Effects of drying conditions on total phenolic content and other parameters of soursop jelly (*Annona muricata* L.)

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Abstract: *Annona muricata* Linn. (soursop) belongs to the family *Annonaceae*. This plant had been traditionally used for treatment of various infectious and inflammatory diseases. This study aimed to determine the effects of convection drying on the nutrient composition of the plant. Measured indicators included protein content, ash content, fat, total ascorbic acid content (TAA), total phenolic content (TPC), color and sensory level of soursop. At different temperatures of 40°C, 50° and 60°C, the evaluation criteria change significantly when supplemented with °Brix at 10%, 15% and 20%. Highest protein content achieved at 20% soluble solids concentration was 2.71 ± 0.09 and 2.68 ± 0.01 at 40 and 60°C, respectively. Most of the percentage of ash of the sample was unaffected and the change of the fat content is negligible. Moreover, TAA and TPC were found to decline after the process. About 68.62% TAA was retained when drying at 40°C (20% Brix) and the figure for TPC was 38.46% (60°C, 10% Brix). Typically, in the L* color space, all samples exhibited the value of higher than 55 and there is a tendency to give a white color. In addition, the a* and b* values increased after drying. Optimal parameters are selected based on the commercial nature of the product and the retention of nutritional value. Final results consisted of the addition of 10% syrup sugar (60 ° Brix) in the sample under the temperature of 40 ° C for 390 minutes.

1. Introduction

The focus on research and innovation in the food and materials sector in the words will increase over the next few years [1–7]. Plant foods play a vital source of nutrients to both human and animals. The advantage of the plant is diverse in different fields such as medicine, cosmetics, food industry. The antioxidant components of plants decrease oxidative stress. Soursop (*Annona muricata* L.) is a plant originating from the Americas and the Caribbean, genus *Annona*, belonging to the family *Annonaceae* [8]. Soursop contains various vitamins (mainly ascorbic acid and thiamin), free amino acids, glutamic acid, glycine-serine, alanine, cysteine, arginine, and lysine [9]. Besides, nutritional components are referred to as high sugar content, protein or lipid [8]. Notably, in food industries, soursop was previously studied to produce drinks and jam, cream, yogurt, fruit jelly and alcohol (volatile odor compounds).

Moreover, the extraction from soursop seed plays a vital role in reducing stress. Soursop is used as
an antispasmodic herb, supporting the liver and preventing urethritis [8]. In addition, soursop is used as a source of pectinesterase extraction which compound acts as an essential additive in the processing industry [10].

Water is known as a major component that has a significant influence on product preservation and physicochemical, biological properties. Therefore, drying technology is more concerned with the water removal mechanism [11]. Plant tissue cells are profoundly changed under the effect of convection drying: the link into a new cell is broken, the phase transition of water from liquid to vapor that makes the structure of the tissue material harden [10]. Convection drying has been widely used in the past with a lot of fruits and vegetables, green olive, spinach, and spinach. At the same time, the influence of drying conditions during processing is significant. The application of convection drying technology to industrial scale production processes brings benefits to manufacturing enterprises. The purpose of this study is to determine the effect of the parameters in the convection drying process on the nutritional quality of Soursop pulp.

2. Methods and materials

2.1 Experimental material
Soursop used in this study was purchased from Tan Phu Dong market, VietNam. Characteristic of these selected Soursop were green, ripe and they were not damaged. The materials were washed and cut for fan shape. The pulp was cut into 0.5 cm thick. Then, flesh is soaked with a solution of Sirop 60 °Brix (10-15-20%) for 1 hour and was put onto stainless steel trays.

2.2 Chemicals
Folin-Ciocalteu Reagent (FCR), Gallic acid, DPPH (2,2-diphenyl-1-picrylhydrazyl) were bought at Sigma-Aldrich Chemie, Co Ltd (USA), and 2,6-dichlorophenolindophenol (DCPIP) was imported from India. Other chemical: Methanol (99.5% purity), Na₂CO₃ (99.5% purity), ascorbic acid (99.7% purity), NaHCO₃ (99.5% purity), diethyl ether (99.5% purity) were originated from China.

2.3 Drying equipment
An industry dryer with 800x1000mm dimension for 24 trays were applied for drying process. Temperature are set from 40°C to 60°C (maximum is 65°C). Equipment has the support of hot air steam from propeller, the moisture drainage rate in the outlet valve is 100%.

![Figure 1. Convection dryer with trays [10]](image-url)
2.4 Methods

2.4.1 Determination of total phenolic
The total phenolic content was measured by the Folin-Ciocalteu colorimetric methods, using gallic acid as a standard and being described previously by Velioglu et al. [14]. 2 gram fresh pulp was crushed several times and extracted with 50ml ethanol absolute. Extracts (0.5ml) were put in a dark tube and added 2.5ml Folin-Ciocalteu reagent (diluted 10 times with distilled water) and 2ml sodium carbonate solution (20% w/v). The sample was placed in dark space before being taken to a photometer (Thermo Scientific™ GENESYS™ 10S UV-Vis Spectrophotometer) at an absorption of 765 nm. The total phenolic content was expressed in mg of gallic acid equivalent per gram of dry matter (mg GAE/g dry matter).

Moisture, protein, lipid, ash in sample was test in triplicate. Total lipid was determined according to the Soxhlet [15] method, use the extraction system with diethyl ether. Ash contents in fruit were heated at 550°C until constant weight for 6h [16]. After destruction of the sample below 370°C for 6 hours. Completely inorganic samples were determined percentage of Nitrogen by Kjehdah analysis [17]. Velp Kjeldahl Systems was used to create residual NaOH reaction, the solution is then titrated by 0.02N H₂SO₄.

The water loss (WL) was calculated according to the following equation:

\[ \% \text{ WL} = \frac{M_1 - M_2}{M_1} \times 100 \]

Where: M₁ is the weight of soursop samples before being put into the drying system and M₂ is the weight after finish heating process.

Color measurements (CIE L*a*b* color space) were performed using 0.3NH Scanner Chroma colorimeter (NR60CP model). Lightness value L* have ranging from 0-100, with two components is a* (from green to red) and b* value (from blue to yellow).

2.4.2 Sensory evaluation
The level of consumer evaluation is conducted on 30 people aged 18 to 25 years old. Table of evaluation includes three samples with different Brix concentrations. Samples are encoded in 3-digit form and given to the tester. The testers evaluated samples on the state, color, and odor on a scale of 6 ÷ 0 according to the TCVN 3215 - 79 test.

2.4.3 Data Analysis
All experiments were conducted in duplicate. The mean and standard deviation of the results were calculated using Microsoft Excel program. Experiment data was analyzed using one-way analysis of variance (ANOVA) test in SPSS program (Statistical Package for the Social Sciences, distributed by IBM Company, USA) with the level of significance at 5%.

3. Result and discussion

3.1 Effect of Drying condition on the Moisture, Ash, Protein, Total Phenolic Content, and Ascorbic Acid of Soursop
Table 1 showed the nutritional properties and colors of Soursop affected by different temperatures during the drying process. When processing samples at 60°C (390 minutes), there was a moisture significant reduction of 10.78 ± 0.76, 13.87 ± 0.39 and 16.05 ± 0.38 with differences Brix concentrations of 10%; 15%; 20%, respectively.

The level of moisture decreases because of the fan of the hot air stream for a long time, which make the water in material escape to the environment. Besides, extended drying time at 390 minutes is proportional to the gradual loss of moisture content. This was previously proved by Hossain et al. [18]. The remaining two drying conditions also yielded similar results. At the same
time, for the critical nutritional indicators such as TAA, the highest TPC retention is 2.58 ± 0.29 and 2.54 ± 0.29 at 20% °Brix 40°C and 50°C, respectively. At the same time, retention for TAA at the same conditions of 60°C treatment, the samples were negligibly different. Nevertheless, this process significantly affects the TPC content, which can be understood TPC degradation fitted the first-order reaction and was influenced considerably by hot air temperature [20]. In particular, at 60°C (15% °Brix) the TPC value is the highest (1.65 ± 0.06).

According to the results, the percentage of Nitrogen in the total sample was analyzed which was affected by the portion of °Brix. This direct influence was previously mentioned by Gundurao et al. [21].

Table 1. Effect of different temperature drying conditions on some physicochemical properties of sour sops

| °C  | 60°Brix (%) | Moisture (%) | Ash (%) | % Nitrogen | TAA (mg/g DM) | TPC (mg GAE/g DM) | L*    | a*   | b*   |
|-----|-------------|--------------|---------|------------|---------------|-------------------|-------|------|------|
|     |             |              |         |            |               |                   |       |      |      |
| Fresh | 83.94 ± 0.38 | 0.86 ±       | 3.76 ±  | 4.29 ±     | 64.35 ±       | 4.18 ± 0.31 a  | 0.57 a|
|       | 0.88 a      | 0.01 a       | 0.40 a  | 0.01 a     | 4.18 a        | 0.31 a           |       |
| 10   | 10.78 ± 2.93 | 2.14 ±       | 0.38 ±  | 1.42 ±     | 62.43 ±       | -1.56 ± 18.85 ± |       |
|       | 0.76 b      | 0.08 b       | 0.16 b  | 0.02 b     | 3.78 ab       | 0.29 b           | 0.11 b|
| 60   | 13.87 ± 2.61 | 2.53 ±       | 0.50 ±  | 1.65 ±     | 56.93 ±       | -1.01 ± 16.89 ± |       |
|       | 0.39 c      | 0.31 b       | 0.01 b  | 0.06 c     | 2.39 c        | 0.79 b           | 2.24 c|
| 15   | 16.05 ± 1.88 | 2.68 ± 0.01 c| 0.57 ±  | 1.45 ±     | 63.68 ±       | -3.13 ± 15.69 ± |       |
|       | 0.38 d      | 0.29 c       | 0.04 b  | 0.15 b     | 3.94 ab       | 0.43 c           | 0.72 c|
| 20   | 11.85 ± 2.56 | 1.63 ±       | 1.37 ±  | 1.08 ±     | 58.32 ±       | -2.86 ± 16.00 ± |       |
|       | 0.86 b      | 0.03 b       | 0.15 b  | 0.04 b     | 1.00 b        | 0.37 b           | 1.31 b|
| 50   | 14.38 ± 3.05 | 1.84 ± 0.02  | 2.07 ±  | 1.11 ±     | 58.42 ±       | -1.48 ± 16.56 ± |       |
|       | 0.24 c      | 0.04 c       | 0.08 c  | 0.00 b     | 1.23 b        | 0.19 b           | 0.69 b|
| 15   | 15.89 ± 3.29 | 2.52 ± 0.02 a| 2.54 ±  | 0.98 ±     | 65.18 ±       | -2.92 ± 17.44 ± |       |
|       | 1.27 c      | 0.09 d       | 0.29 c  | 0.06 c     | 0.98 a        | 0.65 c           | 0.54 c|
| 20   | 13.97 ± 2.56 | 1.63 ±       | 1.49 ±  | 1.22 ±     | 63.25 ±       | -3.65 ± 15.93 ± |       |
|       | 0.81 b      | 0.03 b       | 0.08 b  | 1.15 b     | 3.32 ab       | 0.89 b           | 0.50 b|
| 10   | 14.38 ± 2.28 | 1.82 ± 0.03 b| 2.02 ±  | 0.91 ±     | 66.59 ±       | -3.65 ± 17.36 ± |       |
|       | 0.24 b c    | 0.12 b       | 0.08 b  | 0.31 b     | 5.44 ab       | 0.76 ab          | 0.33 b|
| 40   | 16.15 ± 2.22 | 2.71 ± 0.09  | 2.58 ±  | 1.26 ±     | 56.56 ±       | -2.21 ± 17.00 ± |       |
|       | 0.89 d      | 0.24 b       | 0.29 c  | 0.11 b     | 4.79 c        | 1.12 c           | 2.46 b|

a,b,c,d Means followed by same letter do not differ by the Duncan test (p < 0.05), comparison between different temperature treatment samples with fresh pulp.

Quantitative analysis with Soxhlet system has incredible results on lipid presence inside the product. The lipid content in the sample was tested by this method which is not feasible.

A color system is not much affected by the heating process. The L* value tends to move from light-colored space at 64.35 ± 4.18 to yellow warm, parameters a* (-1.56 ± 0.29) and b* (18.85 ± 0.11) at the highest processing temperature (60°C) with the value of the ivory color expression. Costa et al also reported the same previous results about sour sops through the drying process [22].

The moisture loss content is presented in table 1, at the end of the drying process, the sampling recovery efficiency reached the highest at the highest Brix concentration at all setting conditions. This may be explained when higher concentrations of solute solids limit the movement of water inside the food to the surface, the pressure inside the material is lower than the outside so there is a phenomenon of sugar osmosis. Moreover, when saturated °Brix is reached, the effect of
temperature cannot cause moisture loss in the material. This explanation is also demonstrated in Adhikari B al et's report on fructose (the product of refined sugar hydrolysis) crystallized during the drying process which limits moisture release [23].

3.2 Sensory evaluation

Table 2 shows images of soursop pulp before and after convection drying at 40°C, 50°C and 60°C. The sensory description indicated that the sample treated at 50°C was different from the other two, dark ivory and discrete appearance. The ripeness of soursop depends on the season as well as the post-harvest preservation process, the homogeneity of material source is difficult to implement. At 60°C, there was no difference between the three drying samples (10%, 15%, 20%) at the same temperature. However, they were slightly stiff and sturdy. The colors are bright and close to fresh, slightly flexible and soft samples at 40°C. Therein, 10% °Brix has a stable and flexible structure, which significantly affects their sensory evaluation score. In Table 3, the overall rating of 11.27 is the highest at 10% Brix, lower at the remaining concentrations of 10.65 and 10.74 for 15-20%, respectively. The criteria specify this for evaluating shape and flavor. The first sample was assessed with a significantly higher score, with 4.06 ± 0.77 (color) and 3.25 ± 0.58 (aroma). On the other hand, in convection drying technology, the continuous change of hot air flow has created an oxygen exchange environment that provides this negative reaction with catalytic nonenzyme [24]. At the same time, the Maillard reaction also contributes to lower L* values than fresh samples [25]. The gradual loss of characteristic aroma compounds during drying is described previously by Diana et al. [26]. 20% Brix retain a characteristic aroma of the sample compared to the other with 3.62 ± 0.96 points evaluated.

| Sample | 40°C | 50°C | 60°C |
|--------|------|------|------|
| 10%    | ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) |
| 15%    | ![Image](image4.png) | ![Image](image5.png) | ![Image](image6.png) |
| 20%    | ![Image](image7.png) | ![Image](image8.png) | ![Image](image9.png) |
| Fresh  | ![Image](image10.png) | ![Image](image11.png) | ![Image](image12.png) |

Based on the criteria in table 3, the sample preference is shown in figure 3. This result is obtained from the score of the person receiving the test sample on a sample's favorite level. There is a difference between 10% and 20% samples with 15% sample. Following the explanation that, in the evaluation board, there is a group of testers who like samples that are nearly identical to fresh samples. In contrast, groups of people like to taste sweet. Both groups make up the majority of the test board.
Table 3. Sensory evaluation table describes Soursop (Drying at 40°C)

| Sample      | 10%          | 15%          | 20%          |
|-------------|--------------|--------------|--------------|
| Appearance  | 3.94 ± 0.93a | 3.68 ± 1.14a | 3.56 ± 1.09a |
| Color       | 4.06 ± 0.77a | 3.19 ± 0.83b | 3.56 ± 0.63c |
| Aroma       | 3.25 ± 0.58a | 3.56 ± 0.96ab| 3.62 ± 0.96c |
| Overall     | 11.27        | 10.65        | 10.74        |

Figure 2: Sensory evaluation scores for Dried Soursop (level 1: dislike extremely; level 2: dislike moderately; level 3: Neither like nor dislike; level 4: like moderately; level 5: Like extremely)

4. Conclusion
From the results of this study, it was found that with the convection drying process, the effect of temperature at 60°C was greatest for nutritional indicators (TAA, TPC). Approximate 68.62% TAA, 29.37% TPC was retained when drying at 40°C (20% Brix). Different drying temperatures harm the original color of soursop. At the same time, the higher concentration of sugar syrup helps to retain part of the content of Vitamin C and polyphenol compounds. From the sensory evaluation of color, odor, and taste of soursop’s jelly drying, optimal parameters of the procedure were identified at 40°C (390 minutes) and samples with 10% added sugar syrup (60 °Brix). This is also the parameter selected for businesses to survey for larger scale. The limitation of this study has not been investigating the effects of drying time on the quality of soursop, and the evaluation board has not yet reviewed the training courses.

5. References
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