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Optimization of Vitamin C and Antioxidant Activity in Jelly Candies through the Addition of Tomato Juice and Red Guava

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ABSTRACT
Adding functional foods to confectionery can increase children's nutritional intake. Gummy candy is a type of confectionery that children enjoy. It contains high sugar but low nutritional value. The innovation of adding fruit extracts rich in vitamin C and antioxidants from abundant local foods, such as tomatoes and red guava, was expected to improve the gummy candy's chemical properties. This research contributes to improving the chemical characteristics and sensory acceptability of gummy candy by adding tomato and red guava extract. The ingredients are tomato and red guava juice, gelatin, high-fructose syrup, sucrose, and citric acid. Treatments Formula F0, F1, F2, and F3 received 0, 10, 30, and 30% tomato juice and 0, 10, 20, and 30% red guava. The results of sensory testing showed that the panelists preferred the F3 gummy candy formulation. Chemical characteristics show that the addition of red guava extract increases the moisture content, vitamin C, antioxidants, and total soluble solids. In F0, the moisture content was 31.14%, vitamin C 0.21 mg, antioxidant activity 21.63%, and total soluble solids 30.17 mg/L. The optimal treatment at F3 produced a moisture content of 40.19%, total soluble solids of 35.83 ºBrix, antioxidant activity of 34.56%, and vitamin C of 1.61 mg. Adding tomato and red guava juice to gummy sweets can increase their vitamin C and antioxidant content. Gummy candy is a nutritious food that tastes good and has enough vitamin C and antioxidants for people to consume.

KEYWORDS
Antioxidants; Guava; Gummy; Tomato; Vitamin C

1. INTRODUCTION

Children like candy as a snack, and the most popular type in the community is gummy candy. Food marketing has long been recognized to influence children's food preferences and consumption patterns in branded beverages, fast food, and candy [1]. Gummy candy is quite popular because its main constituents are sucrose, which gives it a sweet taste, and gel, which gives it a chewy texture. The high sugar content makes gummy a source of energy but low in other nutrients [2], limited nutritional value and high levels of "empty calories" without any health-beneficial nutrients [3]. In order to transform gummy candy from a snack into a functional food, innovations are required. Fresh fruits or juices, and bioactive ingredients extracted from fruit peels or seeds, have been used in the Indian Ayurvedic system of medicine to treat various ailments in children and adults [4]. For instance, adding fruit juice can boost vitamins like vitamin C. L-ascorbic acid (LAA) and D-isoascorbic acid (DIAA) are two of the most important antioxidants in industrialized fruit products, such as mixed fruit juices, fruit concentrates, and jams, in which they are added as antioxidants and as a nutrient [5]. Known clinical conditions directly associated with a lack of vitamin C are scurvy, representing the terminal and lethal collapse following prolonged and severe vitamin C deficiency (depletion), and the potential chronic effects of a suboptimal vitamin C status, such as

hypovitaminosis C [6]. Vitamin C also has a role as a natural antioxidant. The body needs antioxidants because they can capture and stabilize free radicals [5].

Tomato production in East Java is abundant at harvest time, so prices are low and tomatoes are easy to obtain; this, in turn, supports the development of tomato-based products. Tomatoes have a slightly sour taste, so some people do not like consuming them directly. Tomatoes (*Solanum lycopersicum*) contain quite high levels of vitamin C, reaching 34 mg per 100 g, with lycopene as the main carotenoid. Tomato lycopene is an antioxidant compound. Lycopene, a powerful antioxidant, protects the body from free radicals. Tomatoes are easily damaged after being harvested, so they cannot be stored for a long time and can only be stored for 3 to 4 days [7]. Hence, they need to be processed into other processed products, such as candied tomatoes, tomato syrup, and tomato juice. Tomatoes are good for health and have the potential as a natural colorant because they contain carotenoid pigments. However, their utilization is still very limited [8], [9].

Red guava *(Psidium guajava* L.*)* has characteristics such as a sweet taste, soft, thick flesh, bright red color, fragrance, and freshness [10]. Vitamin C in guava fruit is very high, reaching 87 mg per 100 g, exceeding the vitamin C content of oranges, which is only 49 mg per 100 g [11]. The high vitamin C in red guava fruit is an antioxidant that has a role in helping fight free radicals and maintain endurance [4]. Red guava is also easily damaged after harvesting, so it cannot be stored for a long time and can only be stored for 3 to 4 days. The respiration rate of guava fruits reached the maximum at 4–6 days under ambient storage conditions, the fruit became softer, and it tasted best during this period. Hence, it needs to be processed into other processed products like gummy [12]. The strong aroma of tomato is due to the presence of several volatile compounds in it, such as acetone, hexanal, geranylaseton, ethanol, and over 400 volatile components have been identified in tomato [13], [14].

Research to combine tomato and red guava in making gummy candy has never been done before. The processing of tomato and red guava mixtures that has been carried out is for the production of juice, honey, and red wine [15], [16], [17]. Guava fruits had the highest vitamin C values, citric acid content, and sucrose [18], [19]. Guava contains the volatile compound, eugenol, which is responsible for giving it its distinctive aroma [20]. The vitamin C and bioactive compounds for characteristic sweet flavor and aroma make them ideal ingredients for functional products, usually in the form of mixed juice and pudding, but those are all perishable products [21], [22], [23]. The sour taste and carotenoid pigments in tomatoes can be used as a natural coloring for gummy candy. This research combined tomato and guava to produce gummy candy as a functional food. This study contributes to increasing the vitamin C content, antioxidants, and sensory acceptance of gummy candy so consumers get health benefits beyond just sugar when consuming candy.

2. MATERIALS AND METHODS

2.1. Materials

The materials used were tomatoes and guava obtained from the Caruban market, granulated sugar (Gulaku), drinking water (Le Minerale brand), fructose syrup (Edna brand), gelatin (Hakiki brand), citric acid (R&W brand), powdered sugar (Edna brand), and tapioca starch (Rose Brand). Chemical reagents used in this research were 70% methanol (Sigma), 70% alcohol (JKcare), 0.01 N iodine solution, 1% amylum indicator, and distilled water (JKCare).

2.2. Preparation of Gummy Candy with the Addition of Tomato Extract and Guava

Sucrose and high-fructose syrup (HFS 55%) were dissolved, and then the solution was heated to 80 °C for 5 minutes. Upon complete dissolution of the sugars, gelatine, tomato juice, red guava juice, and citric acid were incorporated. Subsequently, agitate the mixture at 70 °C until it attains a smooth and thicker consistency, for approximately 3 minutes. Ultimately, the solution was transferred into molds, permitted to cool, and enrobed with a blend of powdered sugar and tapioca flour in a 1:1 ratio. The formulation of tomato juice to red guava juice is presented in Table 1.

Table 1. Gummy candy formulation.

Composition	F0	F1	F2	F3
Tomato extract (%)	0	30	20	10
Guava extract (%)	0	10	20	30
water (g)	40	0	0	0
Gelatin (g)	18	18	18	18
HFS (g)	28	28	28	28
Sucrose (g)	13.7	13.7	13.7	13.7
Citric Acid (g)	0.3	0.3	0.3	0.3

2.3. Moisture Content Analysis

The moisture content of the samples was analyzed using the oven thermogravimetry method. The analysis was performed in triplicate [24].

2.4. Vitamin C Content Analysis

Determination of vitamin C content using the iodine titration method. The gummy candy was weighed at about 5 g, mashed, and placed into a 250 mL measuring flask; then, distilled water was added to the mark. Then the solution was filtered, and 25 mL of filtrate was taken to be put into an Erlenmeyer, followed by the addition of 1% amylum by 1 to 2 mL. The solution was titrated with 0.1 N iodine solution until a color change occurred.

2.5. Antioxidant Activity Analysis

The antioxidant analysis was performed using the DPPH method [25]. Gummy candy was weighed at 0.5 mg and then dissolved in 10 mL of technical methanol and mixed/stirred until homogeneous. Solutions made of various concentration variations were prepared using a 5 mL flask. Taking 2 mL of solution with different concentrations and 2 mL of DPPH solution added, technical methanol solvent was used as a control. The samples were allowed to stand for 30 minutes in a closed room, and then the absorbance was measured and calculated as % inhibition.

2.6. Total Soluble Solid Analysis

Five grams of gummy candy were weighed, mashed, and mixed with five mL of purified water (1:1). Applying the material to the refractometer prism and reading the blue hue of the refractometer lens in units of percentage brix allowed researchers to observe the total sugar values using a refractometer [26].

2.7. Sensory Analysis

A total of 35 panelists ranked the level of liking for color, aroma, texture, and taste [27].

2.8. Data Analysis

Data analysis using the ANOVA General Linear Model with a 95% confidence interval in the Minitab 19 application. If there are significant differences, the results are further tested using the Tukey method. If there is an interaction, it is further tested with the DMRT method with a 95% confidence interval.

3. RESULTS AND DISCUSSION

3.1. Moisture Content

Determining the moisture content of ingredients determines the product's shelf life. Most bacteria require a water activity above 0.91 to grow, while yeasts and molds can survive at progressively lower levels. Free water provides the perfect environment for these microorganisms [28]. The moisture content in this study ranged from 31.47 to 40.19%, whereas the SNI for gummy candy is a maximum of 20%. Adding fruit juice increases the moisture content of gummy candy. The moisture content (Table 2) in this study is lower than seaweed gummy candy with the addition of Kersen fruit pulp (42.46–48.33%) [27].

The F0 sample has a low moisture content because no tomato juice or red guava juice was added. Samples F1, F2, and F3 showed no significant difference, but F1 tended to increase. The higher percentage of tomato juice, followed by the lower percentage of red guava juice, results in higher moisture content. This relates to moisture content, as tomatoes have a higher moisture content than red guava. The impedance values were measured at moisture contents in tomato of 89–92.7% [28], higher than those in red guava fruit, which has a lower percentage of 72.3%. The moisture content of the raw materials used in the manufacturing process determines the final product's moisture content.

Tabel 2. Moisture content of gummy candy.

Sample	Concentration of tomato extract (%)	Concentration of guava extract (%)	Moisture content (%)
F0	0	0	31.47 ± 0.66^{a}
F1	30	10	40.83 ± 0.07^{b}
F2	20	20	40.33 ± 0.72^{b}
F3	10	30	40.19 ± 0.78^{b}

Note: The data presented is the average of 3 repetitions. The numbers presented with different notations show significantly different results based on the DMRT test (α=0.05). The numbers after ± are standard deviation values.

3.2. Vitamin C Content

Vitamin C levels in gummy candy without the addition of fruit juice are different from those in the group that gets the addition of fruit juice (Table 3). Vitamin C comes from fruit juice that became the main ingredient in gummy candy. Another study showed that real fruit affects the vitamin C content of gummy candy because the vitamin C in fruit juice comes from the fruit itself. The vitamin C content of a processed product will increase along with the amount of juice or other ingredients used [29].

Tabel 3. Vitamin C content of gummy candy.

Sample	Concentration of tomato extract (%)	Concentration of guava extract (%)	Vitamin C (mg/L)
F0	0	0	2.05 ± 0.51^{a}
F1	30	10	9.68 ± 0.88^{b}
F2	20	20	13.49 ± 0.50^{c}
F3	10	30	16.13 ± 0.50^{d}

Note: The data presented is the average of 3 repetitions. The numbers presented with different notations show significantly different results based on the DMRT test (α=0.05). The numbers after ± are standard deviation values.

In the samples F0, F1, and F2 showed significant differences, and F3 tended to increase. Vitamin C levels increased when red guava juice was added to this gummy candy. This is in accordance with the data showing that the vitamin C content of fresh ripe tomatoes is 193.82 ± 20.72 mg/L [30] while guava (ascorbic acid) has 277.62 ± 2.62 mg/L [19]. Therefore, the more guava juice added, the higher the total vitamin C content.

The low amount of vitamin C can be caused by heating in the process of making gummy candy. The statement [31] corroborates this: vitamin C is readily oxidized by heat, light, and metals. Exposure to extreme heat for a prolonged period can reduce vitamin C levels. The amount of vitamin C will decrease proportionally to the length of heating time [32], [33]. Another study showed that vitamin C concentration tends to decrease as heating time increases. This can occur due to the vitamin C's easily oxidized nature, especially when heated at high temperatures [34]. Ascorbic acid can be oxidized by vitamin C to produce L-dehydroascorbic acid, which is chemically very unstable. Further transformation of L-dehydroascorbic acid is very unstable. Further transformation of L-dehydroascorbic acid can produce L-diketogulonic acid, which loses its vitamin C action.

3.3. Antioxidant Activity

Antioxidants are compounds that can neutralize oxidation that hurts the body. To prevent harmful free radicals from affecting healthy body cells, antioxidants can help in the process of converting them into a more stable form. Ascorbic acid also has an important role in the intestinal absorption of non-haem iron and as a cellular antioxidant, independently or together with the antioxidant action of vitamin E [34]. The results of antioxidant activity in all treatments showed a significant difference, but F1 tended to increase (Table 4). The antioxidant activity of this gummy candy shows that the higher the ratio of tomato fruit, the greater the antioxidant activity tends to be. Tomatoes have high antioxidant activity, around 79.89%, and the addition of tomato fruit lycopene increases antioxidant activity to 89.79–92.10% [35]. Natural antioxidants contained in tomatoes include lycopene, flavonoids, and vitamin C [30].

Tabel 4. Antioxidant activity of gummy candy.

Sample	Concentration of tomato extract (%)	Concentration of guava extract (%)	Antioxidant activity (%)
F0	0	0	21.63 ± 0.26^{a}
F1	30	10	41.44 ± 0.44^{d}
F2	20	20	39.43 ± 0.23^{c}
F3	10	30	34.56 ± 0.47^{b}

Note: The data presented is the average of 3 repetitions. The numbers presented with different notations show significantly different results based on the DMRT test (α=0.05). The numbers after ± are standard deviation values.

Lycopene antioxidants are a powerful class of antioxidants, with the ability to prevent free radical damage, compared with α-tocopherol (vitamin E), which has five times more antioxidant activity [27]. Compared to tomatoes, red guava has lower antioxidant activity, with a value of about 51.28%. Antioxidant activities in red guava include lycopene, flavonoids, vitamin C, and beta-carotene [30]. The amount of lycopene increases along with the increase in antioxidant activity. The amount of lycopene extract added determines the antioxidant activity of soap containing lycopene; the more tomato extract added, the higher the antioxidant activity [36].

3.4. Total Soluble Solid

Soluble solids in water, measured in °Brix, are known as total soluble solids. The total soluble solids content in this gummy candy was analyzed using a refractometer. The results of the analysis of total soluble solids in all treatments showed a significant difference, but in F3, it tended to increase (Table 5). The higher percentage of red guava juice, followed by the lower percentage of tomato juice, resulted in a greater value of total soluble solids. The content of total soluble solids is related to the amount of sucrose contained in the raw materials to make gummy candy. Tomatoes have a total sugar content ranging from 3.88% to 5.35%, consisting of fructose and glucose, while red guava has a higher total sugar content of 10.3%, mostly glucose, sucrose, and fructose [37]. The addition of sugar produces a higher value of total soluble solids because sugar (sucrose) is composed of glucose and fructose and is very soluble in water, so the more sucrose content in fruit juice, the more total soluble solids the gummy candy will have [38].

Tabel 5. Total Soluble solids of gummy candy.

Sample	Concentration of tomato extract (%)	Concentration of guava extract (%)	Total Soluble solids (°Brix)
F0	0	0	30.17 ± 0.28^{a}
F1	30	10	33.67 ± 0.57^{b}
F2	20	20	34.67 ± 0.57^{c}
F3	10	30	35.83 ± 0.28^{d}

Note: The data presented is the average of 3 repetitions. The numbers presented with different notations show significantly different results based on the DMRT test (α=0.05). The numbers after ± are standard deviation values.

3.5. Sensory Properties

3.5.1. Color

One key factor influencing consumer acceptance of food is its color. Color plays an important role in increasing consumer acceptance [39]. The results of sensory analysis showed a significant difference in all treatment samples. The F0 (control) sample is transparent yellow, significantly different from all treatments. The resulting color is due to the absence of tomato juice and red guava juice. This is in line with other research, which states that fruit juice is often added to gummy candy to impart a natural taste and color [40].

Figure 1 showed that the result of sensory analysis samples F1, F2, and F3 show a significant difference, but F3 tends to increase in the range 0.02 to 0.56 (in range scale likert 1–5, strongly disagree (score 1), disagree (score 2), neutral (score 3), agree (score 4), strongly agree (score 5) and then followed by ranking using yeath sensory table). Sample F1 has an orange-red color, sample F2 is bright red, and sample F3 is pink. This gummy candy produces an orange-red to pink color. This orange-red color is produced from the natural color of tomatoes. Tomatoes contain carotenoids, compounds derived from isoprene that give them an orange, yellow, or red-orange color [41]. The characteristic red color of guava in gummy candy becomes more intense with the addition of more red guava juice. The percentage of red guava juice added is in line with the increase in the intensity of the pink color in the gummy candy. This is in line with the research that state lycopene, a component found in red guava, is what gives the fruit its distinctive red color [42].

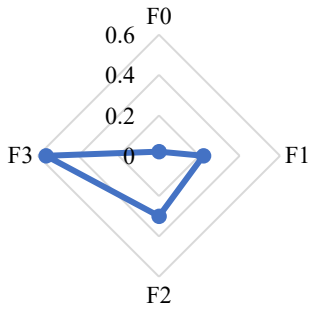

Figure 1. Color sensory analysis results.

3.5.2. Flavor

The results of organoleptic testing of the flavor of gummy candy showed significant differences in several treatment samples. Sample F0 (control) showed a significant difference from all samples. Sample F0 has a distinctive sugar aroma. Red guava juice and tomato juice are not present; instead, the addition of sugar yields the scent. Adding sucrose to food goods during the gummy candy-making process enhances their caramel scent. Consumers may hesitate to try food products with an aroma that is too strong or none at all [43].

Figure 2 depict that F1 and F2 showed no significant difference in the combination of the distinctive aroma of tomato and red guava. The comparison of the concentration of tomato juice and red guava juice contained in the two samples is also almost the same and significant in sensory analysis (in range scale likert 1–5, strongly disagree (score 1), disagree (score 2), neutral (score 3), agree (score 4), strongly agree (score 5) and then followed by ranking using yeath sensory table). Sample F1 with 30% tomato juice and 10% red guava juice, while sample F2 with 20% tomato juice and 20% red guava juice. Tomato has a strong aroma, while red guava has a distinctive aroma. The strong aroma of tomato is due to the presence of several volatile compounds in it, such as acetone, hexanal, geranyl aseton, and ethanol. In contrast, guava contains the volatile compound eugenol, which gives it its distinctive aroma [44].

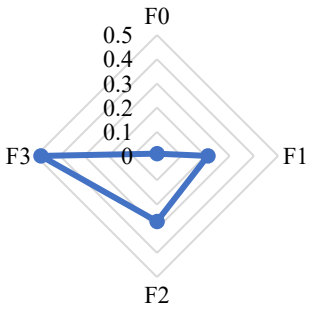

Figure 2. Flavor sensory analysis results.

3.5.3. Taste

Organoleptic test results regarding the taste of gummy candy showed significant differences in several treatment samples. Sample F0 (control) showed a significant difference compared with all samples. Sample F0 has a sweet taste. The sweetness produced is due to the concentration of sucrose given, as well as the absence of tomato juice and red guava juice. In line with the statement in the other research, sucrose functions as a sweetener, preservative, and flavor enhancer [45].

Figure 3 showed that F1 and F2 showed no significant difference. Sweet and sour gummy candy was produced by samples F1 and F2 (in range scale likert 1–5, strongly disagree (score 1), disagree (score 2), neutral (score 3), agree (score 4), strongly agree (score 5) and then followed by ranking using yeath sensory table). Tomato juice and red guava juice combined to create a sweet-and-sour flavor. Guava juice tastes sweet and slightly sour, while tomato juice tastes sour with a little sweetness. The flavor of tomatoes is caused by the content of organic acids (citric acid and malic acid) and the content of sugar components (glucose and fructose). This statement is also supported by research, which indicates that red guava has a sweet-and-sour taste and a sugar content of up to 10.3%. F1 and F2 samples showed a significant difference from F3, but F3 tended to increase. Sample F3 has a red guava-like flavor with a slight sour sweetness. This is because guava juice has a high concentration. Other research reported that red guava has a total sugar content of 10.3%, which consists of glucose, sucrose, and fructose [46]. Among these simple sugars, fructose is the sweetest sugar and is widely found in various types of fruit. The sharper the sweetness of guava juice, the higher the concentration of red guava juice added.

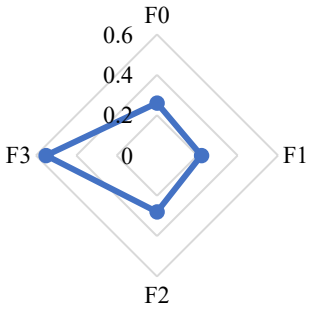

Figure 3. Taste sensory analysis results.

3.5.4. Texture

The results of organoleptic testing on the texture of gummy candy showed significant differences in several treatment samples (Figure 4). Sample F0 (control) with all treatments showed a significant difference. Sample F0 has a chewy texture; this is due to the absence of tomato juice and red guava juice. The amount of pectin in the fruit and the presence of gelatin, which also maintains the gel structure of the gummy candy, can affect the chewiness of the candy [47].

F1, F2, and F3 samples showed no significant difference. However, in F3, there was an increasing trend (in range scale likert 1–5, strongly disagree (score 1), disagree (score 2), neutral (score 3), agree (score 4), strongly agree (score 5) and then followed by ranking using yeath sensory table). This is due to the higher pectin content in red guava compared to tomatoes. Hydrocolloid substances called pectin function as gelling agents, adhesives, and stabilizers in gummy candy. Ripe tomatoes have a pectin content of 0.17–0.25% [48]. Red guava in ripe condition contains higher pectin content [49]. The higher the ratio of red guava juice added, the higher the pectin content and the chewier the texture. The amount of solids will increase, and the moisture content of the material will decrease in proportion to the concentration of pectin in the material, resulting in a strong [50].

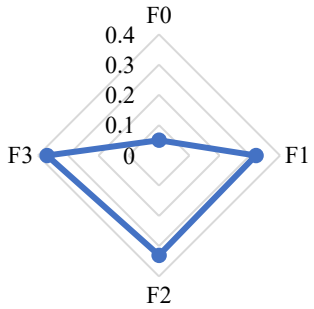

Figure 4. Texture sensory analysis results.

4. CONCLUSION

Adding tomato and red guava juice can increase the vitamin C content of gummy candy. The antioxidants obtained also showed an increase from the control group to F3. Sensory gummy candy produces an orange–red to pink color. The pinker color of F3, which received the reddest guava juice, was the one panelist liked most. Because red guava juice provides a more dominant in providing aroma, the aroma sensory in F0 shows a distinct sugar scent, while the aroma in F3 is more positive. Taste and texture sensory results indicated that F3 was the favored option.

AUTHOR CONTRIBUTION

All author contributed equally to the main contributor to this paper. All authors read and approved the final paper. **Fitriyah Zulfa**: Writing (review & editing), writing (original draft), and formal analysis. **Alfi Nur Rochmah**: Writing (review & editing). **Yenny Febriana Ramadhan Abdi**: writing (original draft). **Dininurilmi Putri Suleman**: investigation, and formal analysis. **Dini Nadhilah**: Investigation, writing (review & editing), supervision. **Prajwalita Rukmakharisma Rizki**: translation. **Dea Yoana Putri**: conceptualization, and funding acquisition.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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