

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(11): 31-37
www.agriculturaljournals.com
Received: 30-08-2026
Accepted: 22-10-2026
Published: 03-11-2026

Jophil Thomas
M.V.Sc Scholar, Department of Livestock Products Technology, CVAS, Mannuthy, Thrissur, Kerala, India

Irshad A
Assistant Professor, Department of Livestock Products Technology, CVAS, Mannuthy Thrissur, Kerala, India

Sathu T
Professor, Department of Livestock Products Technology, CVAS, Mannuthy Thrissur, Kerala, India

Vasudevan VN
Professor and Head, Department of Livestock Products Technology, CVAS, Mannuthy Thrissur, Kerala, India

Harikrishnan S
Assistant Professor and Head, University Poultry and Duck Farm, CVAS, Mannuthy Thrissur, Kerala, India

Kavitha Rajagopal
Assistant Professor, Department of Livestock Products Technology, CVAS, Pookode, Wayanad, Kerala, India

Corresponding Author:
Jophil Thomas
M.V.Sc Scholar, Department of Livestock Products Technology, CVAS, Mannuthy, Thrissur, Kerala, India

Optimisation of functional chicken meat biscuits using millet and evaluation of proximate, sensory attributes and shelf stability during ambient storage

Jophil Thomas[1], Irshad A[2], Sathu T[3], Vasudevan VN[4], Harikrishnan S[5], Kavitha Rajagopal[6]

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i11a.88677

Abstract
Meat-based biscuits are valued for their long shelf life and convenience as ready-to-eat snacks. Adding millets enhances their nutritional profile by increasing protein and dietary fibre while offering an innovative approach to value addition in the meat industry. Control biscuits were prepared using refined wheat flour and chicken meat powder, whereas treatment samples replaced refined wheat flour with 30% finger millet, 40% pearl millet and 30% foxtail millet. Results showed that millet incorporation significantly improved biscuit yield, with finger millet biscuits achieving the highest yield (91.18%). Proximate analysis indicated that foxtail millet biscuits had the highest protein (30.27%) and dietary fibre (3.51%) content, making them nutritionally superior. TBARS and tyrosine values rose significantly but remained within acceptable limits. Microbial analysis confirmed product safety, with total viable counts within permissible levels and minimal yeast and mould growth. Sensory evaluation showed no significant changes in acceptability throughout storage. In conclusion, millet-enriched chicken biscuits offer a fibre source and protein rich snack with good consumer acceptance and a shelf life of up to 60 days when stored under ambient conditions in laminated pouches.

Keywords: Meat-based snacks, Foxtail millet, Chicken meat biscuits, Value addition, Dietary fibre, Storage study, TBARS, Tyrosine value, Yeast and mould count, Sensory evaluation

1. Introduction

Poultry meat is one of the most widely consumed sources of animal protein in India, valued for its affordability, nutritional benefits and broad cultural acceptance. With no significant religious restrictions, it forms an essential part of diets across various communities. In 2023, poultry meat production reached 4.995 million tonnes, contributing 51.14% of the country's total meat output, indicating a steady rise in demand. Among poultry products, broiler meat is particularly preferred due to its high protein content, low fat levels and ease of digestion. Biscuits are among the most popular ready-to-eat snacks globally, known for their convenience and versatility in incorporating nutritious ingredients, making them suitable for a diverse consumer base (Borooah *et al.*, 2024) [1]. Incorporating poultry meat into biscuits presents an opportunity to enhance their protein content, but since meat lacks dietary fibre, fortification with fibre-rich ingredients is essential. Bijlwan *et al.* (2019) [2] suggested that coarse grains and legumes such as whole wheat, rice, oats, maize, black gram, buckwheat, barley, rye, finger millet, pearl millet, sorghum and chickpeas could be used in bakery products to improve their protein and fibre content. Similarly, Liu *et al.* (2011) [3] noted that incorporating millet grains into processed meat products could help meet dietary fibre requirements.

Millets, recognised for their rich nutrient composition and health benefits, have gained global attention, leading to the UN declaring 2023 as the International Year of Millets. Their gluten-free nature, high fibre content and low glycaemic index make them an excellent functional ingredient for health-conscious consumers. Singh *et al.* (2014) [4] observed that the demand for shelf-stable meat-based snacks has risen due to urbanisation and changing food habits. Compared to commonly consumed high-energy snacks like potato chips and crackers, meat-based snacks have been found to contain lower total fat and higher protein and ash content (Cakmak *et al*., 2016) [5].

The incorporation of millets into chicken meat biscuits offered a promising approach to developing a balanced, protein-rich and fibre-enhanced snack. This study examined the formulation and development of chicken meat biscuits enriched with millets to improve their nutritional profile and align with modern health trends.

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

2. Materials and methods

Broiler chickens weighing between 2 and 2.5 kg were procured from the local market and slaughtered hygienically following scientific protocols at the Meat Technology Unit in Mannuthy. After processing, the chickens were dressed, sealed in high-density polyethylene bags and stored under aerobic conditions in a freezer at -21 ± 1 °C until they were used for experimentation.

2.1 Preparation of chicken meat powder

The frozen, dressed chickens were gradually thawed overnight at 4 ± 1 °C. After thawing, the meat was manually deboned, with any visible fat, fascia and loose connective tissue carefully removed. It was then cut into small pieces, boiled and minced. The minced meat was dried in a cabinet tray dryer with a blower set at 60 °C for 3 to 4 hours. Once dried, it was finely ground into a powder using a grinder, packed in low-density polyethylene bags and stored at 4 ± 1 °C.

2.2 Preparation of chicken meat biscuit

Refined wheat flour (RWF) constituted 65 percent of the formulation, while chicken meat powder (CMP) made up 35 percent, bringing the total to 100 percent. Refined wheat flour was replaced by millet flour in the treatment samples. In addition to these, other ingredients were included as follows: butter at 33 percent, sugar at 26 percent, salt at 1 percent, spice mix at 1 percent, baking powder at 0.6 percent, Symega chicken flavour at 0.4 percent and one whole egg.

The ingredients listed were measured according to the specified quantities, following the method described by Kumar *et al.* (2016) [6]. Refined wheat flour (RWF), chicken meat powder (CMP), sugar and salt were first combined in a planetary mixer. Butter, eggs and baking powder were then added and thoroughly mixed. Finally, the spice mix and chicken flavour were incorporated and the mixture was blended until all ingredients were evenly distributed.

Initially, the formulation for chicken meat biscuits was standardised. Subsequently, finger millet (ragi), pearl millet (bajra) and foxtail millet (thinna) were incorporated by replacing 30%, 40% and 30% of RWF. The dough was then shaped into biscuits and baked at 180 °C for 20-25 minutes. After baking, the biscuits were cooled to room temperature, packaged in laminated pouches and stored at ambient temperature. The millet-enriched biscuits and control were evaluated for their proximate composition and cooking yield on the day of preparation, then sensory and microbiological qualities on the 0^{th}, 15^{th}, 30^{th}, 45^{th} day and 60^{th} day of storage period.

2.3 Product yield

The weight of raw and baked biscuits of each replicate was recorded and product yield was expressed as percentage by using following formula:

$$\text{Product yield (\%)} = \frac{\text{Weight of baked chicken biscuits} \times 100}{\text{Weight of raw chicken biscuits}}$$

2.4 Proximate composition

Millet-incorporated chicken meat biscuits, along with control samples, were assessed for their proximate composition including moisture content (determined by oven drying), protein content (measured using the Kjeldahl distillation method), fat content (analysed through the Soxhlet method) and ash content (assessed using a muffle furnace), following the standard procedures outlined by AOAC (2016) [7].

2.5 Dietary fibre content

Control and treatment biscuits were analysed for dietary fibre content according to AOAC (2016) [7].

2.6 Storage study - thio-barbituric acid reactive substances

Thio-Barbituric Acid Reactive Substances (TBARS) value of biscuits was determined by the extraction method of Witte *et al.* (1970) [8]. TBARS estimation can be accomplished by measuring the concentration of secondary lipid oxidised products like malonaldehyde. Twenty grams of the sample was added with 50 mL of chilled extracting solution containing twenty per cent trichloroacetic acid in two molar orthophosphoric acid and was homogenised for about 1.5 to 2 minutes. The resultant slurry was transferred to a 100 mL volumetric flask and made up to 100 mL with deionised distilled water and this solution was filtered through Whatman No.1 filter paper. The filtrate was termed as Tri-Chloro Acetic acid (TCA) extract and five mL of TCA extract was mixed with five mL of 2-thiobarbituric acid solution (0.005 M in distilled water). Blank was constituted with five mL distilled water and 2-thiobarbituric acid solution. The constituted samples along with blank in tightly closed test tubes were placed in a boiling water bath (100℃) for 30 minutes and this was cooled for ten minutes under cold running water. The developed colour was measured as absorbance value at 530 nanometers (Double Beam Spectrophotometer Systronics-India, AU-2703) and expressed as thiobarbituric acid number. TBARS value was expressed as mg malonaldehyde per kg of the sample.

2.7 Tyrosine value

Tyrosine Value (TV) of the samples was estimated as per the method followed by Strange *et al.* (1977) [9]. Tyrosine is the first produced amino acid during proteolysis. Hence, tyrosine readings are indications of meat and meat products proteolysis. Two grams of sample were weighed and 40 mL of five per cent TCA solution was added. After homogenisation for two minutes the sample was filtered and the filtrate was collected. The filtrate, termed TCA extract was used in the estimation of TV. To 2.5 mL of TCA extract, equal quantity of distilled water was added in *a* test tube and shaken with ten mL of 0.5 N sodium hydroxide (NaOH) and three mL of diluted Folin and Ciocalteu's phenol (FC) reagent (one mL of concentrated FC reagent and two mL of distilled water). After mixing, the contents were allowed to stand for 15 minutes at room temperature, the optical density was measured at 660 nanometers in (Double Beam Spectrophotometer Systronics-India, AU-2703) using a blank containing 2.5 mL of five per cent TCA, equal quantity of distilled water was added in *a* test tube and shaken with 10 mL of 0.5 N NaOH and three mL of diluted FC reagent for comparison. TV was analysed and expressed as mg/100g of sample.

2.8 Microbiological parameters

For the estimation of Total Viable Count (TVC) and yeast and mould count in biscuits, the samples were homogenised with peptone water in a Stomacher (Seward Stomacher 400 Circulator).

2.8.1 Total viable count (TVC)

Total viable count of aerobic bacteria of each sample was estimated by pour plate method, as described by Morton (2001) [10] using Standard Plate Count Agar (HiMedia, Mumbai) and incubated at 37 °C for 18 to 24 h and the count expressed as $\log_{10}$ CFU/g.

2.8.2 Yeast and mould count

Method described by Beuchat *et al.* (2001) [11] was followed for the estimation of yeast and mould count per g of the sample. Saburaud's Dextrose Agar (HiMedia, Mumbai) was used. The plates were incubated at 25-27 °C for three days and the count expressed as $\log_{10}$ CFU/g.

2.9 Sensory evaluation

Sensory evaluation was conducted by a semi-trained panel of seven members from the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur. An eight-point Hedonic scorecard was used. The chicken biscuits were assessed for colour and appearance, meat flavor intensity, crispiness,

2664845X, 2026, 8(1), Downloaded from https://www.doi.org/10.33545/2664845X.2026.v8.i1a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

aftertaste and overall acceptability. Uniform samples of millet-incorporated chicken biscuits, labeled with three-digit codes, were provided to the panelists, who rated them using the Hedonic scale. Plain water was provided to rinse their mouths between samples and the average of individual scores was recorded for each attribute.

2.10 Statistical analysis

All the experiments were replicated six times. The data obtained from product yield, proximate composition, microbiological and sensory characteristics of the control as well as treatment chicken biscuits were assessed statistically by repeated measures ANOVA, one-way ANOVA and Kruskal Wallis test using the Statistical Package for Social Sciences (SPSS) software 24.0 version (Snedecor *et al.*, 1994) [12].

Ethical statement on human rights

Participation in the sensory evaluation was voluntary, conducted under ethical guidelines and posed no risk or harm to participants. Therefore, no human rights violations occurred during the conduct of research.

3. Results and discussion

3.1 Product yield, proximate composition and dietary fibre

The product yield of the control and treatment biscuits, as shown in Table I, exhibited significant differences ($p < 0.01$). The highest yield was observed in finger millet-incorporated biscuits (91.18 ± 0.14), which can be attributed to the excellent gelation properties and fibre content of finger millet. These characteristics enhance binding and moisture retention, thereby improving the overall product yield (Saha *et al*., 2011) [13]. In contrast, the control biscuits had the lowest yield (82.72 ± 0.32), likely due to the absence of fibre.

The proximate composition of the control and treatment biscuits given in Table I, was analysed for moisture, crude protein, ether extract, total ash and dietary fibre content. The treatment biscuits had the lowest moisture content, showing a significant difference ($p < 0.05$) compared to the control. This decrease in moisture may be due to the higher concentration of refined flour in the control, which has a greater ability to retain moisture (Anil *et al*., 2023) [14].

Significant differences ($p < 0.01$) in crude protein content were observed between the control and treatment biscuits. The highest protein content (30.27 ± 0.07%) was recorded in foxtail millet-incorporated biscuits, likely due to the naturally higher protein content of millet flour compared to the refined wheat flour (RWF) used in the control. Sharma *et al.* (2017) [15] reported that foxtail millet had crude protein ranging from 11.85 to 20.58 g/100 g and amino acids from 0.25 to 4.31 g/100 g, emphasising its distinct health benefits over other cereals.

The ether extract content of pearl millet-incorporated biscuits showed a significant difference ($p < 0.05$) compared to the other samples. This variation may be due to the relatively higher fat content in pearl millet, as reported by Gopalan *et al.* (2004) [16], who documented fat contents of 1.92 g, 5.43 g and 4.3 g in finger millet, pearl millet and foxtail millet, respectively. Significant differences ($p < 0.01$) in total ash content were observed between the control and treatment biscuits. The higher ash content in finger millet-incorporated biscuits may be attributed to the naturally high mineral content of finger millet. This is supported by Thompson (1993) [17], who reported that finger millet contains 344 mg of calcium per 100 g, along with 0.48 g of phytates and 0.61% polyphenols and tannins, all of which contribute to the total ash content.

Table 1. Effect of different millets on the product yield, proximate composition and dietary fibre of chicken meat biscuits

Parameters	Control	Finger millet	Pearl millet	Foxtail millet	*F* value (*p* value)
Yield (%)	82.72 ± 0.32^{a}	91.18 ± 0.14^{d}	90.27 ± 0.15^{c}	89.09 ± 0.33^{b}	224.3 (< 0.001)**
Moisture (%)	8.51 ± 0.70^{b}	7.06 ± 0.83^{ab}	7.05 ± 0.72^{ab}	6.36 ± 0.20^{a}	4.772 (0.041)*
Crude Protein (%)	28.89 ± 0.26^{c}	25.15 ± 0.16^{a}	27.21 ± 0.06^{b}	30.27 ± 0.07^{d}	180.573 (< 0.001)**
Ether extract (%)	24.71 ± 0.84^{a}	25.63 ± 0.16^{a}	27.28 ± 0.29^{b}	25.5 ± 0.19^{a}	5.348 (0.007)**
Total Ash (%)	2.49 ± 0.06^{c}	2.63 ± 0.01^{d}	2.31 ± 0.01^{b}	1.94 ± 0.007^{a}	72.299 (< 0.001)**
Dietary fibre (g/100g)	1.01 ± 0.07^{a}	2.05 ± 0.02^{b}	2.88 ± 0.03^{c}	3.51 ± 0.01^{d}	346.763 (< 0.001)**

* Significant at 0.05 level; ** Significant at 0.01 level; Means with different superscripts in rows differ significantly. The values are expressed as their Mean ± Standard error.

The dietary fibre content given in Table I, differed significantly ($p < 0.01$) across all samples, with foxtail millet-incorporated biscuits showing the highest value (3.51 ± 0.01%), while the control had the lowest (1.65 ± 0.07%). This trend is consistent with the findings of Elleuch *et al.* (2011) [18], who reported that foxtail millet contains a substantially higher dietary fibre content (60.69 g/100 g) compared to other brans, such as rice bran (27.04%) and wheat bran (44.46%). The incorporation of millet contributed to the increased fibre content in these formulations. The higher fibre content not only enhances the biscuits' nutritional profile but also provides functional benefits, as highlighted by Kausar *et al.* (2019) [19], who found that fibre-enriched meat products exhibit superior functional properties.

As per FSSAI (2018) [20] guidelines, a food product must contain between 3 to 6g of dietary fibre per 100g to be classified as a good source of fibre. Based on this criterion, foxtail millet-incorporated biscuits, with their higher fibre content, can be considered the most nutritionally beneficial among the treatment samples.

3.2 Storage study - TBARS

The thio-barbituric acid reactive substances (TBARS) values as represented in figure 1, which indicate oxidative rancidity, increased significantly ($p < 0.01$) over the 60-day storage period in both the control and treatment biscuits. In the control, the TBARS value rose from 0.136 ± 0.012 to 0.559 ± 0.016 mg of malonaldehyde/kg, while a similar trend was observed in the pearl millet-incorporated biscuits, where values increased from 0.206 ± 0.012 to 0.566 ± 0.016 mg of malonaldehyde/kg. These results are consistent with the findings of Ratanatriwong *et al.* (2011) [21], who reported a gradual rise in TBARS values in fish and chicken snacks stored at ambient temperature. Similarly, Dykes *et al.* (2006) [22] highlighted the susceptibility

2664844X, 2026, 8(1), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i1a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

of pearl millet-based products to oxidation due to their high polyunsaturated fatty acid content. Furthermore, Kumar *et al.* (2016) [6] demonstrated that TBARS values in bran-enriched meat biscuits remained below the 2 mg/kg threshold even after 180 days of storage.

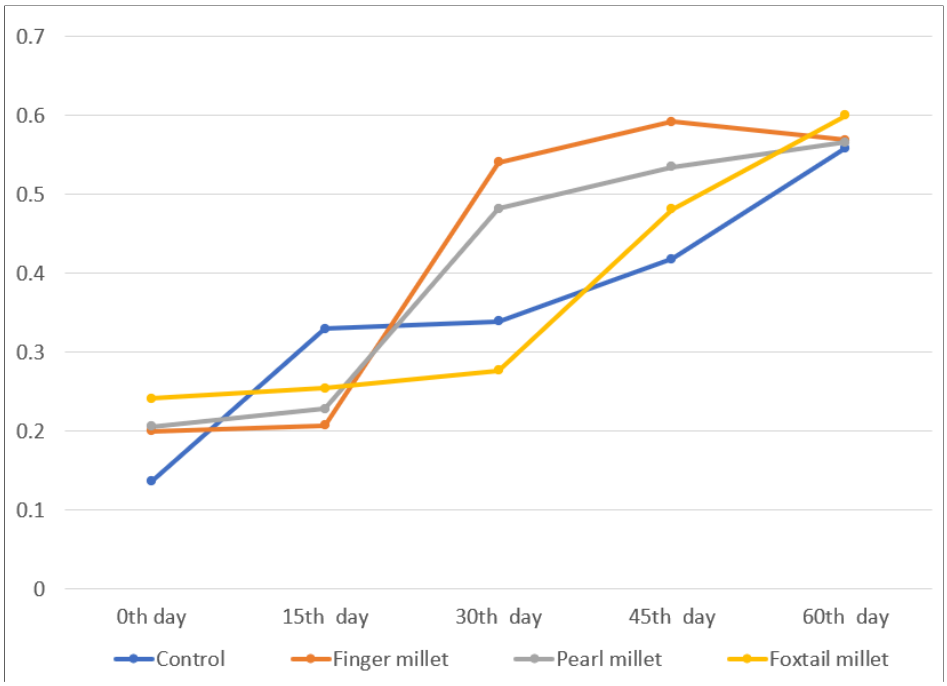


Figure 1. Effect of storage days on TBARS value (mg malonaldehyde/kg) of control and treatment biscuits

3.3 Tyrosine value

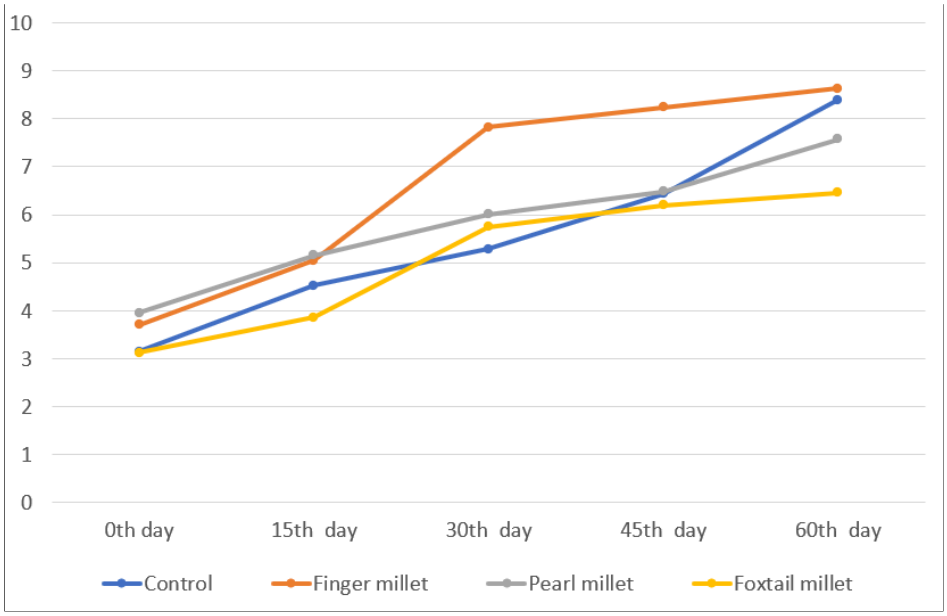


Figure 2. Effect of storage days on tyrosine value (mg tyrosine/ 100g) of control and treatment biscuits

The tyrosine value (TV) shown in the figure 2, a measure of proteolytic activity, increased significantly ($p < 0.01$) in both the control and treatment biscuits over the 60-day storage period. In the control biscuits, the TV rose from 3.15 ± 0.08 to 8.39 ± 0.01 mg tyrosine/100g, likely due to proteolytic changes in meat proteins caused by endogenous enzymes and bacterial proteases, as reported by Balaji (2024) [23]. This trend aligns with the findings of Pavan *et al.* (2019) [24], who observed an increase in tyrosine levels in finger millet-incorporated nuggets during storage. The rise in proteolysis may be linked to the enhanced availability of amino acids from finger millet, which facilitates greater protein breakdown. Interestingly, the foxtail millet-incorporated biscuits exhibited a lower tyrosine value than the control, despite their higher protein content. Bachate *et al.* (2022) [25] highlighted the superior biological value of foxtail millet protein, which contains seven of the eight essential amino acids, potentially influencing tyrosine release or retention during storage. These findings suggest that the unique amino acid composition of millet may play a role in regulating proteolytic activity.

3.4 Microbiological parameters

3.4.1 Total viable count (TVC)

The total viable count (TVC) of all samples as given in figure 3, increased significantly ($p < 0.01$) over the storage period. The initially low TVC across all samples can be attributed to thermal processing, low moisture content and strict hygiene practices maintained during production, as noted by Grohs *et al.* (2000) [26]. A similar trend was

2664844X, 2026, 8(1), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i1a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

reported by Berwal *et al.* (2013) [27], who observed a gradual rise in TVC from day 0 to day 30 in both control and chicken-incorporated biscuits, with peak values recorded on day 75. Despite this increase, the TVC values in the present study remained within the acceptable limits for cooked meat products, as established by Jay (1996) [28].

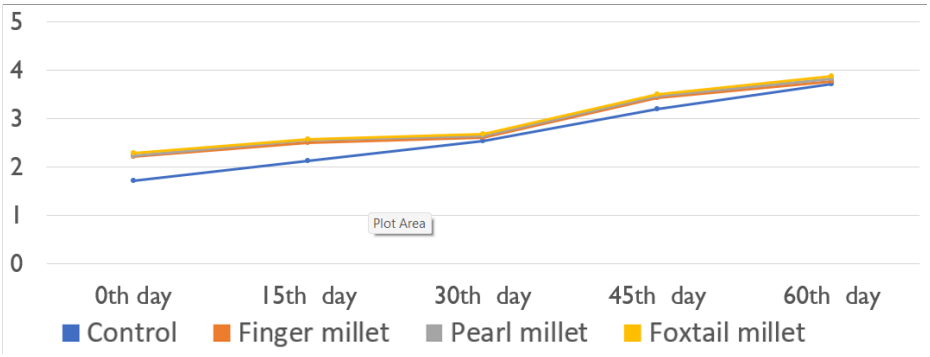


Figure 3. Effect of storage days on total viable count (log_{10} CFU/g) **of control and treatment biscuits**

3.4.2 Yeast and mould count

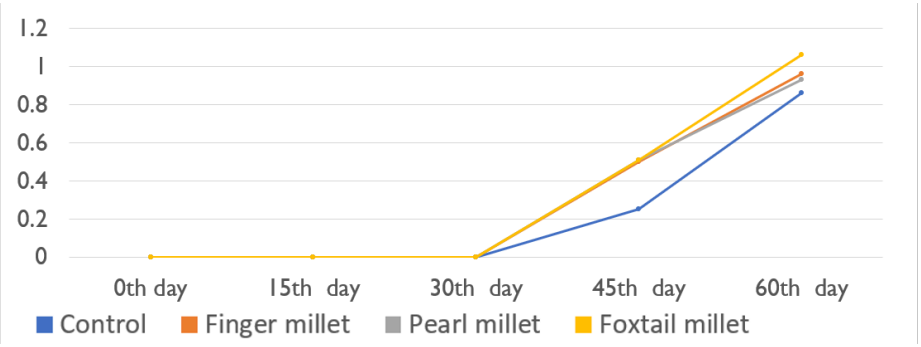


Figure 4. Effect of storage days on yeast and mould count (log_{10} CFU/g) **of control and treatment biscuits**

The yeast and mold count depicted in figure 4, remained undetectable until day 30 in all samples, likely due to the low moisture content, pH and the presence of antimicrobial ingredients such as spices, which inhibited microbial growth. However, from day 45 onward, a significant ($p < 0.01$) increase in yeast and mold count was observed, though the values remained relatively low (ranging from 0.25 to 1.06 log_{10} CFU/g) by day 60. These findings align with those of Berwal *et al.* (2013) [27], who reported similar trends in chicken biscuits and cookies and Sarkar *et al.* (2020) [29], who attributed the absence of yeast and mold growth in traditional bhujia formulations to their reduced moisture content.

3.5 Sensory evaluation

Table 2. Effect of storage days on sensory attributes of control and treatment biscuits

Sample	0th day	15th day	30th day	45th day	60th day	χ^2 value (*p*-value)
			Appearance and colour			
Control	7.35 ± 0.08	7.33 ± 0.08	7.33 ± 0.11	7.33 ± 0.09	7.31 ± 0.11	0.655 (0.957)^{ns}
Finger millet	7.06 ± 0.09	7.06 ± 0.11	7.06 ± 0.13	7.06 ± 0.09	7.04 ± 0.11	1.186 (0.880)^{ns}
Pearl millet	7.21 ± 0.12	7.19 ± 0.09	7.18 ± 0.14	7.17 ± 0.08	7.16 ± 0.12	0.372 (0.985)^{ns}
Foxtail millet	7.32 ± 0.10	7.32 ± 0.05	7.29 ± 0.10	7.29 ± 0.07	7.29 ± 0.10	1.571 (0.814)^{ns}
(*p*-value)	(0.176)^{ns}	(0.105)^{ns}	(0.530)^{ns}	(0.104)^{ns}	(0.234)^{ns}	
			Meat flavour intensity			
Control	6.56 ± 0.10	6.54 ± 0.09	6.54 ± 0.09	6.54 ± 0.07	6.52 ± 0.09	0.211 (0.995)^{ns}
Finger millet	6.56 ± 0.10	6.54 ± 0.07	6.52 ± 0.10	6.52 ± 0.13	6.52 ± 0.10	0.369 (0.985)^{ns}
Pearl millet	6.56 ± 0.11	6.54 ± 0.07	6.52 ± 0.09	6.52 ± 0.10	6.52 ± 0.09	0.183 (0.996)^{ns}
Foxtail millet	6.55 ± 0.10	6.54 ± 0.09	6.53 ± 0.10	6.52 ± 0.10	6.52 ± 0.10	0.149 (0.997)^{ns}
(*p*-value)	(0.999)^{ns}	(0.998)^{ns}	(0.999)^{ns}	(0.964)^{ns}	(0.999)^{ns}	
			Crispiness			
Control	7.29 ± 0.12	7.29 ± 0.12	7.27 ± 0.12	7.27 ± 0.09	7.27 ± 0.10	0.052 (1.00)^{ns}
Finger millet	7.37 ± 0.14	7.37 ± 0.12	7.36 ± 0.07	7.36 ± 0.08	7.35 ± 0.09	1.347 (0.853)^{ns}
Pearl millet	7.34 ± 0.13	7.34 ± 0.11	7.34 ± 0.12	7.33 ± 0.11	7.33 ± 0.14	0.177 (0.996)^{ns}
Foxtail millet	7.33 ± 0.12	7.32 ± 0.12	7.31 ± 0.13	7.31 ± 0.10	7.31 ± 0.09	0.230 (0.994)^{ns}

(continued on next page)

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i11a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

Sample	0th day	15th day	30th day	45th day	60th day	χ^2 value (*p*-value)
(*p*-value)	$(0.907)^{ns}$	$(0.946)^{ns}$	$(0.896)^{ns}$	$(0.788)^{ns}$	$(0.838)^{ns}$	
			After taste			
Control	7.14 ± 0.13	7.14 ± 0.11	7.13 ± 0.12	7.12 ± 0.08	7.12 ± 0.11	0.535 $(0.970)^{ns}$
Finger millet	7.21 ± 0.08	7.21 ± 0.07	7.21 ± 0.09	7.20 ± 0.06	7.18 ± 0.07	0.538 $(0.970)^{ns}$
Pearl millet	7.27 ± 0.14	7.26 ± 0.09	7.26 ± 0.08	7.25 ± 0.09	7.25 ± 0.10	1.353 $(0.852)^{ns}$
Foxtail millet	7.33 ± 0.14	7.31 ± 0.11	7.31 ± 0.13	7.31 ± 0.12	7.31 ± 0.10	0.496 $(0.974)^{ns}$
(*p*-value)	$(0.547)^{ns}$	$(0.690)^{ns}$	$(0.719)^{ns}$	$(0.316)^{ns}$	$(0.334)^{ns}$	
			Overall acceptability			
Control	7.21 ± 0.11	7.21 ± 0.13	7.2 ± 0.09	7.19 ± 0.06	7.19 ± 0.13	0.673 $(0.955)^{ns}$
Finger millet	7.23 ± 0.13	7.23 ± 0.10	7.22 ± 0.08	7.21 ± 0.08	7.20 ± 0.10	1.122 $(0.891)^{ns}$
Pearl millet	7.29 ± 0.14	7.27 ± 0.10	7.27 ± 0.09	7.26 ± 0.10	7.26 ± 0.13	2.583 $(0.630)^{ns}$
Foxtail millet	7.35 ± 0.12	7.35 ± 0.09	7.33 ± 0.09	7.33 ± 0.10	7.32 ± 0.07	0.798 $(0.939)^{ns}$
(*p*-value)	$(0.754)^{ns}$	$(0.824)^{ns}$	$(0.766)^{ns}$	$(0.680)^{ns}$	$(0.871)^{ns}$	

ns – non-significant at 0.05 level. The values are expressed as their Mean ± Standard error.

The results of the sensory analysis for both the control and treatment samples, conducted on days 0, 15, 30, 45 and 60 of storage, are presented in Table II. The evaluation showed no significant ($p > 0.05$) changes in appearance and colour, meat flavor intensity, crispiness, aftertaste or overall acceptability throughout the storage period. This suggests that adding millet did not have an adverse effect on the sensory characteristics of the biscuits. The control biscuits consistently received the highest scores for appearance and colour across storage, which aligns with the findings of Kumar *et al.* (2016) [6]. However, the foxtail millet-incorporated biscuits maintained the highest overall acceptability throughout the storage period, highlighting the potential of millet-based biscuits to retain consumer preference over extended storage durations.

4. Conclusion

Incorporating millets into chicken meat biscuits enhances their protein content and provides a valuable source of dietary fibre, resulting in a well-accepted product. Biscuits formulated with 30% finger millet, 40% pearl millet and 30% foxtail millet had protein levels of 25.15%, 27.2% and 30.27%, respectively. Additionally, their dietary fibre content was 2.05g, 2.88g and 3.51g per 100g, compared to the control sample, which contained 28.89% protein and 1.01g of dietary fibre per 100g. The incorporation of millet flour not only increased the yield but also potentially extending the product's shelf life. Furthermore, chicken meat biscuits made with finger, pearl and foxtail millet can be stored at room temperature for up to 60 days without significant sensory deterioration or microbial spoilage.

Conflicts of interest

The authors declare that they have no conflict of interest.

Disclosure Statements

The authors declare that they have no financial interests that are directly or indirectly related to the work submitted for publication.

Funding Details

This study didn't receive any funding.

Data Availability Statement

No additional data are available beyond those presented in the submitted manuscript.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Jophil Thomas, Irshad A, Sathu T, Vasudevan V N, Harikrishnan S and Kavitha Rajagopal. The first draft of the manuscript was written by Jophil Thomas and all other authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References

1. Borooah R, Das B, Baruah LD, Alam S, Saikia A, Purkayastha MD. Novel biscuits using whey protein and *Ocimum gratissimum* to mitigate protein burden: quality parameters, in vitro protein digestibility, SWOT analysis and implication on public health. Food and Humanity. 2024;3:100318.
2. Bijlwan M, Naik B, Sharma D, Singh A, Kumar V. Recent development in dough-based bakery products: a mini review. J Pharma Innov. 2019;8:654-658.
3. Liu BY, Peng JY, Zeng XM, Zheng HY, Zhong G. Characterisation of dietary fibre from millet brans. Appl Mech Mater. 2011;140:278-285.
4. Singh PK, Kumar S, Kumar P, Bhat ZF. Effect of mincing on the quality characteristics of chevon cutlets. J Anim Res. 2014;4:193-200.
5. Cakmak H, Altinel B, Kumcuoglu S, Kisla D, Tavman S. Production of crispy bread snacks containing chicken meat and chicken meat powder. *Anais* da Academia Brasileira de Ciências. 2016;88:2387-2399.
6. Kumar P, Chatli MK, Mehta N, Malav OP, Verma AK, Kumar D. Quality attributes and storage stability of chicken meat biscuits incorporated with wheat and oat bran. J Food Qual. 2016;39:649-657.
7. AOAC. Meat and Meat Products. In: Official Methods of Analysis of Official Analytical Chemists, 20th edn. Association of Official Analytical Chemists Inc, Rockville, Maryland, USA; 2016:3172p.
8. Witte VC, Krause GF, Bailey ME. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J Food Sci. 1970;35:582-585.
9. Strange ED, Benedict RC, Smith JL, Swift CE. Evaluation of rapid tests for monitoring alterations in meat quality during storage: I. Intact meat. J Food Prot. 1977;40:843-847.
10. Morton RD. Aerobic plate count. In: Downes FP, Ito K, editors. Compendium of Methods for the Microbiological Examination of Foods, 4th edn. APHA, Washington DC; 2001:63-67.
11. Beuchat LR, Cousin MA. Yeasts and moulds. In: Downes FP, Ito K, editors. Compendium of Methods for the Microbiolgical Examination of Food, 4th edn. APHA, Washington DC; 2001:209-215.
12. Snedecor GM, Cochran WG. Statistical Methods, 8th edn. The Iowa State University, Ames, Iowa; 1994:313p.

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

13. Saha S, Gupta A, Singh SRK, Bharti N, Singh KP, Mahajan V, Gupta HS. Compositional and varietal influence of finger millet flour on rheological properties of dough and quality of biscuit. LWT-Food Sci Technol. 2011;44:616-621.
14. Anil A, Renuka Nayar AR, Rajagopal K, Sathu T, Vinod VK. Development and quality evaluation of ready-to-cook porridge mix incorporating chicken meat powder. J Pharma Innov. 2023;12:1400-1403.
15. Sharma N, Niranjan K. Foxtail millet: properties, processing, health benefits and uses. Food Rev Int. 2017;34:329-363.
16. Gopalan C, Ramashastri BV, Balasubramanium SC. Nutritive value of Indian foods. Hyderabad: National Institute of Nutrition (NIN), Indian Council of Medical Research; 2004:59–67.
17. Thompson LU. Potential health benefits and problems associated with *anti*- nutrients in foods. Int Food Res J. 1993;26:131-149.
18. Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H. Dietary fibre and fibre-rich by-products of food processing: characterisation, technological functionality and commercial applications: a review. Food Chem. 2011;124:411-421.
19. Kausar T, Hanan E, Ayob O, Praween B, Azad ZRAA. A review on functional ingredients in red meat products. Bioinformation. 2019;15:358.
20. FSSAI. Food Safety and Standards (Advertising and Claims) Regulations, 2018. Available: https://www.fssai.gov.in/upload/uploadfiles/files/Compendium_Advertising_Claims_Regulations_14_12_2022.pdf. 2018.
21. Ratanatriwong PA, Wongsa-Ngasri W, Suwansri S, Thanasukarn P. Optimisation of drying process efficiency and shelf-life extension by active packaging in crispy minced-fish snacks. The 12th Asean Food Conference; 16th to 18th June, 2011, Thailand. Food Science and Technology Association of Thailand; 2011.
22. Dykes L, Rooney LW. Sorghum and millet phenols and antioxidants. J Cereal Sci. 2006;44:236-251.
23. Balaji SS. Ph.D thesis. Maharashtra Animal and Fishery Sciences University. 2024.
24. Pavan M, Kurian Y, Nayar R, Rajagopal K, Sathu T, Sunanda C. Development and quality evaluation of chicken nuggets incorporated with finger millet (*Eleusine coracana*). Int J Livest Res. 2019;9:116-126.
25. Bachate AH, Pawar VS, Kale PR, Lolge RM. Wonder millets - pearl millet, finger millet and foxtail millet nutritional profile and its role in health promotion: a review. Biol Forum. 2022;14:251-257.
26. Grohs BM, Kliegel N, Kunz B. Bacteria grow slower: effects of spice mixtures on extension of shelf life of pork. Fleischwirtschaft. 2000;80:61-63.
27. Berwal RK, Khanna NITA, Garg SR. Shelf stability of convenience and ready to eat chicken meat mince incorporated cookies. Haryana Vet. 2013;52:82-87.
28. Jay JM. Modern Food Microbiology. 4th edn. C.B.S. Publishers and Distributors, New Delhi; 1996.
29. Sarkar BK, Upadhyay S, Hazarika M, Gogoi P, Das A, Choudhury S. Development and quality evaluation of bhujia incorporated with spent hen meat powder. J Entomol Zool Stud. 2020;8:114-120.

How to cite this article: Thomas J, A I, T S, VN V, Harikrishnan S, Rajagopal K. Optimisation of functional chicken meat biscuits using millet and evaluation of proximate, sensory attributes and shelf stability during ambient storage. *International Journal of Agriculture and Food Science*. 2026;8(11):31-37. doi: https://www.doi.org/10.33545/2664844X.2026.v8.i11a.88677

2664844X, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.88677 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License