The effect of malt, pectin, and gelatin concentrations on elasticity, color and sensory evaluation of soursop (*Annona muricata* L.) jelly candy

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**Abstract.** The confectionery industry produces a wide variety of sugary products for children. The juice of soursop (*Annona muricata* L.) was selected as a flavorant to produce jelly candies with high nutritional value. Addition of food additives such as gelatin, pectin and malt is essential in jelly candy production. Therefore, the present study investigated the effect of adding different concentrations of pectin (0.2-0.8%), malt (12-18%) and gelatin (12-18%) to the elasticity and color change of the resulted soursop jelly candy. Results have shown that a combination of 14% gelatin, 0.4% pectin and 12% malt produced the candies with highest elasticity. Increasing malt concentration further was found to reduce the candy elasticity. The jelly candies also showed oxidative browning after four days of preservation. The sensory acceptance value is feasible and is higher than the commercial circulation point. The present study was the first to produce jelly candy from soursop juice, introducing a high-value confectionery product that could be a promising candidate for industrial-scaled production. Further studies on antioxidant activity, as well as safety and nutritional value of the product are also required.

1. Introduction
The development of food technology has produced high-quality confectionery products [1-5]. In the past, jelly candies were a mixture of water and additives, thus lacking the nutrients and minerals which provide health benefits. Recently, probiotics and vitamin C are commonly supplemented to candies to improve their nutritional values. However, little attention has been given to the manufacture of candy derived from natural sources, limiting the promising applications of many agricultural commodities. For example, juices from a few fruits such as aonla, watermelon and beetroot have been used to produce high-quality jelly candies [6, 7]. Therefore, developing processing and production technologies is required to utilize the significant values of fruit juices in confectionery industries.
Soursop (*Annona muricata* L.) is a perennial woody plant which distributes across the tropical and sub-tropical countries. The fruits are harvested annually, with production yield of over 10000 tons per year. Soursop fruit pulp is a well-known source of vitamins, amino acids, fibers, minerals, protein, sugar and lipid. Over the years, its applications are extremely diverse, ranging from food and beverage production to medicinal treatment. Numerous biological activities have been reported, including anti-cancer, anti-oxidant, antimicrobial and anti-diabetes [8]. With high content of nutrients, soursop fruit pulps have been selected in the present study for producing jelly candies with increasing nutritional values.

Many considerations should be taken in production of jelly candies from soursop pulp extracts. Firstly, elasticity is important for candy shape formation. Secondly, the candies made by fruit juice are highly prone to enzymatic browning, which causes negative impacts on the shelf-life and consumer preferences [9]. Thirdly, pectin and gelatin act as a gelling agent and stabilizer, while malt accelerates the solution viscosity and reduces sugar crystallization [10-12]. Therefore, elasticity, color change and mixture of gelatin, pectin and malt are important parameters that require close monitoring for effective production of jelly candies. Therefore, in the present study, the change in concentrations of gelatin (12-18%), pectin (0.2-0.8%) and malt (12-18%) was accessed for their effect on the elasticity and color of candies produced from the soursop pulp juice. In addition, a sensory evaluation was performed on the obtained candies.

### 2. Materials and methods

#### 2.1. Preparation of fruit materials and food additives

Healthy and ripe soursop fruits were collected from Tan Phu Dong District, Tien Giang Province, Vietnam (10°15’N, 106°39’E). The fruit was thoroughly washed with water, allowed to dry at room temperature and had their peel removed using a sharp knife. Food additives (i.e. gelatin, pectin and malt) were purchased from a local distributor.

#### 2.2. Preparation of sample soursop jelly candy

Preparation of sample jelly candies from soursop pulp juice followed three steps. In the first step, the pre-treated soursop pulp was pressed using a mechanical extractor while water solvent (1:5 w/v) was being added. After removing seeds and other residues, the obtained transparent juice was preserved at 5 °C. In the second step, soursop juice was concentrated by applying heat (90 °C) to remove water, and then was added with different concentrations of pectin (0.2-0.8%), malt (12-18%) and gelatin (12-18%). The mixture was poured into a heat-resistant silicone mold. All the candies had round-shape, smooth surface, 2.5 cm of diameter, 1 cm of height and transparent color. The whole process of soursop jelly candies production was demonstrated in Figure 1.
2.3. Determination of elasticity
The elasticity degree of the sample soursop jelly candies was determined using Brookfield CT-3 Texture Analyzer (CT3-10k, AMETEK Brookfield, USA), with a 12.7 mm diameter cylinder probe (Diameter cylinder probe, ta5) and a fixed table placed below: TA-RT-KIT (fixture). The conditions of elasticity test were as follows: 5.00 mm/s of test speed, 4.5 mm/s of return speed, 2 mm/s of pre-test speed, 30.0 g of trigger load, 4500 g of load cell, and 50% of compression of sample height.

\[ \text{Degree of elasticity} = \frac{\text{recoverable work} \times 100}{\text{total work}} \]

2.4. Determination of color change
The color change of soursop jelly candies production was determined using CIE Lab * color space as previously described by Torres et al. (2011) [13]. The brightness was determined through the Chroma colorimeter (NR60CP model) computer scanner. Results displayed in numerical form via L* (lightness ranged from 0-100), a* (from green to red) and b* value (from blue to yellow). The total color difference (TCD) of the newly obtained sample candies after 4 days was recorded every day and determined based on formula:

\[ \Delta E = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \]
2.5. Sensory evaluation
A total of thirty students of Nguyen Tat Thanh University, Ho Chi Minh City, in the age of 18-23 were participated in evaluating the texture, flavor, color and aroma of sample soursop jelly candies, with the importance factors determined based on the Vietnamese Standard (TCVN) No. 3215-79. The preference of participants was also measured using a 5-point hedonic scale (1=extremely dislike, 5= extremely like). Description of sensory scales is summarized as in Table 1.

| Rating score | Preference       | Texture                                      | Flavor                           | Color                         | Aroma                          |
|--------------|------------------|----------------------------------------------|----------------------------------|-------------------------------|--------------------------------|
|              |                  | (Importance factor: 1.6)                      | (Importance factor: 1.2)         | (Importance factor: 0.8)      | (Importance factor: 0.4)       |
| 5            | Extremely like   | Flexible, non-stick, hard to break off,      | Sweet, medium sour               | Pellucid, deposit             | Especially aroma soursop       |
|              |                  | without air bubbles                          |                                  |                               |                                |
| 4            | Like             | Flexible, non-stick, easy to break off,      | Sweet, high sour                 | Pellucid, low deposit         | Strong                         |
|              |                  | without air bubbles                          |                                  |                               |                                |
| 3            | Accept           | Flexible, sticky, easily broken, low air     | Sweet, low sour                  | Low cloudy                    | Faintly redolent               |
|              |                  | bubbles                                       |                                  |                               |                                |
| 2            | Neither like     | Less flexible, non-stick, easy to break off,| Low sweet, low sour              | Slightly yellow               | Non-soursop aroma              |
|              | or dislike       | low air bubbles                               |                                  |                               |                                |
| 1            | Extremely        | Less flexible, sticky, easily broken, many   | Low sweet                        | Bright yellow, cloudy         | Strange smell                  |
|              | dislike          | air bubbles                                   |                                  |                               |                                |

2.6. Statistical Analyses
The experiment were performed in triplicates. The statistical analysis was carried out using Analysis of Variances (ANOVA) and results were represented as mean value ± standard deviations. \( p < 0.05 \) was considered as significant difference.

3. Results and discussion

3.1. Effects of addictive concentrations on the elasticity of jelly candies
Firstly, the effects of different malt concentrations on the candy elasticity were recorded in Figure 2. It can be seen that increasing concentrations of malt from 12-18% would significantly reduce the candy elasticity [14]. Therefore, the concentration of 12% was selected. While the malt could enhance the sweetness and stabilize the structure, when making soursop jelly candy, it should be added at an appropriate concentration to prevent the loss of candy elasticity [15, 16].
Figure 2. Effect of different malt concentrations (12-18%) on elasticity of soursop jelly candies. Data was represented as mean ± S.D. of three replicates.

Secondly, the effects of different pectin concentrations (0.2-0.8%) on jelly candy were evaluated. As shown in Figure 3, the degree of elasticity increased from 4.460 ± 0.039 mm at 0.2% to 4.523 ± 0.001 mm at 0.8% of pectin concentration, with insignificant difference observed between the concentrations from 0.4-0.8% (p > 0.05). Therefore, the concentration of 0.4% pectin was selected. The strong structural linkages on the role of pectin in plant cell walls and food were outlined previously [17]. Moreover, pectin absorbs water and swelling, which increases viscosity and structural stability [18]. The pectin concentration of 0.4% is thus considered to be essential for making soursop jelly candy.

Figure 3. Effect of different pectin concentrations (12-18%) on elasticity of soursop jelly candies. Data was represented as mean ± S.D. of three replicates.

The results obtained from the Brookfield CT-3 Texture Analyzer elasticity determination were shown as in Figure 4. The jelly candies had an elasticity of 4.514 ± 0.007 mm at the lowest gelatin concentration (12%) and this value increased proportionally with the amount of gelatin, reaching the highest point of 5.345 ± 0.035 mm at the highest concentration (18%). This number is higher than the value found in candies produced by Sukandar [19]. This can be explained by the hydrophilicity of gelatin [20]. As more gelatin was added, it would absorb more water, thus causing the product to become more elastic. However, bubbles were formed when the concentrations exceeded 14%. Therefore, to maintain a good texture, gelatin at 14% was selected to produce the jelly candy in the present study. Expanded and confined polymer granules, particle size homogenization, and the distribution of additives significantly affect the physical structure of the sample candy [21].
Figure 4. Effect of different gelatin concentrations (12-18%) on elasticity of soursop jelly candies. Data was represented as mean ± S.D. of three replicates.

3.2. Change of soursop juice color
The light color change from bright to dark yellow is heavily influenced by oxidation. As shown in Table 2, the L* value of the juice reached white gamut (67.01 ± 3.77) and decreased with increasing storage time. It is worth noting that the value of a* tends to approach the CIE space intersection and that b* increases in the direction of yellow. This resulted in a large TCD of 15.80 ± 1.34 after 4 days compared to the newly obtained sample (control), indicating a noticeable discoloration of the candy. Maintaining the original color of soursop jelly candy is difficult. Oxidative browning constituents during the process of additive dissolution, degradation in polyphenol content, and Maillard reaction might also contribute to the darkening [22, 23]. Internal browning incidence was more rapid and more intense with prolonged preservation time [24].

Table 2. Results of CIE Lab of soursop jelly candies after 4 days. a* (redness/greenness), b* (yellowness/blueness), L* (whiteness/brightness) and ΔE (total color change).

| Day storage | L*       | a*        | b*        | ΔE        |
|-------------|----------|-----------|-----------|-----------|
| Control     | 67.01 ± 3.77 | -3.62 ± 0.31 | 1.70 ± 0.22 | 0         |
| 1           | 68.79 ± 0.79a | -3.58 ± 0.32a | 2.08 ± 0.30a | 1.88 ± 0.72b |
| 2           | 56.78 ± 1.11b | -2.35 ± 0.40b | 2.66 ± 0.29ab | 10.47 ± 1.05c |
| 3           | 54.29 ± 1.04bc | -2.41 ± 0.10bc | 2.73 ± 0.31ab | 12.83 ± 1.05c |
| 4           | 51.81 ± 1.45c | -1.71 ± 0.23c | 5.48 ± 0.37c | 15.80 ± 1.34d |

Different subscripted letters indicate statistical difference between columns

3.3. Sensory evaluation
Sensory study was performed to evaluate the consumer preference for soursop jelly candies in terms of texture, flavor, color and aroma (Figure 5). Based on TCVN, the texture of the candies was referred as the most important, with importance factor of 1.6, followed by flavor (1.2), color (0.8) and aroma (0.4). The produced jelly candies were rated as 16.91 points, which had a higher critical coefficient than the commercial score of 11.2, suggesting the potential commercialization of the manufactured candy product.
4. Conclusion
In the present study, soursop juice was used to manufacture jelly candies and the obtained candies were evaluated for elasticity and color change upon modifying the concentrations of food additives (i.e. gelatin, pectin and malt). The most effective concentrations of these additives were found as 14% gelatin, 0.4% pectin and 12% malt, producing the jelly candies with high elasticity degree. The color of jelly candies became darker after 4 days. However, the sensory evaluation revealed an average score of preference. Further studies are required to assess the safety and nutritional values when consuming the produced jelly candies. In addition, the antioxidant activity of the product should be implemented in the future.

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