

The Effect of Catfish (*Pangasius* sp.) Skin Gelatine Addition on the Physical Characteristics of Butterfly Pea Flower (*Clitoria ternatea*) Jelly Candy

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Abstract

Gelatine, derived from fish skin collagen hydrolysis. The hydrocolloid properties of gelatine make it used as a gelling agent in making jelly candy. Butterfly pea flowers contain antioxidants and produce a purplish blue color so that it can be used as a natural coloring in jelly candy. The purpose of this study was to determine the physicochemical characteristics of butterfly pea flower jelly candy with different concentrations of catfish skin gelatine. Catfish skin gelatine is obtained from the process of protein hydrolysis using citric acid solution ($C_6H_8O_7$). The treatments were different concentrations of 4%, 8%, and 12% catfish skin gelatine in butterfly pea flower jelly candy. The results showed that increasing the concentration of catfish skin gelatine had a significant effect ($p < 0.05$) on texture profile, moisture content, ash content, protein content, antioxidants, and hedonic parameters, but did not have a significant effect ($p > 0.05$) on color parameters. The addition of 8% gelatine produced the best jelly candy characteristics with a hardness of 3.7 kgf, cohesiveness of 0.41, springiness of 10.9 mm, gumminess of 1.42 kgf, and chewiness of $15.62 \text{ kgf} \cdot \text{mm}^{-1}$, fracture force of 3.17 kgf, adhesiveness of -0.3 kgf.mm, moisture content of 15.65%, protein of 9.03%, ash content of 2.26%, IC_{50} of 85.14 ppm, L^* -value of 19.51, a^* -value of 0.44, b^* -value of 0.63, and hedonic of $7.30 < \mu < 7.76$. The addition of gelatine with proper concentration in butterfly pea flower jelly candy produces the best texture, moisture content, ash content, protein content, antioxidants, and hedonic characteristics, but does not affect color.

Keywords: Butterfly pea flower, catfish skin, gelatine, jelly candy

INTRODUCTION

Based on statistical data from the Ministry of Maritime Affairs and Fisheries (KKP), catfish (*Pangasius sp*) aquaculture production in 2021 reached 141,182 tons and increased in 2022 to 161,114 tons (KKP, 2022). The catfish industry in Indonesia is very popular in the domestic market, namely fillet products reaching 50% of the total domestic fillet consumption. The fillet industry produces considerable fishery by-product waste in the form of skin. The high protein content of catfish skin makes it potential to be used as raw material for gelatine production. Based on research (Suptijah *et al.*, 2018), catfish skin has a protein content of 30.28%.

Gelatine is a functional protein product obtained from the hydrolysis of partial collagen from skin. The nature of gelatine that dissolves in the heating process and when cooled again will become a colloid that forms a gel and becomes liquid again when heated makes gelatine referred

to as a hydrocolloid. According to (Sae-leaw *et al.*, 2016; Bian *et al.*, 2023), gelatine traded around the world is made from the skin or bones of mammals, mainly pigs and cows. There is hesitation for Muslims and Hindus to consume products containing gelatine. This problem can be solved by using gelatine from fish skin waste. Gelatine obtained from catfish skin has a yield value of 18.11% with a viscosity of 61.66 mps and a gel strength of 204.01 bloom. This value meets the requirements of the Gelatine Manufactures Institute of America (GMIA) (Nurilmala *et al.* 2021).

Jelly candy is a type of sugar-based soft candy that has a special characteristic of having a chewy and soft texture due to the addition of gelling agents such as gelatine. The role of gelatine in making jelly candy is to inhibit the crystallization process, convert liquids into elastic solids, and improve the texture and shape of the resulting jelly candy (Sachlan *et al.* 2019 and Timisela, et.al, 2023).

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There have been many studies on the addition of gelatine in making jelly candy. However, the addition of catfish skin gelatine with the addition of coloring agents from butterfly pea flower plants in making jelly candy has not been done. Anthocyanin pigments in butterfly pea flowers have good stability, so they have the potential to be used as natural dyes in the food industry. The flavonoid content of butterfly pea flowers has a role as a source of antioxidants so that in addition to being used as a natural dye, butterfly pea flowers can have an effect on health. Butterfly pea flower extract can be used as a coloring material in making jelly candy so that the jelly candy will have a purplish blue color that is attractive for consumption. The natural coloring of butterfly pea flowers applied to food products can increase the antioxidant value of the product (Makasana *et al.*, 2016). So the purpose of this study was to determine the effect of different concentrations of catfish skin gelatine on the physicochemical characteristics of butterfly pea flower jelly candy and to determine the concentration of gelatine that produces the best jelly candy characteristics.

MATERIALS AND METHODS

The main raw material used in this research is catfish skin which is obtained from PT Kurnia Makmur Purwakarta, West Java. Butterfly pea flower symplisia obtained from Magelang, Central Java. The auxiliary materials are Rosebrand brand sucrose, Rosebrand brand high fructose syrup (HFS) and lemon water obtained from minimarket. The chemicals used were citric acid ($C_6H_8O_7$) 0.2%, and distilled water obtained from Indrasari Semarang Chemical Store.

The tools used in the preparation of gelatine include beaker glass, analytical scales, pH meter, blacu cloth, waterbath, baking sheet, oven. While the tools used for making jelly candy are non-stick pans, spatulas, stoves, analytical scales. For analysis, the tools used include analytical balance, oven, furnace, desiccator, chromameter, UV-Vis spectrophotometer, Ta-TX.

Sample preparation consists of two stages, making gelatine and butterfly pea flower extract. The preparation of catfish skin gelatine was carried out based on modifications (Nurilmala *et al.* 2021) in the following way: The fish skin was cut into 1×1 cm pieces and then washed under running water. Fish skin pieces are soaked with water

(50°C) for 2 minutes with 3 repetitions. Fish skin was soaked with 0.2% citric acid at a skin:solvent ratio of 1:3 (w/v) for 12 hours. The fish skin was rinsed under running water until a neutral pH is obtained. Extraction of fish skin with distilled water:skin ratio of 1:2 (w/v) for 3 hours at 70°C waterbath temperature. The extraction results were filtered with blacu cloth, then the filtrate was dried in a 60 °C oven for ± 48 hours. The procedure for making butterfly flower extract was based on a modification (Lakshan *et al.* 2020), butterfly pea flower extract obtained by soaking flower simplisia with a simplisia: distilled water ratio of 1: 10 for 12 hours and filtered until a filtrate is obtained. Then the filtrate was concentrated using a 50 °C waterbath for 30 minutes.

The process of jelly candy production in this study is based on the research conducted by Fransiska and Onphing (2023), with certain modifications (Table 1). The ingredients were measured according to the specified composition. Gelatine was soaked in cold water until it swelled, with a gelatine-to-water ratio of 1:2 (w/v). Water, sucrose, and glucose syrup were heated and thoroughly stirred. The mixture was heated to a temperature of 110-115°C until it solidified or formed a gel. It was then allowed to cool slightly before the addition of butterfly pea flower extract and lemon juice, which were stirred in until the color was evenly distributed throughout the candy. The candy solution was poured into molds and left to set for 30 minutes before being placed in a refrigerator to solidified.

The test carried out on gelatine is the yield while the test for butterfly pea flower jelly candy consists of parametric and non-parametric tests. Parametric test parameters include texture profile analysis (TPA) and color according to Wagiman *et al.* (2024), moisture content, ash content, and protein content based on AOAC (2005), antioxidant activity based on Kusumah *et al.* (2021), and non-parametric test parameters, namely hedonic.

The experimental design used in the study was a completely randomized design (CRD) with one factor consisting of three levels of replication. The factor observed was the addition of catfish skin gelatine with concentrations of 4%, 8%, 12%. Parametric data were analyzed by ANOVA test and Honest Real Difference (BNJ) test while non-parametric data were analyzed by Kruskall Wallis and Mann Whitney.

Table 1. Formulation

Ingredients	Concentrations of gelatine					
	4%		8%		12%	
	(%)	(g)	(%)	(g)	(%)	(g)
Gelatine	4	4	8	8	12	12
Sucrose	32	32	32	32	32	32
High Fructose Syrup	20	20	20	20	20	20
Lemon	1	1	1	1	1	1
Butterfly Pea Flower Extract	2	2	2	2	2	2
Water	41	41	37	37	33	33
Total	100	100	100	100	100	100

RESULT AND DISCUSSION

Characteristics of Catfish Skin Gelatine

The yield is obtained from the ratio of the weight of dry gelatine obtained from the raw material of catfish skin in a clean state through the extraction process. The yield value of catfish skin gelatine in this study was 14.83%. The high and low yield value obtained can be influenced by several factors such as the type of raw material used, pH, extraction temperature, and the solution used in the extraction process. The acidity level and solvent concentration used during soaking will affect the collagen hydrolysis process so that the yield value will increase. Ridhay *et al.* (2016) reported that the higher the H^+ ions owned by the solvent, the more the yield value increases because H^+ ions are the number of ions that hydrolyze collagen. The amount of H^+ ions can facilitate the process of converting collagen into gelatine because of the binding process of calcium minerals so that collagen is freed.

The gel strength value of catfish skin gelatine is 395.15 blooms. This value shows that fish skin gelatine meets the quality requirements of fish gelatine based on SNI 8622: 2018, which is at least 75 blooms and GMIA 2019, which is 50-300 blooms. The gel strength of gelatine can be affected by the concentration of the solvent used. The higher the concentration of acid used will cause the gel strength of gelatine to decrease, this is because the high concentration of acid solvents can cause further denaturation of collagen so as to break all hydrogen bonds and peptide bonds in collagen to become shorter so that the molecular weight becomes low. According to (Nikoo *et al.* 2014), the conversion of collagen to gelatine during the extraction process produces molecules with varying masses due to the cleavage of

covalent cross-links between peptide chains. Acid concentration can affect the protein banding pattern of gelatine, high acid concentration produces gelatine with shorter protein banding pattern while low acid concentration produces gelatine products with long protein banding pattern.

Characteristics of Butterfly Pea Flower Jelly Candy

Hardness is a texture analysis that aims to determine the level of hardness of a product. The highest hardness value was obtained at 12% gelatine addition (Table 2.). These results show that the higher the concentration of gelatine added to jelly candy, the value of hardness increases ($p < 0.05$). The increasing amount of gelatine makes the polymer in the gel matrix increase so that the cross-links formed are tighter. This is in line with research conducted by (Zulfajri *et al.* 2018), gelatine concentration is one of the most important factors in the gel formation process. The greater the concentration of gelatine, the protein molecules will bind each other more tightly to form a network that causes the hardness of the candy to be higher.

Cohesiveness is the degree to which a material is mechanically crushed. The addition of 4% gelatine concentration gave the highest cohesiveness value (Table 2.) However, the 8% and 12% concentrations did not give a significant effect ($p > 0.05$). The two concentrations did not show a significant difference because at a concentration of 12% the process of forming pores in the jelly candy structure was maximized due to the smaller amount of water composition. The water composition of 8% concentration jelly candy is more than 12% concentration so that when testing the texture of jelly candy does not have a stronger resistance than 8% concentration. The

addition of gelatine concentration can cause an increase in volume and form pores that are not uniform, causing the density of the candy structure to decrease, which makes the cohesiveness value decrease. According to (Widija *et al.* 2017), increasing the concentration of hydrocolloids can cause the volume of the product to increase, forming a non-uniform molecular structure. The formation of a non-uniform volume due to the increase in volume makes the density of the product structure decrease, resulting in a decreasing cohesiveness value.

Springiness is a test conducted to determine the elastic value of jelly candy. The addition of catfish skin gelatine with a concentration of 4% had the lowest springiness value (Table 2.) The increase in springiness value occurred after the addition of catfish skin gelatine concentrations of 8% and 12% but both were not significantly different ($p > 0.05$). The increasing springiness value indicates that the jelly candy has an increasingly elastic texture. The elastic texture of jelly candy is due to the use of gelatine. A high concentration of gelatine will increase the gel formation process so that it forms solid properties and is more chewy and elastic while a low concentration of gelatine will form properties that still resemble liquid. More gelatine particles in the material will cause more water to be bound and absorbed. According to Atmaka *et al.* (2013), gelatine is composed of polypeptides, so it has a higher level of elasticity compared to other types of hydrocolloids. Jelly candy made with gelatine as the main ingredient will have a higher elasticity value compared to jelly candy made from carrageenan.

Gumminess is a texture analysis that gives a chewy characteristic, gumminess value increased (Table 2.) along with the addition of gelatine concentration ($p < 0.05$). The increase in the chewiness value is due to the process of binding water so that there is a density between the matrices in the material. Gelatine as a gelling agent has a role in the process of binding water in the gel formation process. The higher the concentration of gelatine, the stronger the gelatine in binding water. According to Yati *et al.* (2013), the addition of a small amount of gelling agent causes the gelling molecules to be weaker against water so that the bond between the gelling agent molecules to water is weak. The weak molecular bond makes the candy have wetter characteristics so that its stickiness decreases.

Chewiness is one of the texture analysis parameters that describe chewability. The increase in gelatine concentration influenced chewiness so that the increase in gelatine concentration (Table 2.) resulted in an increase in chewiness ($p < 0.05$). The increased chewiness is because gelatine can make the texture chewy like rubber due to the gel formation process that can interact with water and sugar to form gelation and chewy gel. Chewiness is influenced by hardness because hardness is the main factor perceived by consumers on the texture of jelly candy. According to (Zhou *et al.*, 2021), hardness and chewiness increased significantly with increasing gelatine concentration. The increase in values is due to the formation of a more compact three-dimensional structure between gelatine molecules.

Fracture force or fracturability is a texture analysis used to determine the level of brittleness of a food ingredient due to the force applied. The fracture force value of jelly candy increased (Table 2) long with the addition of gelatine concentration ($p < 0.05$). The addition of fish skin gelatine concentration causes a higher fracture force value. An increased fracture force indicates that the product is not easily broken. Fracturability describes the brittleness of the product being tested. The higher the fracturability value, the harder the product is so that it does not break easily and the greater the force required to break the product. Factors that can affect the brittleness of the product are composition and processing.

Adhesiveness is one of the parameters in texture analysis to determine the stickiness value of a product. The stickiness of the candy products decreased (Table 2.) as the adhesiveness value decreased due to the increasing use of gelatine ($p < 0.05$). Analysis of the adhesiveness of the product can show positive or negative values. A negative adhesiveness value indicates that the stickiness value of the product is higher. The effect of gelatine on stickiness is that gelatine has the ability to bind water in the process of gel formation. The higher the concentration of gelatine added, the more optimal the performance of gelatine in binding water and forming a three-dimensional network that makes the texture of candy which was initially liquid becomes more compact during the cooking process. According to Pelawi *et al.* (2024), gelatine can bind water in forming the body of jelly candy so that the internal bond formed in the candy will be higher. Adhesiveness can be determined from the viscosity of the candy, the higher the viscosity of the product, the higher the adhesiveness value.

Table 2. Texture Profile of Butterfly Pea Flower Jelly Candy

Parameter	Gelatine 4%	Gelatine 8%	Gelatine 12%
Hardness	0.9 ± 0.01 ^a	3.70 ± 0.10 ^b	5.33 ± 0.18 ^c
Cohesiveness	0.61 ± 0.01 ^b	0.41 ± 0.26 ^a	0.41 ± 0.01 ^a
Springiness	8.81 ± 0.14 ^a	10.90 ± 0.03 ^b	10.94 ± 0.01 ^b
Gumminess	0.55 ± 0.02 ^a	1.42 ± 0.02 ^b	2.40 ± 0.08 ^c
Chewiness	4.87 ± 0.16 ^a	15.62 ± 0.13 ^b	24.30 ± 0.69 ^c
Fracture force	0.09 ± 0.01 ^a	3.17 ± 0.09 ^b	4.67 ± 0.09 ^c
Adhesiveness	0.30 ± 0.04 ^b	-0.30 ± 0.01 ^a	-0.30 ± 0.01 ^a

Note: Data is the mean of three replicates ± standard deviation; Data followed by different lowercase letters in the same row indicate a significant difference ($p < 0.05$); Data followed by the same lowercase sign in the same row indicates no significant difference ($p > 0.05$)

Chemical Properties of Butterfly Pea Flower Jelly Candy

The difference in concentration of catfish skin gelatine gave a significant difference ($p < 0.05$) in the water content of butterfly pea flower jelly candy. The value of water content of jelly candy listed in (Table 3.) has met the quality requirements based on SNI 3547.2-2008 Soft Sugar Confectionery, with a maximum limit of water content of 20%. Increasing the concentration of gelatine used also causes a decrease in the water content of jelly candy, this is due to a decrease in the composition of water used in making jelly candy due to the addition of gelatine. The addition of gelatine in making jelly candy makes the water formulation reduced so that jelly candy with a high gelatine concentration will have a greater amount of solids than the liquid.

The increase in gelatine concentration influenced the ash content so that the increase in gelatine concentration (Table 3.) resulted in an increase in ash content ($p < 0.05$). The quality requirement for the ash content of jelly candy based on SNI 3547.2-2008 Soft Sugar Confectionery is a maximum of 3%. The results of ash content in this study for gelatine concentrations of 4% and 8% have met the SNI requirements because they have ash content $< 3\%$, while the 12% concentration does not meet the SNI quality requirements because the ash content is $> 3\%$. Increasing gelatine concentration causes the ash content value to increase. Ash content is closely related to the mineral content of a material. The mineral content contained in gelatine ranges from 2-4%, so the increasing concentration of gelatine causes the ash content of the product to increase.

The addition of gelatine concentration showed an increase in the protein content of jelly candy ($p < 0.05$). Gelatine is protein derived from the hydrolysis process of collagen owned by connective tissue in the skin. The lowest protein content was in bay flower jelly candy with 4% gelatine concentration, and the highest was in 12% gelatine treatment (Table 3.). The protein content in this study is higher than the research conducted by Prihardhani and Yunianta (2016), jelly candy with the addition of lencam fish skin gelatine with a concentration of 8% has a protein content of 5.20%. The protein content of commercial jelly candy is 3.98%. The difference in value is due to differences in the use of raw materials in the manufacture of gelatine. The protein content of lencam fish skin gelatine is 85.83% while commercial gelatine is 75.13%. Research conducted by Oktaviani *et al.* (2017), catfish skin gelatine extracted using the acid method with sulfuric acid pH 3 has a protein content of 88.36%. The increase in protein content of jelly candy is because gelatine is composed of several types of amino acids such as proline, alanine, glutamic acid, glycine, and hydroxyproline. According to Irvan *et al.* (2019), protein content is influenced by the fish gelatine raw materials used such as species and collagen content. Low collagen content can accelerate the protein degradation process.

Antioxidant Activity

The addition of catfish skin gelatine concentration had a significant effect ($p < 0.05$) on the antioxidant activity of butterfly pea flower jelly candy. The IC_{50} value of the control jelly candy without the addition of butterfly pea flower extract belongs to the weak antioxidant category. Jelly

candy with 4% gelatine added is included in the medium antioxidant. The addition of 8% and 12% gelatine was categorized as strong antioxidant (**Figure 1**). Samples with IC_{50} results of 50-100 ppm are categorized as having strong antioxidant activity. The medium antioxidant activity category is given to samples with IC_{50} values of 100-150 ppm (Cahyaningsih *et al.*, 2019). The decrease in the IC_{50} value of bay flower jelly candy as the concentration of catfish skin gelatine used increases indicates higher antioxidant activity. The role of gelatine can help butterfly pea flower extract to produce antioxidant compounds in jelly candy. The amino acids contained in gelatine have properties that can work as antioxidant, antimicrobial, and antihypertensive compounds. Patin fish skin contains the amino acids proline and glycine. According to (Nikoo *et al.* 2014), glycine and proline are amino acids from gelatine that contribute to counteracting free radicals.

Color

The addition of fish skin gelatine with different concentrations did not give a significantly different effect on the color L^* , a^* , b^* of bay flower jelly candy ($p > 0.05$). The L^* -value of butterfly pea flower jelly candy (Table 4.) shows a low value because the candy has a dark color,

namely purplish blue. The low value of the a^* parameter (Table 4.) indicates that the jelly candy has a tendency to have a color that is close to green. The b^* -value of jelly candy in this study (Table 4.) tends to have a low value because the candy has a characteristic purplish blue color obtained from the addition of butterfly pea flower extract.

Hedonic results showed that different concentrations of catfish skin gelatine did not have a significant effect on the aroma parameter. The most preferred aroma by panelists was the bay flower jelly candy with 8% gelatine formulation with a value of 7.23. The aroma of butterfly pea flower jelly candy is due to the addition of lemon aroma from lemon juice.

Hedonic

Hedonic results showed that different concentrations of catfish skin gelatine had a significant effect on the parameters of taste, texture, and appearance. The most preferred flavor by panelists was the butterfly pea flower jelly candy with 8% gelatine formulation with a value of 7.97. Increasing gelatine concentration causes the sweetness of the jelly candy to decrease.

The appearance of butterfly pea flower jelly candy that is most favored by panelists is in the formulation of adding 8% gelatine with a value of

Table 3. Chemical Properties of Butterfly Pea Flower Jelly Candy

Parameters	Concentrations of Gelatine		
	4%	8%	12%
Moisture Content (%)	19.7 ± 0.48^c	15.64 ± 0.35^b	10.44 ± 0.41^a
Ash Content (%)	1.63 ± 0.01^a	2.26 ± 0.24^b	3.21 ± 1.40^d
Protein Content (%)	5.04 ± 0.31^a	9.03 ± 0.11^b	12.25 ± 0.15^d

Note: Data is the mean of three replicates $\pm$ standard deviation; Data followed by different lowercase letters in the same row indicate a significant difference ($p < 0.05$)

Table 4. Color Characteristics of Butterfly Pea Flower Jelly Candy

Concentration of Gelatine (%)	L^*	a^*	b^*
4	19.59 ± 0.12^a	0.45 ± 0.09^a	0.74 ± 0.09^a
8	19.51 ± 0.67^a	0.44 ± 0.02^a	0.63 ± 0.03^a
12	21.14 ± 1.05^a	0.38 ± 0.03^a	0.68 ± 0.01^a

Note: Data is the mean of three replicates $\pm$ standard deviation; Data followed by the same lowercase sign in the same column indicate no significant difference ($p > 0.05$)

Table 5. Hedonic value of Butterfly Pea Flower Jelly Candy

Concentration of Gelatine (%)	Spesification				
	Appearance	Texture	Fragrance	Flavor	Convidence Interval
4	7.20±1.06 ^a	6.13±1.78 ^a	6.93±1.11 ^a	7.37±1.19 ^a	6.59<μ<7.23
8	8.03±0.89 ^b	6.90±1.37 ^b	7.23±1.10 ^a	7.97±0.72 ^b	7.30<μ<7.76
12	7.73±0.78 ^b	7.63±0.85 ^c	7.10±1.16 ^a	6.87±1.28 ^a	7.12<μ<7.54

Note: Data is the mean of data from thirty panelists (30) ± standard deviation.; Data followed by different lowercase signs in the same column indicate a significant difference ($p < 0.05$); Data followed by the same lowercase sign in the same column indicates no significant difference ($p > 0.05$)

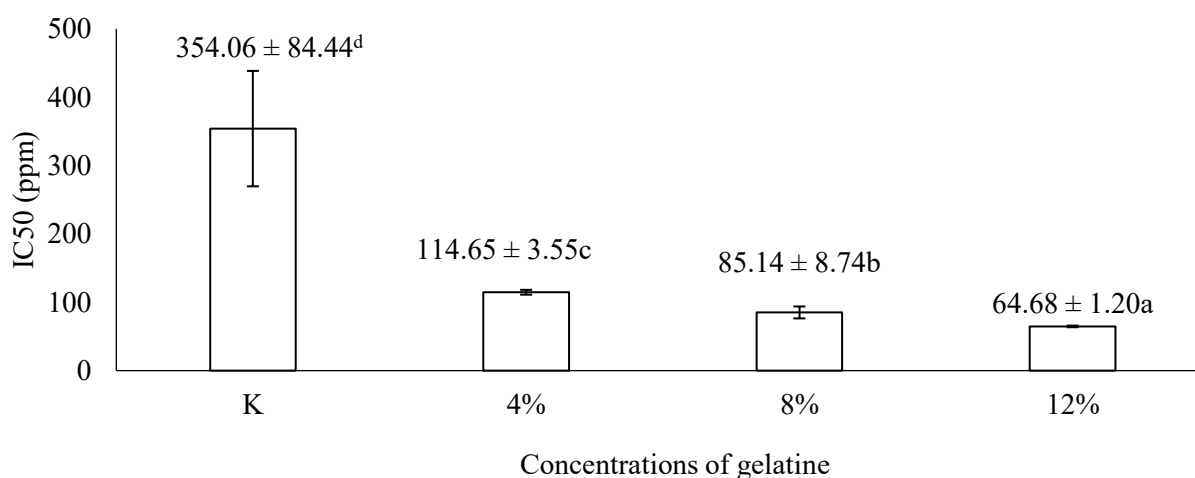


Figure 1. Antioxidant Activity of IC₅₀ in Butterfly Pea Flower Jelly Candy. Data is the mean of three replicates ± standard deviation; Data followed by different lowercase signs indicate a significant difference ($p < 0.05$); K is the control jelly candy without the addition of butterfly pea flower extract.

8.03. Telang flower jelly candy with a low concentration of gelatine has an appearance that is not intact because the characteristics of the candy produced from a low concentration of gelatine tend to be sticky so that the jelly candy becomes easily damaged because it is too sticky to the surface of the mold.

The texture most favored by panelists was the texture of jelly candy with the addition of 12% gelatine with a value of 7.63. The texture of jelly candy is influenced by the addition of gelatine as a gelling agent. The greater the concentration of gelatine, the protein molecules will bind each other more tightly to form a network that causes the hardness of the candy to be higher.

CONCLUSION

The addition of catfish skin gelatine influenced the physicochemical characteristics of

butterfly pea flower jelly candy, including increasing hardness, springiness, gumminess, chewiness, fracture force, protein content, ash content, antioxidant activity, decreasing cohesiveness, adhesiveness, and water content. Butterfly pea flower jelly candy with the addition of 8% catfish skin gelatine is most favored by panelists. Suggestion for further research, method of gelatine extraction using acidic method as well as observe for the shelf life of the product need to be carried out.

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