ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(5): 200-203
www.agriculturaljournals.com
Received: 02-02-2026
Accepted: 06-03-2026

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Assessment of physicochemical and sensory quality of chicken meat nuggets incorporated with *Chenopodium album* seed powder

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DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i5c.1508

Abstract
The purpose of this study was to assess the physico-chemical and sensory quality of chicken meat nuggets incorporated with *Chenopodium album* seed powder. Chicken meat nuggets were prepared with four different levels of *Chenopodium album* seed powder 0% (Control), 3% (T_1), 6% (T_2), and 9% (T_3). Incorporation of *Chenopodium album* seed powder in chicken meat nuggets resulted in significantly higher ($P \leq 0.05$) emulsion stability and cooking yield where as moisture content of *Chenopodium album* seed powder incorporated chicken nuggets was significantly lower ($P \leq 0.05$). Protein and fat content of chicken nuggets were not significantly affected by *Chenopodium album* seed powder incorporation. Ash and crude fiber of chicken meat nuggets increased significantly ($P \leq 0.05$) with an increase in the incorporation level of *Chenopodium album* seed powder. Ash and crude fibre of T_1, T_2, and T_3 increased significantly ($P \leq 0.05$) as compared to the control. Chicken nuggets containing 6% *Chenopodium album* seed powder showed no significant difference in colour and appearance, flavour, texture, juiciness and overall acceptability than control. On the other hand, 9% inclusion level resulted in significantly lower ($P \leq 0.05$) colour and appearance, flavour, juiciness and overall acceptability. Based on the above findings, incorporation of 6% *Chenopodium album* seed powder was found to be optimum in chicken meat nuggets.

Keywords: Chicken meat nuggets, *Chenopodium album* seed powder, physico-chemical quality

Introduction
Maintaining a person's growth, development and well-being requires an adequate, balanced diet. Meat is an extremely nutrient-dense, multipurpose food that contains high-quality proteins, B-complex vitamins and minerals, particularly iron and zinc, with high bioavailability. India's poultry industry has transformed over the past forty years from traditional farming to a fully commercialized system, producing approximately 5.18 million tonnes of poultry meat in 2023-2024, accounting for 49.27% of total meat production (BAHS, 2024). Poultry meat is preferred for its nutritional benefits (high protein and low fat) and its compatibility with processed items like chicken nuggets, which have grown in global popularity (El-Anany *et al*., 2020) [9]. Convenience foods are becoming more and more popular as consumers prefer ready-to-eat meat products due to rapid urbanization. Advances in meat processing technology have facilitated the creation of convenient, value-added products, with chicken nuggets being particularly popular due to their unique flavor and texture. Meat and meat products can be tailored into more "healthier" form by adding ingredients considered beneficial for health (Gupta *et al*, 2021) [13].
Plant-based ingredients, like chia and quinoa, are frequently incorporated into meat products to improve their nutritional, functional, and technological properties. These ingredients have very high technological significance (binding, emulsification, and antioxidant properties) in meat systems (Fernandez-Lopez *et al*., 2021) [11]. *Chenopodium album*, most commonly referred to as bathua in hindi, is characterised as a nutrient-dense and underused plant with significant potential for food applications. It has beneficial phytochemicals and health-promoting characteristics, making it suitable as a functional dietary component. *Chenopodium album* has a rich nutritional profile, including proteins, amino acids and minerals, as well as many phytochemicals and health benefits.

It highlights the presence of bioactive substances that improve antioxidant and nutraceutical properties (Singh *et al*., 2023) [20]. Due to its exceptional nutritional profile, *Chenopodium album* holds great potential as a health-boosting ingredient in food products. Even with its nutritious potential, incorporation of *Chenopodium album* seed powder in meat product formulation is, however, largely unstudied. Therefore, the present study was conducted to assess the physico-chemical and sensory quality of chicken meat nuggets incorporated with *Chenopodium album* seed powder.

Materials and Methods

The present study was conducted in the Department of Livestock Products Technology, NDVSU, Jabalpur. Dressed chicken carcasses were procured from retail meat shops of Jabalpur, India. The carcasses were manually deboned, packed in clean polyethylene bags, and stored under frozen conditions at −18±1°C until further use. Common salt (Tata Chemicals Ltd., Mumbai), soybean oil (Fortune), refined wheat flour (Fortune), sugar, condiments and spices were procured from the local market of Jabalpur. *Chenopodium album* seed powder was obtained from Zyrex Ayurveda, India. All chemicals and reagents used for analytical work were of analytical grade and procured from reputed firms.

Chicken meat nuggets were prepared with the incorporation of different levels of *Chenopodium album* seed powder. Four treatments were formulated: Control (without *Chenopodium album*seed powder), T_1 (3% *Chenopodium album* seed powder), T_2 (6% *Chenopodium album* seed powder), and T_3 (9% *Chenopodium album* seed powder). The formulation details are presented in Table 01. Deboned chicken meat was cut into small pieces and subjected to double mincing using a meat mincer. The minced meat was transferred to a bowl chopper for emulsion preparation. Salt, sodium nitrite, and phosphate were added and chopped for 3 min. Ice flakes were then incorporated, and chopping continued for 1.5 min. Soybean oil was added, and chopping was carried out for an additional 2 min. Subsequently, spice mix, condiment mix, and refined wheat flour were added and chopped for 2 min. Chenopodium album seed powder was incorporated according to treatment levels and further chopped for 2 min to obtain a uniform meat emulsion. The prepared meat emulsion was filled into aluminium moulds and subjected to steam cooking for 30 min. After cooking, the product was cooled at room temperature and cut into uniform nugget pieces.

The pH of the samples was determined following the method of Trout *et al*. (1992) [22]. Emulsion stability was determined using the method of Baliga and Madaiah (1970) [6]. Cooking yield was calculated by recording the weight of nuggets before and after cooking and expressed as a percentage yield. Moisture, crude protein, fat, ash, and crude fibre contents were determined according to AOAC (2005) [1] standard procedures. Sensory evaluation for colour and appearance, flavour, texture, juiciness, and overall acceptability was conducted using an eight-point descriptive scale (Keeton, 1983) [14], where 8 = excellent and 1 = extremely poor. Samples were coded and presented randomly. The experiment was replicated three times, and duplicate samples were analysed for each parameter (n = 6). The data obtained were subjected to statistical analysis using analysis of variance (ANOVA) to determine significant differences among treatments as described by Snedecor and Cochran (1994) [19]. Differences were considered significant at $P \leq 0.05$.

Results and Discussion

Table 02 presents the mean ±SE values for physico-chemical characteristics of chicken meat nuggets incorporated with *Chenopodium album* seed powder. pH of chicken meat nuggets showed an increase in trend corresponding to an increase in the level of *Chenopodium album* seed powder. pH value of chicken meat nuggets incorporated with 6% *Chenopodium album* seed powder (T_2) was comparable to that of Control and T_1, whereas pH value of chicken meat nuggets with 9% *Chenopodium album* seed powder (T_3) treatment was significantly higher ($P \leq 0.05$) than that of Control and T_1. This might be attributed to the higher pH of *Chenopodium album* seed powder than chicken meat. Minerals in *Chenopodium album* seed powder might have changed the balance of ions in chicken meat nuggets and resulted in a change in acid-base balance. Gammal *et al.* (2018) [12] also found similar results in chicken meat nuggets incorporated with Loquat (*Eriobotrya japonica*) seed powder. There was a significant increase ($P \leq 0.05$) in emulsion stability of chicken meat nuggets incorporated with *Chenopodium album* seed powder. Increase in emulsion stability with incorporation of *Chenopodium album* seed powder might be attributed to gelatinising properties of starch during heating and stabilising of the emulsion. This result might be attributed to higher levels of fibre in *Chenopodium album* seed powder. Non-meat ingredients are attracted by meat proteins, forming a protein net that stabilises the product (Olivo, 2006) [18]. Similar results were reported by Akesowan *et al.* (2024) [2] in emulsion stability by incorporating quinoa in chicken meat nuggets.

Cooking yield of chicken meat nuggets increased significantly ($P \leq 0.05$) among treatments. Cooking yield of chicken meat nuggets incorporated with 3%, 6%, and 9% *Chenopodium album* seed powder was significantly higher ($P \leq 0.05$) than that of the control. However, it was comparable among treatments. the cooking yield of T_2 was comparable to that of chicken meat nuggets incorporated with 3% and 9% *Chenopodium album* seed powder. Incorporation of non-meat components rich in dietary fibre improves cooking yield in emulsion-type meat products (Park *et al.*, 2015; Madane *et al.*, 2020) [19, 16]. Similar results were reported by Barros *et al.* (2019) [7] in the cooking yield of chia (*Salvia hispanica L.*) seed flour incorporated in chicken meat nuggets. There was a significant decrease ($P \leq 0.05$) in moisture (%) of chicken meat nuggets as the concentration of *Chenopodium album* seed powder increased. This drop might be attributed to the formation of a more stable protein matrix and the lower moisture content of *Chenopodium album* seed powder than meat. Similar results were reported by Akesowan (2016) [1] in chicken meat nuggets prepared using konjac flour. Chicken meat nuggets incorporated with *Chenopodium album* seed powder did not significantly ($P \leq 0.05$) affect protein content. Similar results were reported by Khatun *et al.* (2022) [15], who also observed no significant difference in protein content of chicken meat nuggets developed by using carrot and ginger. Fat (%) in chicken meat nuggets incorporated with *Chenopodium album* seed powder showed no significant difference among treatments. Ammar (2017) [4] also reported no significant difference in Control and high-fibre chicken

meat nuggets developed by using various plant-derived fibre sources. Ash (%) of chicken meat nuggets increased significantly ($P \leq 0.05$) with an increase in the incorporation level of *Chenopodium album* seed powder. It might be attributed to the incorporation of mineral-rich *Chenopodium album* seed powder. Verma *et al.* (2019) [23] and Nawarathne *et al.* (2021) [17] found a similar trend of increasing ash content of chevon nuggets incorporated with different levels of quinoa seed flours and in chicken meat nuggets incorporated with roasted sesame (*Sesamum indicum*) seeds, respectively. There was a significant increase ($P \leq 0.05$) in crude fibre of chicken meat nuggets with an increase in the incorporation of *Chenopodium album* seed powder. The presence of fibre in *Chenopodium album* seeds suggests that it plays a part in increasing the fibre content of chicken meat nuggets. Similar results were observed by Evanuarini *et al.* (2022) [10] and Yuniarti *et al.* (2023) [24] in chicken meat nuggets by the incorporation of tomato flour and tapioca flour, respectively.

Table 03 presents the mean ±SE values for sensory attributes of chicken meat nuggets incorporated with *Chenopodium album* seed powder. Colour and appearance *scores of chicken meat nuggets incorporated with 3% Chenopodium album seed powder (T_1) and 6% Chenopodium album seed powder (T_2) were comparable to the control. However, the score of chicken meat nuggets incorporated with 9% Chenopodium album seed powder(T_3) was significantly lower ($P \leq 0.05$) than that of the control, T_1, and T_2.* This decrease in the higher level of seed powder might be attributed to the dark colour produced by *Chenopodium album* seed powder. Similar results were reported by Meral *et al.* (2022) in chicken patties incorporated with quinoa flour. Scores for the flavour of chicken meat nuggets displayed a decrease in trend as the level of *Chenopodium album* seed powder increased. Score of T_1 was comparable to that of Control and T_2, whereas score of T_3 was significantly lower ($P \leq 0.05$) *than that of control, T_1, and T_2.* A significant decrease ($P \leq 0.05$) in T_3 might be attributed to a distinct or strong flavour of seed powder that was less favoured by panellists. However, lower inclusion levels maintained flavour profiles that were more closely related to Control. Echeverria *et al.* (2022) [8] found a similar trend in their study on chicken nugget formulations incorporating okara flour and rice bran. There was no significant difference in texture scores among treatments. Physical properties of seed powder did not significantly ($P \leq 0.05$) affect the texture of nuggets at these inclusion levels. Verma *et al.* (2019) [23] found that texture scores for amaranth and quinoa flours incorporated nuggets were considerably superior to the control group. Juiciness scores of chicken meat nuggets decreased with an increase in the level of *Chenopodium album* seed powder. Juiciness of T_3 was significantly lower ($P \leq 0.05$) than that of control, T_1, and T_2; however, T_1 and T_2 were comparable among themselves. Reduced juiciness at 9% seed powder incorporation might be attributed to lower moisture of chicken meat nuggets, producing a drier mouth feel. Similar results were reported by Gammal *et al.* (2018) [12] in chicken meat nuggets incorporated with Loquat (*Eriobotrya japonica*) seed powder. No statistically significant differences ($P \leq 0.05$) in overall acceptability were observed among Control, T_1, and T_2. However, the overall acceptability score of T_3 was significantly lower ($P \leq 0.05$) than that of Control, T_1, and T_2. It might be attributed to the combined effect of reduced colour, flavour, and juiciness at 9% incorporation of *Chenopodium album* seed powder. Similar results were reported by Nawarathne *et al.* (2021) [17], who also reported a significant decrease ($P \leq 0.05$) in overall acceptability of chicken meat nuggets at higher inclusion levels of sesame seeds.

Table 1: Formulation used for the preparation of chicken meat nuggets

Formulation	Control	T_1	T_2	T_3
Chicken meat (%)	68.5	65.5	62.5	59.5
Salt (%)	1.7	1.7	1.7	1.7
Spices (%)	1.5	1.5	1.5	1.5
Condiments (%)	3.5	3.5	3.5	3.5
Refined wheat flour (%)	4	4	4	4
Ice flakes (%)	10	10	10	10
Soyabean oil (%)	10	10	10	10
Chenopodium album seed powder (%)	0	3	6	9
Tetra-Sodium Pyrophosphate (Anhydrous) (%)	0.3	0.3	0.3	0.3
Sugar (%)	0.5	0.5	0.5	0.5
Sodium Nitrite (ppm)	150	150	150	150

Table 2: Physico-chemical characteristics of chicken meat nuggets incorporated with *Chenopodium album* seed powder

Treatment	Parameters							
	pH	Emulsion Stability (%)	Cooking Yield (%)	Moisture (%)	Crude Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)
Control	6.28^{c}±0.06	84.84^{d}±0.27	94.72^{c}±0.23	66.73^{a}±0.07	18.55±0.20	10.38±0.11	1.41^{d}±0.04	0.88^{d}±0.04
T_1	6.31^{bc}±0.04	88.75^{c}±0.08	98.05^{b}±0.32	64.82^{b}±0.12	18.43±0.15	10.34±0.10	1.67^{c}±0.03	1.23^{c}±0.03
T_2	6.34^{ab}±0.03	89.30^{b}±0.04	98.51^{ab}±0.26	62.76^{c}±0.24	18.32±0.12	10.31±0.08	2.19^{b}±0.02	1.59^{b}±0.02
T_3	6.37^{a}±0.05	89.78^{a}±0.10	99.07^{a}±0.28	60.61^{d}±0.09	18.20±0.24	10.27±0.06	2.37^{a}±0.05	1.95^{a}±0.05

Mean ±SE with different superscripts in lower case in a column differ significantly ($p \leq 0.05$), n=6.

Table 3: Sensory attributes of chicken meat nuggets incorporated with *Chenopodium album* seed powder

Treatment	Attributes				
	Colour and Appearance	Flavour	Texture	Juiciness	Overall Acceptability
Control	7.65^{a}±0.09	7.59^{a}±0.04	7.49±0.09	7.45^{a}±0.08	7.49^{a}±0.05
T_1	7.60^{a}±0.06	7.47^{ab}±0.08	7.46±0.05	7.19^{b}±0.06	7.46^{a}±0.04
T_2	7.52^{a}±0.07	7.37^{b}±0.05	7.41±0.07	7.06^{b}±0.04	7.40^{a}±0.03
T_3	7.23^{b}±0.13	6.84^{c}±0.10	7.33±0.08	6.54^{c}±0.11	6.51^{b}±0.09

Mean ±SE with different superscripts in lower case in a column differ significantly ($p \leq 0.05$), n=21.

Conclusion

Based on the above findings, incorporation of 6% *Chenopodium album* seed powder was found to be optimum in chicken meat nuggets. This study provides valuable insights into the formulation of chicken meat nuggets with *Chenopodium album* seed powder and its practical implications for the meat processing industry.

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