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Characterization of Jelly Candy with Different Percentage of Gelatin from Patin Fish Skin (*Pangasius pangasius*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

*Pangasiuspangasius*is a type of marine fish that has thick and hard skin so it is only used as waste. Waste *pangasius pangasius*skin can be used to make gelatin. Gelatin is a protein compound extracted from animal collagen tissue found in skin, bones and connective tissue by means of acid hydrolysis. Jelly candy is a food product that has a chewy texture. This texture is formed due to the formation of a gel, namely gelatin. The purpose of this study was to determine the effect of adding gelatin from pangasius skin to the characteristics and quality of jelly candy and to determine the best concentration of gelatin in the process of making jelly candy. The research method used a

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completely randomized design (CRD) with the addition of 3%, 5% and 7% gelatin concentration. The data obtained were tested by normality test, homogeneity test, ANOVA test and BNJ follow-up test to determine differences between treatments. Data analysis results show that the use of different concentrations of gelatin has a significantly different effect (P<5%) on jelly candy. Jelly candy with the addition of 7% gelatin concentration has a better value with a chewiness gel strength value of 8.46 k.gf, gumminess 3.13 k.gf, hardness 0.62 k.gf, water content 39.57%, ash content 0.15%, protein content 8.88% and hedonic test with a confidence interval of 7.39<μ<7.67 which means the panelists liked it.

Keywords: Pangasiu spangasius skin; gelatin; jelly candy; texture.

1. INTRODUCTION

Patin fish (*Pangasius pangasius*) has emerged as a highly sought-after commodity in the fisheries industry, with its production in Indonesia experiencing significant growth in recent years. Freshwater fish, such as patin, hold global popularity due to their nutritional richness, particularly in protein and fatty acids. According to statistics from the Ministry of Marine Affairs and Fisheries [1], the aquaculture yield of patin fish over the past three years (2019-2021) amounted to 13,021,523 tons. Patin fish finds extensive application in various processing industries, notably in fillet production, which is marketed fresh or frozen. However, fillet processing generates approximately 45% waste, comprising bones, skin, scales, offal, fins, tails, and heads [2].

The skin of patin fish can be utilized for gelatin extraction, as it contains collagen, the primary protein component. Collagen consists mainly of the amino acids glycine, proline, and hydroxyproline, categorized as fibril proteins. These amino acids serve as the primary constituents for gelatin formation [3]. Gelatin derived from patin fish skin offers a solution to concerns regarding the halal status of gelatin products, as many commercial gelatins are derived from mammalian sources like cattle and pigs. Some countries and communities, particularly those of Muslim faith, prohibit the consumption of such products due to health and safety concerns, including the risk of bovine spongiform encephalopathy (BSE) transmission [4]. Gelatin extracted from patin fish skin undergoes acid pretreatment due to the softer collagen tissue, leading to the cleavage of bonds between carboxyl and amide groups within collagen molecules. This process disrupts the triple helix structure of collagen into α-helix chains, resulting in gelatin with a molecular weight range of 90-300 kD [5].

The primary protein produced by degrading fish collagen is fish gelatin, a widely used hydrocolloid, particularly in the food industry [6]. Gelatin possesses properties such as solubility in hot water, colorlessness, and ease of gel formation. Its addition in the food industry serves purposes including binding, gelling, stabilizing, thickening, emulsifying, and adhering [7]. Gelatin, as a hydrocolloid, finds extensive application in modern manufacturing industries, particularly in food processing, pharmaceuticals, cosmetics, and photography, owing to its unique functional properties. In food products, gelatin enhances texture and stability in both liquid and semi-solid forms. Gelatin is commonly applied in gummy jelly formulations, acting as a gel-forming agent dispersed in water to create a three-dimensional gel network [8].

Jelly candy, a subgroup of gel candies primarily composed of sucrose, is a popular dessert worldwide. The desirable characteristics of jelly candy include soft, elastic texture, resistance to brittleness, and non-stickiness. Traditional jelly candies rely on sweeteners and gel-forming agents to achieve a sticky, dry, and chew-resistant texture. Gelatin addition in jelly candy formulations plays a crucial role in forming the gel network, enhancing elasticity, and imparting desirable characteristics [9]. The elasticity of jelly candy texture serves as a key parameter in determining its quality. The objective of this research is to investigate the influence of gelatin addition and determine the optimal concentration for enhancing the characteristics of jelly candy.

2. METHODOLOGY

2.1 Materials and Equipment

The materials utilized in this study for the production of gelatin encompass the skin of pangasius fish, sourced from the residual fillet processing waste of Pangasius fish at CV. AJS situated in Gambekan, Trangsan, Gatak Subdistrict, Sukoharjo Regency, Central Java. Additionally, acetic acid, sodium hydroxide, distilled water (aquadest), and water were employed. For the manufacture of jelly candy, the ingredients comprised gelatin extracted from pangasius fish skin, sucrose, high fructose syrup, citric acid, strawberry flavor, and sodium benzoate. The equipment utilized encompassed a digital balance, water bath, beaker glassware, Blancu cloth, stirrer, cooking utensils set, silicone molds, texture analyzer, desiccator oven, electric furnace, Kjeldahl flask, destruction equipment, and a scoresheet.

2.2 Pangasius-Skin Gelatin Production

The production process of gelatin from pangasius fish skin involves several steps. Firstly, the fish skin is thoroughly cleaned to remove any impurities. Subsequently, it undergoes soaking in a solution of sodium hydroxide (NaOH) at a ratio of 1:3 (w/v) for 18 hours, followed by immersion in a 3% acetic acid (CH_3COOH) solution at a ratio of 1:3 (w/v) for 24 hours. Next, the skin is rinsed until its pH approaches neutrality, and extraction is carried out using a ratio of 1:3 (w/v) at a temperature of 60°C for 2 hours. After extraction, the gelatin solution is filtered and poured into molds, then dried at 60°C for approximately 48 hours. Once dried, the gelatin is pulverized into powder form. It's worth noting that the selection of extraction temperature and duration significantly influences the final product's quality and characteristics.

2.3 Jelly Candy Production

The production of jelly candies involves varying concentrations of gelatin, namely 0%, 3%, 5%, and 7%, dissolved in hot water, followed by the addition of sucrose, glucose syrup, citric acid, and food coloring. Stirring is performed until homogenous, and flavoring is added before pouring the mixture into molds. Once poured into the molds, the jelly candies are cooled at room temperature for one hour.

2.4 Texture Profile Analysis (TPA)[10]

The procedure for conducting texture testing on jelly candies involves ensuring that the data cable from the Lloyd LF2157 Texture Analyzer is connected to the computer's CPU, followed by powering on the computer. A spherical sample probe is attached and positioned near the sample, then the computer program is operated to run the probe. Prior to testing, it's confirmed that the monitor displays zero values. Next, the "start test" menu is selected on the computer to initiate the probe's movement towards piercing the jelly candy sample, and the test concludes when the probe returns to its original position. Test results are displayed as both a graph and numerical values on the computer monitor. The gel strength is measured at a probe speed of 0.5 m/s with a penetration depth of 4 mm. Throughout the test, a graphical representation will appear on the computer monitor, with force measured in grams-force (gf).

2.5 Water Content [11]

The determination of moisture content is based on the difference in weight of the product before and after drying. This method operates on the principle that water contained within a substance will evaporate when the substance is heated at 105°C for a specific duration. The procedure for determining moisture content involves first homogenizing the jelly candy sample and then wrapping it securely. An empty dish is placed in an oven for approximately 2 hours, then transferred to a desiccator for 30 minutes until it reaches room temperature. The dish from the desiccator is then weighed (w_0). Approximately 2 grams of the homogenized sample is placed into the pre-weighed dish, which has been dried in the oven and cooled in the desiccator. The dish containing the sample is covered, weighed (w_1), and placed in an oven at 100-105°C for 6 hours. After completion, the dish is removed from the oven using tongs and cooled in the desiccator for 30 minutes. Once cooled, the dish can be weighed again (w_2).

Water content could be calculated using the following fomula:

$$\text{Water content (\%)} = \frac{w_1 - w_2}{w_1 - w_0} \text{X } 100\%$$

Information:

w_0 = weight of empty cup and lid (g)

w_1 = weight of the cup, lid, and sample before drying (g)

w_2 = weight of the cup, lid, and sample after drying (g)

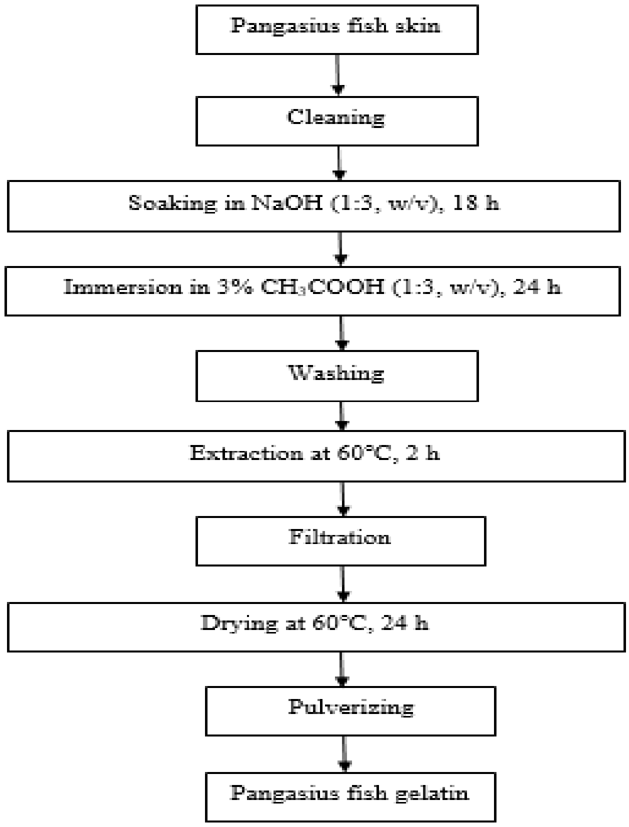

Fig. 1. Pangasius fish gelatin production

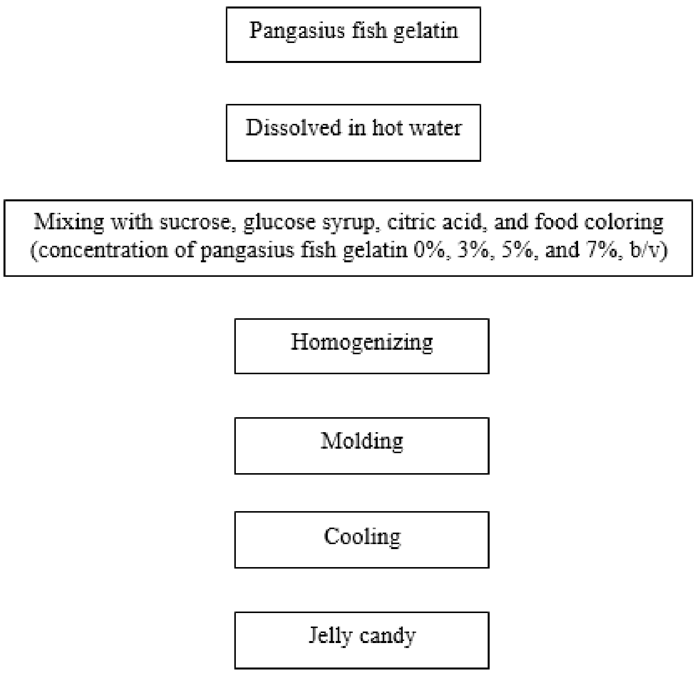

Fig. 2. Jelly candy production

2.6 Ash Content [12]

The analysis conducted on the ash content of the product refers to the ash content determination method outlined in AOAC (2005). Firstly, clean dish and lid are heated in a muffle furnace at 100-105°C for 3 hours and then weighed as the empty weight (a). Approximately 2 grams of the sample is weighed and placed into a pre-weighed porcelain dish, then re-weighed (b). The sample is then incinerated in a combustion furnace at 600°C for 6 hours. The porcelain dish containing the incinerated sample is then placed in a desiccator for 30 minutes, subsequently weighed until a constant weight is obtained (c).

Ash content could be calculated using the following fomula:

$$\text{Ash content} = \frac{C-A}{B-A} \times 100\%$$

Information:

A = weight of empty cup
B = weight of cup and sample
C = weight of cup and sample after ashing

2.7 Protein Content [12]

The testing is conducted by preparing a sample of 0.5 g, to which 0.5 g of selenium and 3 ml of concentrated H2SO4 are added into a 100 ml Kjeldahl flask. The sample is then destructed at a temperature of approximately 410°C until a clear solution is obtained. After cooling, 50 ml of distilled water and 20 ml of 40% NaOH are added, followed by the distillation process at 100°C. The distillation result is transferred into a 125 ml Erlenmeyer flask previously added with 10 ml of 2% borate acid and methyl red indicator. The obtained 40 ml of bluish-green distillate is further distilled with 0.1 N HCl until the color changes to pink. The volume of titrant and blank solution (sample) are recorded for subsequent calculations using the following formula:

Protein content (%) = ((Va-Vb)HCl x NHCl x 14,007 x 6,25 x 100%)/(W X 1000)

Information:

Va	: ml HCl for sample titration
Vb	: ml HCl for blank titration
N	: Normality of standard HCl used
14,007	: Nitrogen atomic weight
6,25	: Fish protein conversion factors
W	: Sample weight (g)

2.8 Hedonic Test [13]

The prepared jelly candy samples are then subjected to hedonic testing procedures, with 30 pieces of jelly candy for each treatment, totaling 120 pieces required. Panelists will conduct hedonic evaluations by examining the appearance and shape, smelling the aroma, tasting the flavor, and experiencing the texture of the jelly candies, then marking (v) on the provided score sheet. The hedonic testing of jelly candies employs a score sheet with rating criteria ranging from 1 to 9. The rating criteria are as follows: 1 for extremely dislike, 3 for dislike, 5 for neutral, 7 for like, and 9 for extremely like. Taste, aroma, texture, appearance, and color are the criteria for hedonic evaluation of jelly candies. Hedonic testing is utilized to determine which food product is most preferred, including aspects such as color, taste, aroma, and texture. It also serves as a reference for identifying the level of consumer preference for the treated jelly candy samples. A total of 30 semi-trained panelists are involved in evaluating the hedonic attributes of the jelly candies.

2.9 Data Analysis

Data parametric tests include normality test, homogeneity test, ANOVA, and post-hoc test (Honestly Significant Difference - HSD). Parametric tests cover gel strength, Texture Profile Analysis (TPA), moisture content, ash content, and protein content. Statistical analysis begins with normality and homogeneity tests to assess data distribution and homogeneity. Subsequently, Analysis of Variance (ANOVA) or analysis of variance is conducted. ANOVA is employed to analyze experimental research data. If the obtained F-value is greater than the critical F-value, it indicates that there is an effect of treatment on the observed variables at a significance level of 5%. If the obtained data significantly differ, a post-hoc test like HSD is performed to determine treatment differences.

Sensory data is analyzed using the Kruskal-Wallis test. If the calculated chi-square value (X2) is greater than the tabulated chi-square value at a 5% significance level, the hypothesis H1 is accepted or H0 is rejected.Non-parametric data analysis is utilized for assessing the hedonic test data of jelly candy products made from gelatin with different concentrations. Kruskal-Wallis test is applied to identify if treatments have an effect ($\rho<5\%$) or not ($\rho>5\%$). If treatments show an effect, Mann-Whitney test is conducted.

This method aims to determine if two or more samples have the same value. The test helps ascertain whether there is a statistically significant difference between two or more groups of independent variables on dependent variables with numerical data (interval or ratio) and ordinal scale.

3. RESULTS AND DISCUSSION

3.1 Gelatin Characteristics

3.1.1 Sensory results of pangasius skin gelatin

The characteristics of pangasius skin gelatin can be seen in Table 1.

Table 1. Characteristics of Pangasius Skin Gelatin

Parameter	Results
Sensory	Yellowish color, odorless and tasteless
Yield	6,82%
Gel Strength	298,38 bloom

The research findings indicate favorable sensory attributes, wherein gelatin exhibits a yellowish hue, devoid of odor and taste. Gelatin manifests characteristics of bright yellow or nearly transparent white coloration, presenting in sheet, powder or flour-like form, rod-shaped, leaf-like, soluble in hot water, glycerol, citric acid, and other organic solvents [14]. Gelatin should range from colorless to a pale-yellow hue. Sensory observations regarding the color, odor, and taste of pangasius skin gelatin obtained are not significantly different from commercial fish gelatin [15].

3.1.2 Yield

The research yielded a yield calculation result of 6.82%. Yield refers to the ratio of the amount of dry gelatin produced from a given quantity of raw material in a clean state through the extraction process. This figure surpasses that of a previous study [16], which reported a gelatin yield of 4.76% from skipjack tuna (Katsuwonus pelamis) bones. Furthermore, it exceeds the findings of another study [17], which reported a gelatin yield of 6.12% from unicorn leatherjacket fish (Aleterus monoceros) using acetic acid solvent.

The increase in gelatin yield in this research is presumed to be attributed to the augmentation of organic acids, which are believed to facilitate the provision of acidic ions (H+). Acidic ions play a crucial role in breaking hydrogen bonds between collagen during the soaking process. Gelatin yield is influenced by pH, extraction temperature, and acid concentration. During soaking, acids break the collagen helix bonds within the bone matrix through the acidic ions present in them. The higher the acidity level of a solvent (resulting in a lower pH value), the greater the amount of collagen helices degraded. Gelatin yield values using various acid solvents yield varied results. Higher acidity levels and an increased number of H+ ions in the solvent lead to higher gelatin yield [16].

3.1.3 Gel Strength

The gel strength test result for pangasius skin gelatin is 298.38 bloom. Gel strength is a primary physical property of gelatin because it indicates the gelatin's ability to form a gel. The gel strength value obtained is relatively high as it approaches the upper limit of gelatin values, which is typically between 50-300 bloom [15]. This result surpasses the findings of a previous study [18], where gelatin derived from fish exhibited gel strength values ranging from 0-270 bloom.

Gel strength is a crucial physical property of gelatin as it demonstrates its ability to transform liquids into solids or solid forms into a gel. Gel strength is associated with the length of the amino acid chain, where longer chains result in higher gel strength. Optimal hydrolysis yields longer amino acid chains during the conversion of collagen to gelatin. Gel strength is vital because one of gelatin's essential properties is its capacity to reversibly transform liquids into solids or sols into gels. This versatility accounts for the widespread use of gelatin in various fields such as food, pharmaceuticals, and others [19].

Factors that can influence the high or low gel strength include the level of yield and viscosity because low viscosity corresponds to low gel strength. This is because viscosity significantly affects gel formation and gel strength. Additionally, factors such as temperature, differences in concentration, and pH can affect gel strength. A lower pH value results in slightly lower gel strength due to the presence of polypeptide chains resulting from hydrolysis, which degrade and reduce gel strength. Other factors affecting gel formation include temperature, concentration, and pH. High concentration significantly affects lower gel strength because further hydrolysis of collagen occurs, resulting in the cleavage of covalent bonds between amino acids, reducing collagen's molecular weight and the length of amino acid chains, consequently lowering gel strength. The molecular weight of gelatin and amino acids also affects gel formation. Gelatin's molecular weight is related to the length of the amino acid chain that makes up the gelatin. The longer and larger the chain, the higher the molecular weight and gel strength. Moreover, the length of the amino acid chain in gelatin is determined by the extraction process temperature. Excessive temperatures during extraction can lead to further hydrolysis of collagen already converted to gelatin, resulting in the breakdown of amino acid sequences and consequently reducing gel strength [20].

3.2 Characteristics of Jelly Candy

3.2.1 TPA (Texture Profile Analysis)

A description of texture, particularly relevant to jelly candies, includes hardness, springiness, and gumminess. The maximum force required to distort jelly candies upon the first bite is directly related to hardness. Springiness arises from the multiplication of hardness and compactness, while gumminess stems from the multiplication of hardness, compactness, and springiness [8].

A. Hardness

Hardness is a primary factor influencing the chewiness of gummy jelly candies and is the first textural characteristic consumers perceive, directly impacting their acceptance of the product. The texture of hardness in jelly candies falls within a range of 0.31-0.62 k.gf. Jelly candies without gelatin additives exhibit low hardness, around 0.31 k.gf, whereas those with a 7% gelatin concentration show the highest hardness value at 0.62 k.gf.

The testing results indicate that the addition of gelatin can enhance the hardness of jelly candies. However, the hardness values obtained in this study are lower than those found in research conducted by Renaldi et al. [8], who investigated jelly candy production using gelatin with added pectin as a hydrocolloid, resulting in a hardness value of 89.56 N or approximately 9.08 k.gf. The significant difference in hardness values between these two products can be attributed to the presence of other hydrocolloid additives. Gelatin added to the product serves as a binder and thickener in jelly candies.

There is a notable difference in hardness between the control and gelatin-added jelly candy products, with an evident increase in hardness observed in the latter. The processing of jelly candies with added gelatin is more effective due to gelatin's amino acid content. Gelatin's hydrocolloid properties enable it to absorb water effectively and aid in gelation processes. Additionally, during heating, water from the ingredients evaporates, leaving behind residual water bound by sugar, resulting in reduced water content in the product, contributing to its firm texture. This is corroborated by research conducted by Yusof et al. [21], indicating a direct relationship between jelly hardness and water content. As water content decreases, texture transitions from soft to hard. However, since the water content of both jelly types is the same, hardness primarily depends on the type of hydrocolloid used. Foods with low-scale hardness and high chewiness exhibit good elasticity.

Increasing gelatin concentration in jelly candy production leads to the formation of triple helix bonds between gelatin and water molecules, wherein gelatin absorbs water and traps it within gelatin micelles. The functional property of gelatin as a gelling agent transforms jelly candies into a gel, solidifying them. Above the gel-forming temperature, gelatin molecules in the solution adopt random conformational networks. During subsequent cooling below the gel-forming temperature, helix nucleation rapidly occurs, leading to the formation of loose networks that eventually reach equilibrium through the slow formation of independent triple helices. The gel structure continues to evolve after gel formation due to the instability of low-energy interactions connecting gel networks, as demonstrated in the results for gummy gelatin with 6.35% gelatin [22].

B. Gumminess

Based on the data presented in Table 2, the average gumminess values for jelly candies under different treatments are as follows: control (no addition of pangasius skin gelatin) - 0.38 k.gf, 3% pangasius skin gelatin concentration - 0.79 k.gf, 5% concentration - 1.87 k.gf, and 7% concentration - 3.13 k.gf. The lowest gumminess was observed in the control group, while the highest gumminess was found in jelly candies with a 7% gelatin concentration. The range of gumminess values in the research varied from 0.38 k.gf to 3.13 k.gf.

Gelatin containing amino acid proteins strengthens the gel network structure in the product, resulting in a firmer and more elastic product. Research by Kia et al. [23] suggests that incorporating or adding gelatin to a product enhances the synergistic value of gel network strength. Gummy candy products with added beetroot extract had a gummines value of 240 N or approximately 24.47 k.gf with a 1.5% gelatin addition, which is higher than the findings of this study. The disparity in results can be attributed to differences in raw materials and shapes used.

Gumminess represents the stickiness calculated by combining hardness and cohesiveness values. Gumminess values correlate positively with hardness values, where gumminess increases with increasing hardness [21]. Consistent with this study, a significant increase in gumminess was observed with increasing concentrations of pangasius skin gelatin. Higher gelatin additions result in higher gumminess values, indicating that adding gelatin to jelly candies can enhance gumminess. Gelatin, as a gelling agent, imparts a unique characteristic known as "melt-in-mouth," or melting in the mouth. So far, no gel-forming protein has been found to replace the characteristic of gelatin as a gelling agent [24].

Higher gelatin additions increase protein content, allowing existing proteins to fill empty spaces in the protein matrix of jelly candies, resulting in a denser matrix structure that is resistant to chewing. Higher gumminess values indicate a denser matrix of jelly candies that are difficult to crush, requiring more chewing effort. Gelatin is a triple helix collagen that, when heated, undergoes denaturation and forms random coils, which then form a gel system upon cooling [25].

C. *Chewiness*

Data from Table 2 indicates the average chewiness values for jelly candies with gelatin concentrations of 3% as 3.85 k.gf, 5% as 5.96 k.gf, 7% as 8.46 k.gf, and the control group (without gelatin) as 2.90 k.gf. The lowest chewiness value was observed in jelly candies without gelatin, while the highest was found in those with a 7% gelatin concentration. Chewiness refers to the work required to chew a food sample until it is ready to be swallowed. Chewiness results depend on factors such as firmness, cohesiveness, and springiness, and it is closely related to the elastic strength of the protein matrix. Gelatin added to jelly candies can enhance their chewy texture due to its water-absorbing properties and protein content [26].

The chewiness values obtained in this study are greater than those reported by Kumkong et al. [27], who stated that bastard oleaster gummy jelly with gelatin additions ranging from 8% to 10% exhibited chewiness values between 11.04 to 12.9 N, or approximately 1.13 to 1.32 k.gf. The increase in gumminess, chewiness, and springiness through simultaneous gelatin addition acts as a gel-forming agent that interacts with sugar, water, and acid, leading to gelation and increased elasticity.

Chewiness, also referred to as the chewing force, is calculated by multiplying gumminess by elasticity. Statistical analysis revealed significant differences resulting from the addition of pangasius skin gelatin in each formulation ($p < 0.05$). Chewiness is a crucial component in assessing jelly candy texture characteristics. It represents the food's ability to withstand chewing until it is ready to be swallowed [28]. Therefore, chewiness identification is commonly used in analyzing jelly candy texture.

Higher gelatin additions lead to higher chewiness values, indicating that adding gelatin to jelly candies can enhance chewiness. Excessive gelatin concentrations in food products can result in stiff gels, while too low concentrations may yield soft gels or even fail to form gels [29]. Elasticity is a critical texture characteristic for agar-agar products and represents the energy required to chew solid foods until ready to be swallowed [21]. Similar to gumminess, elasticity increases with increasing hardness levels. Water and protein content can determine the hardness level of the resulting jelly candies. Higher gelatin concentrations result in higher chewiness values in jelly candies, consistent with research by Cheng et al.[30], indicating that higher gelatin concentrations lead to higher chewiness values.

3.3 Water Content

Water content is the amount of water contained in a material. The results of testing water content in jelly candy are shown in Fig. 1.

Table 2. Average results of TPA testing of jelly candy with different gelatin concentrations

Parameter	A	B	C	D
Hardness	0,31±0,07[a]	0,46±0,07[b]	0,47±0,03[b]	0,62±0,05[c]
Gumminess	0,38±0,06[a]	0,79±0,06[b]	1,87±0,13[c]	3,13±0,25[d]
Chewiness	2,90±0,14[a]	3,85±0,34[a]	5,96±0,72[b]	8,46±0,52[c]

Information:

- *Data are the average of three replications ± standard deviation*
- *Data followed by different lowercase letters on the same line show significant differences (p<0.05)*
- *Data followed by the same lowercase letter on the same row shows no significant differences (ρ<0.05).*

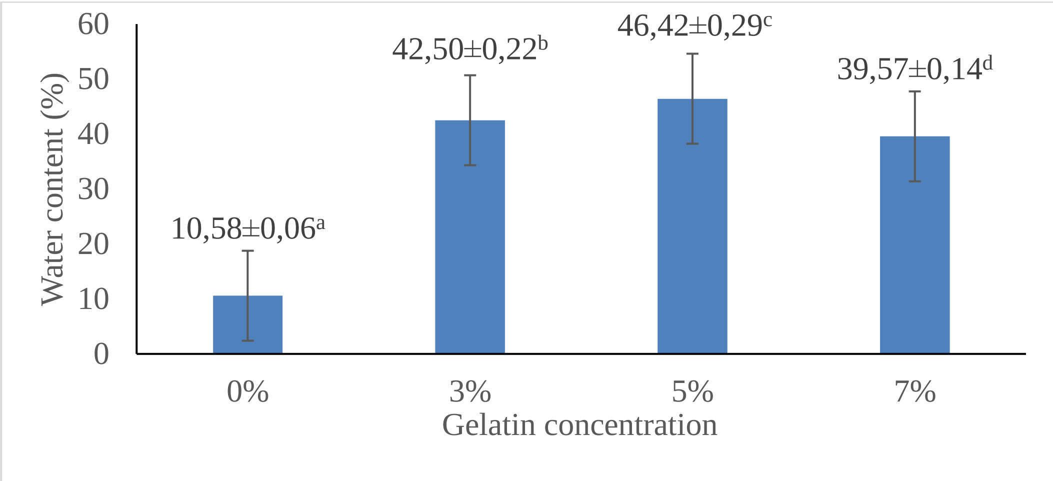

Fig. 3. Analysis results of water content testing in jelly candy

Keterangan:

- *Data merupakanhasil rata-rata daritigaulangan ± standardeviasi;*
- *Data yang diikutitandahurufkecil yang berbedamenunjukkanadanyaperbedaan yang nyata (p<0,05)*
- *Data yang diikutitandahurufkecil yang samamenunjukkantidakadanyaperbedaan yang nyata (p<0,05)*

Fig.1 illustrates that the addition of pangasius skin gelatin at concentrations of 0%, 3%, 5%, and 7% yields significantly different results. The moisture content of jelly candies without pangasius skin gelatin is 10.58%, while those with gelatin concentrations of 3%, 5%, and 7% have moisture contents of 42.50%, 46.42%, and 39.57%, respectively. The moisture content of jelly candies in this study ranges from 10.58% to 46.42%. These results are higher compared to research by Mufida et al. [26], where jelly candies with added fish scale gelatin had moisture content ranging from 15.81% to 18.06%. Referring to the standard moisture content for jelly candies according to Indonesia National Standardization Agency [31] (maximum of 20%), all moisture content values in the jelly candies do not meet the standard. The addition of gelatin can increase the moisture content in jelly candies. This is likely due to the weak bonds formed between gelatin molecules and water, resulting in a small amount of water trapped within the gelatin molecular structure. Lower concentrations of hydrocolloids in the solution lead to weaker bonds between molecules, resulting in less water trapped within the hydrocolloid molecules [32]. The hydroxyl groups of hydrocolloids bond with water molecules through hydrogen bonds, reducing the water content in food products, thereby thickening jelly drinks. Gelatin can absorb water in food ingredients and forms a colloid dispersion system that can easily absorb large amounts of water. Gelatin helps bind large amounts of water and forms a network that impedes water movement [33]. This is also supported by Zia et al.[34], where the addition of gelatin can increase the moisture content of jelly candies produced. This is because the addition of gelatin can increase the water bound in the gelatin gel micelles in the jelly candies.

Factors that can affect the moisture content of jelly candies include temperature, water volume, cooking time, and cooling time. Referring to Giyarto et al. [35], lower heating temperatures increase the moisture content of jelly candies, while higher heating temperatures decrease their moisture content. Consistent with research by Nilasariet al.[36], increased cooking time reduces moisture content due to more water evaporation. Gelatin is a colloid dispersion system that can easily absorb large amounts of water (hydrophilic) [37]. This is also in line with the statement by Setyawan et al.[38], where the more gelatin added in the production of jelly candies, the more interconnected molecules there are, resulting in more water within the gelatin molecules than evaporated water during cooking.

Based on the research results, adding a 7% gelatin concentration leads to lower moisture content. This is because free water binds within the gelatin gel micelles. Low moisture content does not cause a tough texture but rather makes it more elastic, resulting in decreased hardness of jelly candies. Gelatin acts as a hydrocolloid, which can dissolve in water and also absorb water. Gelatin is a derivative of hydrolyzed collagen, which contains protein compounds. Gelatin has hydrophilic properties, meaning it is water-loving, and it also has reversible properties. These properties make gelatin melt when heated and form a gel when cooled. Gelatin can retain and bind water. The moisture content in jelly candy products is due to the ability of gelatin to bind water and reduce free water content. Gelatin contains proline and hydroxyproline amino acids that can form hydrogen bonds. During the heating process, the molecular bonds of gelatin molecules are opened and decomposed, allowing free water to be trapped within the gelatin structure. Gelatin has the ability to form and stabilize hydrogen bonds by forming three-dimensional gels on water molecules [39]. According to research by Sudaryati et al. [40], gelatin is a colloid dispersion system that can easily absorb large amounts of water. Sucrose acts as a water attractant and forms long chains linking molecules.

3.4 Ash Content

Fig. 2 illustrates that the addition of gelatin to jelly candies at a concentration of 3% in the ash content test yielded a result of 0.93%, which is higher compared to other concentration levels. The ash content test results for concentrations of 5% and 7% were both 0.15%, while the concentration of 0% resulted in 0.25%. The obtained ash content test results in this study ranged from 0.83% to 1.31%. This indicates that the addition of gelatin affects the ash content value of jelly candies. The ash content value in this study still complies with the quality standards for jelly candies according to SNI 3574.2-2008, which requires a value of less than 3.0%. The test results in this study showed a higher ash content value compared to the study conducted by Nurismantoet al. [41], where jelly candies with 4% carrageenan and 13% gelatin addition had an ash content of 0.62%. The difference in ash content results between the two products may be attributed to variations in the gelatin manufacturing process. The ash content test results for jelly candies are presented in Fig. 2.

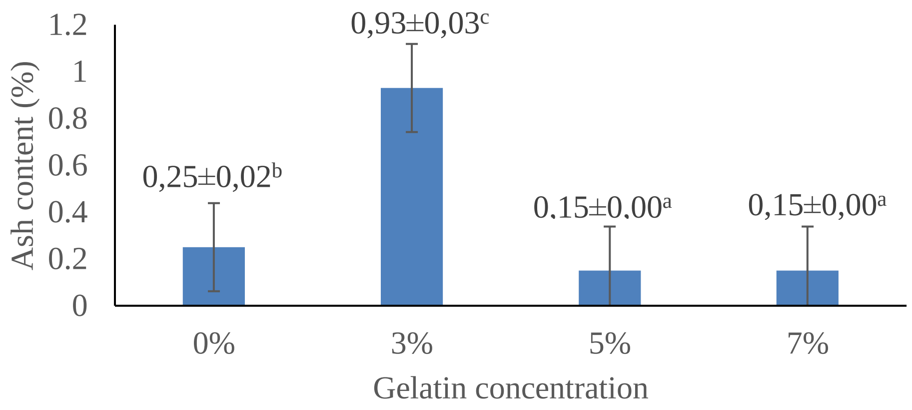

Fig. 4. Analysis results of ash content testing in jelly candy

Information:

- *Data are the average of three replications ± standard deviation;*
- *Data followed by different lowercase letters indicates a significant difference (p<0.05).*
- *Data followed by the same lowercase letter indicates no significant difference (p<0.05).*

Ash is an inorganic substance remaining from the combustion of organic materials at high temperatures. The difference in ash content results in jelly candy was caused by the addition of different concentrations of pangasius skin gelatin. The results of a 3% concentration tend to be higher than those of a 5% and 7% concentration. Jelly candy products at a concentration of 3% tend to have high residual inorganic substances because the added gelatin contains more minerals and does not dissolve completely during the demineralization process. The demineralization process takes place optimally because it is able to degrade the minerals in pangasius skin so that more peptide bonds in the collagen are cut, causing more minerals to dissolve in the gelatin solution. The ash content is determined by the leaching or demineralization process, the more minerals are lost, the lower the ash content value [42].

Ash content is an indicator of gelatin purity. The higher the ash content, the greater the impurities or residual inorganic substances in the gelatin. If the ash content is lower, the purity of the collagen or gelatin will be higher. Another factor that can cause high ash content values is the high content of minerals or inorganic substances in the ingredients used to make jelly candy, such as the water used. The purity of gelatin can be affected by impurities from the raw materials or the gelatin manufacturing process. The presence of dirt deposits produced on pangasius skin gelatin is thought to be impurities or residual inorganic substances which result in higher ash levels. This statement is supported by Nurwantoro et al. [43], stating that unclean raw materials will increase the ash content. The high ash content is due to the presence of minerals that are bound to collagen during the washing process so that mineral impurities are also extracted. Apart from that, the high or low ash content of gelatin is determined by washing or demineralization, the more minerals that dissolve in the washing process, the lower the ash content.

3.5 Protein Content

Fig. 3 illustrates that the protein content in jelly candies with the addition of 7% gelatin concentration is 8.88%, which is higher compared to jelly candies with 5% gelatin concentration, with a protein value of 6.41%, and jelly candies with 3% gelatin concentration, with a protein value of 4.56%. Jelly candies without gelatin tend to have low protein content, specifically at 0.46%. The differences in results among the four gelatin concentrations in jelly candy products indicate significant variations. The basic raw materials used in jelly candies tend not to contain protein, resulting in jelly candies without gelatin having lower or no protein content at all. The protein content values obtained in this research are lower compared to the study conducted by Osiriphun et al. [44], where gummy jelly with 5% gelatin concentration had a protein content value of 8.76%. The discrepancy in protein content values is attributed to differences in the types of gelatin raw materials used. The raw material in this study is patin fish skin, while the comparison involved tilapia fish skin. Differences in habitat and diet can affect the collagen content present in the fish skin.

The protein content of jelly candy with the addition of pangasius skin gelatin whose concentration increases, the protein content value will be higher. This is because gelatin has a high protein content from amino acids. Gelatin which has a high protein content has many remaining amino acids, possibly because the polypeptide chain is still long, and the hydrogen bonds between protein molecules are also strong so that the water holding capacity is higher [45]. The large amount of amino acid protein contained in gelatin can function as a certain nutritionally balanced food. The protein in gelatin can also function as a substitute for fat and carbohydrates 46].

Jelly candy with the addition of gelatin can be used as a functional food. Gelatin has good nutraceutical value and contains various types of amino acids. The amino acid content in the protein is what makes jelly candy have more nutrients apart from the flavor content and sugar content. Foods high in protein are increasingly recommended for weight maintenance, management of muscle loss that occurs with aging, control of blood sugar and high blood pressure, and to combat obesity and aging [46]. As a result, alternative protein sources, products that are naturally high in protein, foods and beverages with added protein, and protein supplements are one of the fastest growing categories targeting sustainable and health-focused consumers [47].

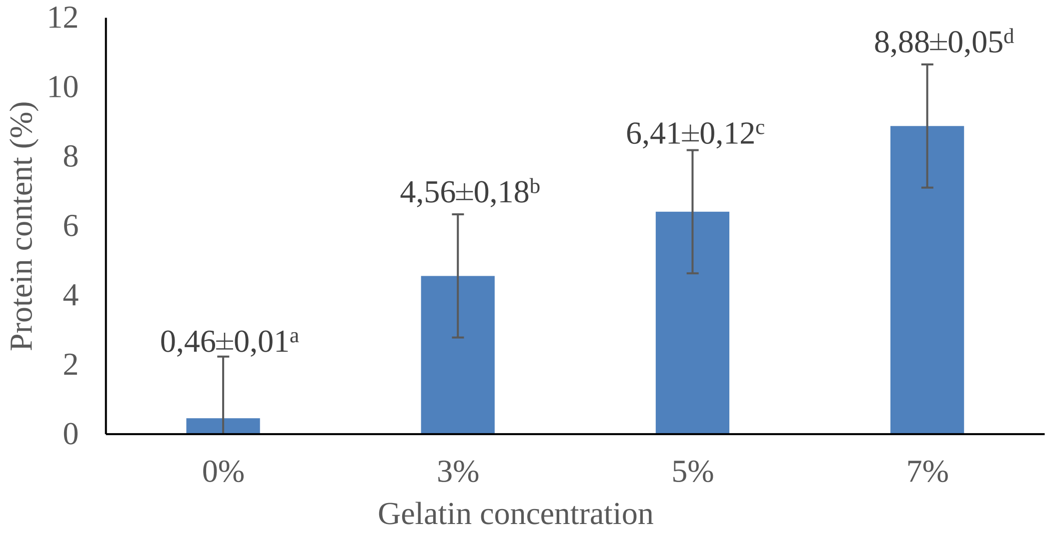

Fig. 5. Analysis results of protein content testing in jelly candy

Information:

- *Data are the average of three replications ± standard deviation;*
- *Data followed by different lowercase letters indicates a significant difference (p<0.05).*
- *Data followed by the same lowercase letter indicates no significant difference (p<0.05).*

Jelly candy with a high protein content tends to have a chewier, denser and more compact texture. This happens because high protein will affect the texture of food. Gelatin is a product of the breakdown process of collagen found in skin, bones and connective tissue which is the main component of all connective tissue. The functional properties of gelatin are related to gel strength, gel formation time, melting temperature, viscosity, water content and texture. Gelatin properties are also related to surface properties such as shape and stability, emulsion, colloid protection, foam stability and texture formation in food. Gelatin is used as the main ingredient in processing jelly candy because it has properties as a stabilizer, gel-former, binder and thickener. The characteristic chewy nature of gelatin makes it widely used in the food industry because it acts as a gelling agent, this is what makes jelly candy manufacturers use gelatin more than other gelling ingredients [34].

4. RESULTS OF HEDONICANALYSIS

The hedonic testing results for jelly candies with different concentrations of patin fish skin gelatin, based on appearance, texture, aroma, and taste parameters, yielded varying outcomes. The scale used ranged from 1 to 9, where 1 indicates "extremely dislike," 2 indicates "strongly dislike," 3 indicates "dislike," 4 indicates "somewhat dislike," 5 indicates "neutral," 6 indicates "somewhat like," 7 indicates "like," 8 indicates "strongly like," and 9 indicates "extremely like." The results of the hedonic testing for jelly candies with varying concentrations of patin fish skin gelatin are presented in Table 3.

Table 3. Hedonic value of jelly candy with different pangasius skin gelatin concentrations

Sample	Parameter				
	Apppearance	Texture	Aroma	Taste	Confidence interval
Control	6,82±1,02a	6,98±0,79a	5,27±0,69a	6,73±1,16a	5,85<μ<6,11
3%	7,03±0,82b	7,15±0,88a	6,82±1,02a	6,97±1,10a	6,35<μ<6,65
5%	6,95±1,13b	6,95±081a	7,12±0,83b	7,35±0,61b	6,54<μ<6,78
7%	7,47±0,57c	7,70±0,70b	7,53±0,62c	7,40±1,12c	7,39<μ<7,67

Information:

- *The data is the average of thirty panelists ± standard deviation.*
- *Data followed by different lowercase letters in the same column indicates significant differences.*

4.1 Appearance

The overall appearance of jelly candy has a value range from 6.82-7.47, meaning that the jelly candy is somewhat liked by consumers to liked by consumers. These results indicate that the different concentrations of fish skin gelatin have a significant influence on the appearance characteristics of jelly candy. The next test is the Mann-Whitney test to determine the relationship between treatments in the jelly candy samples. Based on the results of further tests, it is known that differences in the use of different gelatin concentrations have an effect on the hedonic appearance of jelly candy.

The appearance of the jelly candy was quite favorable, even to the point that the panelists liked it, indicating that the jelly candy had the characteristics of being intact, brownish in color and uniform in size. The lowest average appearance value results were in samples with control treatment which had an average hedonic value of 6.82 (somewhat favorable). The appearance of a product is the most important attribute of a product. Consumers will consider appearance first when buying a product and ignore other sensory attributes [48]. This is because the appearance of a good product tends to be considered to have a good taste and high quality. Products with a neat, good and intact shape are definitely preferred by consumers compared to products that are less neat and incomplete [49].

4.2 Texture

The average texture score for jelly candy without treatment was 6.98, 3% concentration was 7.12, 5% concentration was 6.95 and 7% concentration were 7.70, so the overall hedonic texture test results showed that the texture of jelly candy was slightly liked until consumers like it. The texture of food is influenced by the mixing formula, raw materials used and storage methods. The texture of jelly candy is quite popular, even to the point that panelists like it, indicating that jelly candy has the characteristics of being chewy, dense and compact. The lowest average texture value results were in the sample with 5% treatment which had an average hedonic value of 6.95 (somewhat favorable). The chewy texture can be caused by the addition of gelatin with different concentrations so that it contains proteins that can bind water. Protein also has the ability to bind water, the more protein content, the more water content is bound. This will also have implications for reducing product hardness [25].

4.3 Aroma

The average aroma score for jelly candy without treatment was 5.27; addition of 3% pangasius skin gelatin, namely 6.82; the addition of 5% pangasius skin gelatin is 7.12 and the addition of 7% pangasius skin gelatin is 7.53, so that the overall results of the hedonic aroma test show that the aroma of jelly candy is neutral and is liked by consumers.The addition of different pangasius skin gelatin has a different impact, where jelly candy added with pangasius skin gelatin at a concentration of 7% tends to have a specific aroma of pangasius skin gelatin. The aroma of the control jelly candy has a specific jelly candy scent because there is no additional raw material of pangasius skin gelatin in the product. This is in accordance with the statement from Fransiska and Onphing [50], which states that the ingredients used in the formulation of a product can influence the aroma of food. The food processing process will also affect the aroma of the product.

The deliciousness of a food is largely determined by the aroma factor. The food industry considers it important to carry out an aroma test because it can quickly assess whether a product likes or dislikes it. This is supported by Mariana et al. [51], the aroma emitted from food is a strong attraction and is able to stimulate the sense of smell, thereby arousing the panelists' appetite. Aroma is also called a long-distance sense where people can smell it from food because the olfactory apium cells in the walls of the nasal cavity are sensitive to olfactory components [52].

4.4 Taste

Based on the hedonic test, the taste of jelly candy is influenced by the addition of sucrose and glucose syrup which produces a sweet taste in jelly candy. The sour taste of jelly candy comes from the addition of citric acid. The taste of jelly candy with the addition of pangasius skin gelatin 3%, 5%, and 7% was sweet and slightly sour, while the control without gelatin was sweeter than with the addition of gelatin. The taste of the jelly candy shows that the panelists accepted the jelly candy product when treated with different concentrations of pangasius skin gelatin with a hedonic value that was still acceptable to the panelists. Taste is a very important factor in determining consumers' final decision to accept or reject a product [53]. Although other assessment parameters are good, taste can determine whether the product is liked or disliked by consumers. The taste of food is influenced by the components contained in the food such as protein, fat and carbohydrates that make up it [54,55].

5. CONCLUSION

Jelly candy added with pangasius skin gelatin in various concentrations has different texture and quality characteristics. The quality of jelly candy in terms of chewy texture with the addition of gelatin becomes increingly chewy and gummy. The jelly candy that has the best treatment is jelly candy with the addition of 7% concentration of gelatin. These results can be seen from the characteristics of jelly candy in terms of chewiness of 8.46 k.gf, gumminess of 3.13 k.gf and hardness of 0.62%. Jelly candy water content 39.57%; low ash content of 0.15% and the highest protein content of 8.88%. Jelly candy with a concentration of 7% is also preferred by panelists because of its sweet taste and chewy texture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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