed powders improve storage stability and physicochemical properties in chicken meat products.

Conclusion

This study confirms that pumpkin seed powder and chia seed

powder can be successfully incorporated into chicken meat cutlets to enhance their nutritional and functional quality. Inclusion of pumpkin seed powder (5%) improved protein content, sensory characteristics, and overall acceptability, while chia seed powder (3%) contributed to increased moisture retention, dietary fibre, and desirable textural properties such as juiciness and crispiness. Both ingredients enriched the cutlets with higher fibre and mineral content, thereby improving their health value. Pumpkin seed incorporation resulted in higher fat and energy levels, whereas chia seed addition helped in reducing fat content while improving moisture retention. In summary, pumpkin seed powder was more effective in enhancing sensory quality, whereas chia seed powder played a key role in improving functional properties. The findings indicate that these plant-based ingredients can be effectively used to develop nutritionally enriched, value-added meat products that cater to the growing demand for healthier food options.

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