

Formulation and Sensory Evaluation of Crystal Candy Containing Collagen Extract from Milkfish (*Chanos chanos*) Scale Waste

Original Article

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Abstract

Stunting remains a major public health issue in Indonesia, with a prevalence of 21.6% in 2023, primarily caused by chronic nutrient deficiencies. While collagen does not directly address all nutritional causes of stunting, its protein content may contribute to improving dietary quality. This study aimed to develop a functional crystal candy formulation incorporating collagen extracted from milkfish (*Chanos chanos*) scale waste as a potential source of protein supplementation. Collagen was extracted through maceration using 0.05 M NaOH for 8 hours, followed by hydrolysis in 0.3 M acetic acid for 72 hours, heating in a water bath, and drying at 50°C. The extraction yield was 18%, with the presence of amino compounds confirmed through the ninhydrin assay. The extracted collagen was incorporated into crystal candy formulations at concentrations of 0% (F1), 5% (F2), and 10% (F3). Physical quality was evaluated through organoleptic, pH, and hedonic sensory tests involving 80 panelists. The F2 formulation demonstrated the highest sensory acceptability, with an average pH of 6.32. This study provides preliminary data on the feasibility of utilizing fish scale waste as a functional ingredient in confectionery products; however, further analyses of nutritional content, collagen bioactivity, and storage stability are required to substantiate its potential health benefits.

Keywords: Collagen, Crystal Candy, Functional Food, Milkfish Scales, Sensory Evaluation.

1. Introduction

Stunting is a condition of impaired growth in children characterized by inhibited physical development and brain function due to chronic nutritional deficiencies. Children with stunting generally have a height below the standard for their age and often experience cognitive, motor, and socio-emotional developmental delays (Atamou et al., 2023; Beal et al., 2018). Without appropriate preventive measures, this condition can lead to decreased academic performance, productivity, and overall quality of human resources in the future. In addition, stunting is also associated with an increased risk of chronic diseases and even mortality (Aghniya, 2022). Stunting commonly occurs from the prenatal period up to the age of two years, known as the first 1,000 days of life (Handayani, 2023).

The high prevalence of stunting, ranging from 30-39%, indicates that this issue represents a serious public health concern. In Indonesia, the stunting rate reached 21.6% in 2023, highlighting a significant challenge in improving the nutritional status of children under five (PAUDPEDIA, 2023). Globally, approximately 165 million children suffer from stunting, with 80% of them living in only 14 countries. Therefore, innovations in the form of supplements or nutraceutical products that are easily accepted by the community are urgently



needed as preventive efforts (Pratiwi et al., 2024). One promising material that can be utilized is milkfish (*Chanos chanos*) scale waste, which is known to contain a high concentration of collagen. Collagen is a structural protein that plays a vital role in the formation of body tissues such as skin, bones, tendons, and muscles (Nurhidayah et al., 2019; Thahir & Wahyuni, 2021).

In the context of improving community nutrition, the consumption of animal protein in Indonesia remains relatively low (Desreza et al., 2022; Zuhkrina et al., 2020), approximately 20-30 grams per capita per day, which is less than that of other ASEAN countries (Bloem et al., 2013). Increased protein intake has been proven to support optimal child growth (Sholikhah & Dewi, 2022). Stunting is a chronic growth disorder in children caused by prolonged nutritional deficiencies, resulting in impaired physical and cognitive development. In Indonesia, the stunting rate was 21.6% in 2023 (PAUDPEDIA, 2023). Addressing this issue requires innovations that improve dietary protein intake through affordable, culturally acceptable food products.

Fish scale waste, particularly from milkfish (*Chanos chanos*), represents an underutilized source of collagen, a structural protein that supports tissue formation and maintenance (Nurhidayah et al., 2019). Although collagen is not rich in all essential amino acids, it can complement other dietary proteins and thus enhance overall nutritional quality. Developing collagen-enriched foods such as crystal candy could promote sustainable waste utilization and provide supplemental protein sources.

2. Literature Review

2.1. Stunting

Nutritional problems are common issues, particularly in Indonesia. According to data from UNICEF, Indonesia ranks 27th out of 154 countries in terms of stunting prevalence. This indicates that the country still faces a relatively high rate of stunting, with approximately 21.6% of children under five experiencing the condition, a figure that remains above the government's target of reducing stunting to 14% by 2024. Stunting is a chronic growth disorder caused by nutritional deficiencies that affect a child's physical and cognitive development. Children who experience stunting exhibit height measurements below the standard for their age, serving as an indicator of impaired growth compared to peers with normal nutritional status (Anggryni et al., 2021; Sefrina & Imanah, 2024).

Stunting has adverse effects on a child's growth and development, both in the short and long term. In the short term, this condition increases the risk of morbidity and mortality, while also impairing cognitive, motor, and verbal development, which consequently leads to higher healthcare costs. In the long term, stunting may result in shorter adult stature, an increased risk of obesity and metabolic diseases, reproductive disorders, reduced learning ability, poor academic achievement, and decreased productivity and work quality (Abbas et al., 2021; Martony, 2023).

Nutritional problems are a multidimensional challenge that must be addressed from the period of pregnancy through old age. Combating malnutrition is an essential component of the national strategy to develop healthy, intelligent, and productive human resources. Therefore, improving the quality of caregiving and fostering a supportive family environment are crucial to preventing infectious diseases and health disorders in children from an early age (Nurhidayati et al., 2020).

2.2. Milkfish Scale

Milkfish (*Chanos chanos*) is a type of brackish water fish known for its distinctive flavor and has been widely recognized by the Indonesian population. This fish contains 14.2% omega-3 fatty acids, which is significantly higher than that found in salmon (2.6%) and tuna (0.2%). According to the East Java Central Bureau of Statistics, East Java produced approximately 170,389 tons of milkfish in that year. The abundant availability of milkfish makes its flesh commonly utilized as a primary raw material, both in the processing industry and for household consumption (Ivanajayadi & Sutanto, 2019; Niam et al., 2022; Susanti et al., 2019).

The parts of the fish that are not classified as flesh are categorized as by-products, while the edible portion constitutes only about 40-50% of the total body weight. The remaining portions, which are often underutilized, are generally discarded as waste (Riski et al., 2022). These waste components include scales, skin, bones, and internal organs, although they possess potential value for development as alternative raw materials in both food and non-food industries. Fish scale waste is believed to contain collagen compounds that are beneficial for stunting prevention. Collagen plays a crucial role in the human body, serving as a major structural component in the formation of bones, teeth, joints, muscles, and skin (Nurhidayah et al., 2019). Therefore, it is an essential substance required for maintaining overall body health and development.

The intake of nutrients such as protein, energy, and zinc plays a crucial role in the growth and development of toddlers. These nutrients are essential for promoting cell division during the growth period, with protein serving as the primary component. Protein is one of the essential nutrients that significantly contributes to the overall growth and developmental processes in young children. An increase in protein intake of approximately 15% is associated with accelerated developmental progress in children (Nurhidayah et al., 2019).

2.3. Extraction

Extraction is a process of separating components from solids or liquids using a solvent, through a mass transfer mechanism in which substances move from the solid phase into the solvent across an interface layer and then gradually diffuse into the solvent (Riwanti et al., 2018). To obtain collagen compounds from milkfish (*Chanos chanos*) scales, several extraction methods can be applied, including salt-soluble collagen (SSC), acid-soluble collagen (ASC), and pepsin-soluble collagen (PSC) methods, as well as enzymatic hydrolysis. Among these techniques, the acid extraction method is the most widely used. The acids commonly employed in this process are organic acids such as chloroacetic acid ($C_2H_3ClO_2$), citric acid ($C_6H_8O_7$), lactic acid ($C_3H_6O_3$), or acetic acid (CH_3COOH) (Gustini et al., 2022; Paudi et al., 2020). The solubility of collagen in salt solutions is very low, making salt-based solvent extraction methods limited in their application. In addition, the cost of specific enzymes required for enzymatic hydrolysis is considerably high. Therefore, collagen extraction in this study was carried out using the acid extraction method (Paudi et al., 2020).

2.4. Crystal Candy

Crystal Candy has quickly gained popularity among the public due to its unique characteristics and visually appealing, crystal-like appearance. Its attractive shape and vibrant colors make it not only a favored snack but also a decorative element for various occasions, such as birthday parties, weddings, and other celebrations. In addition to its captivating visual appeal, Crystal Candy offers a sweet flavor and a crisp texture, providing an enjoyable sensory experience for consumers of all ages (Amalia et al., 2021; Ryveka et al., 2024).

The ease of public acceptance of Crystal Candy is also supported by its wide availability and affordable price. This product is easily found in various stores, both online and offline, making it a practical choice for consumers. Moreover, Crystal Candy is frequently featured as creative content on social media platforms, which helps expand its reach and strengthen its popularity. These factors contribute to making Crystal Candy not merely a temporary trend, but a product with the potential to maintain long-term sustainability in the snack market (Miranti et al., 2017).

3. Methods

3.1. Study Design

This study employed an experimental formulation design to evaluate the effect of collagen concentration on the physical and sensory properties of crystal candy. Three formulations were prepared: F1 (0%), F2 (5%), and F3 (10%) collagen extract.

3.2. Materials and Tools

The equipment used in this study included a 1 L and 100 mL beaker glass, an analytical balance, a maceration jar, a porcelain dish, a 100 mL measuring cylinder, a water bath, an electric oven, a stove, a jelly mold, a pot, aluminum foil, a filter cloth, a pipette, a spatula, and a stirring rod. The materials used in this study were milkfish (*Chanos chanos*) scales, NaOH, CH₃COOH, ninhydrin reagent, distilled water, sucrose, and jelly powder, the details can be found in table 1.

Table 1. Formulation of Crystal Candy

Material	Formulation % (w/v)		
	F1	F2	F3
Collagen Extract	0%	5%	10%
Jelly Powder	10	10	10
Sucrose	300	300	300
Essen	qs	qs	qs
Mineral water	Ad 300	Ad 300	Ad 300

3.3. Collagen Extract Production

The extraction process consisted of several stages. First, a pretreatment was carried out by weighing 100 g of milkfish (*Chanos chanos*) scales, which were then soaked in 0.05 M NaOH solution at a ratio of 1:10 (w/v) for 8 hours at room temperature. After soaking, the scales were thoroughly rinsed with running water. Next, a hydrolysis process was conducted using 0.3 M CH₃COOH at a ratio of 1:10 (w/v) for 72 hours. The hydrolyzed fish scales were then washed repeatedly until they were clean and free from acidic odor. Subsequently, the extraction process was performed using distilled water at a ratio of 1:2 (w/v) in a water bath at 45°C for 2 hours, resulting in wet collagen. The wet collagen was then dried in an oven at 50°C for 24 hours. Finally, the yield of the extracted collagen was calculated and expressed as a percentage (% w/v). Given the use of acid hydrolysis and thermal treatment, the extracted product likely corresponds to a gelatin or collagen hydrolysate rather than native triple-helix collagen (Riski et al., 2022; Sumadi & Ansar, 2021).

3.4. Qualitative Ninhidrin Test

The ninhydrin assay serves as a qualitative screening method to confirm the presence of amino compounds in the extract. While it is not specific to collagen, a positive result supports the presence of proteinaceous material, consistent with gelatin-type collagen hydrolysate. A total of 3 g of dried collagen was weighed and placed into a test tube, followed by the addition of 1 M NaOH and 1% ninhydrin reagent. The mixture was then heated, and any color changes were observed. A positive result was indicated by the appearance of purple, blue, or pale-yellow coloration, depending on the type of amino acids present (Riski et al., 2022).

3.5. Crystal Candy Formulation

To prepare the crystal candy, all equipment and materials were first prepared and weighed. Water was then heated to a temperature of 80°C over medium heat. Jelly powder was added to the hot water and stirred until completely dissolved. Afterward, sucrose (sugar) was added and stirred until dissolved, followed by the addition of flavoring essence and mixed until a homogeneous solution was obtained (Miranti et al. 2017; Ryveka et al. 2024).

Next, milkfish scale collagen extract was added to the mixture and stirred until fully dissolved and homogeneous. The mixture was then continuously stirred until it thickened. Once the desired consistency was reached, the mass was poured into molds and allowed to stand until it formed a jelly-like texture. The formed jelly was then removed from the molds and dried in an oven at 50°C for 12 hours. After drying, the crystal candy was removed from the oven and stored in a clean, tightly closed container (Umami et al., 2021).

3.6. Physical Properties Test

3.6.1. Organoleptic test

This test was carried out through a visual evaluation of the crystal candy preparation, which included the observation of color, odor, shape, texture, and taste of the preparation (Rohmaniyah et al., 2023).

3.6.2. pH Test

The success of crystal candy production depends on the acidity level (pH), with the optimal pH range for crystal candy being 5.5–7.0. An acidic pH can inhibit microbial growth, thereby extending the shelf life of the product. The pH test was conducted using a pH meter by immersing the electrode into the sample, allowing it to stabilize for a few seconds, and then reading the pH value displayed on the meter (D. K. Sari & Dominica, 2022).

3.6.3. Hedonic Sensory Test

The hedonic test was conducted by distributing samples of crystal candy to 80 participants of various age groups. The participants were asked to evaluate the samples based on organoleptic attributes, including odor, taste, color, texture, and shape of the product. The level of preference was measured using a four-point hedonic scale, where: (1) strongly dislike, (2) dislike, (3) like, and (4) strongly like, A 4-point scale was used to minimize neutral responses and to encourage clear preference differentiation (D. K. Sari & Dominica, 2022; Umami et al., 2021).

4. Results and Discussion

4.1. Extraction Results

Table 2. Extraction Results

Milkfish Scale	NaOH 0,05 M	CH ₃ COOH 0,3M	Aquadest	Extract	Yield %
100g	1000ml	1000ml	200ml	18g	18%

The collagen extracted from milkfish (*Chanos chanos*) scales was obtained through a pretreatment process using NaOH, followed by hydrolysis with CH₃COOH, and subsequently extracted using distilled water. Based on the results of our study, the data obtained are presented in Table 2. Based on the extraction results, a yield of 18% was obtained. The yield obtained may vary depending on the concentration of acetic acid used. The yield calculation was carried out by comparing the weight of the dried collagen to the initial weight of the raw material or sample, and the extraction yield was expressed as % (w/v).

4.2. Qualitative Ninhidrin Test

Table 3. Ninhidrin Test Results

Compound	Literature Description	Result +/-	Figure
Collagen	The extract changes color to purple, blue, or yellow.	+	

The ninhydrin test aims to determine the presence of protein compounds in a sample, including collagen. The test was conducted by adding ninhydrin reagent to the collagen sample extracted from milkfish scales and observing any color changes (Jones, 2002; E. M. Sari et al., 2022). A color change to purple, blue, or yellow indicates a positive result for the presence of protein compounds. Based on the results of this study, a positive reaction was observed (Table 3), as indicated by the color change of the sample to blue after treatment.

4.3. Physical Properties Test

4.3.1. Organoleptic test

Table 4. Organoleptic Test Results

Formulations	Week	Texture	Odor	Taste	Color
F1	1	Crunchy and soft like crystal candy	Essence Taro	Taro essence	Purple Color
	2				
	3				
F2	1	Crunchy and soft like crystal candy	Essence Taro	Taro essence + collagen characteristics	Purple Color
	2				
	3				
F3	1	Crunchy and soft like crystal candy	Essence Taro	Taro essence + collagen characteristics	Purple Color
	2				
	3				

Based on our observations, the following data were obtained (Table 4). No significant changes were observed in the preparation during the three-week organoleptic testing period, which included evaluations of color, odor, shape, texture, and taste of the preparation. The three-week observation period served only as preliminary stability monitoring; microbial stability was not assessed in this study (Musdalipah et al., 2024).

4.3.2. pH Test

Table 5. pH Test Results

Formulations	Week	pH	Average ± SD
F1	1	5.98	6,02 ± 0,05
	2	6.00	
	3	6.08	
F2	1	6.20	6,32 ± 0,07
	2	6.34	
	3	6.32	
F3	1	5.80	5,85 ± 0,05
	2	5.86	
	3	5.90	

The pH measurement test was conducted as in table 5 to evaluate the safety and stability of the crystal candy formulations containing collagen extract. The pH values obtained for each formulation were 5.90 for F1, 6.32 for F2, and 5.85 for F3, with an average pH of 6.0. The pH range of the crystal candy samples was found to be between 5 and 7, which is considered acceptable for oral formulations. The slightly acidic pH of the crystal candy is influenced by the collagen content in the formulation, as collagen hydrolysate exhibits mildly acidic properties (Grigio et al., 2022; E. M. Sari et al., 2022).

4.3.3. Hedonic Sensory Test

Table 6. Hedonic Sensory Test Results

Parameter	F1 (Mean ± SD)	F2 (Mean ± SD)	F3 (Mean ± SD)
Texture	3.60 ± 0.84	3.60 ± 0.84	3.60 ± 0.84
Odor	3.00 ± 0.79	3.00 ± 0.79	3.00 ± 0.79
Taste	3.20 ± 0.82	3.20 ± 0.82	3.20 ± 0.82
Color	3.40 ± 0.85	3.40 ± 0.85	3.40 ± 0.85

The hedonic evaluation was conducted as in table 6 to assess four sensory attributes of the crystal candy formulation, namely texture, taste, odor, and color. A total of 80 panelists participated in the evaluation. The results showed that the panelists preferred the F2 formulation, which contained 5% collagen concentration in the crystal candy preparation (Rustan et al., 2023). The higher preference for the F2 formulation was attributed to its chewy texture and balanced flavor when combined with the added essence, resulting in a more favorable overall taste profile. In addition, the odor and color of the F2 formulation were also rated positively by the panelists, contributing to its higher acceptability (Panda et al., 2023; Park et al., 2021).

5. Conclusion

Collagen extracted from milkfish scale waste can be effectively incorporated into crystal candy formulations with good sensory acceptance. The 5% collagen formulation (F2) exhibited optimal physical and organoleptic properties. This preliminary work supports the use of fishery by-products for functional food innovation however, future research should include nutritional profiling, collagen bioactivity assays, microbial stability testing, and extended storage evaluation to substantiate its potential contribution to nutritional improvement and protein supplementation. This formulation demonstrates the feasibility of utilizing fish scale waste as a protein-enriched functional food ingredient, potentially supporting improved dietary protein intake. Further work should evaluate the nutritional composition and microbiological stability to substantiate its broader health applications.

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