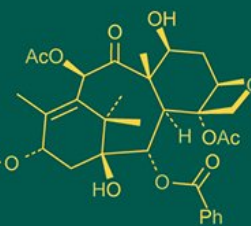
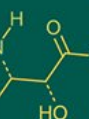
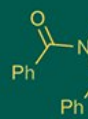


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Development and standardization of value-added momos using indian mackerel (*Rastrelliger kanagurta*, Cuvier, 1816) and plant-based ingredients

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Abstract

The study aimed to standardize and evaluate the acceptability of fish-based momo prepared using Indian mackerel (*Rastrelliger kanagurta*) incorporated with hydrated soy chunks. The objective was to determine the sensory attributes and proximate composition of the developed product. Two formulations control and treatment were prepared. The treatment formulation was optimized by varying the levels of fish meat, soya chunks, and onion. Fish meat was incorporated at three levels: FM1 (20 g), FM2 (25 g), and FM3 (30 g). Soy chunks were added at S1 (20 g), S2 (25 g), and S3 (30 g), while onion was incorporated at O1 (36.2 g), O2 (46.2 g), and O3 (56.2 g). Sensory evaluation was conducted using a nine-point hedonic scale, and data were analyzed using one-way ANOVA followed by Tukey's HSD test. Proximate analysis revealed that the treatment sample contained higher protein and ash levels, whereas the control sample exhibited higher moisture and fat contents. Sensory evaluation indicated that both samples were acceptable; however, the treatment formulation consistently received higher scores across all attributes. The results demonstrate that fish momo prepared from Indian mackerel can be successfully standardized as a nutritious, value-added seafood product. Incorporation of soy chunks improved texture, masked fishy odour, and enhanced nutritional quality, particularly protein content.

Keywords: Fish, momo, Indian mackerel, soya chunks, onion, standardization.

Introduction

Fish is an essential component of the human diet and plays a vital role in global food and nutrition security. It provides high-quality, easily digestible protein, essential amino acids, vitamins, minerals, and polyunsaturated fatty acids (Huss, 1995; Bogard et al., 2015) [4, 11]. Regular consumption of fish contributes to healthy growth, development, and overall well-being, while also helping to prevent micronutrient deficiencies (Kawarazuka & Béné, 2011) [12]. Increasing awareness of the health benefits associated with fish has led to a steady rise in global fish consumption. Fish lipids are particularly valued for their omega-3 fatty acids, including α -linolenic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), which support cardiovascular health, brain development, immune function, and cognitive performance (Calder, 2012; Swanson et al., 2012; Pal et al., 2018) [5, 13, 16]. According to the Food and Agriculture Organization (FAO, 2024), global fisheries and aquaculture production reached 235 million tonnes, comprising 195 million tonnes of aquatic animals and 40 million tonnes of algae. India contributed 17.545 million tonnes of fish, with Maharashtra accounting for approximately 0.59 million tonnes (Handbook of Fisheries Statistics, 2025). Indian mackerel (*Rastrelliger kanagurta*), belonging to the family Scombridae, is one of the most commercially important marine fish species in India. It is widely distributed along both the west and east coasts and is highly valued for its rich nutritional composition. The species contains essential amino acids such as arginine, histidine, threonine, valine, isoleucine, leucine, phenylalanine, and lysine, along with non-essential amino acids including glutamic acid, serine, glycine, alanine, proline, and tyrosine (Chakraborty et al., 2013) [6]. Its lipid profile includes saturated, monounsaturated, and polyunsaturated fatty acids, while minerals such as calcium, iron, manganese, zinc, copper, and magnesium further enhance its nutritional value.

Growing consumer demand for convenient, nutritious, and ready-to-eat foods has encouraged the development of innovative fish-based products. Value addition not only enhances the economic worth of fish but also reduces post-harvest losses and improves marketability (FAO, 2022). Among popular convenience foods, momo a steamed dumpling widely consumed across South Asia has gained significant popularity due to its taste, affordability, and ease of preparation (Baral, 2024) [3]. Traditionally prepared with meat or vegetable fillings, momo offers a versatile platform for incorporating nutrient-rich ingredients. Integrating Indian mackerel into momo formulations can improve the nutritional profile of this widely consumed food by increasing protein content and providing beneficial omega-3 fatty acids. Additionally, incorporating plant-based ingredients such as soy chunks may enhance texture, mask strong fish odours, and further improve nutritional quality. Therefore, developing a value-added momo using Indian mackerel and selected plant-based ingredients represents a promising approach to producing a healthy, protein-rich, and consumer-acceptable seafood product. The present study was undertaken to develop and standardize a fish-based momo formulation using Indian mackerel (*Rastrelliger kanagurta*) and plant-based ingredients. The study also aimed to evaluate the proximate composition and sensory attributes of the developed product to determine its acceptability and nutritional potential.

Material and methods

Collection of Raw Materials

Fresh Indian mackerel (*Rastrelliger kanagurta*, Cuvier, 1816) were procured from Mirkarwada Jetty, Ratnagiri, Maharashtra, India. Plant-based ingredients including soy chunks, onion, ginger–garlic paste, green chilli paste, spring onion, coriander leaves, salt, garam masala, sunflower oil, and rice flour were purchased from the local market. All ingredients were food-grade and used on the day of procurement.

Preparation of Fish Meat

Fresh fish were washed thoroughly with potable water, followed by beheading and gutting. The cleaned fish were boiled for 10 minutes, cooled, and manually deboned to obtain clean fish meat. Skin and bones were removed carefully to ensure uniformity in the final product.

Preparation of Control Sample

The control momo formulation was prepared according to the recipe standardized by the Central Institute of Fisheries Technology (CIFT, 2018). The ingredient composition is presented in Table 1.

Table 1: Control Sample Formulation (CIFT, 2018)

Sl. No	Ingredients	Quantity (g)
1	Fish meat	32
2	Additives	
	Onion	64.2
	Ginger paste	0.6
	Garlic paste	0.6
	Green chilli pastes	0.6
3	Aromatics	
	Coriander leaves	0.5
	Spring onion	0.5
4	Flavoring agents	
	Garam masala	0.5
	Salt	0.5
	Total (%)	100

Sensory Panel Feedback and Recipe Modification

After sensory evaluation of the control sample, panel members provided suggestions to improve flavour balance, texture, and overall acceptability. These suggestions included:

- Slight reduction in fish meat to minimize strong fishy odour
- Incorporation of lightly fried soy chunks to improve texture and mask odour
- Reduction in onion quantity to balance flavour
- Replacement of refined wheat flour (maida) with rice flour for a softer, healthier wrapper

Table 2: These suggestions and corresponding actions are summarized in

Sl. No	Ingredients	Control (C) CIFT (2018) 32:68	T1 40:60	T2 50:50	T3 60:40
1	Fish meat	32g	20g	25g	30g
2	Soya chunks	NIL	20g	25g	30g
3	Additives				
	Onion	64.2g	56.2g	46.2g	36.2g
	Ginger paste	0.6g	0.6g	0.6g	0.6g
	Garlic paste	0.6g	0.6g	0.6g	0.6g
	Green chili paste	0.6g	0.6g	0.6g	0.6g
4	Aromatics				
	Coriander leaves	0.5g	0.5g	0.5g	0.5g
	Spring onion	0.5g	0.5g	0.5g	0.5g
5	Flavouring agents				
	Garam masala	0.5g	0.5g	0.5g	0.5g
	Salt	0.5g	0.5g	0.5g	0.5g
		Total = 100g	Total = 100g	Total = 100g	Total = 100g

Standardization of Treatment Formulation

To optimize the stuffing formulation, three levels of fish meat, soy chunks, and onion were tested:

- **Fish meat:** FM1 (20 g), FM2 (25 g), FM3 (30 g)
- **Soy chunks:** S1 (20 g), S2 (25 g), S3 (30 g)
- **Onion:** O1 (36.2 g), O2 (46.2 g), O3 (56.2 g)

All other ingredients were kept constant. Each formulation was evaluated for appearance, taste, texture, colour, odour, and overall acceptability using a nine-point hedonic scale. Based on sensory scores, the optimized treatment formulation consisted of:

- **30 g fish meat (FM3)**
- **30 g soy chunks (S3)**
- **36.2 g onion (O1)**

Table 3: The final standardized recipe is presented in

Sl.No	Ingredients	Quantity(g)
1	Fish meat	30
2	Soya chunks	30
3	Additives	
	Onion	36.2
	Ginger paste	0.6
	Garlic paste	0.6
	Green chilli paste	0.6
4	Aromatics	
	Coriander leaves	0.5
	Spring onion	0.5
5	Flavoring agents	
	Garam masala	0.5
	Salt	0.5
	Total (%)	100

Preparation of Momo Wrapper

Maida was completely replaced with rice flour to improve nutritional quality and achieve a soft, desirable wrapper texture. Dough was prepared using rice flour and warm water, kneaded until smooth, and rested for 10 minutes before shaping.

Sensory Evaluation

Sensory evaluation of fresh fish and momo samples was conducted using a nine-point hedonic scale (1 = dislike extremely; 9 = like extremely), following the method described by Hough (2010). Semi-trained panelists (n = 10) assessed appearance, colour, odour, texture, taste, and overall acceptability.

Proximate Composition Analysis

Proximate composition (moisture, protein, fat, and ash) of fresh fish and momo samples was determined using standard

AOAC (2005) [2] methods:

- Moisture: Hot-air oven drying
- Protein: Kjeldahl method
- Fat: Soxhlet extraction
- Ash: Muffle furnace incineration

Carbohydrate content was calculated by difference.

Biochemical Quality Analysis of Fresh Fish

Biochemical parameters were analyzed as follows:

- pH: AOAC (2005) [2]
- Trimethylamine nitrogen (TMA-N): Beatty & Gibbons (1936)
- Total volatile base nitrogen (TVB-N): Beatty & Gibbons (1936)
- Peroxide value (PV): AOAC (2005) [2]
- Free fatty acids (FFA): AOAC (2005) [2]

Microbiological Analysis

Microbiological quality of fresh fish was assessed according to USFDA (2022) methods:

- Total Plate Count (TPC)
- *Escherichia coli*
- *Staphylococcus aureus*
- *Salmonella* spp.

All analyses were performed under aseptic conditions.

Statistical Analysis

All experiments were conducted in triplicate using a Completely Randomized Design (CRD). Data were analyzed using one-way Analysis of Variance (ANOVA), and significant differences among treatment means were determined using Tukey's HSD test at $p < 0.05$. Statistical analysis was performed using SPSS version 16.0 (SPSS Inc., Chicago, USA).

Results

Proximate Composition of Fresh Indian Mackerel

The proximate composition of fresh Indian mackerel is presented in Table 4. The fish exhibited high moisture content (72.83%), moderate protein levels (18.85%), and relatively low fat content (6.67%). Ash and carbohydrate contents were 1.13% and 0.52%, respectively. These values are consistent with typical biochemical profiles of pelagic fish species.

Table 4: Proximate Composition of Fresh Indian Mackerel

Parameter	Composition (%)
Moisture	72.83 ± 0.09
Protein	18.85 ± 0.07
Fat	6.67 ± 0.08
Ash	1.13 ± 0.01
Carbohydrate	0.52 ± 0.01

Biochemical and Microbiological Quality of Fresh Fish

Biochemical parameters indicated that the fish were fresh and of acceptable quality. pH (6.41), TMA-N (2.34 mg/100 g), and TVB-N (7.36 mg/100 g) values were well within acceptable limits for fresh marine fish. Peroxide value (1.65 meq O₂/kg) and free fatty acids (0.34% as oleic acid) were low, indicating minimal lipid oxidation.

Microbiological analysis revealed a low total plate count (2.12 log cfu/g), while *E. coli*, *Staphylococcus aureus*, and *Salmonella* were not detected, confirming good hygienic quality.

Table 5: Biochemical and Microbiological Quality of Fresh Indian Mackerel

Quality parameters	Observed values
Biochemical quality	
pH	6.41 ± 0.04
TMA-N (mg/100g)	2.34 ± 0.02 mg/100 g
TVB -N (mg/100g)	7.36 ± 0.02 mg/100 g
PV (meq of O ₂ /kg)	1.65 ± 0.03 meq of O ₂ /kg
FFA (% as oleic acid)	0.34 ± 0.02 % as oleic acid
Microbial quality	
Total plate count (log cfu/g)	2.12 ± 0.02 (log CFU/g)
<i>Escherichia coli</i> (log cfu/g)	Not detected
<i>Staphylococcus aureus</i> (log cfu/g)	Not detected
<i>Salmonella</i> (log cfu/g)	Not detected

Sensory Standardization of Fish Meat

Sensory scores for fish meat incorporation levels (FM1, FM2, and FM3) are presented in Table 6. The formulation containing **30 g fish meat (FM3)** achieved the highest overall acceptability (8.90), significantly higher than FM1 and FM2 ($p < 0.05$). FM3 also received superior scores for appearance, taste, texture, colour, and odour.

Table 6: Sensory Scores for Fish Meat Standardization

Attributes	Control (T ₀)	FM ₁ (20 g)	FM ₂ (25 g)	FM ₃ (30 g)
Appearance	7.90±0.36 ^b	7.20±0.22 ^a	7.70±0.47 ^{ab}	8.50±0.18^c
Taste	7.80±0.28 ^b	6.70±0.47 ^a	7.20±0.51 ^{ab}	8.90±0.10^c
Texture	7.80±0.28 ^{ab}	7.30±0.52 ^a	8.10±0.31 ^b	8.70±0.28^c
Colour	7.50±0.54 ^{ab}	7.20±0.56 ^a	7.80±0.31 ^{ab}	8.30±0.56^b
Odour	7.80±0.31 ^{ab}	6.90±0.56 ^a	7.60±0.51 ^{ab}	8.50±0.38^b
Overall Acceptability	7.50±0.70 ^b	6.80±0.42 ^a	7.40±0.84 ^b	8.90±0.10^c

Values are presented as mean ± standard deviation (n = 10). Statistical analysis was performed using one-way ANOVA followed by Tukey's HSD post hoc test to determine significant differences among treatments. Means with different superscript letters within the same row indicate significant differences ($p < 0.05$), while means sharing common superscripts are not significantly different. Sensory evaluation was conducted using a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely, where FM indicates fish meat).

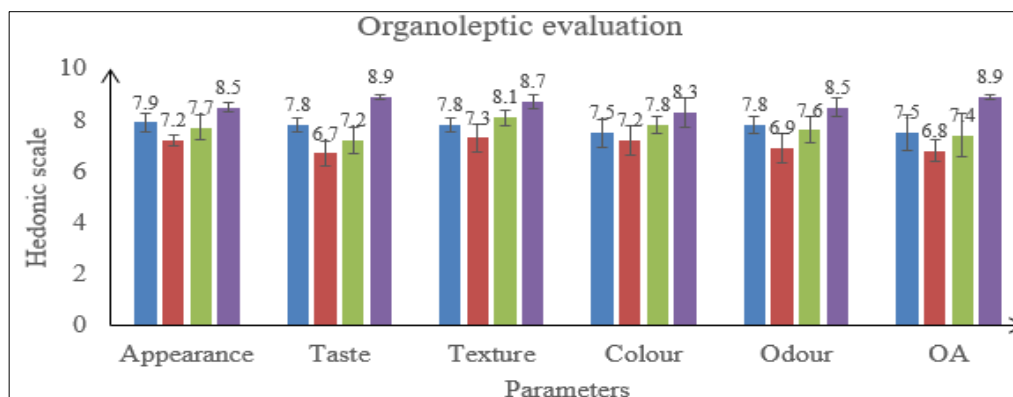


Fig 1: Mean results of sensory characteristics for standardization of fish meat

4.4 Sensory Standardization of Soy Chunks

Soya chunk incorporation significantly improved texture, taste, and odour. The highest overall acceptability was

observed for **S3 (30 g)** with a score of 8.40. Increasing soy chunk levels enhanced mouthfeel and masked fishy odour.

Table 7: Sensory Scores for Soy Chunk Standardization

Attributes	Control (T ₀)	S ₁ (20 g)	S ₂ (25 g)	S ₃ (30 g)
Appearance	7.30±0.48 ^a	7.90±0.13 ^{ab}	8.30±0.34 ^b	8.50±0.22 ^b
Taste	6.90±0.73 ^a	7.90±0.46 ^b	8.40±0.31 ^{bc}	8.80±0.18 ^c
Texture	7.00±0.94 ^a	8.00±0.61 ^b	8.30±0.34 ^b	8.70±0.24 ^c
Colour	7.20±0.63 ^a	7.60±0.69 ^{ab}	7.90±0.73 ^{ab}	8.30±0.67 ^b
Odour	6.80±0.63 ^a	7.70±0.82 ^b	8.10±0.54 ^b	8.40±0.41 ^b
Overall Acceptability	6.90±0.31 ^a	7.70±0.48 ^b	8.00±0.47 ^{bc}	8.40±0.51 ^c

Values are presented as mean ± standard deviation (n = 10). Statistical analysis was performed using one-way ANOVA followed by Tukey's HSD post hoc test to determine significant differences among treatments. Means with different superscript letters within the same row indicate significant differences ($p < 0.05$), while means sharing common superscripts are not significantly different. Sensory evaluation was conducted using a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely), where S indicates soya chunks

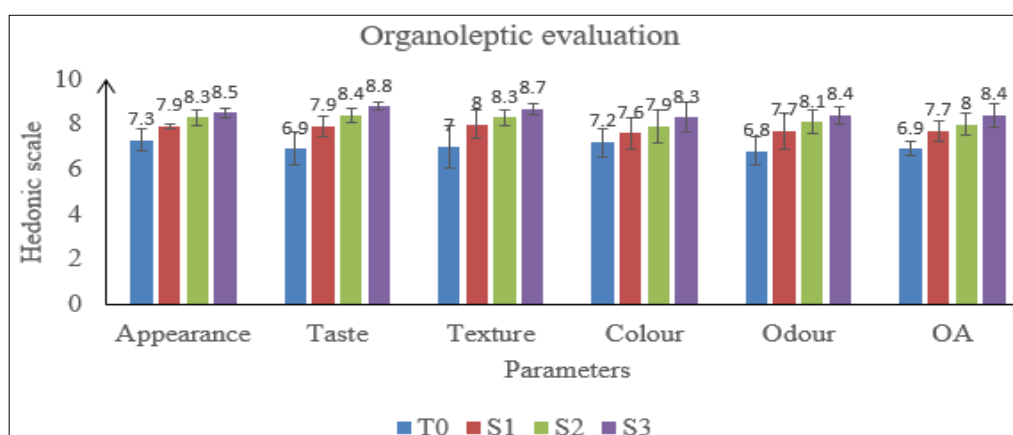


Fig 2: Organoleptic Evaluation of Samples T₀, S₁, S₂, and S₃ Based on Sensory Attributes

4.5 Sensory Standardization of Onion

Onion levels significantly influenced flavour balance and texture. The formulation containing **36.2 g onion (O₁)**

achieved the highest overall acceptability (8.60). Higher onion levels (O₃) reduced acceptability due to excessive sweetness and moisture.

Table 8. Sensory Scores for Onion Standardization

Attributes	(Control) T ₀	O ₁ (36.2 g)	O ₂ (46.2 g)	O ₃ (56.2 g)
Appearance	7.30±0.48 ^a	8.50±0.42 ^c	8.10±0.47 ^{bc}	7.60±0.69 ^{ab}
Taste	7.00±1.05 ^a	8.70±0.24 ^c	8.20±0.42 ^{bc}	7.60±0.51 ^{ab}
Texture	7.00±0.47 ^a	8.60±0.31 ^c	8.00±0.10 ^{bc}	7.50±0.51 ^{ab}
Colour	7.60±0.97 ^a	8.40±0.59 ^b	7.90±0.77 ^{ab}	7.70±0.94 ^{ab}
Odour	6.80±0.63 ^a	8.60±0.31 ^c	7.80±0.31 ^b	7.30±0.48 ^{ab}
Overall Acceptability	7.00±0.10 ^a	8.60±0.34 ^c	8.00±0.10 ^b	7.40±0.51 ^{ab}

Values are presented as mean ± standard deviation (n = 10). Statistical analysis was performed using one-way ANOVA followed by Tukey's HSD post hoc test to determine significant differences among treatments. Means with different superscript letters within the same row indicate significant differences ($p < 0.05$), while means sharing common superscripts are not significantly different. Sensory evaluation was conducted using a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely, where O indicates onion).

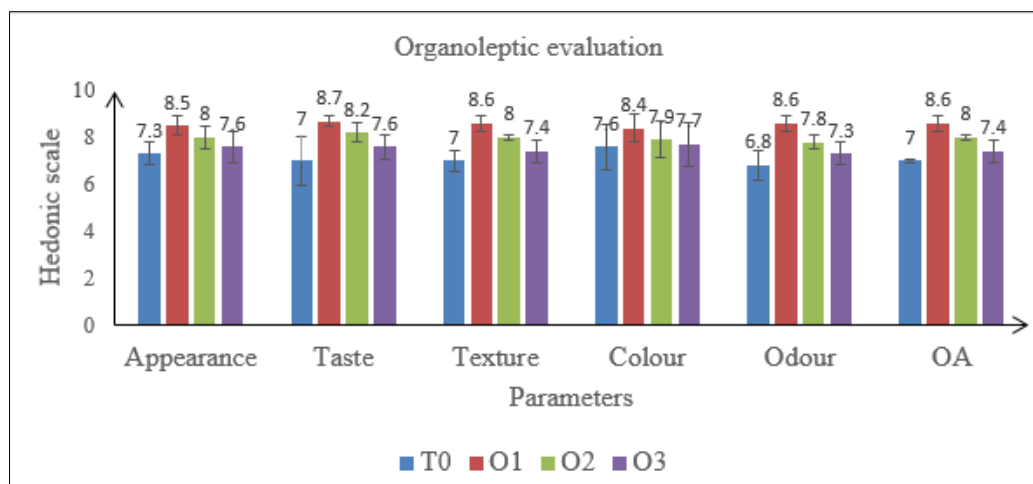


Fig 3: Organoleptic Evaluation of Samples T0, O1, O2, and O3 Based on Sensory Attributes

4.6 Proximate Composition of Control and Treatment Momo

Proximate composition of the final momo samples is presented in Table 9. The treatment sample exhibited significantly higher protein (11.60%) and ash (2.05%) contents compared to the control. Moisture was lower in the treatment sample, likely due to higher soy chunk incorporation.

Table 9: Proximate Composition of Control and Treatment Momo

Parameter	Control (%)	Treatment (%)
Moisture	49.47 ± 0.02	44.31 ± 0.03
Ash	1.96 ± 0.01	2.05 ± 0.01
Protein	7.48 ± 0.02	11.60 ± 0.01
Fat	8.51 ± 0.02	8.35 ± 0.01
Carbohydrate	32.55 ± 0.02	33.68 ± 0.01

Discussion

Standardization of Fish Meat

The incorporation level of fish meat had a significant influence on the sensory attributes of the momo. Among the formulations tested, FM3 (30 g fish meat) achieved the highest overall acceptability (8.90 ± 0.10), outperforming FM1 (20 g) and FM2 (25 g). The superior sensory scores of FM3 may be attributed to the balanced contribution of Indian mackerel meat to flavour, juiciness, and texture. At this level, the fish imparted a pleasant savoury taste without producing an overpowering fishy odour, resulting in improved consumer acceptance. In contrast, the control sample containing 32 g fish meat exhibited slightly lower acceptability. This reduction may be due to the stronger fish flavour and firmer stuffing texture associated with higher fish content. Excess fish meat can intensify odour and reduce cohesiveness of the filling. Similar observations were reported by Tanuja et al. (2014) [18], who noted that moderate incorporation of Indian mackerel improved sensory quality in chicken meat momos. These findings support the conclusion that 30 g fish meat is optimal for achieving desirable sensory characteristics.

Standardization of Soy Chunks

Soy chunks significantly enhanced the sensory attributes of the momo, particularly texture, taste, and odour. The formulation containing 30 g soy chunks (S3) received the highest overall acceptability score (8.40 ± 0.51). Increasing soy chunk levels improved mouthfeel due to their fibrous,

hydrated structure, which contributed to a softer and more cohesive filling. Additionally, soy chunks effectively masked the strong fishy odour of mackerel, resulting in improved flavour balance. These results align with previous studies demonstrating the beneficial effects of soy-based extenders in meat products (Todd et al., 1989; Pszcola, 1991; Troutt et al., 1992; Thebaudin et al., 1997) [19, 20, 21]. Ahmad et al. (2010) [1] and Sushma et al. (2020) [15] also reported improved sensory quality in meat products when soya ingredients were incorporated. The present study confirms that hydrated soy chunks serve as an effective textural and flavour-enhancing ingredient, improving acceptability beyond the control sample.

Standardization of Onion

Onion levels significantly influenced the sensory profile of the momo. The formulation containing 36.2 g onion (O1) achieved the highest overall acceptability (8.60 ± 0.34). This moderate level of onion contributed to improved flavour, aroma, and moisture balance. Excessive onion (O3: 56.2 g) resulted in reduced acceptability due to increased sweetness and moisture, which negatively affected texture. Conversely, lower onion levels (control: 64.2 g) produced an imbalanced flavour profile. Similar findings were reported by Desai (1999) [9], who observed that optimal onion levels enhance sensory quality in fish-based products. The present study confirms that 36.2 g onion provides the best balance of flavour, aroma, and texture in fish momo formulations.

Proximate Composition of Control and Treatment Momo

Proximate analysis revealed notable differences between the control and treatment samples. The treatment sample exhibited significantly higher protein content (11.60%) compared to the control (7.48%). This increase is attributed to the combined contribution of fish meat and soy chunks, both of which are rich protein sources. The ash content was also higher in the treatment sample (2.05%), indicating improved mineral content. Moisture content was lower in the treatment sample (44.31%) than in the control (49.47%). This reduction may be due to the higher proportion of soy chunks, which bind water more effectively and reduce free moisture. Fat content remained comparable between the two samples, suggesting that soy chunk incorporation did not significantly alter lipid levels. Carbohydrate content was slightly higher in the treatment sample, likely due to the

presence of plant-based ingredients. Overall, the treatment formulation demonstrated superior nutritional quality, particularly in terms of protein and mineral content, making it a healthier alternative to traditional momo formulations.

Overall Interpretation

The combined incorporation of 30 g fish meat, 30 g soy chunks, and 36.2 g onion resulted in a momo formulation with enhanced sensory and nutritional qualities. Soy chunks played a crucial role in improving texture and masking fishy odour, while optimal onion levels contributed to balanced flavour and aroma. The standardized formulation demonstrated high consumer acceptability and improved nutritional value, supporting its potential as a value-added, protein-rich seafood product suitable for commercial development.

Conclusion

The present study successfully developed and standardized a value-added momo formulation using Indian mackerel (*Rastrelliger kanagurta*) and plant-based ingredients. Sensory evaluation demonstrated that the optimized formulation containing 30 g fish meat, 30 g hydrated soy chunks, and 36.2 g onion achieved the highest overall acceptability among all tested combinations. The balanced incorporation of fish meat contributed desirable flavour and juiciness, while soy chunks enhanced texture, improved mouthfeel, and effectively masked the strong fishy odour characteristic of mackerel. The optimized onion level further improved flavour balance and aroma. Proximate analysis revealed that the treatment sample possessed superior nutritional quality, particularly in terms of protein and ash content, compared to the control. The combined use of fish meat and soy chunks significantly increased protein levels, making the product a healthier alternative to traditional momo formulations. Lower moisture content in the treatment sample indicated improved binding and reduced free water, contributing to better textural attributes. Overall, the study demonstrates that Indian mackerel can be effectively utilized in the development of a nutritious, protein-rich, and consumer-acceptable momo product. The standardized formulation offers potential for commercial production, value addition, and diversification of fish-based convenience foods. Incorporating soy chunks and optimized seasoning levels further enhances product quality, making it suitable for wider acceptance in the market.

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