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Development of Roselle (*Hibiscus sabdariffa* L.) Calyx Jelly Candy

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Abstract

Jelly candy is syrup-phase, non-crystalline candy made using sugar, corn syrup and gelling agents such as gelatin, natural gums, pectin or starch. Roselle (*Hibiscus sabdariffa* L.) has red edible calyx that is the potential to be used as a natural colorant for jelly candy as it contains anthocyanins. The objective of this research was to determine the effect of different concentrations of dried roselle calyx and sucrose on the characteristics of roselle calyx jelly candy developed. The concentrations of sucrose used were 63.56%, 70.62%, 77.68% and 84.75%. The concentrations of dried roselle calyx used were 6.67%, 10.00%, 13.33% and 16.67%. Sensory analysis was done with 70 untrained panelists to analyze physical characteristics and preferences toward the jelly candies. Results of hedonic tests indicated that the best-formulated jelly candy according to aroma, texture, color and taste was made using 16.67% of dried roselle calyx and 63.56% of sucrose. The best-formulated jelly candy contains 19.52% of moisture, 0.03% of ash, 8.24% of protein, 1.72% of fat and 70.49% of carbohydrates. The selected jelly candy contains 14.23±0.23 mg $100g^{-1}$ of anthocyanin and an antioxidant capacity (IC_{50}) value of 16863.8346 $\mu g\ ml^{-1}$. This research shows the potential use of roselle calyx as a natural colorant in jelly candy manufacturing and can be consumed as a healthier option for sweet treats.

Keywords: anthocyanin; antioxidant; color; physicochemical properties; roselle calyx

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INTRODUCTION

Candy has always been one of the most popular sweet treats. People usually enjoy it as an occasional treat between meals. The sweet nature of sugar used in candy creates pleasure. The market for confectionery products such as hard, soft, jelly candy and nougat is growing because they have relatively low prices with high organoleptic acceptance. Therefore, the amount of daily consumption of candy has increased globally (Ali et al., 2021). Indonesian household has a significantly high consumption rate of confectionery products, especially among children due to their desirable sweet taste. One of the most popular sugar confectionery products is jelly candy. Jelly candy is made using several hydrocolloid components such as agar, gum, pectin, starch, carrageenan, gelatin, etc. Hydrocolloids are used to modify the texture to become a chewy product that can be molded into different shapes (Novelina et al., 2020).

Jelly candy is readily available in various flavors and colors. Globally, jelly candy

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represents about 50% of the candy market value (Charoen et al., 2015). However, candy is often perceived as junk food with high sugar content that is produced using artificial sweeteners, flavors and colors. There is a growing concern about the effect of the consumption of artificial sweeteners, flavors and colors on human health. Furthermore, the interest in natural colorants has increased significantly due to the increased demand for natural products, with a special interest in the food industry in the limited availability of red pigments (Azza et al., 2011). Nowadays, roselle is one of the plants that is attracting the attention of food and beverage manufacturers (Islam, 2019).

Roselle (*Hibiscus sabdariffa* L.) is a tropical plant that belongs to the *Malvaceae* family and is widely found in tropical and sub-tropical regions such as India, Indonesia and Malaysia (Wu et al., 2018). The cultivation of roselle in Indonesia has started since the beginning of the 20th century (Ansari et al., 2013) and nowadays, roselle plantation is commonly found in the highlands in West Java (Inggrid et al., 2016). In some places, the plant is primarily cultivated for several purposes. Roselle plays an important role as a source of income for rural farmers in developing countries (Akanbi et al., 2009). The stem of the plant can be used to produce bast fiber (Islam, 2019), leaves can be taken advantage of as a vegetable (Islam et al., 2016) and its petal can be benefited as a substitute source for synthetic antibiotics (Abdallah, 2016). The fiber of roselle is considered a sustainable agricultural waste and has been used for nanocomposite fabrication (Kian et al., 2018). However, the most exploited part of the roselle plant is its calyces. Roselle calyces may be green, red or dark red (Awad and Shokry, 2019). The calyx is found on the hibiscus that protects and supports the hibiscus plant (Islam, 2019). Roselle calyces extract contains high antioxidant activity. The antioxidants present in roselle calyx are cyanidin-3-glucoside, delphinidin-3-glucoside, cyanidin-3-sambubioside and delphinidin-3-sambubioside (Borrás-Linares et al., 2015). Those compounds are also known to act as antioxidant, anti-inflammatory, antitumor, antibacterial, antihypertensive and hepatoprotective (Jabeur et al., 2017).

Furthermore, color is an important quality attribute of roselle (Juhari et al., 2021). The aqueous extract of roselle calyces has a rich red pigmentation due to the presence of anthocyanins. It also has a pleasant acidic taste (Selim et al., 2019), even though the taste of roselle calyx might be unpleasant when consumed in high concentration (Pacome et al., 2014). Roselle calyces' aqueous extract was also reported to be stable in acidic conditions (Piyarat et al., 2014). Therefore, roselle calyces have been considered a promising source of water-soluble red colorants that could be applied as natural food colorants (Shruthi et al., 2016). Other than color, anthocyanins in general are known to have antioxidant and bioactive properties and are usually linked to certain health benefits, such as anti-diabetic, anti-inflammatory and anticancer (Wu et al., 2018).

Fresh calyx can be eaten raw in salads or cooked, and used as a flavoring in bakery products and is also used in making several food products, such as jellies, soups, sauces and pickles (Shruthi et al., 2016). Roselle calyces have been utilized in the production of many food products including beverages, jam and sauces (Salami and Afolayan, 2020). In the beverage industry, roselle calyces have been sold in the form of dried calyces or ready-to-drink beverages (Fellows and Axtel, 2014) and herbal tea (Islam et al., 2016). The green calyces are used for making vegetable stew while the red and dark red ones are made into tea. Furthermore, the calyces drink is considered to be an inexpensive source of vitamin C and contains nine times more vitamin C than citrus (Awad and Shokry, 2019). Roselle calyces have also been used in folk medicine as a diuretic and mild laxatives, to reduce blood pressure and to treat cancer, cardiac and nerve diseases (Pacome et al., 2014). Therefore, there is the great market potential for roselle for farmers located in warmer climates where it grows well (Islam et al., 2016). Overseas demand for roselle products also increases (Juhari et al., 2021).

In this research, roselle calyces were dried and used in jelly candy making as a natural colorant in jelly candy to replace the use of synthetic colorants. The use of roselle calyx was also expected to add functional properties to the jelly candy. Therefore, this research aimed to develop roselle calyx jelly candy by determining the most preferred concentration of dried roselle calyx and sucrose based on the preference test, as well as to determining anthocyanin content and antioxidant activity of the best-formulated roselle calyx jelly candy.

MATERIALS AND METHOD

Materials

Materials used for this experiment were roselle calyx obtained from a supplier located in Bandung, West Java, Indonesia; sucrose "Gulaku"; corn syrup; powdered gelatin "Bloom 150" from "PT. Brataco"; purified water "Amidis" and sorbitol 70%. For the analysis, the chemicals used were H_2SO_4, K_2SO_4, Selenium, H_2O_2, NaOH, Boric acid, HCl, mixed indicator, glycerol, hexane PA, ethanol, DPPH, $CH_3CO_2Na.3H_2O$ and KCl.

Methods

Preparation of dried roselle calyces

Roselle calyx was dried to preserve its shelf life, based on the methods from Pacome et al. (2014) and Hahn et al. (2011), with modification. The preparation of roselle calyces was started by separating the fresh roselle calyces from their seeds. The calyces were washed under tap water until fully cleaned, about three times. Roselle calyces were dried using a cabinet dryer at 60°C for 12 hours. Lastly, they were size-reduced to reach 0.25 mm powder using mesh number 60.

Production of roselle calyx jelly candy

The production process of roselle calyx jelly candy was done based on the method from Jackson (1999). It started by weighing all the raw materials according to the formulation. One hundred and fifty gram of water and dried roselle calyces were heated to 100°C to create roselle-infused water. Roselle-infused water was separated from the calyces by straining.

To gel the gelatin, 10 g of water and 40 g of sorbitol were heated to 60°C for 10 minutes. The foam that was formed in the gelatin and water mixture was discarded. Sugar syrup was prepared by combining sucrose and corn syrup at 115°C until all the sugar was dissolved. Sugar syrup was then cooled to 70°C. The gelatin mixture was combined with sugar syrup. Then, 25 g of roselle water was added. The mixture was transferred to silicone molds. It was conditioned at 10°C for 24 hours. Finally, jelly candy was removed from the molds. The flowchart of roselle calyx jelly candy production can be seen in Figure 1, the formulation of roselle-infused water is presented in Table 1, while the formulation of roselle calyx jelly candy is detailed in Table 2.

Experimental design

The experimental design used in this research was a completely randomized factorial design with two factors and two replications. Factors observed were concentration of sucrose (63.56%, 70.62%, 77.68% and 84.75%) and concentration of dried roselle calyces (6.67%, 10.00%, 13.33% and 16.67%). Data obtained were analyzed using Two-way ANOVA by IBM SPSS Statistic 22.

Table 1. Formulation of roselle-infused water

Ingredients	Formulation (g)	Formulation (%)
Water for dried roselle calyx	150	100
Dried roselle calyx (% based on water for dried roselle calyx)	10/15/20/25	6.67/10.00/13.33/16.67

Table 2. Formulation of roselle calyx jelly candy

Ingredients	Formulation (g)	Formulation (%)
Corn syrup	141.6	100.00
Other ingredients (% based on corn syrup)		
Water for gelatin	10	7.06
Roselle-infused water	25	17.66
Gelatin	31.2	22.03
Sorbitol	49.2	34.75
Citric acid	1.875	1.32
Sucrose	90/100/110/120	63.56/70.62/77.68/84.75

Source: Jackson (1999)

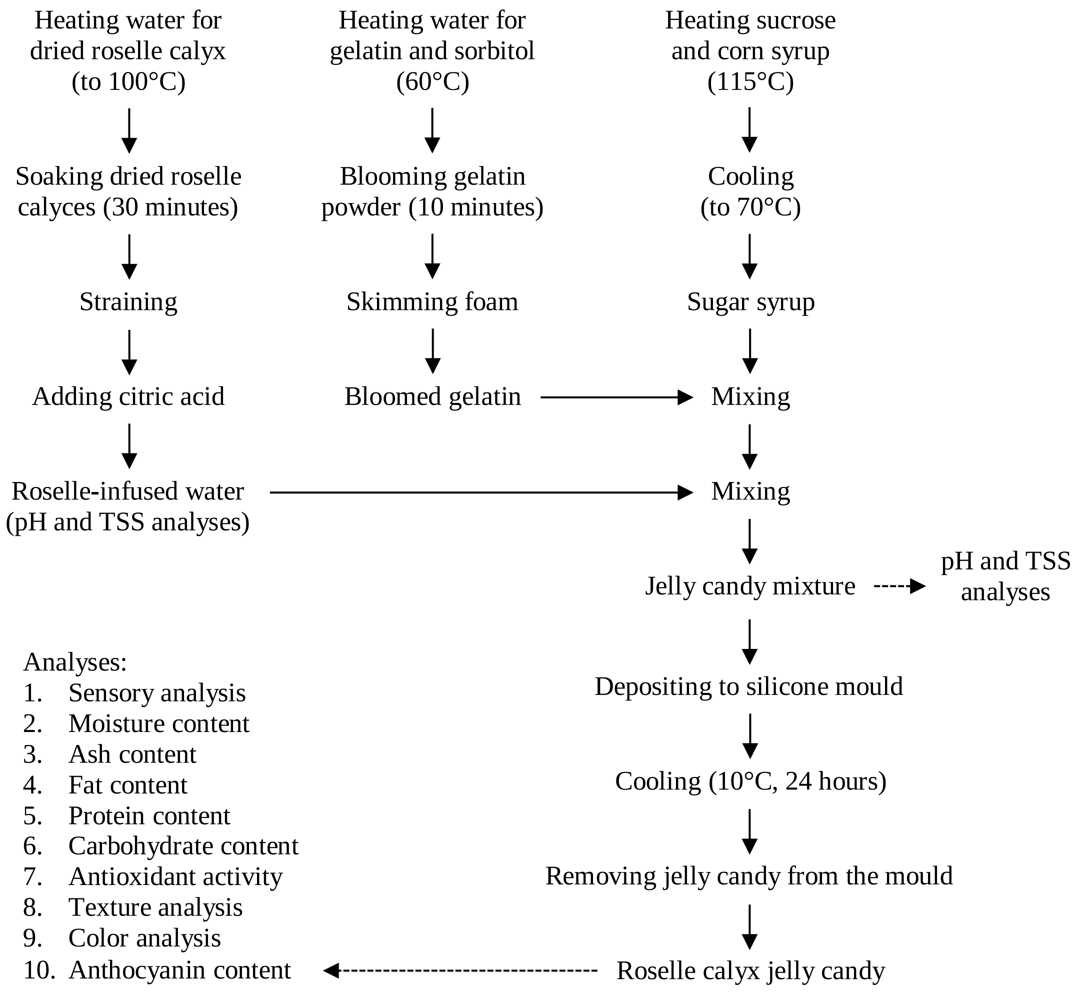

Figure 1. Flowchart of roselle calyx jelly candy production
Source: Jackson (1999), with modification

Analyses

Control candy in this research was made using the best-formulated concentration of sucrose with no roselle solution. All the formulations of jelly candy were analyzed for their texture, color, pH and total soluble solid (AOAC, 2005). Color analysis was performed using CR-400 Konica Minolta Chroma meter (Mutlu et al., 2018). Texture analysis was performed using TA.XT Plus texture analyzer using spherical cylinder probe. The test performed was texture profile analysis (TPA) and the settings used were 1 mm second^{-1} speed test, 75% strain and 60 seconds. The amount of candy was 5 g with 1 cm thickness for each measurement (Csima et al., 2014 with modification).

Sensory evaluation was done using a hedonic test by analyzing jelly candies with different concentrations of sucrose and dried roselle calyces. The parameters for sensory tests were color, aroma, texture, sweet taste and overall acceptance. Seventy untrained panelists were used in this hedonic test. The panelists who participated in this hedonic test were housewives aged 33 to 40 years old. It is because based on the preliminary survey done, they are the ones who are interested in consuming or buying a roselle calyx candy as an alternative for a healthier snack option for their family. The result of the hedonic test was analyzed using Two-way ANOVA by IBM SPSS Statistic 22 to determine the most preferred combination of sucrose and dried roselle calyces. Moreover, the control, dried roselle calyces and jelly candy with the best formulation were analyzed to determine their ash content using the dry-ashing method, fat content using the Soxhlet extraction method, protein content using the Kjeldahl method, carbohydrate content using by difference method, moisture content using oven-drying method (AOAC, 2005), anthocyanin content (Lee et al., 2005) and antioxidant activity using DPPH method (Tangkanakul et al., 2009; Pilerood and Prakash, 2014).

RESULTS AND DISCUSSION

Characteristics of dried roselle calyx

Dried roselle calyx was obtained from the drying and size reduction process of roselle calyces. The percentage of yield of dried roselle calyx obtained in this research was 37.88±0.00%. Several physical and chemical analyses were done on dried roselle calyces and the results are presented in Table 3.

Based on the analysis results of antioxidant capacity (IC_{50}), roselle calyx has high antioxidant activity, with an IC_{50} value between 1000 to 10000 µg ml^{-1} (Qusti et al., 2010). There are differences between the nutritional composition of analysis and literature, especially on the fat content. A significant increase in the value of fat content compared to the literature can be caused by different varieties of roselle calyx used. Roselle pigment hydrolysates can produce two major anthocyanidins, which are red and violet pigments. The red pigment of roselle is cyanidin, while the violet pigment represents delphinidin. Different varieties of roselle exhibit distinct intensities of calyx color (Borrás-Linares et al., 2015). Roselle calyx, which is composed of a high concentration of red pigment and low concentrations of violet pigment, is also known as dark red roselle. Purple roselle calyces contain 8.21% of crude fat, while red calyces contain 7.6% of fat. Roselle calyces used for the analysis have dark red color, suggesting a significant concentration of delphinidin (Ajala et al., 2013), whereas roselle calyces used in literature have red color (Adanlawo and Ajibade, 2006).

Physical and chemical characteristics measured from dried roselle calyx were the pH, total soluble solid, lightness and hue. The results are presented in Table 4. There are differences between the physical and chemical characteristics, especially in lightness and hue value. These differences can be caused by the dissimilarities in the maturity level of the calyx, conditions and region of the plantation and treatments of cultivation (Ortega and Beltran, 2014).

Effect of concentration of dried roselle calyx and sucrose on the textural properties

The texture is one of the main parameters in jelly candy. Some parameters analyzed in this research included hardness, gumminess and chewiness. These results can be observed in Table 5.

Table 3. Nutritional composition of dried roselle calyx

Nutritional composition	Unit	Literature	Analysis
Moisture	g 100g^{-1}	7.60	9.03±0.00
Protein	g 100g^{-1}	4.71	3.99±0.01
Fat	g 100g^{-1}	2.01	7.40±0.01
Ash	g 100g^{-1}	12.24	11.28±0.01
Carbohydrate	g 100g^{-1}	68.75	68.30±0.00
Anthocyanin (CA)	mg 100g^{-1}	318.9±64.0	357.94±6.78
Antioxidant capacity (IC_{50})	µg ml^{-1}	1051.72±184.20	1204.37±56.77

Source: Adanlawo and Ajibade (2006); Yang et al. (2012); Ortega and Beltran (2014)

Table 4. Physical and chemical characteristics of dried roselle calyx

Parameter	Literature	Analysis
pH	2.27±0.12	2.30±0.00
Total soluble solid (Brix)	5.53±0.26	5.00±0.00
Lightness (L*)	38.37±0.20	46.00±1.76
Hue	13.94±0.06	28.84±0.52

Source: Ortega and Beltran (2014)

Table 5. Textural profile of roselle calyx jelly candy

Sucrose concentration (%)	Concentration of dried roselle calyx (%)	Hardness (g)	Gumminess	Chewiness
63.56	6.67	642.8655±5.1100^{a}	527.1275±5.4094^{a}	492.2196±7.7320^{a}
	10.00	642.3095±25.6209^{a}	532.8438±9.4863^{a}	527.4600±15.3186^{ab}
	13.33	633.6108±4.9795^{a}	535.4600±21.2576^{a}	522.5252±14.5813^{ab}
	16.67	643.7933±16.0138^{a}	527.0828±4.7528^{a}	487.5645±7.3507^{a}
70.62	6.67	625.7365±14.8514^{b}	560.6538±27.9370^{b}	524.6832±23.9860^{ab}
	10.00	631.3533±1.4750^{b}	549.7130±12.4038^{b}	546.1245±11.4541^{ab}
	13.33	630.5645±16.3641^{b}	537.6273±10.0909^{b}	534.1113±8.6371^{ab}
	16.67	625.2863±5.7586^{b}	566.2853±4.0437^{b}	531.6495±18.1725^{ab}
77.68	6.67	765.0833±12.5253^{c}	568.9155±23.128^{c}	562.3433±26.5746^{b}
	10.00	766.3633±16.5618^{c}	582.6503±3.2019^{c}	546.2358±3.5690^{b}
	13.33	766.8170±8.8268^{c}	563.7750±25.7240^{c}	551.9823±26.6780^{b}
	16.67	754.7853±2.6736^{c}	582.8293±9.1188^{c}	547.5238±10.6707^{b}
84.75	6.67	918.3583±8.9355^{d}	673.8305±13.8048^{d}	644.4981±8.3965^{c}
	10.00	911.2075±8.0367^{d}	673.4533±17.2388^{d}	643.0252±19.5762^{c}
	13.33	925.4268±18.2630^{d}	662.4378±32.6251^{d}	663.0908±22.6340^{c}
	16.67	919.5795±5.7533^{d}	663.3588±5.7325^{d}	631.8138±5.7007^{c}
63.56	0 (Control)	1043.9065±45.6049^{e}	924.3265±32.7977^{e}	914.1357±31.1298^{d}

Notes: Different superscript on the same column indicates a significant difference ($p \leq 0.05$)

Hardness is defined as the force necessary to attain a given deformation, which is measured by the peak force of the first compression cycle (Chandra and Shamasundar, 2015). The statistical analysis result shows there is a significant effect of concentration of sucrose on the hardness of jelly candy ($p \leq 0.05$). There is no significant effect of the concentration of dried roselle calyx on the hardness of jelly candy and no significant interaction between the concentration of sucrose and the concentration of dried roselle calyx on the hardness of jelly candy ($p > 0.05$). The result of the Post hoc test using Duncan can be observed in Table 5, which shows that a high concentration of sugar contributes to the hard texture of jelly candy and vice versa. This can be caused by the ability of sugar to strengthen the structure and promote the rigidity of jelly candy. When compared to the control, roselle calyx jelly candy had a lower hardness value.

Gumminess is the energy required to disintegrate semi-solid food so that it is ready to be swallowed. Jelly candies with lower gumminess are generally easier to swallow (Kreungngern and Chaikham, 2016). Based on the results statistical presented in Table 5, there is a significant effect of concentration of sucrose on the gumminess of jelly candy ($p \leq 0.05$). There is no significant effect of the concentration of dried roselle calyx towards the gumminess of jelly candy and no interaction between the concentration of sucrose and the concentration of dried roselle calyx on the gumminess of jelly candy ($p > 0.05$).

Table 5 shows that a higher concentration of sucrose yields a high gumminess value. This is caused by the high level of hardness and cohesiveness of the jelly candy. Gumminess can be obtained by multiplying hardness with cohesiveness (Garrido et al., 2015). The gumminess value obtained from roselle calyx jelly candy in this research is comparable to jelly candies made from different fruit juices, which was about 269.6 to 959 (Cano-Lamadrid et al., 2020).

Furthermore, the chewiness of different formulations of jelly candy was measured. The statistical analysis results signify a significant effect of concentration of sucrose and dried roselle calyx on the chewiness of jelly candy ($p \leq 0.05$). However, there is no interaction between the concentration of sucrose and dried roselle calyx towards the chewiness of jelly candy ($p > 0.05$).

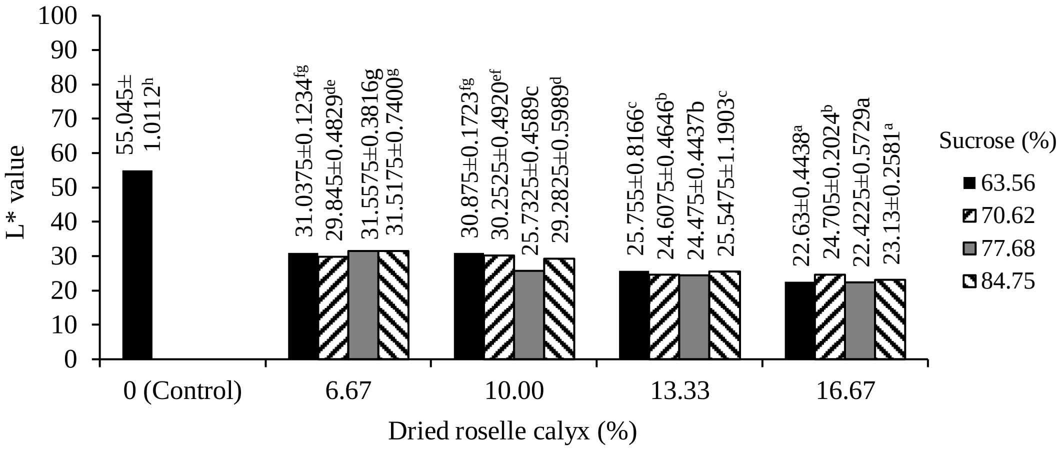

Figure 2. Effect of dried roselle calyx and sucrose concentration on the lightness of roselle calyx jelly candy

Note: L* = lightness. Different notations indicate significant differences ($p \leq 0.05$)

Table 5 also summarizes that a higher concentration of sucrose causes the jelly candy to have a chewier texture. Chewiness can be obtained by multiplying springiness and gumminess. Therefore, higher springiness and gumminess values may contribute to a higher value of chewiness. Moreover, jelly candies made without roselle have a significantly higher value of chewiness as compared to the jelly candy made using roselle solution. This is because the presence of water decreases the hardness value of jelly candy (Teixeira-Lemos et al., 2021), thus lowering the gumminess and chewiness of jelly candy.

According to DeMars and Ziegler (2001), firmer or short gummy candies that are prone to fracture can be described as chewy, while softer gummy candies that can dissolve during mastication can be described as gummy. Since all of the formulations of jelly candy are not able to fracture when subjected to texture profile analysis, the jelly candies can be categorized as a gummy type of jelly candy.

Effect of concentration of dried roselle calyx and sucrose on the physical and chemical properties

Some physical and chemical properties observed on roselle calyx jelly candy were color, total soluble solids and pH. The results of the color analysis can be divided into the lightness and the hue value. Based on the results of the statistical analysis presented in Figure 2, there is a significant effect, and also an interaction ($p \leq 0.05$) between the concentration of sucrose and dried roselle calyx towards the lightness of jelly candy.

A higher value of lightness indicates that the product is lighter, while a lower value indicates darker color. The high value of lightness comes from the high concentration of sucrose and a low concentration of roselle. This can be caused by the natural anthocyanin of roselle calyx that has deep-red color. Therefore, the more diluted the roselle calyx is, the lighter the color of jelly candy will be.

The hue value of the roselle calyx jelly candy ranges between 20.55 and 30.44, indicating that the candies have a red color. Moreover, the control made with no jelly candy has a yellowish-red color (Yenrina et al., 2016). The lower value of hue is obtained from jelly candies with a higher concentration of dried roselle calyx combined with a higher concentration of dried roselle calyx. The lower value of hue makes the color of the product to be purplish-red, while the higher value of hue will cause the product to have yellowish-red color. Roselle calyx has deep red color from its anthocyanin (Manjula et al., 2022).

Higher sucrose concentration affects the red color of jelly candy due to pH value. An increase in pH changes the color of anthocyanin to colorless carbinol pseudo-base, or purplish quinoidal anions (pH 5.5 to 6.0). Thus, a large concentration of sucrose may affect the pH of jelly candy and promote a change in its color (Aguirre et al., 2016). Statistical analysis shows a significant effect, and there is also an interaction ($p \leq 0.05$) between the concentration of sucrose and dried roselle calyx on the pH of jelly candy. The results are summarized in Figure 3.

Figure 3 shows that a higher concentration of dried roselle calyx and a lower concentration of sucrose results in low pH of jelly candy. This effect is most likely caused by the low pH of roselle solution based on the physical analysis result of dried roselle calyx, which is 2.27. It is according to Morales-Cabrera et al. (2013) that roselle calyx extract has a pH between 1.5 to 2.4 depending on its variety. Moreover, jelly candy acting as a control has a higher pH of 4.76 due to the absence of roselle solution. Therefore, a higher concentration of roselle is added to the jelly candy and a lower concentration of sucrose results in lower pH of the jelly candy solution. Jelly candy usually has a pH of 4.5 to 6.0 (Rochmawati and Ermawati, 2021), which means that roselle calyx jelly candy has a more sour taste compared to commercial jelly candy.

A total soluble solid is defined as a concentration of solids that are dissolved in a substance. The results of the total soluble solid analysis are detailed in Figure 4. There is a significant effect, and also an interaction ($p \leq 0.05$) between the concentration of sucrose and dried roselle calyx on the total soluble solid of jelly candy. Figure 4 shows that a higher concentration of sucrose and a high concentration of roselle calyx results in a higher value of total soluble solids. This is because both ingredients contribute as soluble solids in jelly candy.

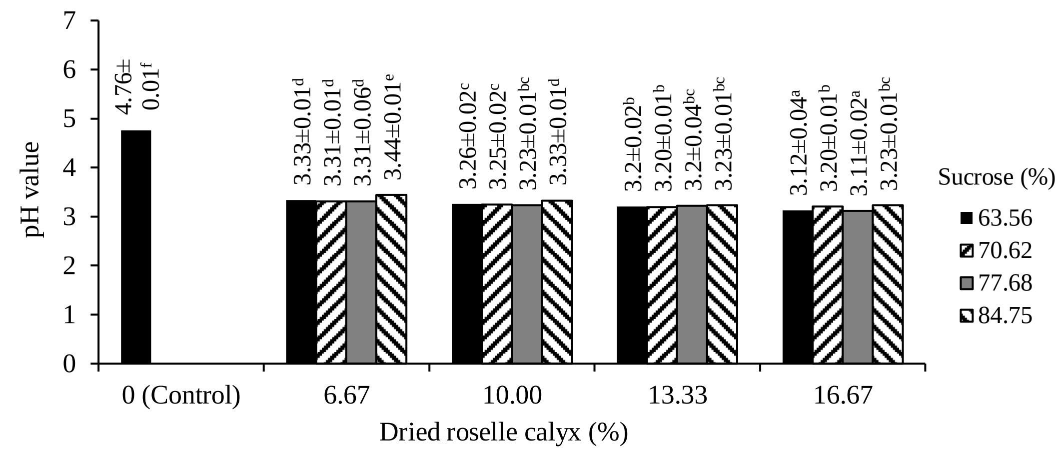

Figure 3. Effect of dried roselle calyx and sucrose concentration on pH of roselle calyx jelly candy
Note: Different notations indicate significant differences ($p \leq 0.05$)

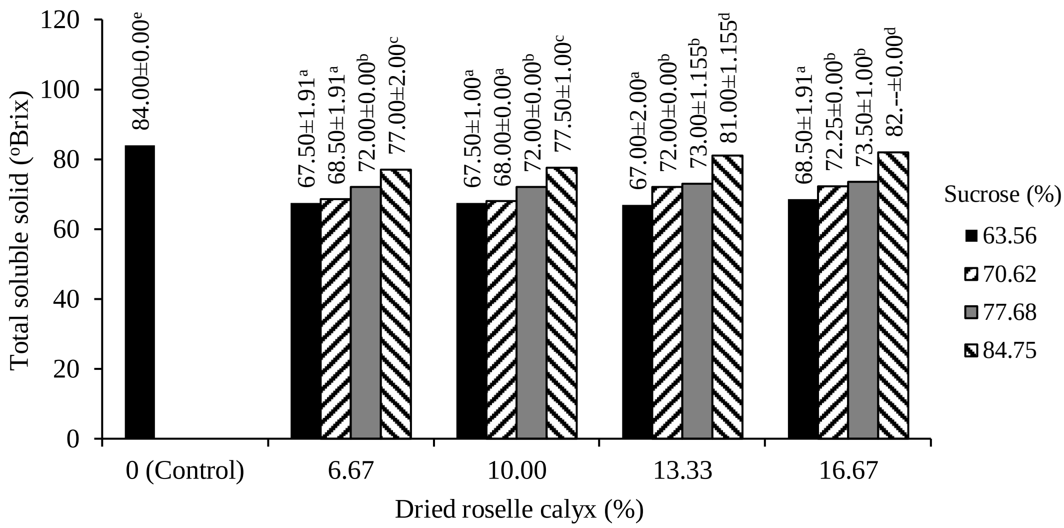

Figure 4. Effect of dried roselle calyx and sucrose concentration on total soluble solids of roselle calyx jelly candy
Note: Different notations indicate significant differences ($p \leq 0.05$)

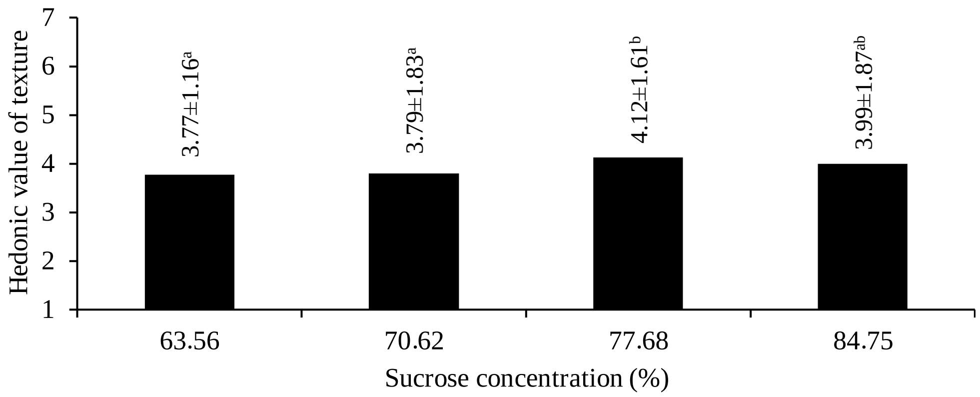

Figure 5. Effect of sucrose concentration on hedonic value of texture of roselle calyx jelly candy
Notes: 1 = strongly dislike; 7 = strongly like. Different notations indicate significant differences ($p \leq 0.05$)

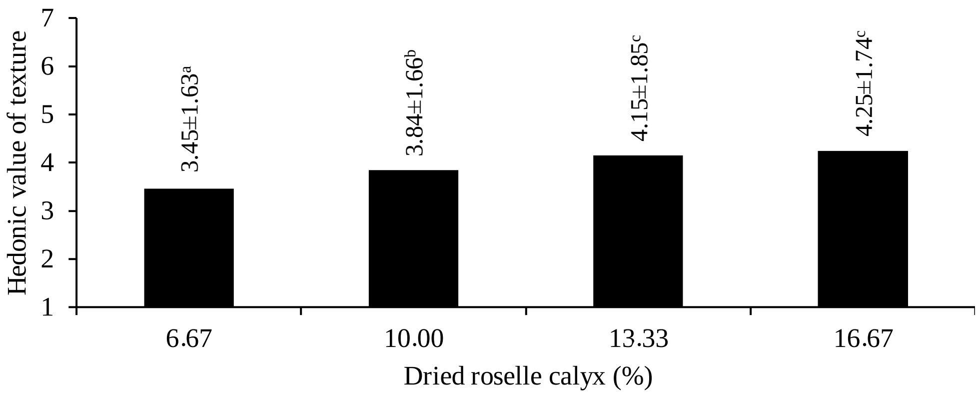

Figure 6. Effect of dried roselle calyx concentration on hedonic value of texture of roselle calyx jelly candy
Notes: 1 = strongly dislike; 7 = strongly like. Different notations indicate significant differences ($p \leq 0.05$)

Effect of concentration of dried roselle calyx and sucrose on the sensory properties

The hedonic sensory evaluation test was performed to identify the acceptance of panelists toward roselle calyx jelly candy. The sensory evaluation questionnaire along with 16 formulations of dried roselle calyx and sucrose were given to 70 untrained panelists. To avoid fatigue during the evaluation, the first eight samples were given at once. When panelists completed the evaluation of the samples, eight remaining jelly candy samples were given.

Based on the results of statistical analysis of the hedonic test of aroma, there is no significant effect of different concentrations of sucrose and dried roselle calyx towards aroma preference of jelly candy. Moreover, there is no interaction between the concentration of sucrose and dried roselle calyx towards the aroma preference of jelly candy ($p \leq 0.05$). The mean score of preference value of aroma of jelly candy is 4.04±1.78, which is positioned between neutral (4 out of 7) and slightly like (5 out of 7), but reaching toward neutral value.

Figures 5 and 6 present a significant effect of different concentrations of sucrose and dried roselle calyx on the texture preference of jelly candy ($p \leq 0.05$). However, there is no interaction between the concentration of sucrose and dried roselle calyx towards the texture preference of jelly candy ($p > 0.05$).

Figure 5 presents that panelists prefer candy with a concentration of sucrose of 77.68% and 84.75%. Texture analysis results summarized in Table 5 indicate that jelly candy with 77.68% of sucrose has a medium hardness value, while 84.75% sucrose-jelly candy has the highest hardness value. Therefore, it can be concluded that the panelists prefer jelly candies with a harder texture. Moreover, Figure 6 shows that the panelists prefer dried roselle calyx with 13.33% and 16.67% concentrations in terms of texture.

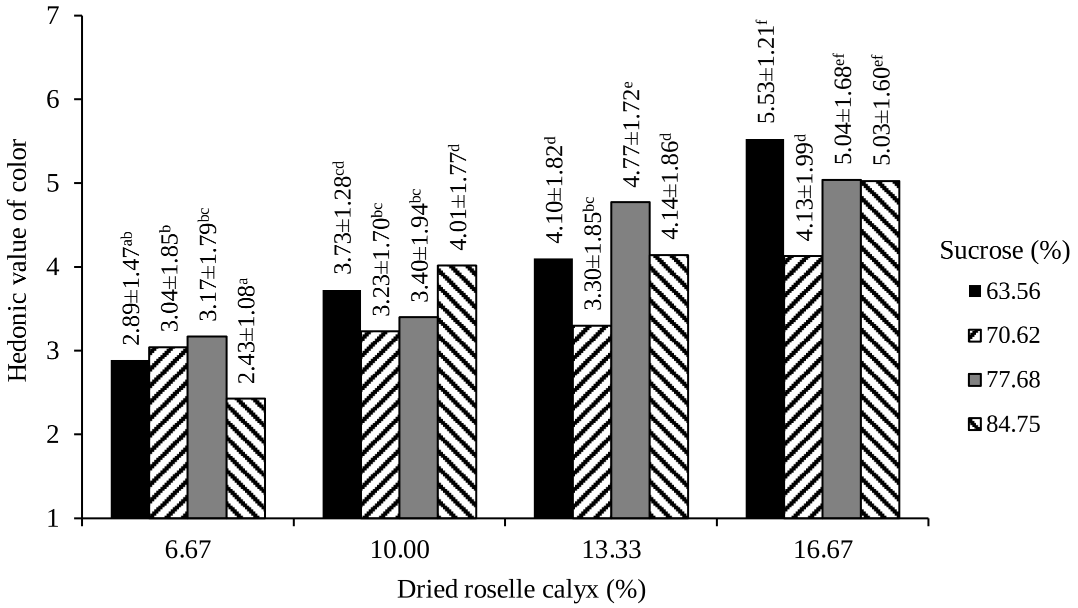

Figure 7. Effect of sucrose and dried roselle calyx concentration on hedonic value of the color of roselle calyx jelly candy

Notes: 1 = strongly dislike; 7 = strongly like. Different notations indicate significant differences ($p \leq 0.05$)

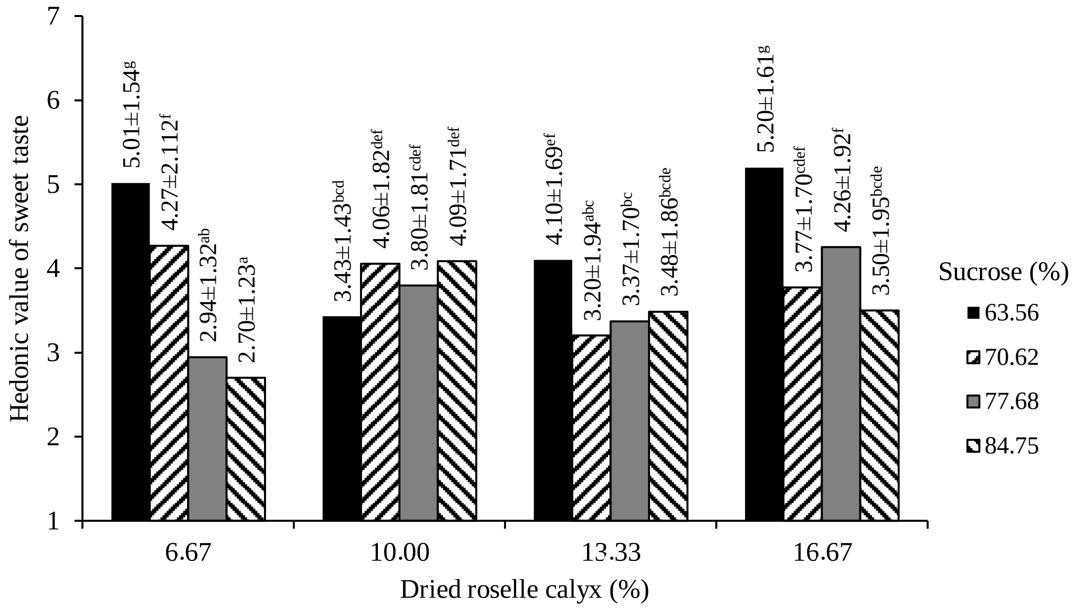

Figure 8. Effect of sucrose and dried roselle calyx concentration on hedonic value of sweet taste of roselle calyx jelly candy

Notes: 1 = strongly dislike; 7 = strongly like. Different notations indicate significant differences ($p \leq 0.05$)

The results of statistical analysis of the color preference displayed in Figure 7 show a significant effect of different concentrations of sucrose and dried roselle calyx on the color preference of jelly candy. There is also an interaction between the concentration of sucrose and dried roselle calyx on the color preference of jelly candy ($p \leq 0.05$). Based on the results of the hedonic test detailed in Figure 7, panelists prefer jelly candy that has a sucrose concentration of 63.56% and a concentration of dried roselle calyx of 16.67%, followed by jelly candies with sucrose concentration of 84.75% and 77.68% with a concentration of dried roselle calyx of 16.67%.

The statistical analysis of the hedonic test of the sweet taste of jelly candy (Figure 8) confirms a significant difference in preference for the sweet taste of jelly candy made using different concentrations of sucrose and dried roselle calyx. There is also an interaction between the concentration of roselle calyx and sucrose toward the preference for the sweet taste of jelly candy ($p \leq 0.05$). Hedonic test results show that panelists prefer jelly candy with a concentration of sucrose of 63.56% and a concentration of dried roselle calyx of 6.67%. Another formulation that is also preferable is jelly candy with a concentration of sucrose of 63.56% and a concentration of dried roselle calyx of 16.67%. Based on the color analysis using chroma meter (Figure 2), it can be concluded that panelists favor jelly candy with a darker color.

The results of the statistical analysis of overall acceptance are demonstrated in Figure 9. The findings show a significant effect of different concentrations of sucrose and dried roselle calyx on the overall acceptance of jelly candy. There is also an interaction between the concentration of sucrose and dried roselle calyx towards the sweet taste preference of jelly candy. Based on the value of overall acceptance of jelly candy detailed in Figure 9, the panelists prefer jelly candy with a concentration of sucrose of 63.56% and a concentration of dried roselle calyx of 16.67% with a score of 4.97.

Selection of best-formulated jelly candy based on hedonic test

Based on hedonic test results, the best-formulated jelly candy is candy with a concentration of sucrose of 63.56% and a concentration of dried roselle calyx of 16.67%, with a hedonic score of 4.97. This formulation has the highest values in overall acceptance, color and sweet taste. Furthermore, hedonic test values of texture confirm that the panelists prefer jelly candy with a concentration of dried roselle calyx of 16.67%.

Nutritional composition of best-formulated roselle calyx jelly candy

The selected formulation of roselle calyx candy was then analyzed for its IC_{50} value and anthocyanin content. The anthocyanin content of the best-formulated jelly candy is 14.235±0.2345 mg $100g^{-1}$. This result is higher compared to *Eucheuma cottonii* seaweed jelly candy added with 15% of roselle calyx extract, which is 1.35 to 3.16 mg $100g^{-1}$ (Susanty, 2016). Meanwhile, the control made using no roselle calyx shows 0.0310±0.0022 mg $100g^{-1}$ anthocyanin content. A high concentration of anthocyanin contributes to the high antioxidant activity of the food product. However, the decrease in the anthocyanin content of the best-formulated jelly candy as compared with the dried roselle calyx (357.94±6.78 mg $100g^{-1}$) is due to the small portion of roselle calyx that is present in the jelly candy solution. Although anthocyanin is water-soluble, it is unstable and depends on the pH (Selim et al., 2019). Furthermore, less water existed in the jelly candy may also reduce the presence of anthocyanin in the final product.

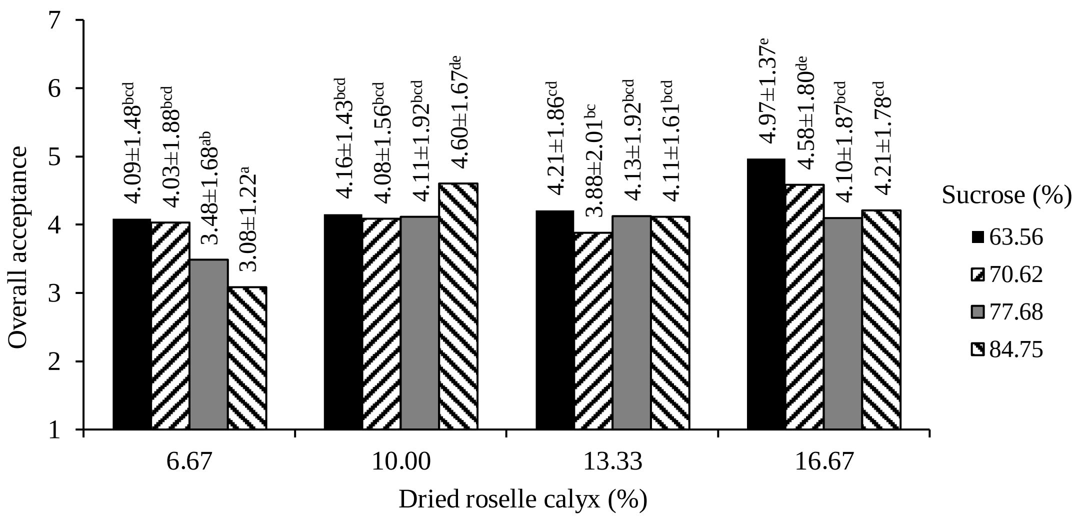

Figure 9. Effect of sucrose and dried roselle calyx concentration on overall acceptance of roselle calyx jelly candy

Notes: 1 = strongly dislike; 7 = strongly like. Different notations indicate significant differences ($p \leq 0.05$)

Table 6. Results of proximate analysis of best-formulated jelly candy and control

Nutritional composition	Unit	Best formulated jelly candy	Control
Moisture	g $100g^{-1}$	19.52±0.00	11.58±0.01
Ash	g $100g^{-1}$	0.03±0.00	0.01±0.00
Protein	g $100g^{-1}$	8.24±0.001	7.46±0.00
Fat	g $100g^{-1}$	1.72±0.06	1.16±0.00
Carbohydrate	g $100g^{-1}$	70.49±0.01	79.79±0.01

The IC_{50} value of the best-formulated jelly candy is 16863.8346±687.8346 µg ml^{-1}. Meanwhile, the IC_{50} value of the control could not be detected. Roselle calyx jelly candy has a moderate antioxidant capacity, as it contains IC_{50} values between 10000 µg ml^{-1} and 30000 µg ml^{-1} (Qusti et al., 2010). Proximate results of the best-formulated jelly candy and control are summarized in Table 6. The best-formulated roselle calyx jelly candy has higher moisture and protein content compared to the control. However, the moisture content is still comparable to jelly candy made from Moringa leaves and pineapple juice, i.e., 18.4462% to 22.0090% (Purba et al., 2018), jelly candy added with rosemary extract, i.e., about 21.60% to 22.42% (Cedeño-Pinos et al., 2020).

CONCLUSIONS

The sensory evaluation concludes that the best-formulated jelly candy is made using 63.56% of sugar and 16.67% of dried roselle calyx. The best-formulated roselle calyx jelly candy contains 14.235 mg $100g^{-1}$ anthocyanin, IC_{50} of 16863.8346 µg ml^{-1}, 19.52% of moisture, 0.03% of ash, 8.24% of protein, 1.72% of fat and 70.49% of carbohydrate. Therefore, the best-formulated jelly candy can be recommended for consumption as a healthier option for sweet treats. However, to complete the findings in this research, analysis of other aspects, such as total phenolic content to confirm the antioxidant properties of jelly candy, is required.

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REFERENCES

Abdallah, E. M. (2016). Antibacterial activity of *Hibiscus sabdariffa* L. calyces against fospital isolates of multidrug resistant *Acinetobacter baumannii. Journal of Acute Disease*, *5*(6), 512–516. https://doi.org/10.1016/j.joad.2016.08.024

Adanlawo, I. G., & Ajibade, V. A. (2006). Nutritive value of two varieties of roselle (*Hibiscus sabdariffa*) calyces soaked with wood ash. *Pakistan Journal of Nutrition*, *5*(6), 555–557. http://dx.doi.org/10.3923/pjn.2006.555.557

Aguirre, F. J., Garcia, J. R., Ruiz N. R. M., Robles, A. I. C., Diaz, S. O. M., Parrilla, E. A., Aguilar, G. A. G., Rosa, L. A., Jimenez, A. R., & Medrano, A. (2016). Cyanidin-3-O-glucoside: Physical-chemistry, foodomics and health effects. *Molecules*, *21*(9), 1264. https://doi.org/10.3390/molecules21091264

Ajala, L., Oyeleke, G., & Olangunjo, E. (2013). Nutritional assessment of juice extract from *Hibiscus sabdariffa*. *International Journal of Biology, Pharmacy and Allied Sciences*, *2*(1), 10–19. Retrieved from https://ijbpas.com/pdf/1356456105MS%20IJBPAS%202012%201268.pdf

Akanbi, W. B, Olaniyan, A. B., Togun, A. O., Ilupeju, A. E. O., & Olaniran, A. O. (2009). The effect of organic and inorganic fertilizer on growth, calyx yield and quality of roselle (*Hibiscus sabdariffa* L.). *American-Eurasian Journal of Sustainable Agriculture*, *3*(4), 652–657. Retrieved from http://www.aensiweb.net/AENSIWEB/aejsa/aejsa/2009/652-657.pdf

Ali, M. R., Mohamed, R. M., & Abedelmaksoud, T. G. (2021). Functional strawberry and red beetroot jelly candies rich in fibers and phenolic compounds. *Food Systems*, *4*(2), 82–88. https://doi.org/10.21323/2618-9771-2021-4-1-82-88

Ansari, M., Eslaminejad, T., Sarhadynejad, Z., & Eslaminejad, T. (2013). An overview of the roselle plant with particular reference to its cultivation, diseases and usages. *European Journal of Medicinal Plants*, *3*(1), 135–145. https://doi.org/10.9734/EJMP/2013/1889

AOAC. (2005). *Official methods of analysis of the Association of Official Analytical Chemists*. Gaithersburg, MD, USA: AOAC International. Retrieved from https://www.researchgate.net/publication/292783651_AOAC_2005

Awad, S. M. S., & Shokry, A. M. (2019). Usage of red beet (*Beta vulgaris* L.) and roselle (*Hibiscus sabdarriffa* L.) in jelly production. *International Journal of Environment*, *8*(2), 142–150. Retrieved from https://www.curresweb.com/ije/ije/2019/142-150.pdf

Azza, A. A., Ferial M. A. S., & Esmat, A. A. (2011). Physico- chemical properties of natural pigments (anthocyanin) extracted from roselle calyces (*Hibiscus subdariffa*). *Journal of American Science*, *7*(7), 445–456. Retrieved from http://www.jofamericanscience.org/journals/am-sci/am0707/067_6293am0707_445_456.pdf

Borrás-Linares, I., Fernández-Arroyoab, S., Arráez-Romana, D., Palmeros-Suárez, P. A., Val-Díaz, R. D., Andrade-Gonzáles, I., Fernández-Gutiérreza, A., Gómez-Leyva, J. F., & Segura-Carretero, A. (2015). Characterization of phenolic compounds, anthocyanidin, antioxidant and antimicrobial activity of 25 varieties of Mexican roselle (*Hibiscus sabdariffa*). *Industrial Crops and Products*, *69*, 385–394. https://doi.org/10.1016/j.indcrop.2015.02.053

Cano-Lamadrid, M., Calin-Sanchez, Á., Clemente-Villalba, J., Hernandez, F., Carbonell-Barrachina, A. A., Esther, S., & Wojdyło, A. (2020). Quality parameters and consumer acceptance. *Foods*, *9*(4), 516. https://doi.org/10.3390/foods9040516

Cedeño-Pinos, C., Martínez-Tomé, M., Murcia, M. A., Jordán, M. J., & Bañón, S. (2020). Assessment of rosemary (*Rosmarinus officinalis* L.) extract as antioxidant in jelly candies made with fructan fibres and stevia. *Antioxidants*, *9*(12), 1289. https://doi.org/10.3390/antiox9121289

Chandra, M. V., & Shamasundar, B. A. (2015). Texture profile analysis and functional properties of felatin from the skin of three species of fresh water fish. *International Journal of Food Properties*, *18*(3), 572–584. https://doi.org/10.1080/10942912.2013.845787

Charoen, R., Savedboworn, W., Phuditcharnchnakun, S., & Khuntaweetap, T. (2015). Development of antioxidant gummy jelly candy supplemented with *Psidium guajava* leaf extract. *KMUTNB International Journal of Applied Science and Technology*, *8*(2), 145–151. http://dx.doi.org/10.14416/j.ijast.2015.02.002

Csima, G., Varvolgyi, E., & Vozary, H. E. (2014). Effect of non-ideal storage conditions on candy gum quality. *International Conference of Agricultural Engineering*, 1–8. Retrieved from http://www.geyseco.es/geystiona/adjs/comunicaciones/304/C04820001.pdf

DeMars, L. L., & Ziegler, G. R. (2001). Texture and structure of gelatin/pectin-based gummy confections. *Food Hydrocolloids*, *15*(4–6), 643–653. https://doi.org/10.1016/S0268-005X(01)00044-3

Fellows, P. J., & Axtell, B. (2014). *Opportunities in food processing: A handbook for setting up and running a smallscale business producing high-value foods*. Wageningen, The Netherlands: Technical Centre for Agricultural and Rural Cooperation (CTA). Retrieved from https://publications.cta.int/media/publications/downloads/1808_PDF.pdf

Garrido, J. I., Lozano, J. E., & Genovese, D. B. (2015). Effect of formulation variables on rheology, texture, colour, and acceptability of apple jelly: Modelling and optimization. *LWT-Food Science and Technology*, *62*(1), 325–332. https://doi.org/10.1016/j.lwt.2014.07.010

Hahn, F., Hernandez G., Hernandez, J., Perez, C., & Vargas, J. J. (2011). Optimization of roselle drding time and drying quality. *Canadian Biosystems Engineering*, *53*, 31–38. Retrieved from Retrieved from https://library.csbe-scgab.ca/docs/journal/53/C1136.pdf

Inggrid, H. M., Jaka, & Santoso, H. (2016). Natural red dyes extraction on roselle petals. *IOP Conference Series: Materials Science and Engineering*, *162*, 012029. https://doi.org/10.1088/1757-899X/162/1/012029

Islam, A. K. M., Jamini, T. S., Mominul Islam, A. K. M., & Yeasmin, S. (2016). Roselle: A functional food with high nutritional and medicinal values. *Fundamental and Applied Agriculture*, *1*(2), 44–49. Retrieved from https://www.f2ffoundation.org/faa/index.php/home/article/view/56

Islam, M. M. (2019). Food and medicinal values of roselle (*Hibiscus sabdariffa* L. Linne Malvaceae) plant parts: A review. *Open Journal of Nutrition and Food Sciences*, *1*(1), 1003. Retrieved from http://www.medtextpublications.com/open-access/food-and-medicinal-values-of-roselle-hibiscus-sabdariffa-l-linne-121.pdf

Jabeur, I., Pereira, E., Barros, L., Calhelha, R. C., Soković, M., Oliveira, M. B. P. P., & Ferreira, I. C. F. R. (2017). *Hibiscus sabdariffa* L. as a source of nutrients, bioactive compounds and colouring agents. *Food Research International*, *100*(1), 717–723. https://doi.org/10.1016/j.foodres.2017.07.073

Jackson, E. B. (1999). *Sugar confectionery manufacture*. New York: Springer. Retrieved from https://link.springer.com/book/9780834212978

Juhari, N. H., Martens, H. J., & Petersen, M. A. (2021). Changes in physicochemical properties and volatile compounds of roselle (*Hibiscus sabdariffa* L.) calyx during different drying methods. *Molecules*, *26*(20), 6260. https://doi.org/10.3390/molecules26206260

Kreungngern, D., & Chaikham, P. (2016). Rheological, physical, and sensory attributes of chao kuay jelly added with gelling agents. *International Food Research Journal*, *23*(4), 1474–1478. Retrieved from http://www.ifrj.upm.edu.my/23%20(04)%202016/(18).pdf

Kian, L. K., Jawaida, M., Ariffin, H., & Karim, Z. (2018). Isolation and characterization of nanocrystalline cellulose from roselle-derived microcrystalline cellulose. *International Journal of Biological Macromolecules*, *114*, 54–63. https://doi.org/10.1016/j.ijbiomac.2018.03.065

Lee, J., Durst, R. W., & Wrolstad, R. E. (2005). Total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method: Collaborative study. *Journal of AOAC International*, *88*(5), 1269–1278. Retrieved from https://www.ars.usda.gov/ARSUserFiles/37108/pdf/leejaoac.pdf

Manjula, G. S., Khrisna, H. C., Mushrif, S. K., Manjunatha, R. T. B., & Shankarappa, T. H. (2022). Standardization of anthocyanin extraction from roselle (*Hibiscus sabdariffa* L.) calyces for edible colour. *The Pharma Innovation International Journal*, *11*(3), 1337–1342. Retrieved from https://www.thepharmajournal.com/archives/?year=2022&vol=11&issue=3&ArticleId=11475

Morales-Cabrera, M., Hernández-Morales, J., Leyva-Rúelas, G., Salinas-Moreno, Y., Soto-Rojas, L., & Castro-Rosas, J. (2013). Influence of variety and extraction solvent on antibacterial activity of roselle (*Hibiscus sabdariffa* L.) calyxes. *Journal of Medicinal Plants Research*, *7*(31), 2319–2322. http://dx.doi.org/10.5897/JMPR12.1242

Mutlu, C., Tontul, S. A., & Erbaş, M. (2018). Production of a Minimally Processed Jelly Candy for Children using Honey instead of sugar. *LWT*, *9*, 499–505. https://doi.org/10.1016/j.lwt.2018.03.064

Novelina, Anggraini, T., & Putri, L. N. (2020). Characteristics of jelly candy made from soybean milk and addition of eggshell powder. *Asian Journal of Applied Research for Community Development and Empowerment*, *4*(1), 41–47. https://doi.org/10.29165/ajarcde.v4i1.37

Ortega, S. C., & Beltran, J. A. G. (2014). Roselle calyces particle size effect on the physicochemical and phytochemicals characteristics. *Journal of Food Research*, *3*(5), 83–95. https://doi.org/10.5539/jfr.v3n5p83

Pacome, O. A., Bernard, D. N., Sekou, D., Joseph, D. A., David, N. J., Mongomake, K., & Hilaire, K. T. (2014). Phytochemical and antioxidant activity of roselle (*Hibiscus sabdariffa* L.) petal extracts. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, *5*(2), 1453–1465. Retrieved from https://www.rjpbcs.com/pdf/2014_5(2)/%5B175%5D.pdf

Pilerood, S. A., & Prakash, J. (2014). Evaluation of nutritional composition and antioxidant activity of borage (*Echium amoenum*) and valerian (*Valerian officinalis*). *Journal of Food Science and Technology*, *51*(5), 845–854. https://doi.org/10.1007/s13197-011-0573-z

Piyarat, K., Walaisiri, M., & Pornpen, W. (2014). Comparison of stability of red colorants from natural sources, roselle and lac in micelles. *International Food Research Journal*, *21*(1), 325–330. Retrieved from http://www.ifrj.upm.edu.my/21%20(01)%202014/46%20IFRJ%2021%20(01)%202014%20Pornpen%20114.pdf

Purba, C. F., Sinaga, H., & Nurminah, M. (2018). Effect of ratio of moringa leaves juice with pineapple juice and Arabic gum on the quality of jelly candy. *Indonesian Journal of Agricultural Research*, *1*(2), 162–171. https://doi.org/10.32734/injar.v1i2.303

Qusti, S. Y., Abo-khatwa A. N., & Lahwa, M. A. (2010). Screening of antioxidant activity and phenolic content of selected food items cited in the Holly Quran. *European Journal of Behaviour Sciences*, *2*(1), 20–51. Retrieved from https://www.semanticscholar.org/paper/SCREENING-OF-ANTIOXIDANT-ACTIVITY-AND-PHENOLIC-OF-Qusti-Abo-khatwa/b6eba4f56247f0b0656e99d7a424873d973151af

Rochmawati, N., & Ermawati, D. E. (2021). Pengaruh konsentrasi karagenan pada sifat fisika dan kimia sediaan gummy jamu kunyit asam. *Majalah Farmaseutik*, *17*(2), 230–237. https://doi.org/10.22146/farmaseutik.v17i2.63615

Salami, S. A., & Afolayan, A. J. (2020). Suitability of roselle-*Hibiscus sabdariffa* L. as raw material for soft drink production. *Journal of Food Quality*, *2020*, 8864142. https://doi.org/10.1155/2020/8864142

Selim, K. A., Abass, M., & Samir, A. (2019). Effect of extraction condition, heat treatments and spay-drying on stability of roselle anthocyanins as natural food colorant. *International Journal of Food Science and Agriculture*, *3*(2), 139–149. Retrieved from https://www.hillpublisher.com/UpFile/201906/2019061866217034.pdf

Shruthi, V. H., Ramachandra, C. T., Nidoni, U., Hiregoudar, S., Naik, N., & Kurubar, A. R. (2016). Roselle (*Hibiscus sabdariffa* L.) as a source of natural colour : A review. *Plant Archives*, *16*(2), 515–522. Retrieved from http://plantarchives.org/PDF%20162/515-522.pdf

Susanty, A. (2016). Pengaruh penambahan rosella (*Hibiscus sabdariffa* L) terhadap sifat fisikokimia permen jelly rumput laut *Eucheuma cottonii*. *Jurnal Riset Teknologi Industri*, *9*(1), 30–40. http://dx.doi.org/10.26578/jrti.v9i1.1699

Tangkanakul, P., Auttaviboonkul, P., Niyomwit, B., Lowvitoon, N., Charoenthamawat, P., & Trakoontivakom, G. (2009). Antioxidant capacity, total phenolic content, and nutritional composition of Asian foods after thermal processing. *International Food Research Journal*, *16*, 571–580. Retrieved from http://www.ifrj.upm.edu.my/16%20(4)%202009/14%20IFRJ-2009-128%20Tangkanakul%20Thailand%203rd%20proof.pdf

Teixeira-Lemos, E., Almeida, A. R., Vouga, B., Morais, C., Correia, I., Pereira, P., & Guiné, R. P. F. (2021). Development and characterization of healthy gummy jellies containing natural fruits. *Open Agriculture*, *6*(1), 466–478. http://dx.doi.org/10.1515/opag-2021-0029

Wu, H. Y., Yang, K. M., & Chiang, P. Y. (2018). Roselle anthocyanins: Antioxidant properties and stability to heat and pH. *Molecules*, *23*(6), 1357. https://doi.org/10.3390/molecules23061357

Yang, L., Gou, Y., Zhao, T., Zhao, J., Li, F., Zhang, B., & Wu, X. (2012). Antioxidant capacity of extracts from calyx fruits of roselle (*Hibiscus sabdariffa* L.). *African Journal of Biotechnology*, *11*(17), 4063–4068. https://doi.org/10.5897/AJB11.2227

Yenrina, R., Sayuti, K., & Anggraini, T. (2016). Effect of natural colorants on color and antioxidant activity of "kolang kaling" (sugar palm fruit) jam. *Pakistan Journal of Nutrition*, *15*(12), 1061–1066. https://dx.doi.org/10.3923/pjn.2016.1061.1066