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Research of Gelatin and Sucrose Augmentation on Physicochemical and Organoleptic Characteristics of Tepache Jelly Candy

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A B S T R A C T

Tepache is a traditional Mexican beverage crafted from pineapple peels, celebrated for its potent antioxidant properties. This research seeks to evaluate the influence of incorporating gelatin and sucrose on the physicochemical and sensory characteristics of jelly candies, while also determining the ideal combination of gelatin and sucrose augmentations that result in a jelly candy preferred by consumers. The experimental design utilized a fully randomized factorial arrangement with two distinct factors. Factor I focused on varying gelatin concentrations of 15%, 25%, and 35%, whereas Factor II involved different stages of sucrose augmentation at 40%, 50%, and 60%. Data analysis was carried out through analysis of variance, followed by the DMRT test in instances of notable variations. The research revealed that the most optimal treatment entailed incorporating 25% gelatin and 60% sucrose, outcoming in jelly candy with a moisture content of 18.55%, ash content of 0.67%, pH of 4.75, vitamin C content of 42.31 mg/100g, the antioxidant activity of 58.55%, omitting sugar content of 13.92%, pattern of 9.25N, and an average liking score, encompassing color (3.36 - neutral), aroma (3.32 - neutral), taste (3.72 - neutral), and pattern (3.76 - neutral).

1. INTRODUCTION

1.1. Research Background

Tepache, commonly crafted by pineapple peel, highlights the pineapple as a favored plant due to its appealing taste, freshness, and subtle sourness. The processing of pineapple yields approximately 40% waste, with 5% constituting the scales on the pineapple skin [1]. Despite its abundance, this waste remains largely underutilized and is typically discarded. Therefore, a viable solution is imperative to address this issue. Pineapple peel comprises 81.72% water, 17.53% carbohydrates, 4.41% protein, 13.65% omitting sugars, and 20.87% crude fiber. [2]. Jelly candy, as described by [3], is confectionery produced by a blend of fruits, and gelling agents, or supplemented with flavoring agents to yield various flavors, characterized by a clear and transparent physical appearance. The term "jelly candy" is described by the [4] as a confection with a soft pattern created by incorporating hydrocolloid ingredients like gum, agar, pectin, starch, carrageenan, gelatin, and other additives to achieve a chewy consistency. One alternative to the consumption and introduction of tepache is its transformation into jelly candy, serving as a substitute for fruit juice as a primary ingredient in jelly candy production.

The augmentation of gelatin serves multiple purposes, including the formation of a gel, stabilization of emulsions, thickening, clarification, and binding water. Sucrose is incorporated to enhance pattern, appearance, and flavor. According to Ref, [5], sucrose functions as a sweetening agent and preservative. augmentationally, the inclusion of sucrose can enhance the pattern of food products by increasing viscosity and enhancing taste perception, thus improving the chewing quality of food items. Moreover, sucrose can caramelize when heated, imparting a more appealing color and aroma.

Tepache, originating in Mexico and crafted from pineapple skin, is renowned for its simplicity in preparation, rendering it a popular beverage within Mexico. However, its popularity is less pronounced in Indonesia. To introduce tepache to Indonesian consumers, a jelly candy derived from tepache was created. Tepache boasts a composition rich in beneficial bacteria (probiotics), promoting digestive health and bolstering the immune system, while also exhibiting high antioxidant stages. Among the identified microorganisms are *Bacillus megaterium, and Bacillus subtilis*, as well as yeasts such as *Saccharomyces* *cerevisiae*, *Pichia membranifaciens*, *Candida biodinii*, and *Candida inconspicua* .

1.2. Literature Review

Jelly candy, or soft confectionery, represents a category of solid snack foods comprising sugar or a blend of sugar and sweeteners, with or without augmentational food ingredients and approved food additives. According to Ref. [6], typical attributes of jelly candy include a chewy consistency ranging from soft to firm, a sweet taste accompanied by a fruity aroma, and a transparent physical appearance with a chewy pattern. Commonly utilized components include glucose syrup, citric acid, and gelatin [7].

A key component of jelly candy is gelatin, along with sucrose. According to Ref [8], gelatin is a gelling agent capable of preventing sugar crystallization, transforming liquids into elastic solids, and enhancing the shape and pattern of jelly candy. Gelatin's gel formation process commences with the conversion of gelatin sol, heading to protein molecule modification where proteins denature into polypeptides with open folds. These unfolded polypeptides gradually combine to form a three-dimensional matrix, trapping water inside. This process is facilitated by covalent and non-covalent interactions among groups along adjacent polymer chains, including sulphide bonds, hydrogen bonds, and ionic bonds, overcoming the formation of a solid matrix [9]. Sucrose serves as one of the sweetening agents. It is a disaccharide sugar composed of glucose and fructose. Sucrose predominates as the primary constituent in jelly candy production. When heated, sucrose melts at approximately 160°C to yield a clear liquid that subsequently caramelizes, imparting a rich color and flavor [5].

Based on the outcomes of reference [10], the improved incorporation of gelatin and sucrose leads to a firmer and more rigid pattern in the outcoming jelly candy. This is attributed to the phenomenon of hydrogen bonding among gelatin molecules, which results in the breakdown and subsequent formation of cross-links among molecules. Sucrose will help connect these bonds to trap water so that the outcoming gel is stronger.

1.3. Research Objective

This research aims to evaluate the influence of gelatin and sucrose supplementation on the physicochemical and organoleptic characteristics of jelly candy, as well as to determine the most effective treatment, whether it involves the augmentation of gelatin or sucrose, in producing jelly candy that is favored by consumers.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The materials utilized in this research comprised pineapple peel, brown sugar, cinnamon, water, Hakiki brand gelatin, sucrose, citric acid, glucose, distilled water, methanol, DPPH solution, buffer solution, luff scroll solution, 1N H_2SO4 solution, starch indicator, sodium sulphate, 1% starch solution, 0.01 N iodine solution, 0.85% physiological NaCl solution, MRSA medium, glucose solution, sulfuric acid, 0.5N HCl solution, 0.1N alcohol solution, 0.1N NaOH solution, 1N CH_3COOH solution, etc.

The tools used are analytical scales, measuring cups, stirrers, Erlenmeyer, test tubes, funnels, ovens, desiccators, furnaces, pH meters, titration tools, porcelain cups, weighing bottles, etc.

2.2. Design of Experiment and Analysis

The research was structured with a fully randomized design (FRD) comprising two factors. Factor I involved varying concentrations of gelatine (15%, 25%, and 35%), and factor II involved different stages of sucrose (40%, 50%, and 60%).

Table 1. Treatment combinations Jelly candy

Gelatin (%)	Sucrose (%)		
	B1	B2	B3
A1	A1B1	A1B2	A1B3
A2	A2B1	A2B2	A2B3
A3	A3B1	A3B2	A3B3

Where,

A1B1 = augmentation of 15% gelatine and 40% sucrose
A1B2 = augmentation of 15% gelatine and 50% sucrose
A1B3 = augmentation of 15% gelatine and 60% sucrose
A2B1 = augmentation of 25% gelatine and 40% sucrose
A2B2 = augmentation of 25% gelatine and 50% sucrose
A2B3 = augmentation of 25% gelatine and 60% sucrose
A3B1 = augmentation of 35% gelatine and 40% sucrose
A3B2 = augmentation of 35% gelatine and 50% sucrose
A3B3 = augmentation of 35% gelatine and 60% sucrose

Product observation data were assessed utilizing analysis of variance (ANOVA) and subsequently headed to the Duncan Multiple Range Test (DMRT) at a significance stage of 5%. The acquired observation data was then categorized, and graphed in the form of a regression curve utilizing Microsoft Excel.

2.3. Research Procedure

The process of making tepache begins with the ingredients used, such as pineapple skin, which must be washed thoroughly and cut lengthwise so that it can be easily tied together, preparing 100 ml water and 20% brown sugar. Then mix the brown sugar and water until all the brown sugar dissolves in the water. After that, put the pineapple peel pieces and cinnamon powder in a glass container then stir and make sure all the ingredients are completely submerged in the sugar solution. Then cover it with cloth which will then be tied with a rubber band until it is tight. The storage procedure was conducted at ambient temperature (28°C) for 3 days in a dimly lit environment. Following this period, foam has accumulated on the surface, which should be deleted, along with the discarding of the pineapple skin. Then store the tepache in the refrigerator because served cold is more delicious.

The process of producing tepache jelly candy in this research was adapted from prior research [11]. Initially, the ingredients were weighed, followed by heating 100 ml of tepache with sucrose at a predetermined concentration of 40°C. Subsequently, 50% glucose syrup and 0.3% citric acid were put. Gelatin was dissolved in 50 ml of hot water at 50°C in a separate container, and then mixed. Further heating was conducted until the temperature reached 100°C for 10 minutes. The outcoming thick liquid jelly candy was poured directly into moulds and cooled at 28°C for 1 hour before being refrigerated for 24 hours. Finally, the jelly candy was deleted by the moulds.

2.4. Observation

2.4.1. Raw Material Observation

Analysis of raw materials comprised determination of ash content, concentration of vitamin C (mg/100g), antioxidant activity, pH evaluation, total lactic acid bacteria count (cfu/ml), and pectin content.

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2.4.2. Physicochemical Observation of Jelly Candy

Parameters assessed encompassed moisture content, ash content, stages of omitting sugar, antioxidant activity, pH examination, vitamin C content, and pattern analysis.

2.4.3. Jelly Candy Sensory Observation

The sensory characteristics chosen for evaluating the quality of the jelly candy included aroma, hue, flavor, and consistency. A total of 25 panellists were tasked with evaluating the product's acceptability utilizing a 5-point scale, which ranged from "strongly prefer" to "strongly dislike". The data analysis encompassed the utilization of the Friedman test.

3. RESULT AND DISCUSSION

3.1. Physicochemical Analysis

3.1.1 Raw Material Analysis

The analysis of raw materials encompassed pH stages, vitamin C concentration, antioxidant capacity, omitting sugar content, total lactic acid bacteria (LAB) count, pectin stages, and ash content. The outcomes of the raw material analysis are detailed in Table 2.

Table 2. Raw Material Analysis

Variable	**Result**
pH	3.25 ± 0.2121
Vitamin C (mg/100g)	20.81 ± 0.3267
Antioxidant Activity (%)	35.18 ± 0.0524
Reduced Sugar (%)	10.74 ± 0.04455
Total LAB (cfu/ml)	6.5×10^7
Pectin Content (%)	6.10 ± 0.3465
Ash Content (%)	1.03 ± 0.0688

Based on the outcomes of the raw material examination outlined in Table 2, the pH of the pineapple peel was recorded at 3.25, surpassing the reference value provided in Ref. [12]. The vitamin C content in pineapple peel was found to be 20.81 mg/100g, a value that falls below the figures recorded in the literature [13]. augmentationally, the antioxidant activity of pineapple peel was determined to be 35.18%, also lower than the values recorded in the literature [13]. The analysis of omitting sugars in pineapple peel yielded a concentration of 10.74%, which is below the value recorded in Ref. [14]. The total count of lactic acid bacteria (LAB) in tepache was determined to be 6.5 x 107 cfu/ml, a result that aligns with the outcomes in the existing literature [15]. The examination of the pectin content in pineapple peels revealed a concentration of 6.10%, which was found to be below the values recorded in the literature [16]. augmentationally, the analysis of the ash content in pineapple peels showed a percentage of 1.03%, a figure that was lower than what has been documented in prior studies [17].

3.1.2 Analysis of Jelly Candy

Physicochemical analysis of jelly candy includes analysis of water content (%), ash content (%), omitting sugar (%), antioxidant activity (%), pH, vitamin C content (cfu/100mg), pattern analysis (N) shown in Table 3.

3.1.2.1 Water Content

The water content percentage in jelly candy ranges from 15.77% to 19.86%. The analysis of variance indicates a significant interaction ($p \leq 0.05$) between the incorporation of gelatin and sucrose on the moisture content of jelly candy, as illustrated in Figure 1. The higher the concentration of gelatin and sucrose, the higher the moisture content of jelly candy. This is due to the hydrocolloid properties of gelatin, which readily absorbs water, and the hygroscopic nature of sucrose, allowing it to easily absorb free water. With improved gelatin content, the gelatin matrix and fine fibers formed within become more pronounced, enhancing the binding strength among gelatin fibers. As a result, the water trapped within the matrix is less likely to evaporate.

This is corroborated by Ref. [9], who assert that the gelatin gel formation process initiates with gelatin sol, which undergoes denaturation, outcoming in polypeptides with unfolded folds. These unfolded polypeptides subsequently aggregate to form a matrix that entraps water, leading to an improvement in the water content of jelly candy.

Moreover, the augmentation of sucrose also contributes to the elevated water content in jelly candy, as noted by Ref. [18]. They suggest that sucrose, being hygroscopic, can absorb free water, which becomes challenging to evaporate during heating, consequently leading to an improvement in the water content of jelly candy.

3.1.2.2 Ash content

The ash content percentage in jelly candy varied from 0.22% to 0.94%. An analysis of variance revealed a noteworthy correlation ($p \leq 0.05$) between the incorporation of gelatin and sucrose in jelly candy, as illustrated in Figure 2. With the augmented incorporation of gelatin and sucrose, there was a corresponding rise in the ash content of jelly candy. This occurrence can be ascribed to the mineral elements present in gelatin and sucrose, which serve to heighten the ash content in jelly candy.

This outcome is corroborated by Ref. [19], who recorded that gelatin in powder form typically contains approximately 84-86% protein content, 2-4% minerals, and minimal fat, while the ash content of sucrose alone is approximately 0.013% [20]. Gelatin comprises minerals such as sodium, iron, calcium, phosphorus, magnesium, potassium, and zinc [20]. augmentationally, according to Ref. [21] the presence of iron and zinc in sucrose.

3.1.2.3 pH

The analysis of variance results revealed a lack of significant interaction ($p \geq 0.05$) among the incorporation of gelatin and sucrose concerning the pH of the jelly candy. With an improvement in the quantity of gelatin put in, a corresponding rise in the pH of the jelly candy was observed. This improvement in pH is likely attributed to the alkaline nature of the gelatin utilized in jelly candy production, with a pH range typically between 4.5 and 6.5 [22]. Likewise, an improved amount of sucrose led to a higher pH stage in the jelly candy. This is due to the neutral nature of sucrose, which means that its inclusion does not cause a substantial change in the pH of the jelly candy [23].

3.1.2.4 Vitamin C

The vitamin C percentage in jelly candy ranges between 34.94% and 52.69%. Analysis of variance reveals a significant interaction ($p \leq 0.05$) between the augmentation of gelatin and sucrose treatments and the vitamin C content of jelly candy, as illustrated in Figure 3. Specifically, higher augmentations of gelatin and sucrose correspond to lower stages of vitamin C in the jelly candy. This phenomenon can be attributed to the improved water content outcoming by higher augmentations of gelatin and sucrose, which consequently leads to a decrease in the vitamin C stages. This outcome is handled by [24], who explains that high sucrose augmentations cause more water to be released by the food, and water can dissolve vitamin C, resulting in a reduction in the vitamin C content of the material. augmentationally, the heating process during production can also contribute to the decrease in vitamin C stages.

When gelatin absorbs water, water molecules bound to vitamin C can be pushed out of the gel structure, causing vitamin C to be more easily oxidised and degraded, vitamin C is a compound that is easily oxidised especially when exposed to air, light, and heat. This ability to bind water causes high oxidation that occurs due to free oxygen, thus omitting vitamin C stages [25].

3.1.2.5 Antioxidant Activity

The antioxidant activity percentage of jelly candy ranged from 56.45% to 62.83%. The statistical analysis showed a notable interaction ($p \leq 0.05$) between the incorporation of gelatin and sucrose in the jelly candy, impacting its antioxidant properties, as illustrated in Figure 4. Improved quantities of gelatin and sucrose resulted in a decline in the antioxidant potency of jelly candy. This decrease is primarily due to the retention of water content by gelatin and sucrose, consequently omitting the antioxidant effectiveness. Augmentationally, the heating process during production contributes to the decreased stability of antioxidant activity. Antioxidant compounds are inherently unstable and susceptible to damage by heating processes.

This is corroborated by [10], who asserts that the concentration of gelatin and sucrose also influences the stability of beta-carotene in jelly candy. improved gelatin concentration results in a decrease in beta carotene and the color intensity of the jelly candy. Augmentationally, the augmentation of sucrose can induce Maillard reactions, further compromising beta-carotene stability and altering polyphenol compounds.

3.1.2.6 Reduced Sugar Content

According to the outcomes of the analysis of variance, there was no statistically significant interaction ($p \geq 0.05$) identified among the treatment incorporating gelatin and sucrose on the decrease in sugar content of jelly candy, as depicted in Figure 5. While the augmentation of sucrose exhibited a notable effect, the incorporation of gelatin did not significantly impact the reduction of the sugar content of the produced jelly candy. The lack of sugar in gelatin is the reason behind this phenomenon. According to research by Ref. [26], gelatin is composed of vital amino acids crucial for the body, such as valine, threonine, phenylalanine, methionine, lysine, leucine, isoleucine, and histidine.

The higher the concentration of sucrose, the more pronounced the reduction in sugar stages. This escalation in omitting sugars can be attributed to the incorporation of sucrose during the cooking process under elevated temperatures and acidic environments, heading to the generation of inverted sugar and consequently elevating the quantity of omitting sugars present in jelly candy. Inverting sugar with too much amount results in extra heating which can damage the flavor and color, besides that, it can cause sticky products or even products that cannot harden [27].

3.1.2.7 pattern

The analysis of variance revealed a notable interaction ($p \leq 0.05$) among the treatments involving the augmentation of gelatin and sucrose about the pattern of the jelly candy, as illustrated in Figure 6. The higher the augmentation of gelatin and sucrose, the pattern of the *jelly* candy improved. The reason behind this phenomenon is the application of heat to gelatin, causing the bonds within the gelatin molecules to open up. This process leads to the formation of cross-links between molecules, enhancing the pattern of *jelly candies.* While sucrose helps connect bonds and trap water so that the outcoming gel is stronger.

According to Ref. [9], suggested that gelatin is a protein that when denatured becomes a polypeptide whose folds are open. The unfolded polypeptides join slowly to form a three-dimensional braid called a matrix with water trapped inside. When cooled, gelatine molecules that were priorly in the form of compact coils in liquid form will break down to form cross-links among other adjacent molecules to form a gel. The formation of the gel can be influenced by the presence of sucrose. Sucrose will fill the gaps in the junction zones, creating a strong connection. According to [10], the augmentation of sucrose can help connect these bonds to trap water so that the outcoming gel is stronger.

3.2 Sensory Analysis

3.2.1 Aroma

The highest aroma score recorded was 3.44 (neutral). Various ingredients utilized in jelly candy production can influence the resultant aroma, particularly the raw materials employed in tepache preparation and the augmentation of sucrose. This assertion is handled by Ref. [28], who elucidates that the formation of flavor compounds occurs through the caramelization of the sugar, yielding pyrodextrin and melanoidin, alongside the generation of aroma by aromatic compounds comprising aldehydes, ketones, diverse esters, acids, and alcohols. augmentationally, the utilization of tepache derived from pineapple peel imparts the distinctive aroma of tepache to jelly candy products.

3.2.2 Colour

According to Table 2, the highest color score recorded was 3.88 (neutral). This is attributed to the incorporation of gelatin and sucrose, which triggers the Maillard reaction. The Maillard reaction commences through the interaction of primary or unbound amino groups by proteins with aldehydes or ketones by omitting sugars and sucrose. Generates compounds with a brown hue [29], therefore, the higher the quantities of gelatin and sucrose, the more pronounced the Maillard reaction will be, heading to a deeper hue of the final product.

3.2.3 Flavour

According to Table 2, the highest flavor score attained was 3.80 (neutral). The sweet flavor observed resulted from the incorporation of sucrose in each *jelly candy* preparation treatment. This is corroborated by Ref. {5] who notes that sucrose is commonly put in food and beverages to impart a sweet flavor. augmentationally, the inclusion of gelatin did not influence the flavor of the jelly candy, as gelatin itself lacks flavor.

3.2.4 pattern

According to Table 2, the highest score recorded was 3.76 (neutral). This observation is substantiated by Ref. [10], indicating that improved augmentations of gelatin and sucrose result in a firmer and harder pattern of the produced jelly candy. This occurs due to the process of hydrogen bonding among molecules in gelatin, wherein the molecules break down and form cross-links among them. augmentationally, sucrose aids in connecting these bonds, thereby trapping water and strengthening the outcoming gel.

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Table 2. Physicochemical Analysis of Tepache Jelly Candy

Treatment	Physicochemical Analysis						
	Moisture content (%)	Ash content (%)	pH	Vitamin C (cfu/ml)	Antioxidant activity (%)	Reduced sugar (%)	pattern (N)
A1B1	15.77 ± 0.08	0.22 ± 0.03	4.20 ± 0.14	52.69 ± 0.07	62.83 ± 0.12	12.25 ± 0.04	4.53 ± 0.11
A1B2	16.74 ± 0.10	0.33 ± 0.03	4.30 ± 0.14	52.64 ± 0.07	62.17 ± 0.12	12.32 ± 0.13	6.00 ± 0.28
A1B3	17.15 ± 0.27	0.42 ± 0.04	4.35 ± 0.07	52.49 ± 0.07	61.76 ± 0.23	12.41 ± 0.23	0.14 ± 0.21
A2B1	17.70 ± 0.02	0.58 ± 0.02	4.60 ± 0.14	43.91 ± 0.06	60.70 ± 0.12	13.29 ± 0.20	7.65 ± 0.21
A2B2	17.74 ± 0.33	0.59 ± 0.02	4.65 ± 0.07	43.80 ± 0.03	60.05 ± 0.35	13.59 ± 0.17	8.65 ± 0.21
A2B3	18.56 ± 0.16	0.67 ± 0.01	4.75 ± 0.07	42.11 ± 0.85	58.74 ± 0.35	13.72 ± 0.18	9.25 ± 0.07
A3B1	19.45 ± 0.36	0.74 ± 0.03	5.20 ± 0.14	35.15 ± 0.02	57.35 ± 0.23	14.52 ± 0.30	9.65 ± 0.07
A3B2	19.78 ± 0.09	0.89 ± 0.05	5.15 ± 0.07	35.08 ± 0.02	56.86 ± 0.23	14.28 ± 0.25	10.35 ± 0.21
A3B3	19.86 ± 0.07	0.94 ± 0.02	5.25 ± 0.07	34.94 ± 0.02	56.45 ± 0.12	14.41 ± 0.23	12.00 ± 0.28

The average value accompanied by different letters shows a significant difference at $p \leq 0.05$

Table 3. Sensory Analysis of Tepache Jelly Candy

Treatment	Sensory analysis			
	Aroma	Color	Flavour	pattern
A1B1	3.44	3.88	3.80	2.84
A1B2	3.28	3.76	3.84	3.4
A1B3	3.4	3.68	3.52	3.08
A2B1	3.12	3.32	3.56	3.36
A2B2	3.28	3.24	3.48	3.32
A2B3	3.32	3.36	3.72	3.76
A3B1	3.08	3.28	3.16	2.8
A3B2	3.16	3.76	3.16	2.84
A3B3	3.12	3.6	3.28	3.2

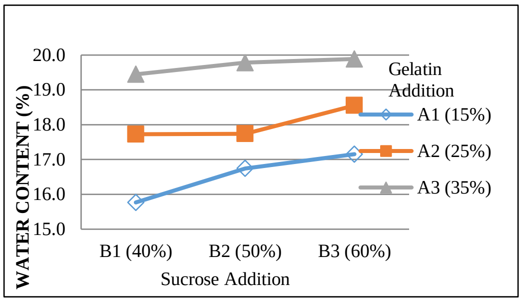

Fig. 1. Relationship among gelatine and sucrose augmentation on the moisture content of jelly candy

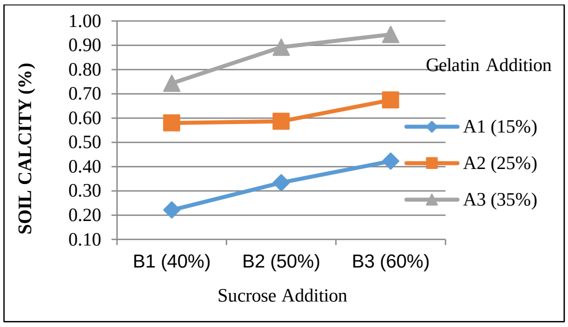

Fig. 2. Relationship among gelatin and sucrose augmentation on ash content of jelly candy

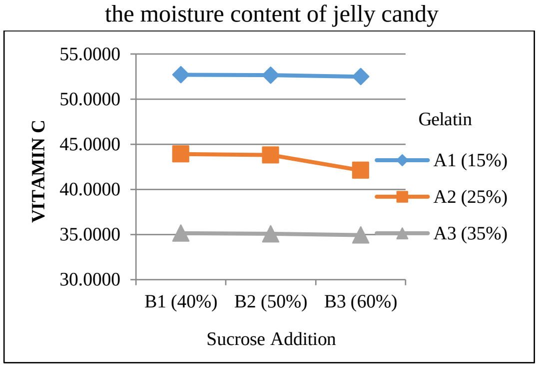

Fig. 3. Relationship among gelatin and sucrose augmentation to vitamin C of jelly candy

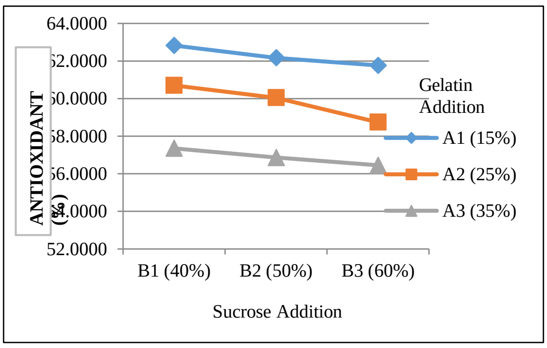

Fig. 4. Relationship among gelatin and sucrose augmentation on antioxidant activity of jelly candy

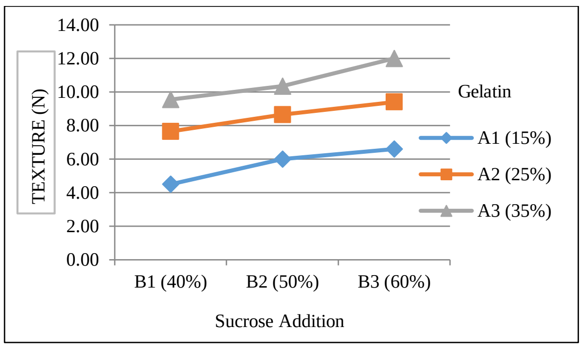

Fig. 5. Relationship among gelatine and sucrose augmentation on the pattern of jelly candy

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4. CONCLUSION

A notable correlation was detected among the treatments incorporating gelatin and sucrose about the moisture content, ash content, vitamin C, antioxidants, and pattern of tepache jelly candy. However, no significant interaction was noted regarding the pH and reduced sugar content. The optimal treatment entailed the augmentation of 25% gelatin and 60% sucrose, resulting in moisture content of 18.55%, ash content of 0.67%, pH of 4.75, vitamin C content of 42.31 mg/100g, antioxidant activity of 58.74%, omitting sugar content of 13.92%, and pattern of 9.25 N. augmentationally, the average liking score encompassed color (3.36 - neutral), aroma (3.32 - neutral), taste (3.72 - neutral), and pattern (3.76 - neutral).

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