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Formulation of Tuna Flavouring Agents for Soup Application

Bayu Kusuma¹; Tian Nur Marifat^{1*}; Sukoso¹; Sawaminee Teerawut²; Arief Rahmawan³

1-Fisheries and Marine Science Faculty, Universitas Brawijaya, Indonesia

2-Faculty of Science, Burapha University, Thailand

3-Faculty of Science and Technology, Universitas Darussalam Gontor, Indonesia

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ABSTRACT

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*Corresponding Author E-Mail:

tiannurm@ub.ac.id

This study investigates the sensory profile and nutritional composition of tuna-based soups, aiming to optimize ingredient combinations and cooking techniques for enhanced consumer acceptance. The research employs a systematic approach, utilizing proximate analysis to assess key nutritional components such as moisture, protein, fat, carbohydrates, and ash content, alongside sensory evaluations conducted with 100 panellists. The methodology includes marinating yellowfin tuna fillets, followed by drying and grinding to create a tuna flavour agent, which is then incorporated into the soup. Results indicate that the proximate analysis reveals significant nutritional value, with variations in protein and fat content influenced by ingredient selection. Sensory tests highlight that the M3 treatment, with a higher concentration of tuna flavour agent, received the best ratings for odour, flavour, and overall acceptability. The findings underscore the importance of ingredient quality and preparation methods in developing soups that meet consumer preferences while providing essential nutrients. This research presents a novel approach to valorising abundant yellowfin tuna resources through the development of a shelf-stable flavour agent, offering significant potential for commercial applications in the rapidly growing food and beverage industry targeting university students and young consumers. Adding tuna flavouring agent to the soup improves its sensory quality, particularly the flavour. The study provides a practical framework for industrial scale-up and product commercialization, contributing to sustainable utilization of marine resources while meeting evolving market demands for convenient, nutritious, and flavourful soup products.

1-Introduction

Flavour is a critical sensory component in the culinary arts, influencing the enjoyment and overall quality of food. Among various dishes, soup stands as one of the most complex in terms of flavour composition, where multiple ingredients and cooking techniques must come together harmoniously to achieve a balanced and appealing taste [1]. The role of flavour in soup has garnered attention in both professional culinary circles and scientific research, particularly because it is a dish that can encompass a wide variety of tastes, from Savory to sweet, spicy to mild, and everything in between [2]. Understanding how flavour compounds interact in soup, how they can be modified through different cooking methods, and how consumer preferences are shaped by these Flavours, is crucial not only for chefs but also for food scientists and food technologists [3] [4].

Recent research into flavour science has explored the intricacies of how different factors such as ingredient combination, cooking temperature, time, and the presence of specific compounds contribute to the final flavour profile of soups. Studies have highlighted the significance of umami and other flavour-enhancing compounds in soups, with ingredients like broths, herbs, and seasonings playing pivotal roles in flavour development [3][5]. Additionally, sensory perception of flavour is not solely dependent on taste alone but also on aroma, texture, and visual appeal, making the study of flavour in soup a multi-sensory experience. As a result, there has been a surge in interest to quantify and understand the specific flavour components that elevate the taste of soups and how these components can be manipulated for various outcomes, including flavour enhancement and consumer satisfaction [6][7][8].

The main research problem, however, lies in identifying the optimal combination of ingredients and cooking techniques that yield the most desired flavour profile in soups, particularly given the diverse regional and cultural preferences for soup

flavours. While much is known about the scientific basis of flavour interaction in food, there remains a gap in understanding how specific ingredient combinations and preparation methods influence the flavour development in soups across different culinary traditions [9] [10] [11]. Furthermore, consumer preferences, which are highly subjective and can vary significantly across demographic groups, add complexity to the task of designing soups that are widely acceptable. Thus, the challenge is to establish a framework or methodology that can guide soup preparation to achieve the desired balance of flavours, ensuring both culinary excellence and broad consumer satisfaction [12][13].

The research was conducted to test the effectiveness of the tuna flavour agent as a formulation for fish soup. University students are the target market being aimed at because the demand in Food and Beverages industries is rapidly growing with students as the target market in Indonesia [14][15]. Yellowfin tuna, which is abundant in Indonesian waters, is expected to be processed to enhance the product's utility as a tuna flavour agent [16] [17]. Testing of the tuna flavour agent needs to be conducted for product commercialization and preparation for industrial scale-up.

2-Materials and Methods

Materials

The ingredients for making the tuna flavour agent were purchased from the Klandungan market in Malang City. Yellowfin Tuna was purchased from the Klandungan market in Malang City and transported to the laboratory using a cool box (Marina cooler type 35s). Yellowfin tuna is transported with added crushed ice in a 1:1 ratio. The tuna that has arrived at the laboratory is immediately gutted, filleted, skinned, and washed with running water until the dirt and residual blood are clean. The cleaned yellowfin tuna fillets were then

drained and given ice in a 1:1 ratio while waiting for treatment preparation. Salt, garlic powder, white pepper powder, garlic, salt, white pepper, fried shallots, nutmeg, and ginger for the tuna flavour agent research were purchased from the market along with the fish samples.

Preparation of Tuna Flavour Agent and Soup Formulations

Yellowfin tuna fillets (approximately 500 g per batch, cut into uniform pieces of 5 cm × 3 cm × 1 cm) were subjected to marination, drying, and grinding processes. The marinade solution was prepared by dissolving 10% salt (w/v, Kapal Api brand), 5% garlic powder (w/v, Koepoe brand), and 5% white pepper powder (w/v, Koepoe brand) in 1 litre of distilled water, stirred continuously for 5 minutes until completely dissolved. The tuna fillets were then immersed in the marinade solution at a 1:2 (w/v) ratio in a covered plastic container and stored at chiller temperature ($4^{\circ}\text{C}\pm 2^{\circ}\text{C}$) for 1 hour with gentle mixing every 20 minutes to ensure uniform marination. After marination, the fillets were removed, excess marinade was drained for 10 minutes on a stainless-steel mesh rack, and fillets were blotted with sterile paper towels to remove surface moisture. The marinated fillets were then arranged in a single layer on dehydrator trays (food dehydrator model: Excalibur 3926TB, 9-tray capacity) and dried at 80°C for 12 hours with continuous air circulation (fan speed: 2400 rpm). The dehydration process was considered complete when the moisture content reached approximately 10-12% (determined by weight loss monitoring). The dried tuna was cooled to room temperature (25°C) for 30 minutes before grinding. Grinding was performed using a high-speed blender (Philips HR2115, 600W) at maximum speed (25,000 rpm) for 3 minutes, with 2-minute cooling intervals between each grinding cycle, repeated 3 times to achieve fine particle size. The ground tuna flavour agent was sifted using

a 60-mesh stainless steel flour sieve (250 μm opening) to obtain uniform powder consistency, with particles larger than 250 μm re-ground and re-sifted. The final tuna flavour agent powder was immediately packaged in zip-lock bags (capacity: 100 g), evacuated to remove excess air, sealed, and stored at refrigeration temperature ($4^{\circ}\text{C}\pm 1^{\circ}\text{C}$) until use in soup formulation.

Tuna soup was prepared by incorporating the tuna flavour agent into a standardized soup base formulation. The soup base ingredients included: minced garlic (3% w/v, approximately 30 g), salt (5% w/v, 50 g, Kapal Api brand), white pepper powder (1% w/v, 10 g, Koepoe brand), fried shallots (2% w/v, 20 g), ground nutmeg (1% w/v, 10 g), minced ginger (1% w/v, 10 g), and 1 litre of distilled water. The soup base was prepared by heating water in a stainless-steel pot (2-liter capacity) on a gas stove at medium heat (temperature monitored using a digital thermometer). When the water temperature reached 80°C , garlic and ginger were added first and simmered for 3 minutes. Subsequently, salt, white pepper, nutmeg, and fried shallots were added when the temperature reached 100°C . Three treatment levels were established based on preliminary trials and literature review of flavour concentration in soup products: M1 (1% w/v tuna flavour agent, equivalent to 10 g/L), M2 (3% w/v, equivalent to 30 g/L), and M3 (5% w/v, equivalent to 50 g/L). The tuna flavour agent was added to the boiling soup base according to treatment level, stirred continuously for 1 minute to ensure complete dispersion, and the mixture was maintained at 100°C for an additional 10 minutes with continuous stirring every 2 minutes to prevent settling and ensure flavour extraction. After heating, the soup was removed from heat and allowed to cool at room temperature ($25^{\circ}\text{C}\pm 2^{\circ}\text{C}$) for 30 minutes. The cooled soup was filtered through sterile cheesecloth to remove particulate matter, transferred into sterilized glass jars (250 mL capacity), sealed with airtight lids, and immediately stored at

refrigeration temperature ($2^{\circ}\text{C}\pm 1^{\circ}\text{C}$) until analysis (within 24 hours of preparation).

Proximate, Color, and Sensory Testing

The prepared Fish soup was then subjected to proximate tests (5 repetitions), colour test (5 repetitions) and sensory tests (100 panellists). Proximate tests were conducted according to the method recommended by AOAC (2010). The protein test was conducted using the macro Kjeldahl method, the fat test was conducted using the Goldfisch method, the moisture and ash content tests were conducted using the gravimetric method, and the carbohydrate content test was conducted using the by difference method. The colour test was conducted using Konica Minolta Chromameter to evaluate L^* , a^* , and b^* .

Sensory evaluation was conducted using untrained consumer panellists ($n=100$ per treatment) recruited from the student population at Universitas Brawijaya. Panellists were selected based on the following inclusion criteria: (1) healthy individuals with no reported problems or impairments in sensory organs (taste, smell, or vision), (2) regular soup consumers (consumed soup at least once per week), (3) no known allergies to fish, seafood, or any ingredients used in the soup formulation, and (4) willingness to participate in the study. Prior to participation, all panellists were provided with detailed information about the study objectives, procedures, and their right to withdraw at any time without penalty. Written informed consent was obtained from all participants before they participated in the sensory evaluation. The sensory test was conducted using an online questionnaire via Google Forms, which asked about respondent data and product evaluation using an 8-point hedonic scale (1 being the worst and 8 being the best). The sensory test was conducted by heating the soup to a temperature of 40°C and serving it in plastic cups.

Statistical Analysis

The test results for each parameter are first examined using the Shapiro-Wilk test to determine data normality. Normal data is tested with ANOVA and Duncan's post hoc test (95% confidence interval). Statistical tests were conducted using IBM SPSS Statistics version 26.0 for Windows. Qualitative data were subjected to nominal data statistical tests using IBM SPSS Statistics version 26.0 for Windows.

All quantitative data were analysed using IBM SPSS Statistics version 26.0 for Windows. Prior to parametric analysis, data normality was assessed using the Shapiro-Wilk test. For proximate composition and colour parameters, data that met normality assumptions were subjected to one-way Analysis of Variance (ANOVA) to determine significant differences among treatments (M1, M2, M3) at 95% confidence level. When ANOVA revealed significant differences ($p < 0.05$), Duncan's Multiple Range Test was applied as a post-hoc test to identify specific pairwise differences among treatment means and rank the treatments. For sensory evaluation data, which employed an 8-point hedonic scale (ordinal data), non-parametric Kruskal-Wallis test was used to detect differences among treatments, followed by pairwise comparisons when significant differences were found.

3-Results

Statistical analysis revealed varying levels of significance across different parameters evaluated in this study. For proximate composition (Table 1), ANOVA showed no significant differences among treatments (M1, M2, M3) for all parameters measured, including moisture, protein, fat, ash, and carbohydrate content ($p > 0.05$). Colour analysis (Table 2) demonstrated significant differences among treatments for the L parameter (lightness) ($p < 0.05$), with Duncan's test identifying M3 as significantly different from M1 and M2, while a (redness-greenness) and b^* (yellowness-blueness) parameters showed

no significant differences ($p > 0.05$). Sensory evaluation (Table 3) revealed significant differences among treatments for odor, flavor, texture, and overall acceptability ($p < 0.05$), with M3 treatment receiving significantly higher hedonic scores than M1 and M2 according to post-hoc analysis. However, appearance ratings

Table 1. Proximate attribute of Tuna fish soup

Proximate Attribute	Treatment		
	M1	M2	M3
Carbohydrate	1.36±0.64 ^{ns}	1.38±0.35 ^{ns}	1.04±0.72 ^{ns}
Protein	0.57±0.03 ^{ns}	0.56±0.03 ^{ns}	0.56±0.03 ^{ns}
Fat	0.25±0.03 ^{ns}	0.27±0.04 ^{ns}	0.27±0.03 ^{ns}
Ash	0.09±0.01 ^{ns}	0.11±0.01 ^{ns}	0.27±0.35 ^{ns}
Moisture content	97.73±0.06 ^{ns}	97.68±0.31 ^{ns}	97.86±0.52 ^{ns}

*ns indicates no significant difference among treatment (5% significant level)

Table 2. Color attribute of Tuna fish soup

Color Attribute	Treatment		
	M1	M2	M3
L*	53.6±2.01 ^a	52.4±1.45 ^a	48.56±1.22 ^b
a*	0.7±0.31 ^{ns}	0.58±0.22 ^{ns}	0.58±0.36 ^{ns}
b*	15.16±1.01 ^{ns}	15±0.89 ^{ns}	14.9±0.73 ^{ns}

*ns indicates no significant difference among treatment (5% significant level)

Table 3. Sensory attribute of Tuna fish soup

Sensory Attribute	Treatment		
	M1	M2	M3
Appearance	5.54±1.12 ^{ns}	5.66±0.97 ^{ns}	5.74±1.01 ^{ns}
Odor	5.3±1.07 ^a	5.94±0.96 ^b	6.93±0.79 ^c
Flavor	5.34±1.17 ^a	5.89±1.18 ^b	7.44±0.61 ^c
Texture	5.55±0.87 ^a	5.61±1.10 ^a	6.17±0.85 ^b
Overall	5.73±1.07 ^a	5.98±1.05 ^a	6.91±0.67 ^b

*ns indicates no significant difference among treatment (5% significant level)

*Superscript indicates significant difference among treatment

4-Discussion

Proximate Composition

Proximate analysis of soup and broth is a systematic method used to determine the fundamental nutritional composition of these culinary products, focusing on key components such as moisture, protein, fat, carbohydrates, and ash content. This analysis provides valuable insights into the nutritional value and quality of soups and broths, which can vary significantly based on their ingredients and preparation

showed no significant differences among treatments ($p > 0.05$). These results indicate that while tuna flavour agent concentration significantly influenced sensory attributes and colour lightness, it did not affect the nutritional composition of the soup products.

methods [18]. For instance, broths derived from animal bones typically exhibit higher protein and collagen content, contributing to their rich mouthfeel and health benefits. Conversely, vegetable-based soups may have lower protein levels but are often rich in dietary fibre and essential vitamins. The fat content in soups can also vary, influenced using oils or fatty meats, which can enhance flavour but may also impact healthfulness [19] [20]. By conducting proximate analysis, food scientists can assess the nutritional profile of soups and broths, enabling manufacturers to optimize

formulations for health-conscious consumers while ensuring that flavour and texture are not compromised. This analytical approach is essential for developing products that meet both consumer preferences and nutritional standards [21].

The proximate test showed that all treatments of tuna flavour agents in fish soup were statistically not significantly different from each other (Table 1). ANOVA was conducted because the data met the criteria for normality when tested using the Shapiro-Wilk test. The carbohydrate content test (using the by difference approach) on average ranges from 1.04% to 1.38%. The crude protein content test (using the macro Kjeldahl approach) averages between 0.56% and 0.57%. The fat content test (using the Goldfish approach) averages between 0.25% and 0.27%. Ash content test (using the gravimetric approach) on average ranges from 0.09% to 0.27%. The moisture content test (using the gravimetric approach) on average ranges from 97.68% to 97.86%.

Proximate analysis was conducted to determine the nutritional composition of various types of soup and broth. Data shows that soup and broth have different nutritional compositions, but both are rich in protein, fat, and carbohydrates. Based on the proximate analysis results, soup and broth have significant nutritional compositions for health [22]. The protein in soup and broth comes from ingredients such as meat, vegetables, and spices used. Furthermore, fats and carbohydrates also contribute to the flavour and texture of the product [23]. Previous research has shown that this nutritional composition is very important in determining the quality and acceptability of the product [24]. The differences in nutritional composition can be explained by the variations in the ingredients used in the formulation process [25]. Soup tends to be richer in protein due to the use of meat and vegetables that are high in protein, while broth has higher

levels of fat and carbohydrates due to the use of spices and flour that are rich in carbohydrates [26].

The optimized tuna soup formulation (M3: 5% tuna flavour agent) showed moisture 97.68%, protein 0.56%, fat 0.27%, ash 0.27%, and carbohydrates 1.04%. When compared to published fish soup research, the nutritional profile shows significant variation based on soup preparation method and fish species. Research reported two types of clear fish broths from crucian carp (*Carassius auratus*) and snakehead (*Channa argus*) with remarkably similar values to the current study : crucian carp soup contained moisture 98.82%, protein 0.82%, fat 0.18%, and ash 0.14%, while snakehead soup showed moisture 99.16%, protein 0.41%, fat 0.15%, and ash 0.34%[27]. The tuna soup qualities closely align with these clear broth-style soups. These findings represent a light, low-calorie formulation rather than a protein-dense traditional fish soup.

In contrast, traditional whole-fish soups demonstrate substantially different nutritional profiles. Previous research prepared soup from European anchovy (*Engraulis encrasicolus*) containing 17.34% fish content, resulting in moisture 82.05%, protein 5.04%, fat 6.22%, ash 1.46%, and carbohydrates 5.23%[28]. Similarly, other research reported rainbow trout (*Oncorhynchus mykiss*) soup with moisture 87.56%, protein 7.22%, fat 1.59%, ash 2.44%, and carbohydrates 0.07%[29]. These soups utilized fish as the primary ingredient (17-20% fish content), explaining their higher protein and fat content compared to the tuna flavour agent soup.

This fundamental difference in formulation strategy creates distinct product categories. First, clear fish broths, including this study and crucian carp-snakehead soup[27] with moisture >97%, protein <1%, fish used as a flavouring component at low concentrations. Second, Traditional fish soups [28], [29]: moisture 82-88%, protein

5-7%, fish used as the primary ingredient at 17-20% concentration.

Colour Analysis

Colour analysis of soup and broth using a chromameter is an essential technique for evaluating the visual appeal and quality of these culinary products. This method quantitatively measures colour attributes, providing objective data on hue, saturation, and brightness, which are critical factors influencing consumer perception and acceptance [30]. The chromameter allows for precise colour differentiation, enabling researchers to assess the impact of various ingredients and cooking methods on the final colour of soups and broths. For instance, the addition of certain vegetables or spices can enhance the richness and vibrancy of the colour, while prolonged cooking times may lead to darker hues due to the Maillard reaction and caramelization processes [31]. By analysing colour parameters, food scientists can correlate visual characteristics with sensory attributes, such as flavour and freshness, ultimately guiding product development to ensure that soups and broths not only taste good but also appear appetizing to consumers. This systematic approach to colour analysis is vital for maintaining quality standards and meeting consumer expectations in the food industry [32].

The color test shows that there are statistically significant differences between treatment groups in the L^* parameter and no significant differences in the a^* and b^* parameters (Table 2). The Duncan test results indicate that the best treatment parameter for L^* is treatment M3. The color test results show that the L^* parameter ranges from 48.56 to 53.6.

Color analysis using a chromameter shows that soup and broth have different L^* , a^* , and b^* values. Soup has a lower L^* value (darker) compared to broth, while the a^* and b^* values show greater color variation in soup. Color analysis using a chromameter provides an accurate depiction of the product's visual

characteristics [33]. Different L^* , a^* , and b^* values indicate that soup and broth have different colors, which can affect consumer acceptance (S41538-022-00168-w, 2022). Soup has a lower L^* value, indicating that soup is darker compared to broth, while higher a^* and b^* values indicate greater color variation in soup [23]. This color difference can be explained by the different ingredients used in the preparation process [25]. Soup tends to be darker due to the use of vegetables and spices that impart a darker color, while broth has a lighter color because of the use of spices that impart a lighter color [34].

Sensory Evaluation

Sensory analysis is a critical aspect of evaluating the quality and acceptability of soups and broths. This analysis involves assessing various sensory attributes, including taste, aroma, texture, and appearance, which collectively influence consumer preferences. Research has shown that the umami flavor, often enhanced by the presence of amino acids and nucleotides, significantly impacts the overall palatability of broth [35][36]. The texture, influenced by the cooking method and ingredient composition, also plays a vital role; for example, a well-prepared broth should have a smooth mouthfeel, while soups may benefit from a hearty, chunky texture. Aroma is another essential factor, as the scent of herbs and spices can evoke positive emotional responses and enhance the eating experience.

The sensory test was conducted on 100 individual panelists for each treatment using a market test approach. The collected respondent data was subsequently subjected to descriptive analysis. The gender ratio of the respondents is 62% male and 38% female. The age ratio of the respondents is 2% for 17-18 years, 35% for 19-20 years, 56% for 21-22 years, and 7% for over 22 years.

Food safety assurance for panellists by the researchers was conducted through a preliminary study approach on

microbiological quality (data not shown). The preliminary study consisted of qualitative tests for Salmonella, qualitative tests for *Clostridium botulinum*, quantitative tests for *E. coli*, and Total Plate Count. The preliminary study results on the soup production process showed negative results for all samples tested for Salmonella and *Clostridium botulinum*, *E. coli* <3 MPN, and TPC <10³. These results were sufficient to serve as food safety assurance. The sensory test showed that there were statistically significant differences between the treatment groups in the parameters of odour, flavour, texture, and overall, but no significant differences in the appearance parameter (Table 3). The results of the Duncan test indicate that the best treatment parameters for odour, flavour, texture, and overall are the M3 treatment. The results of the sensory test showed that the hedonic scale range for the odour parameter was between 5.3 to 6.93, the flavour parameter between 5.34 to 7.44, the texture parameter between 5.55 to 6.17, and the overall parameter between 5.73 to 6.91. Odor, flavour, texture and overall parameters showed M3 was the best treatment of sensory test.

Sensory evaluation is conducted to determine the taste, texture, and aroma of various types of soup and broth. Data shows that soup has a stronger flavour and a thicker texture compared to broth, while broth has a more fragrant aroma. Sensory evaluation provides an accurate depiction of the sensory characteristics of the product [22]. Soup has a stronger taste and a thicker texture due to the use of meat and nutrient-rich vegetables, while broth has a more fragrant aroma because of the spices that impart a more aromatic scent [23]. These differences in sensory characteristics can be explained by the differences in the ingredients used in the preparation process [25]. Soup tends to have a stronger flavour and a thicker texture due to the use of meat and vegetables rich in nutrients, while broth has a more fragrant aroma because of the

spices used that impart a more aromatic scent [26].

4-Conclusion

The study demonstrates that the M3 treatment of tuna soup significantly enhances sensory attributes, particularly odour, flavour, and texture, leading to higher consumer acceptance. These findings highlight the importance of ingredient quality and preparation methods in developing nutritious and appealing soups, offering valuable insights for food manufacturers in product formulation. The tuna flavour agent-based soup represents a novel approach to valorising abundant yellowfin tuna resources, offering an umami-rich product suitable for health-conscious consumers.

While this study successfully demonstrates the nutritional value and consumer acceptability, several critical aspects remain to be investigated before commercialization. Future research should prioritize comprehensive shelf-life studies, oxidative stability assessment, and microbiological safety evaluation of both the tuna flavour agent powder and prepared soup products. These investigations are essential to ensure food safety and establish proper storage recommendations. Such work will be crucial in translating these laboratory findings into commercially viable products that can contribute to increased seafood consumption and sustainable utilization of marine resources.

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