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Application of Carrageenan and Arabic Gum in Improving the Characteristics of Jelly Candy from Musa Sapientum L.

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A B S T R A C T

Carrageenan is a versatile hydrocolloid used as a gelling agent, emulsifier, stabilizer, and viscosity enhancer. It enhances jelly texture to make it chewier. Current jelly candies in the market often suffer from a hard texture and lackluster flavor. Carrageenan and gum arabic are key additives that can improve jelly candy quality. This study analyzed how different concentrations of these additives affect Musa sapientum L. jelly candy. The research used a completely randomized design with triplicate experiments, analyzing data with ANOVA followed by HSD for significant differences. Parameters such as moisture, ash content, reducing sugar, and texture were measured. The study found that varying carrageenan and gum arabic concentrations significantly affected the jelly candy's characteristics. The optimal quality was achieved with 15% carrageenan and 3% gum arabic, resulting in a texture hardness of 3.27 Kg/f, moisture content of 11.86%, ash content of 2.1%, reducing sugar of 5.72%, and an organoleptic score between 7.67 and 8.23.

Keywords: Carrageenan, Arabic gum, jelly candy.

1. Introduction

Soft jelly confectionery, commonly referred to as jelly candy, attains its characteristic chewy consistency through the incorporation of hydrocolloids such as agar, gum, pectin, starch, carrageenan, and gelatin. This confection undergoes specific processing and maturation to achieve the desired properties. Bananas are a viable ingredient for jelly candy production due to their high potassium content, which is vital for cardiac function and efficient blood circulation, thereby potentially mitigating the risk of strokes associated with hypertension. Additionally, bananas offer nutritional benefits, comprising 131 calories, carbohydrates, proteins, vitamins A and C, minerals, iron, calcium, and ascorbic acid. Pectin, a gel-forming polysaccharide, has been recognized for centuries and is predominantly located in the flesh and peel of fruits. Apples, oranges, bananas, and carrots are considered excellent sources of pectin **(Perina et al., 2007, Fitriani, 2003)** . Bananas contain 5.24% dry weight pectin, which can be used to make jelly candy **(Hanum et al. 2012)**. Bananas have low methoxyl levels (< 7%), making it hard to achieve a firm texture in jelly candy. Thus, additional gelling agents are needed **(Saparinto, 2011)**.

Carrageenan, a polysaccharide from seaweed, is widely used in the food industry as an emulsifying agent, gel-making ingredient, stabilizer, and thickener. It contains potassium, sodium, calcium, magnesium, and ammonium sulfate esters. Its use has recently increased, reflecting a growing trend in food processing. Seaweed extracts like agar, carrageenan, and alginate are common stabilizers **(Winarno, 1996)**. Carrageenan functions as a thickening agent and has been employed as an alternative to borax in the preparation of meatballs, wet noodles, and various other food products. It is classified as a hydrocolloid, which is extracted from red seaweed through the application of hot water or alkaline solutions at elevated temperatures **(Jumri et al., 2015)**. Rahmah (2012) indicates that the incorporation of up to 10% carrageenan enhances the stability and density of jelly candy. Increased levels of carrageenan are associated with a firmer texture. However, an optimal formulation that combines both carrageenan and banana juice remains unestablished. Several studies have explored various formulations to assess their effects on the physical, chemical, and sensory attributes of jelly candy **(Utomo, 2016)**. Gelling agents such as carrageenan and gum arabic, employed as thickeners, emulsifiers, and stabilizers, have an impact on the quality of jelly candy. Carrageenan, classified as a hydrocolloid, is capable of forming gels and thickening liquids, whereas gum arabic exhibits higher water solubility. This study investigates the influence of carrageenan and gum arabic on the characteristics of *Musa sapientum* L. jelly candy.

2. Materials and Methods

2.1 Material

The primary constituent utilized in the production of jelly confectionery is the citronella plantain (*Musa sapientum* L.), sourced from the Jambu Dua market in Bogor, West Java. To minimize the risk of degradation, the raw materials are processed in immediate proximity to the site of research execution. Carrageenan, gum arabic, brown sugar, and granulated sugar are incorporated into the jelly candy manufacturing process.

2.2 Methdod

2.2.1 The process of making banana juice

The production of king *Musa sapientum* L. jelly banana candy involved two main processes: banana juice production and jelly candy formation. First, fresh bananas were selected, washed, and steam-blanched for 5 minutes at 50°C. After peeling, the banana flesh was homogenized with water in a 1:2 ratio (w/v) for 5 minutes, then filtered to separate juice from solids. The juice was a key ingredient in the jelly candy **(Setyaningsih et al., 2010)**.

2.2.2 The process of making jelly candy

Combine 100 milliliters of banana juice, 50 g of sugar, carrageenan, and gum arabic at the specified ratios (13%: 5%, 14%: 4%, and 15%: 3%). Thoroughly blend the components. Subject the mixture to heating in boiling water for a duration of 10 minutes while continuously stirring until complete dissolution is achieved. Subsequently, transfer the mixture into a mold with dimensions of 10 by 5 by 1 cm and allow it to solidify for 1 h. Upon solidification, section the product into pieces measuring 2 by 2 by 2 centimeters, systematically arrange these pieces within a baking dish, and proceed to dry them in an oven for a period of 24 hours at a temperature of 500 degrees Celsius. Finally, store the desiccated jelly confections in a suitable container.

2.3 Hardness

The texture or ductility test used a 2 cm cube jelly candy. The texture analyzer was connected to the computer, which was powered on. A P/6 probe (6 mm SS) at 2 mm/s speed was aligned with the sample. The test started with the monitor at zero, and the probe engaged the sample. The test finished when the probe returned to its start position. Results were in graphical or numerical format. The device is a TA-XT21 with a 25 kg load capacity.

2.4 Water Content

The weighing bottle was preheated for 30 minutes at 100 - 105°C, cooled in a desiccator, and then weighed. A pulverized sample of 1 g was placed in the cup. The bottle with the sample was heated for 6 hours without touching oven walls, cooled in a desiccator, and weighed. It was then dried and weighed repeatedly until a constant mass (c g) was reached. The water content was calculated using a specific formula.:

$$\% \text{ moisture content} = \frac{B - C}{B - A} x 100\% \qquad (1)$$

Information: A = empty weight of they weighing bottle (g)

B = bottle and sample weight (g)

C = weight of bottles and samples after baking (g)

2.5 Ash content

To determine ash content, the porcelain cup was preheated in an oven at 100-1050°C for 30 minutes, cooled in a desiccator, and weighed. A 2-gram sample was placed in the cup, burned until smoke stopped, then ashed in a furnace at 550-6000°C. The ash was cooled in a desiccator and weighed until a constant weight was achieved.

2.6 Reducing Sugar

A homogenized sample of 2.5 to 5 grams was added to a 10 ml volumetric flask, filled with distilled water to the mark. A 10 ml portion of this was mixed with 25 ml of Luff solution in a 250 ml Erlenmeyer flask, boiled for 10 minutes, and cooled. Then, 10 ml of 15% KL solution, 25 ml of H2SO4, and 25 ml of starch indicator were added. For the blank, a separate flask contained 25 ml of Luff solution and 25 ml of water. Titration used 0.1 N sodium thiosulfate, with 2-3 ml of starch indicator added at the endpoint change from blue to milky white. The volume of thiosulfate used correlated to the amount of reducing sugars.

2.7 Scanning Electron Microscope

The Scanning Electron Microscope (SEM) images a sample's surface using a high-energy electron beam. It characterizes surface morphology by reflecting the beam, creating a secondary electron beam. The SEM detects the beam with the highest intensity. Electron waves from the gun are focused by lenses, and the scanning coil's magnetic field directs the beam. When it hits the sample, secondary electrons form, collected by detectors. The image, shown on a screen, depicts the specimen's topography as dots of varying intensities.

2.8 Sensory analysis

Organoleptic tests include testing color, scent, texture, and overall appearance. Organoleptic properties were measured using hedonic or preference tests **(Iwanda et al., 2016)**. In the preference test, 30 panelists were asked to give their impressions of the appearance, smell, texture, taste, and overall taste.

2.9 Data Analysis

The data obtained from the test results using the Completely Randomized Design (CRD) method was then analyzed using variance analysis (ANOVA) at the 95% confidence level. Data processing uses the SPSS application where the results are significantly different ($p<0.05$) and will be further analyzed with Honest Significant Differences (HSD) for parametric data. Nonparametric data analysis was carried out using the Kruskal Wallis test, where if the results were significantly different ($p<0.05$), then the Mann-Whitney test was used.

3. Result and Discussion

3.1 Hardness

Texture of *Musa sapientum L.*jelly candy with carrageenan treatment: gum arabic successively 13%, 5%, 14%, 4% and 15% : 3% of the total banana juice used 100 ml. The average chewiness values of the *Musa sapientum L.* jelly candy from plantain are shown in Table 1.

Table 1. Hardness Value of *Musa sapientum* L. Jelly Candy Using Different Treatments

Treatment	Hardness (Kgf)
K	$1{,}47 \pm 0{,}08^{a}$
P1	$2{,}08 \pm 0{,}09^{b}$
P2	$2{,}97 \pm 0{,}10^{c}$
P3	$3{,}27 \pm 0{,}06^{d}$

The study on *Musa sapientum* L. jelly candy showed that varying carrageenan and gum arabic levels significantly affected its texture. The HSD test confirmed significant differences ($p < 0.05$) across treatments due to these variations. Higher carrageenan levels increased chewiness and elasticity but decreased beyond 100% concentration **(Harijono et al., 2001)**. Excessive carrageenan results in a stiff gel, reducing palatability **(Wijana et al., 2014)**. Cooking time affects jelly's elasticity, increasing thickness as fruit juice evaporates. Longer cooking makes it harder to chew due to water loss. Carrageenan increases jelly elasticity. In texture tests, the third treatment (15% carrageenan, 3% gum Arabic) scored highest at 3.27 kgf. The second (14% carrageenan, 4% gum Arabic) scored 2.97 kgf, and the first scored lowest at 2.08 kgf. Pineapple jelly candy's hardness averaged 22.20 g to 107.65 g. Carrageenan concentration significantly impacts hardness, linked to its and gelatin's water-binding capacity **(Mahardika et al., 2014)**.

Table 2. Test results for water content, ash content and reduction of *Musa sapientum* L. jelly candies

Treatment	Water Content (%)	Ash Content (%)	Reducing sugar (%)
K	$19{,}52 \pm 0{,}34^{d}$	$1{,}41 \pm 0{,}066^{a}$	$6{,}98 \pm 0{,}17^{b}$
P1	$14{,}16 \pm 0{,}16^{bc}$	$1{,}93 \pm 0{,}040^{b}$	$7{,}61 \pm 0{,}19^{d}$
P2	$13{,}56 \pm 0{,}58^{b}$	$2{,}07 \pm 0{,}035^{c}$	$7{,}00 \pm 0{,}12^{bc}$
P3	$11{,}86 \pm 0{,}36^{a}$	$2{,}10 \pm 0{,}025^{cd}$	$5{,}72 \pm 0{,}06^{a}$

3.2 Water Content

Table 2 details the proximate test findings. *M. sapientum* L jelly candy's water content was lowest in treatment P3 with 15% carrageenan and 3% gum arabic at 11.86%. Treatment P2 used 14% carrageenan and 4% gum arabic, resulting in 13.56%, while P1 had the highest at 14.16%. The study showed a significant effect of gum arabic and carrageenan ($p <0.01$) on the water content of passion fruit jelly. Higher carrageenan concentration and longer cooking reduced water content, affecting the candy's firmness (Winarno, 2002). The water content in raw materials is crucial for processed products (Santoso et al., 2013).

Table 2 shows that high carrageenan and low arabic gum reduce water content in *M. sapientum* jelly candy, while low carrageenan and high arabic gum increase it, due to gum arabic's superior water-binding. Water binding depends on hydroxyl group quantity and molecular mass. More carrageenan thickens fruit juice and reduces water as solids increase, due to negative charge repulsion (Suptijah et al., 2013). Sulfate groups also stiffen molecular chains and thicken the solution. Gel strength increases with reduced water content (Wijana et al., 2014).

3.3 Ash content (Luff school)

Statistical tests showed significant differences ($p<0.05$). Follow-up HSD tests revealed that treatments P1 and P2 had significantly different ash content; P2 and P3 were similar, while P1 differed from K. Treatment K also differed from P2 and P3. The highest ash content was in P3 (15% carrageenan, 3% gum arabic) at 2.1%, followed by P2 (14% carrageenan, 4% gum arabic) at 2.07%, and the lowest in P1 at 1.93%. Average ash content ranged from 0.510% to 1.160%. ANOVA showed significant differences due to carrageenan concentration variation. The increased ash content might be due to more carrageenan and gelatin (Mahardika et al., 2014). This is supported Hunaefi, 2002), as ash content rises with added carrageenan and alginate. More carrageenan increases mineral (inorganic) content, raising ash content. The study's ash content ranged from 1.41% to 2.1%, varying due to inorganic compounds (**Rosida and Taqwa, 2019**). Winarno (2008) stated that ash content corresponds to the mineral presence in the product.

3.4 Reducing Sugar

The reducing sugar content is detailed in Table 2. The HSD test ($p<0.05$) shows significant differences in sugar reduction between treatments P1 and P2, with P2 and P3 having similar values in jelly candy. Treatment P3 differed significantly from treatment K, which was different from P1 and P3 but not from P2. The lowest sugar content was found in treatment P3 (15% carrageenan, 3% gum arabic) at 5.72%, followed by P2 (14% carrageenan, 4% gum arabic) at 7%, and the highest in P1 at 7.61%. The jelly candy meets SNI 3547-2-2008 standards with a maximum of 25% sugar **(Juliyanti et al., 2018)**. Purple sweet potato jelly candy sugar content ranges from 22.70 to 23.09% **(Less & Jackson, 2004)**. Reducing sugars result from sucrose inversion due to heat and acid interaction **(Praseptianggal et al., 2016)**. Increased gum arabic and decreased carrageenan raise reducing sugar. More gum arabic lowers reducing sugar in jelly candy. Plantain *M. sapientum* jelly candy has reducing sugar values between 5.72% to 7.61%. Higher gum arabic levels increase reducing sugar in jackfruit leather. Gum arabic is a heteropolysaccharide comprising 26.1% arabinose, 9.9% rhamnose, 40.1% galactose, and 9.4% glucuronic acid **(Qi et al., 1991)**.

Gum arabic contains arabinose, glucuronic acid, and galactose, functioning as a reducing sugar due to a free aldehyde group in glucuronic acid and galactose. Higher gum arabic levels increase reducing sugar content. Bananas also boost reducing sugars in jelly candy, mainly due to fructose, a monosaccharide with reducing properties **(Mandiri et al., 2022)**.

Scanning electron microscopeelectron microscope

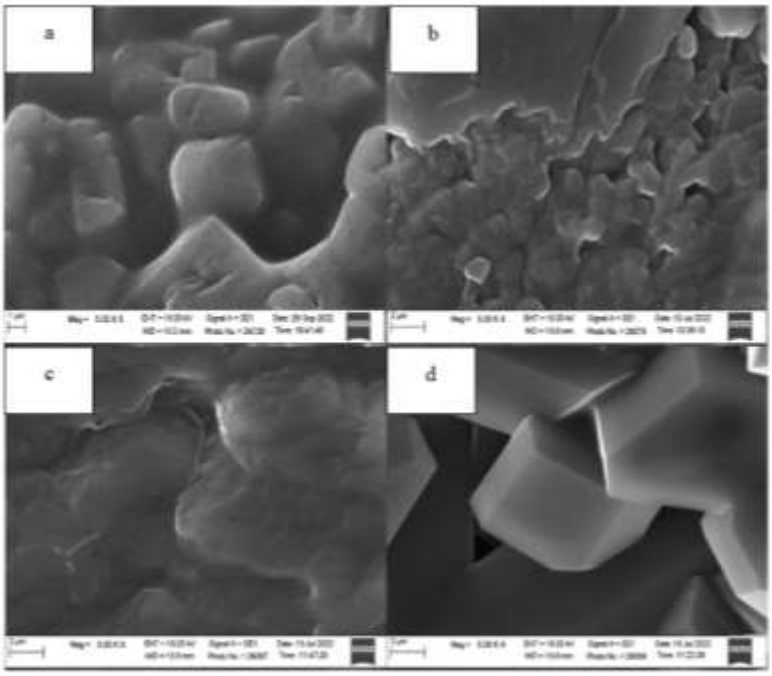

Fig. 1. Observation results of the surface of jelly candy at 5000X Magnification. (a) Control; (b) Treatment 1; (c) Treatment 2; (d) Treatment 3.

SEM analysis shows that K treatment of *M. sapientum* jelly candy has a dense, stacked-cube surface. P1 has loosely constructed cube shapes, P2 has a dense, tightly structured morphology, and P3 has a thick, tightly structured surface with varied sizes. SEM micrographs reveal carrageenan in ice cream cones improves density, reduces water content, enhances crispness, and increases durability. This aligns with water content, texture, and durability test findings **(Marpaung & Sinulingga, 2020)**.

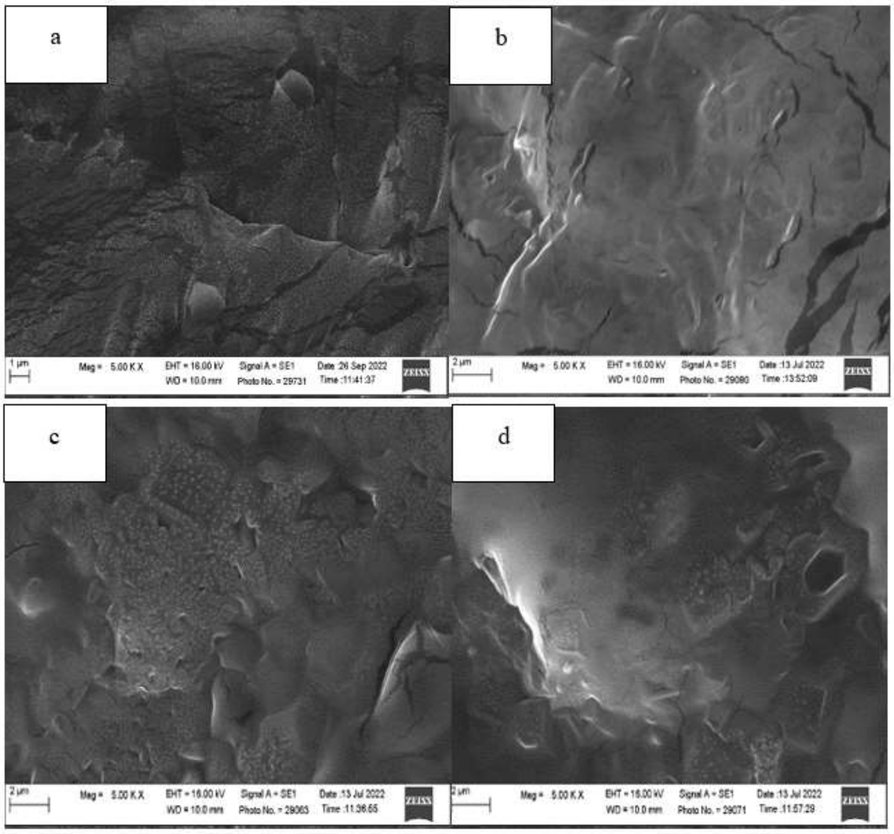

Fig. 2. Observation Results of the Inside of the Jelly Candy 5000X Magnification. (a) Control; (b) Treatment 1; (c) Treatment 2; (d) Treatment 3.

The SEM analysis of four *M. sapientum* jelly candy treatments showed variations in internal morphology: K treatment had a dense structure with white spots, P1 displayed a repetitive structure with a white point, P2 featured bubbles and white dots, and P3 had a tightly packed structure. Microstructural analysis precisely determines the shape and composition of food ingredients, correlating with moisture, texture, and durability tests. SEM, a high-resolution electron microscope, assesses sample morphology and surface thickness. Differences in jelly candy structure are linked to varying concentrations of carrageenan and gum arabic, which contribute to a cohesive structure. Carrageenan forms a reticular structure under thermal conditions, resulting in a densely packed gel matrix with minimal voids **(Tarwendah, 2017)**.

3.5 Sensory analysis

Sensory analysis were carried out by evaluating four parameters: appearance, scent, taste, and texture, as shown in Table 3.

Table 3. Sensory analysis of *M. sapientum* Jelly Candy

Treatment	**specification**				**confidence interval.**
	Appearance	**Scent**	**Flavor**	**Texture**	
K	$7,06 \pm 1,11^{b}$	$7,26 \pm 0,98^{a}$	$6,06 \pm 1,01^{a}$	$5,13 \pm 1,04^{c}$	$6,19 \leq \mu \leq 6,57$
P1	$7,53 \pm 1,27^{b}$	$7,73 \pm 0,98^{a}$	$8,00 \pm 1,02^{a}$	$7,53 \pm 0,89^{c}$	$7,55 \leq \mu \leq 7,85$
P2	$7,66 \pm 1,32^{b}$	$7,80 \pm 0,86^{a}$	$7,93 \pm 1,01^{a}$	$7,60 \pm 0,93^{bc}$	$7,56 \leq \mu \leq 8,14$
P3	$7,80 \pm 1,34^{b}$	$8,00 \pm 1,01^{a}$	$8,13 \pm 1,00^{a}$	$7,86 \pm 1,00^{b}$	$7,67 \leq \mu \leq 8,23$

The organoleptic evaluation, meticulously conducted through a hedonic scale, unveiled remarkable impacts on the vibrant plantain *M. sapientum* jelly candy's attributes. The P3 treatment, boasting a precise blend of 15% carrageenan and 3% gum arabic, achieved an impressive confidence interval ranging from 7.67 to 8.23, showcasing its exemplary quality. In contrast, the P2 and P1 treatments, though slightly trailing, alongside treatment K with intervals between 6.19 and 6.57, collectively affirmed the candy's delightful suitability for consumption (see Table 3). Visual allure is of paramount importance, mirroring consumer preferences, with appearance scores spanning from 7.06 to 7.8. Intriguingly, the Kruskal-Wallis analysis revealed no significant differences in appearance ($p>0.05$) across varying carrageenan and gum arabic concentrations—a testament to their consistent attractiveness. Appearance forms a crucial link to consumer choice, tied to the product's esteemed quality, encompassing dimensions like color, shape, and size **(Wijana et al., 2014)**. Sensory evaluations can also delve into surface characteristics, notably texture **(Tarwendah, 2017)**. Furthermore, scent emerges as a pivotal aspect, with preference tests yielding scores between 7.26 and 8, underscoring the candy's favorable reception among consumers. Kruskal-Wallis analysis demonstrated that ingredient variations did not significantly alter the scent ($p>0.05$), ensuring a steadfast aromatic appeal.

Aromas are crucial in shaping consumer preferences and product desirability, right after visual impressions. The fragrance significantly enhances consumer acceptance, especially when it aligns with the core ingredients' natural smell. In food products, scent perception is a multisensory experience involving volatile compounds entering the nasal cavity, either through breathing or while eating **(Winarno, 2008)**. Notably, the aroma of K-treated jelly and carrageenan-enhanced with gum arabic shows no significant effect due to the near-odorless nature of carrageenan and gum arabic. Organic acids, mainly esters and volatile compounds, though present in trace amounts, greatly influence the flavor profile. Carrageenan and gum arabic, essential for jelly formation, are hydrocolloids with minimal volatile constituents, hence having little impact on the aromatic appeal of jelly confections **(Sukmana, 2012)**.

The jelly candy preference assessment indicated that varying carrageenan and gum arabic concentrations impacted preferences, ranging from 6.06 to 8.13, showing strong consumer interest. Kruskal-Wallis analysis revealed significant taste effects from these concentrations ($p<0.05$), creating diverse flavors. Main ingredients like *M. sapientum*, carrageenan, gum arabic, and sugar contribute to the candy's sweet flavor, with sugar enhancing sweetness, aroma, and reducing saltiness. According to Suryaningrum et al. (2017), taste is influenced by proteins, fats, and carbohydrates due to the solubility of food components on taste buds **(Astawan, et al., 2004)**. Sensory analysis showed differences due to carrageenan and gum arabic sweetness, with ANOVA findings confirming significant taste influence ($p<0.05$). Table 5 presents taste scores from 1.74 to 2.13 (sweet to subtly sour) **(Harijono et al., 2001)**. Taste is impacted by factors like chemical composition, temperature, concentration, and flavor interactions. Sucrose and fructose syrup add sweetness, while dragon fruit and citric acid provide a sour note. A balanced blend of sucrose, fructose syrup, and acid is used in dragon fruit jelly candy. More carrageenan enhances sweetness and forms a firm gel, creating a pleasing sweet gel for consumers **(Bactiar et al., 2017)**.

The jelly candy preference assessment showed that adding carrageenan and gum arabic significantly enhanced preference scores from 5.13 to 7.86, indicating high consumer approval. Treatment P1, with increased carrageenan, achieved the highest texture score due to greater gel strength. Texture scores ranged from 2.52 to 2.96, marking the candy as slightly chewy. Carrageenan and gum arabic were key in developing the chewy, gel-like texture. Higher carrageenan concentration produced a stronger texture, enhancing quality.

4. Conclusion

The P3 care jelly candy, with 15% carrageenan and 3% Arabic gum, significantly outperformed P1 and P2 candies. It demonstrated notable characteristics: texture hardness of 3.27 Kg/f, water content of 11.86%, ash content of 2.1%, reducing sugar content of 5.72%, and a hedonic value of $7.67 < \mu < 8.23$.

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