



Development and evaluation of functional “Harukam” jelly gum for oral health in stunted children

Pengembangan dan evaluasi permen jeli fungsional “Harukam” untuk kesehatan mulut pada anak stunting

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Abstract

Snakehead fish (*Channa striata*) bones exhibited antibacterial activity against cariogenic bacteria, while Banjar Siam orange (*Citrus reticulata*) provided complementary antibacterial effects. The combination of these ingredients has the potential to be formulated into a functional saliva-stimulating jelly gum to support oral health in stunted children. This study aimed to obtain an optimal formulation of “Harukam” jelly gum as a saliva stimulant for caries prevention. The research was conducted at the Health Polytechnic of the Ministry of Health Banjarmasin and the Industrial Service Standardization Center Banjarbaru, Indonesia, from June to October 2025. A completely randomized design was applied using four concentrations of snakehead fish bone flour: P0 (0%), P1 (1%), P2 (2%), and P3 (3%). Sensory evaluation was performed using the Hedonic Scale, while the chemical composition was determined through proximate analysis. Optimization was determined using the DeGarmo method, and statistical analysis was performed using the Friedman test. The addition of snakehead fish bone flour significantly affected sensory acceptance ($p < 0.001$) and increased most proximate values, except for carbohydrates. The P1 formulation received the highest preference score. In conclusion, P1 “Harukam” jelly gum showed potential as a functional food to stimulate saliva secretion and support caries prevention in stunted children.

Keywords: *Channa striata*, *Citrus reticulata*, food, functional, Jelly gum

Abstrak

Tulang ikan gabus (*Channa striata*) memiliki aktivitas antibakteri terhadap bakteri kariogenik, sedangkan jeruk siam Banjar (*Citrus reticulata*) memberikan efek antibakteri komplementer. Kombinasi keduanya berpotensi diformulasikan sebagai permen jeli fungsional perangsang saliva untuk mendukung kesehatan mulut pada anak yang mengalami stunting. Penelitian ini bertujuan memperoleh formulasi optimal jelly gum “Harukam” sebagai perangsang saliva pencegah karies. Metode, penelitian telah dilakukan di Politeknik Kesehatan Kemenkes Banjarmasin dan Balai Standardisasi Pelayanan Jasa Industri Banjarbaru, Indonesia, pada Juni–Oktober 2025. Rancangan acak lengkap digunakan dengan empat perlakuan konsentrasi tepung tulang ikan gabus: P0 (0%), P1 (1%), P2 (2%), dan P3 (3%). Analisis sensorik menggunakan Skala Hedonik, sedangkan komposisi kimia ditentukan melalui analisis proksimat. Optimasi ditetapkan menggunakan metode DeGarmo. Uji statistik dengan Friedman test. Hasil, penambahan tepung tulang ikan gabus signifikan memengaruhi penerimaan sensorik ($p < 0.001$) dan meningkatkan sebagian besar nilai proksimat, kecuali karbohidrat. Formula P1 menunjukkan tingkat kesukaan tertinggi. Kesimpulan, jelly gum P1 “Harukam” berpotensi dikembangkan sebagai pangan fungsional

untuk merangsang sekresi saliva dan mendukung pencegahan karies pada anak stunting.

Kata Kunci: Jelly gum, ikan gabus, jeruk siam banjar, pangan fungsional, analisis proksimat

Introduction

Dental caries is a major global health problem, particularly in children (Chen et al., 2024; Zhai et al., 2025). This is caused by enamel demineralization caused by acids produced during bacterial metabolism. Although preventable, it affects nearly half of children worldwide, leading to pain, infection, and a reduced quality of life (Nath et al., 2023). Therefore, early preventive efforts are urgently needed to reduce the global burden.

Saliva is essential for oral health because it neutralizes acids, supports remineralization, and has antibacterial properties (Giacaman et al., 2023). Even small amounts can reduce acid production in the enamel and dentin. It provides calcium and phosphate ions that sustain hydroxyapatite supersaturation, thereby aiding enamel repair (Enax et al., 2024). Higher salivary buffering capacity, flow rate, and antimicrobial peptide levels, such as HNP1–3, are linked to lower caries activity (Singh, 2023). Hence, maintaining saliva production and quality is a key preventive strategy.

Chewing sugar free gum, particularly xylitol-based gum, effectively stimulates saliva production and improves its buffering capacity. Studies have shown that xylitol gum significantly lowers *Streptococcus mutans* levels compared to other gums or controls (Aluckal & Ankola, 2018; Chavan et al., 2015). It also enhances enamel remineralization by increasing salivary pH and providing minerals (Cocco et al., 2020; Ludovichetti et al., 2025). Thus, gum serves as an effective adjunct for caries prevention. There is limited research on local functional food interventions targeting stunted children's caries risk.

Natural bioactive ingredients derived from local resources offer innovative potential for oral healthcare. Snakehead fish bones show antibacterial activity against *S. mutans* (Dewi et al., 2024), while Banjar Siamese orange (*Citrus reticulata*) contains polymethoxyflavones, flavonoids, and limonene with antioxidant, antibacterial, and anti-biofilm effects (Torshabi et al., 2023). The peel extract also contains calcium and phosphate, supporting its remineralization potential (Hidayah et al., 2022).

The extracts of Banjar orange peel were evaluated for their mineral content (high in calcium and phosphate) and tested for their potential to promote remineralization in demineralized deciduous teeth.

This study developed a novel jelly gum combining snakehead fish and Banjar Siamese orange extracts as a natural saliva stimulant to prevent dental caries in children. The formulation merges the antibacterial and protein-rich properties of snakehead fish with the antioxidant and antimicrobial compounds of Banjar Siamese orange to enhance salivation, support enamel remineralization, and inhibit *S. mutans*, thereby improving children's oral health using natural, locally sourced ingredients. Therefore, it is necessary to conduct a study to determine the optimal proportion of snakehead fish bone flour and Banjar Siamese orange extract to obtain a jelly gum product that can be chewed to stimulate saliva.

By combining these natural sources, this study aimed to determine the best formula for jelly gum from snakehead fish bone and Banjar Siamese orange and to determine its proximate content. Thus, saliva stimulant products can be developed to improve the oral health of toddlers, especially stunted children.

Methods

This experimental study employed a Completely Randomized Design consisting of four formulations: one control and three treatments supplemented with snakehead fish bone meal. The treatments included P0 (0%), P1 (1%), P2 (2%), and P3 (3%). Preliminary trials indicated that the addition of 4% snakehead fish bone meal resulted in poor acceptability; therefore, concentrations above 3% were not tested in this study. This study aimed to determine the optimal formulation of "HARUKAM" (Haruan Jeruk Siam—Snakehead Fish and Banjar Siamese Orange) jelly based on nutritional composition and sensory quality.

The research was conducted at the Polytechnic of Health, Ministry of Health Banjarmasin, and the Laboratory of the Industrial Services Standardization Center,

Banjarbaru, Indonesia, from June to October 2025. Ethical approval was obtained from the Health Research Ethics Commission, Polytechnic of Health, Ministry of Health, Banjarmasin (No. 163/KEPK-PKB/2025).

The preparation of the snakehead fish bone meal began with washing and cleaning the fish bones, followed by grinding them into 80-mesh flour. Banjar Siamese orange juice was also prepared separately. The processing steps for both the ingredients are presented in Figure 1. The “HARUKAM” jelly gum was produced following the procedure shown in Figure 2. The ingredients were weighed according to Table 1 and mixed. Treatments were supplemented with 0.5 g (P1), 1.0 g (P2), and 1.5 g (P3) of snakehead fish bone meal, while the control (P0) contained no supplementation.

The jelly gum preparation involved forming dough A and B, which were subsequently combined and molded into “HARUKAM” jelly gum (Figure 2).

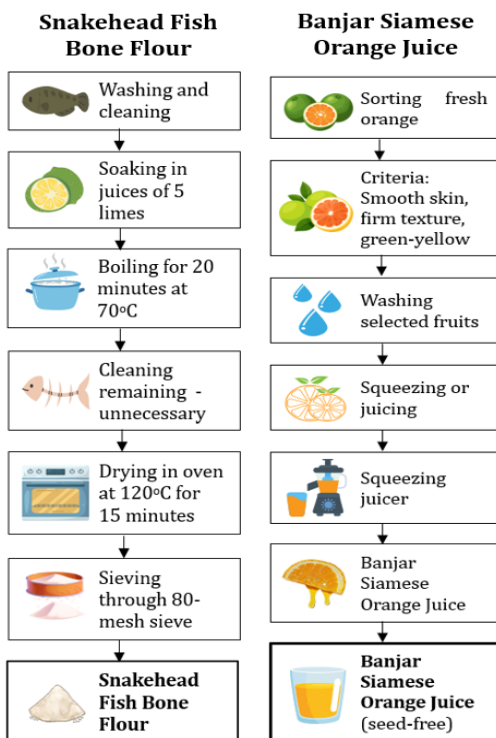


Figure 1. Snakehead fish bone meal and Banjar Siamese orange juice procedures

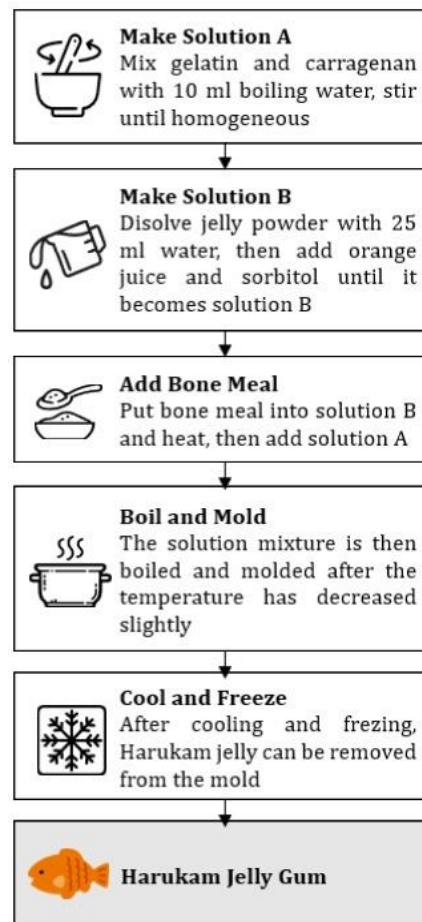


Figure 2. “Harukam” jelly gum Procedure

Sensory evaluation of the “HARUKAM” jelly included assessments of color, texture, aroma, and taste using a hedonic scale administered via a questionnaire. The sensory panel consisted of 30 semi-trained panelists from the Nutrition Department, Polytechnic of Health–Ministry of Health Banjarmasin, all of whom had completed coursework in Food Science and Technology. Sensory data were analyzed using the Friedman Test ($\alpha = 0.01$).

The water, ash, and crude fiber contents were analyzed using gravimetric methods. Protein content was determined using the Kjeldahl method, fat content using the Soxhlet extraction method, and carbohydrate content using titrimetric analysis.

Table 1.Ingredients of “Harukam” Jelly Gum

Ingredients	Amount				Unit
	0	1	2	3	
Snakehead fish bone meal	0	0.5	1.0	1.5	Percent
Gelatin	3	3	3	3	g
Carrageenan	1	1	1	1	g

Boiling water (to dissolve gelatin and carrageenan)	10	10	10	10	ml
Sorbitol	15	15	15	15	g
Banjar Siamese orange juice	25	25	25	25	ml
Orange-flavored jelly powder	2	2	2	2	g
Boiled water (to dissolve jelly powder)	25	25	25	25	ml

The optimal formula was determined using deGarmo effectiveness analysis. Sensory data were first transformed to calculate the effectiveness value (EV), productivity value (PV), and overall effectiveness score, following the method described by deGarmo (1984), Wulandari and Nirmalawaty (2025), and Astuti et al. (2024). The following formulas were applied:

$$EV = \frac{NPH - NTKH}{NTBK - NSH}$$

$$PV = EV \times W \quad (1)$$

$$\text{Effectiveness Test} = \sum PV \quad (2)$$

Where:

EV = effectiveness value for each treatment based on sensory attributes.

NPH = mean sensory score of each treatment for each attribute (color, aroma, texture, and taste).

NTKH = lowest sensory score for each attribute across treatments.

NTBK = highest sensory score for each attribute across treatments.

NSH = difference between the best and worst mean values for each attribute.

PV = productivity value for each sensory attribute.

W = weighting factor for each sensory attribute.

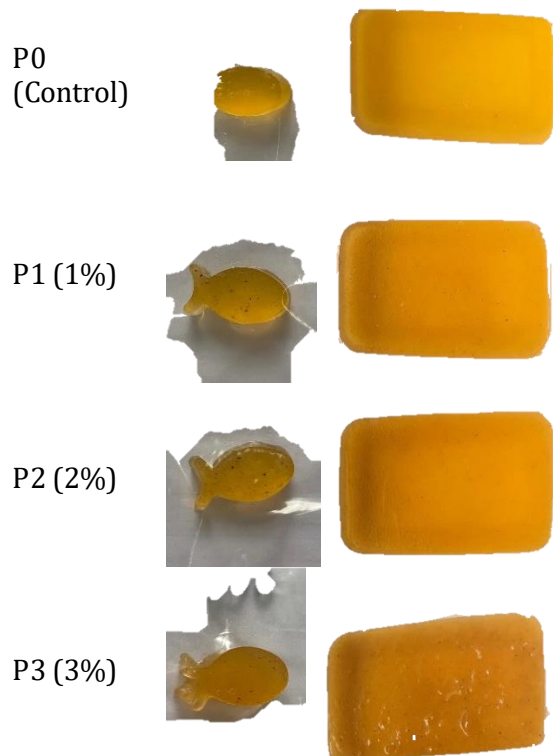
ΣPV = total productivity value across all sensory attributes.

The calculated attribute weights were as follows: color = 0.34, aroma = 0.21, texture = 0.29, and taste = 0.16.

Result and Discussion

This study evaluated four formulations of “Harukam” jelly, consisting of one control and three treatments supplemented with snakehead fish bone meal: P0 (0%), P1 (1%), P2 (2%), and P3 (3%). The visual characteristics of all

formulations, including the control, are shown in Figure 3.



Formulations: P0 = 0%, P1 = 1%, P2 = 2%, and P3 = 3% snakehead fish bone meal.

Figure 3. “Harukam” jelly with three levels of snakehead fish bone meal addition and control.

The sensory parameters assessed included color, aroma, texture, and taste, using a five-point hedonic scale. Table 2 presents the average panelist responses for each of the attributes. All sensory attributes differed significantly among the treatments ($p = 0.000$, $\alpha = 0.01$). Higher levels of snakehead fish bone meal were associated with lower preference scores across attributes; however, some formulations remained within the “slightly like” category.

Color evaluation showed that “Harukam” jelly maintained a normal and visually acceptable appearance, supporting the well-documented influence of color on sensory appeal and consumer preference (de Figueiredo Muniz et al., 2023). Subjective color assessment

plays a key role in product development, as instrumental and sensory analyses help determine the effects of ingredient interactions on visual quality (Ünal Şengör et al., 2019). Color is especially important for confectionery products targeted at children, who rely heavily on visual cues.

The color acceptance of P1, P2, and P3 fell within the "slightly like" category (Figure 4). Small variations in sample characteristics can alter color perception (Spence, 2015), and the reduced liking in P1 suggests that subtle deviations may have affected visual appeal. The overall pattern reflected mild sensory

dissonance, consistent with reports that undesirable color variations may lead to product rejection (Shu et al., 2025).

These observations align with broader findings on the importance of visual cues in food choices and preferences (Malheiros et al., 2025; Motoki et al., 2025; Schifferstein et al., 2022; Vermeir & Roose, 2020). Aroma also plays a major role in food acceptance, as volatile compounds detected by the olfactory system influence appetite, physiological responses, and perception of quality (Djekic et al., 2021). Therefore, optimizing aroma is essential for product development (Rodrigues et al., 2024).

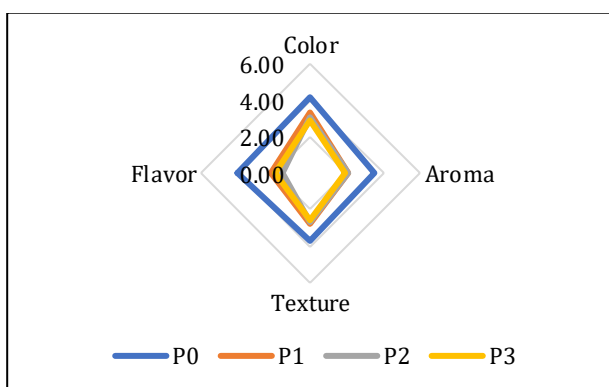
Table 2. Sensory test results of "Harukam" jelly gum (mean scores, 1–5 scale)

Parameter	Formula				p-value
	P0	P1	P2	P3	
Color	4.167±0.747 Like	3.333±0.994 Slightly Like	3.067±1.201 Slightly Like	2.900±1.185 Slightly Like	0.000*
Aroma	3.500±0.900 Like	2.067±1.105 Dislike moderately	2.067±0.980 Dislike moderately	1.900±0.845 Dislike moderately	0.000*
Texture	3.700±1.149 Like	2.767±1.135 Slightly Like	2.667±1.093 Slightly Like	2.567±1.006 Slightly Like	0.000*
Taste	4.000±0.830 Like	2.167±0.913 Dislike moderately	1.553±0.629 Dislike moderately	1.933±1.048 Dislike moderately	0.000*

Note:

n= 30 panelists; *Significantly different with 99% confident interval on Friedman Test

Formulation: P0=0% Snakehead Fish Bones meal, P1=1% Snakehead Fish Bones, P2=2% Snakehead Fish Bones, P3=3% Snakehead Fish Bones



Formulation: P0=0% Snakehead Fish Bones meal, P1=1% Snakehead Fish Bones, P2=2% Snakehead Fish Bones, P3=3% Snakehead Fish Bones

Figure 4. Sensory test results of "Harukam" jelly gum with three formulas for adding *Channa striata* bones and control.

Aroma preference declined from P0 to P3 (Table 2; Figure 4), likely due to the volatile amines and aldehydes generated during protein and lipid oxidation in the snakehead fish bone meal, which may overshadow the citrus aroma of Banjar Siamese orange juice. Similar declines in aroma acceptance have been documented in fish bone-fortified cookies (Talawi et al., 2018) and nano-fish bone treated marinated fish (Rahman et al., 2025). Nonetheless, low levels of fish bone meal remain acceptable, particularly when combined with citrus or cocoa flavors (Talawi et al., 2018).

Formulations containing moderate amounts of Banjar Siamese orange juice produced favorable hedonic responses. This finding is consistent with that of Wardhani (2022), who noted that appropriate gelatin-agar ratios support desirable aroma and taste in jelly

products. However, excessive fish bone addition reduced aroma acceptance, consistent with the findings of Murillo et al. (2022) and other studies on fish protein-enriched foods. Future improvements may include taste masking, encapsulation and enzymatic deodorization (Al-Khalili et al., 2025; Embling et al., 2024).

Texture and liking were also influenced by the ingredient composition (Figure 4). The highest preference for the control (P0) reflects the familiar texture of traditional, gelatin-based jelly. These findings align with prior reports that mineral or protein fortification can alter textural properties (Rahman et al., 2025; Rosmawati et al., 2021; Muliajaya et al., 2024). Increasing fortification (P1-P3) reduced texture acceptance, consistent with studies showing that mineral content and gel matrix modifications from fish bone meal may weaken the gel structure (Rosmawati et al., 2021; Herpandi et al., 2025).

Taste acceptance also declined at higher levels of fortification (Figure 4). This may be attributed to the dominant fishy notes, undesirable aftertaste, or excessive acidity (Helmizar et al., 2021). Although fish bone meal can provide umami properties, improper concentration can cause off-flavors (Herpandi et

al., 2025). Banjar Siamese orange juice contributes acidity that can mask fishy odors; however, excessive amounts may also produce bitterness, as observed in P2 and P3. Overall, the combination of fish bone meal and citrus juice shows potential for nutrient-enriched confections, although formulation optimization is still required (Anggresani et al., 2022; Helmizar et al., 2021).

The Best Formula

The formulations were further evaluated using deGarmo’s method, which incorporates four sensory attributes color, aroma, texture, and taste to calculate the normalized evaluation values (EV) and productivity values (PV). Table 3 summarizes the performance scores.

Based on the deGarmo matrix, P1 demonstrated the best overall performance, achieving the highest aggregate score (1.00). The strength of its texture and color indicates favorable physicochemical interactions among fish-derived proteins, citrus compounds, and standard jelly ingredients, in agreement with previous findings (Joy et al., 2024; Oslan et al., 2022; Saini et al., 2022).

Table 3. Best “Harukam” Jelly Formula Based on deGarmo analysis

Attributes	Value	Formulas							
		P0		P1		P2		P3	
		NE	NP	NE	NP	NE	NP	NE	NP
Color	0.34	1.00	0.34	0.34	0.11	0.13	0.04	0.00	0.00
Aroma	0.21	1.00	0.21	0.11	0.02	0.11	0.02	0.00	0.00
Texture	0.29	1.00	0.29	0.18	0.05	0.09	0.03	0.00	0.00
Taste	0.16	1.00	0.16	0.26	0.04	0.00	0.00	0.16	0.03
Total	1.00		1.00		0.23*		0.09		0.03

Note: EV=Effectivity Value, PV=Productivity Value; *the best formula

Texture, which is closely associated with the gel network structure, is a key determinant of jelly acceptability. Although fishbone collagen differs from mammalian gelatin, it can still produce cohesive gels when properly processed (Joy et al., 2024). The high texture score of P1 suggests an optimal gelatin concentration that avoids excessive firmness or weakness in the product. Reported TPA trends indicate that P1 exhibits intermediate-to-high hardness, high cohesiveness, and moderate springiness (Gao et al., 2024; Oslan et al., 2022).

Taste in protein-citrus systems is strongly influenced by the sugar-acid balance and bitterness masking, with fish-derived proteins

contributing umami notes that enhance palatability (Guo et al., 2024; Osiriphun et al., 2022; Permatananda et al., 2024; Saini et al., 2022). The combined contributions of these sensory attributes explain why P1 received the highest final score.

Proximate Profile

Proximate analysis is crucial for evaluating the nutritional quality, formulation balance, and potential contaminants. The “Harukam” jelly showed moisture levels of 63–70% (Table 4), meeting the SNI 3547.2 (2008) standard of 55–70%, with water content playing a key role in shelf life by slowing microbial growth at lower

levels of water content. Formulation P1 had the highest moisture content (70.17%), which is consistent with the typical hydrocolloid confectionery moisture range of 60–75% (Chandel et al., 2022). The high water retention of the sausage is attributed to citrus pectin and soluble fibers from Banjar Siamese orange, which enhance water binding (Rawat et al., 2024), and collagen/gelatin from snakehead fish bone meal, which forms a water-holding gel matrix (Guo et al., 2024). The favorable protein–pectin ratio in P1 likely further improved moisture retention and minimized the syneresis.

While excessive moisture can reduce gel firmness, lower moisture levels, such as in P0 (63.47%), increase chewiness and stability. An ideal range of 65–70% maintains a smooth texture and minimizes water migration during storage (Rani et al., 2021). The “Harukam” formulations fell within this optimal range, indicating a well-balanced texture and stability profile. Overall, the water content of “Harukam” jelly gum reflects an effective formulation balance that optimizes hydration, texture, and shelf stability of the product. The synergistic use of fish collagen and citrus pectin produces a cohesive gel system consistent with modern functional confectionery objectives, focusing on texture optimization and controlled water activity.

Table 4. Proximate Profile of “Harukam” Jelly

Nutrients	Levels (%)	
	P0	P1
Water	63.467±4.221	70.173±2.534
Ash	0.607±0.129	0.617±0.369
Protein*	4.330±0.145	4.413±0.097
Fat	2.073±1.901	2.290±0.849
Carbohydrates	8.247±6.770	8.460±0.085
Crude Fiber	0.297±0.081	0.557±0.085

The ash content of “Harukam” jelly gum (0.62%) increased with the addition of snakehead fish bone meal, reflecting higher mineral levels dominated by calcium, phosphorus, magnesium, and trace elements, as noted by Khairul et al. (2025). *Channa striata* contains 30–40% calcium phosphate, along with magnesium, zinc, and iron (Ghalamara et al., 2024), which enhance nutrition and contribute to gel strengthening through ionic cross-linking between collagen peptides and citrus pectin. The higher ash content in P1 indicates greater

mineral incorporation, which improves gel stability and reduces syneresis via calcium–pectin interactions (Rani et al., 2021).

Nutritionally, the increased mineral content supports oral and bone health, with fish bone–derived calcium being highly bioavailable (Torres et al., 2024) and citric acid potentially improving absorption (Wang et al., 2020). Thus, the ash content contributes to both the structural and nutritional values of jelly gum. Technologically, an ash level of 0.6–1.0% promotes stability without sensory defects, consistent with the standards for gelatin–pectin confectionery (Chandel et al., 2022). Overall, the rising ash content reflects balanced mineral fortification, which strengthens the texture and enhances the nutritional value.

Adequate protein intake is vital for preventing stunting and supporting good oral health. The “Harukam” jelly gum showed increasing protein levels with added snakehead fish bone meal, with P1 reaching 4.41% (Table 4). This increase reflects the contribution of collagen, gelatin, and peptides from fish bone protein hydrolysates, which enhance both nutrition and texture (Zhang et al., 2025). Snakehead fish bone meal, which is rich in type I collagen and minerals, improves gelling and emulsifying properties (Ghalamara et al., 2024) and forms protein–pectin networks that stabilize jelly and improve water retention (Guo et al., 2024). A protein content of 4–5% provides meaningful nutritional value for children because of the high biological quality of fish–derived proteins (Rosmawati et al., 2021). Functionally, these proteins enhance chewiness, elasticity, and mouthfeel through heat-reversible gelation (Guo et al., 2024), with the increase from P0 to P1 demonstrating effective protein–polysaccharide synergy.

The fat content of “Harukam” jelly candy increased with the addition of snakehead fish bone meal, reflecting the contribution of fish–derived structural and functional lipids, which is a common pattern in protein–polysaccharide systems, where emulsified fats are dispersed within hydrocolloid matrices (Guo et al., 2024). Snakehead fish lipids supply nutritionally valuable PUFAs, such as DHA and ARA, which support brain development, inflammation control, and tissue repair (Sasongko et al., 2023), and their incorporation enhances flavor stability and mouthfeel. The higher fat content in P2

suggests effective emulsification between collagen peptides and citrus polysaccharides, stabilizing lipid droplets (Cassani & Gomez-Zavaglia, 2024; Pascuta et al., 2022). Moderate fat levels (2–5%) generally improve the smoothness and elasticity of jelly systems (Guo et al., 2024). P2's fat content of 5.48% likely provided optimal cohesiveness, whereas P3's lower fat content (3.13%) produced firmer gel. Nutritionally, snakehead fish lipids enrich the jelly with essential fatty acids that promote growth, neural and oral health, and modulate inflammation and the salivary microbiome (Lee & Tribble, 2023; Lessa et al., 2021; Ribeiro-Vidal et al., 2020; Stańdo-Retecka et al., 2023), aligning the product with functional confectionery trends that emphasize natural bioactive lipid enrichment (Jayaprakash et al., 2024).

Carbohydrates serve as key energy sources, but excessive simple sugar intake increases the risk of caries, making a balanced complex carbohydrate and fiber intake important. The "Harukam" jelly gum contained 8.46% carbohydrates, a moderate level derived from gelling agents and natural sugars from Banjar Siamese orange juice. Minimal variation among formulations indicated that carbohydrate levels were influenced by the citrus extract concentration and macronutrient balance of the snakehead fish bone meal (Guo et al., 2024). In jelly products, carbohydrates function as texture builders and energy contributors, with citrus-derived sugars and pectic polysaccharides enhancing the gel strength and sweetness (Rawat et al., 2024). Consistent carbohydrate content suggests stable pectin levels, which create a cohesive hydrocolloid network with fish bone proteins (Huang et al., 2022; Nawaz et al., 2021; Said et al., 2023).

The slightly higher carbohydrate content in P1 reflects increased pectin and soluble sugars, with pectin-protein interactions improving the gel structure and stability (Cassani & Gomez-Zavaglia, 2024; Pascuta et al., 2022). An approximately 8% carbohydrate level offers moderate energy for children, while natural citrus carbohydrates provide flavonoids and oligosaccharides with antioxidant and prebiotic benefits (Xu et al., 2025), potentially supporting oral health through saliva stimulation and reduced cariogenic activity.

Although the total fiber content in "Harukam" jelly gum is low, as is typical for gel-based confections, it gradually increases across

formulations due to the addition of citrus-derived components from Banjar Siamese orange, providing soluble and insoluble fibers such as pectin, cellulose, and hemicellulose that enhance water-binding, viscosity, and texture (Bugarín & Gómez, 2023). Citrus peel, rich in dietary fiber (30–50% dry mass), mainly contributes pectin, which significantly influences gel formation and texture (Zhang et al., 2025). The higher fiber content in P1 indicated an increased orange extract content. Moreover, the interactions between fish-derived collagen peptides and citrus fibers promote gel crosslinking, enhancing elasticity and stability (Guo et al., 2024). Even modest fiber levels support children's oral health by reducing sugar availability to cariogenic bacteria, stimulating saliva production, and acting as prebiotics to benefit gut microbiota and immune function (Tailor et al., 2023). Technologically, crude fiber content below 1% preserves smoothness and clarity, whereas higher levels may cause graininess (Bugarín & Gómez, 2023). Overall, the fiber content (0.30–0.68%) demonstrated synergy between marine proteins and citrus polysaccharides, enhancing gel texture, stability, nutrition, and oral health, exemplifying the functional use of local bioresources.

The nutrient content of the jelly gum formulations demonstrates the functional and nutritional advantages of integrating snakehead fish bone meal into a citrus-based jelly matrix. This combination provides a dual benefit: bioavailable nutrients and structural enhancement for product stability. The use of local, sustainable nutrient sources aligns with current innovations in functional food development, particularly those targeting children's nutrition and oral health.

Conclusion

The addition of snakehead fish bone flour significantly influenced the sensory quality of "Harukam" jelly. Formulation P1 was the most preferred formulation. Incorporating snakehead fish bone flour also increased the proximate nutrient levels of "Harukam" jelly gum.

Further research is recommended to evaluate the effectiveness of "Harukam" jelly gum in stimulating saliva production and reducing fishy odor through approaches such as flavor masking, microencapsulation of fish bone

powder, or enzymatic deodorization. In addition, in vivo studies, consumer acceptance testing, and shelf-life evaluation are required to further validate the functional benefits and stability of the product

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