Physicochemical and Dissolution Properties of Pulp and Freeze-Dried Powder of Pineapple Tablets

Faridatul Ain, M. R.¹, Yusof, Y.A*¹, Aziz, M.G.¹³, Chin, N.L.¹, Mohd Amin, N.A.¹, Mohd Ghazali, H.², Taufiq, A. M.¹

¹Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
²Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
³Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
*Email: yus.aniza@upm.edu.my

Abstract

Pineapple pulp and associated freeze-dried powder prepared from Josapine pineapple were assessed for their physicochemical properties such as colour, titratable acidity, total soluble solids, proximate composition, water activity, caking, pH, sensory and dissolution. Based on the physicochemical properties data and analysis, the one-way analysis of variance can help in discriminating freeze-dried powder prepared from pulp with addition of maltodextrin and also pulp with addition of sugar. No significant nutrient loss was observed in the freeze-dried powder compared to the fresh pulp. It was also found that addition of additives can overcome caking problem of soft and hygroscopic pineapple powder. For comparisons of the dissolution properties of the pulp and freeze dried powder, simply the pineapple powder had double dissolution time than the pulp. These investigations can be used to understand and develop an innovative product from pineapple.

Keywords: Josapine pineapple, physicochemical analysis, pulp, freeze-dried pineapple powder, caking, dissolution

1. Introduction

Pineapple is the most important representative of the Bromeliaceae family and is cultivated in tropical and subtropical countries including Malaysia, Hawaii, South Africa, Philippines and Thailand for local consumption and also international export [1]. Josapine hybrid used in this study was officially released by MARDI on 5 August 1996 and it has been commercialized successfully [2]. Ananas comosus is a delicious and popular fruit due to its good aroma, flavour, juiciness, sweetness and texture. It is also a very nutritious as it is a good source of vitamins A and C, fibre and also minerals [3].

Additives are incorporated mainly to reduce the hygroscopic nature of the powder and also to prevent caking. Currently, maltodextrin is the most widely used additive to obtain fruit juice powders since it satisfies the demand and is also reasonably cheap. According to Mahendran [4], freeze drying process produced the best quality guava powder in terms of colour, flavour and ascorbic acid retention though it was hygroscopic in nature, but with additional of maltodextrin, the stickiness and caking problem were improved. This is an agreement with Nurhadi et al., [5] where the use of maltodextrin decrease the hygroscopicity of honey powder, wetting time, dispersing time and increase the sensoric acceptance of honey powder by the panellist. Research concerning a comparative study of the physicochemical properties of pineapple pulp and freeze dried powder as affected by the added additives is scarce. The objective of this study is to investigate the physicochemical properties including the proximate analysis, colour, antioxidant properties and other quality attributes of Josapine pineapple pulp and powder with respect to different treatments using maltodextrin and sugar. For further study, dissolution of the Josapine pineapple pulp and powder were investigated.

2. Materials and Methods

2.1 Fruit Pulp Preparation

Fresh pineapple fruits of the Josapine variety were purchased from the Pasar Borong Selangor, Malaysia (Selangor wholesale market). After the removal of the crown and skin, the whole fruit was crushed into a pulp using a domestic blender. The pulp then was put into an airtight plastic container and kept in the freezer (-20 ± 1°C) for further preparation and analysis.
2.2 Fruit Powder Preparation
The pineapple pulp was prepared in several containers and added with 10 % maltodextrin, 20 % maltodextrin, 10 % sugar, and 20 % sugar separately. Corn maltodextrin DE 10 (food grade) was used and as for the sugar, a combination of 9 % sucrose, 3 % fructose and 3 % glucose was adapted for the treatments. Then, the prepared pulp was frozen in plastic containers for 5 h at -20 ± 1 °C. After freezing, the samples were transferred to a vacuum freeze dryer (Ben Hay, United Kingdom) and dried at -35 ± 1 °C for 48 h at 0.25 mbar. The freeze-dried pineapple powder was crushed into a smaller size, sealed in plastic and stored in a refrigerator (-4 ± 1 °C) until further tests were carried out.

2.3 Colour Measurement
The instrumental measurement of samples, pineapple pulp and freeze-dried powders was carried out using a colourimeter (Konica Minolta CM-3500d Spectrophotometer, USA). The average of three replicates for L*, a* and b* was recorded.

2.4 Titratable Acidity (TA)
Samples were weighed as 10 g and mixed with 200 ml of distilled water, and boiled for one hour. Then the mixture was cooled before filtering. 10 ml of filtrate was titrated with 0.1M NaOH up to pH 8.1 using an automatic titratable machine [6].

2.5 Proximate analysis
Moisture content was measured using the oven method according to the standard method. Ash content was determined using the standard method whereby 5 g of sample was kept in a muffle furnace and converted to ash at the maximum temperature (525 ± 1 °C) for 6 hours. Next, the ash was cooled in a desiccator and weighed. [7]. Protein was determined using the Kjeldahl method while the Soxhlet method was used for the fat determination. The determination of fibre was adapted from the method of using sulphuric acid followed by sodium hydroxide [6]. The total carbohydrate content of a sample was calculated by the difference of the total weight of the sample (100 %) and summation of other constituents (protein, fat, moisture content, ash and fibre) [8].

2.6 pH, Total Soluble Solid (TSS), Water Activity (a_w)
The pH of the sample was measured using a pH meter (Mettler Toledo, Switzerland). In addition, for the pineapple powder sample, 8 % (w/v) powder suspension was prepared and stirred for 5 min, allowed to stand for 30 min, then the powder suspension was filtered and the pH of the filtrate measured [9]. Using the same suspension for the powder sample, the total soluble solids (TSS) was measured using a refractometer (Atago PAL-1, Japan) [10]. In the case of the pulp samples, the TSS value was obtained directly using a refractometer [9]. Water activity for the samples was determined by using a digital a_w meter (Model 3TE, Aqualab, WA).

2.7 Bulk and Tapped Density
The bulk density of the powders was determined and calculated manually. Powder with a strong structural strength will resist collapse when dispersed in a container and will have a low bulk density, whereas a weak structural powder will easily collapse and have a high bulk density [11]. The tapped density was measured mechanically by using a tapped density analyser (Micromeritics GeoPyc 1360, USA).

2.8 Hausner Ratio and Carr Index
The Hausner Ratio [12] is calculated based on the equation generated by Hausner. The Carr Index [13] is determined based on the equation by Carr.

2.9 Sensory Analysis
The samples were coded with random letters and given to thirty panelists aged between 19 to 48 years. The panel measured the selected critical attributes such as aroma, flavour, colour, sweetness and total acceptability. All the sensory panelists had to taste the Josapine pineapple drink and then give scores for the taste for each sample.

2.10 Dissolution Test
The dissolution test was determined by using modified method from [14].

2.11 Statistical Analysis
All the analysis was conducted over three replications. One-way analysis of variance (ANOVA) was adapted to compare the experimental analysis. Differences among the analysis means were determined using the Least Significant Different (LSD) test. Values of p<0.05 were defined as significant. All the statistical analysis was conducted using the Statistical Analysis Software (SAS) Version 7.2 [15].

3. Results and Discussion
3.1 Colour Measurement
The lightness (L*) and yellowness (b*) are the major colour parameters for quality determination of pineapple processing [16]. Table 1 shows the value of L*, a* and b* of Josapine pineapple pulp and freeze-dried powder. An increase in L* and b* values was observed resulted in a darker yellow product. This was probably due to the non-enzymatic browning which occurred during the freeze drying process. Pineapple contains glucose, fructose and amino acids which fulfil the prerequisites for non-enzymatic browning during processing. This is in agreement with the result of Moβhammer et al. [17] who obtained a slightly darker cactus pear freeze-dried powder from drying cactus pear concentrates. Chopda and Barrett [18] also get the similar result in their study. However, it should be mentioned that the freeze drying process has the ability to improve the colour of the product after processing compared to other drying methods [19]. The colour of the freeze-dried pineapple powder became lighter after the drying process. Chopda and Barrett [18] reported the production of a bright white guava powder after freeze drying of the guava puree with maltodextrin. An increase in the L* value and a decrease in the a* value were reported during the freeze drying process due to the oxidation of pigments which increasingly exposed the white colour of the maltodextrin.

Table 1: Change in L*, a* and b* of Josapine pineapple pulp and freeze-dried powder under different treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pure</td>
<td>37.59±0.03</td>
<td>52.37±0.04</td>
<td>3.47±0.04</td>
</tr>
<tr>
<td>2. Pure + Maltodextrin 10%</td>
<td>49.62±0.03</td>
<td>74.19±0.06</td>
<td>3.89±0.01</td>
</tr>
<tr>
<td>3. Pure + Maltodextrin 20%</td>
<td>49.59±0.03</td>
<td>75.27±0.12</td>
<td>3.93±0.02</td>
</tr>
<tr>
<td>4. Pure + Sugar 10%</td>
<td>46.11±0.03</td>
<td>52.19±0.57</td>
<td>3.40±0.03</td>
</tr>
<tr>
<td>5. Pure + Sugar 20%</td>
<td>46.02±0.01</td>
<td>51.11±0.01</td>
<td>3.35±0.01</td>
</tr>
</tbody>
</table>

Data represents mean ± SD of triplicate analysis

Figure 1: Changes in titratable acidity, TA (% c.a.) and total soluble solid, TSS (°Brix) of Josapine pineapple pulp and freeze-dried powder under different treatments.

3.2 Titratable Acidity (TA) and Total Soluble Solids (TSS)
The titratable acidity (TA) for the Josapine pineapple pulp under different treatments ranged from 0.60 to 0.69% c.a. and from 0.54 to 0.66% c.a. for the powder under different treatments, respectively as shown in Figure 1. The TA values for the pure pulp were lower than that reported for Valencia oranges by [20] and slightly higher than the results reported by MARDI [2]. The loss of acids might be the reason of the reduction of some acidity [18]. Askar et
al. [22] reported a significant loss of TA after freeze drying of guava puree. From the figure, the increase in TSS after the freeze drying process may be the result of the concentration of the soluble solids. A decrease in acidity and an increase in TSS are the important parameters in flavour development [23]. Furthermore, the sugar-acid ratio has been used as a maturity index and found to increase with the ripening of fruits [24].

3.3 Proximate Composition (Moisture, Protein, Ash, Fibre, Fat Content)

The results of the proximate analysis of Josapine pineapple pulp and freeze-dried powder are presented in Table 2. The moisture content for the treatment with the addition of maltodextrin for pulp and freeze-dried powder showed a significant difference (p<0.05). Similar results were reported by Abadio et al. [25] for pineapple, Mahendran [4] for guava, and Brennan et al. [26] for orange. A higher concentration of maltodextrin during the freeze drying process results in a decrease in the moisture content of the freeze-dried powder, possibly due to the high solids content and the reduced amount of water (Table 2). The high moisture content (>80%) in pineapple pulp indicates a low energy value for the Josapine pineapple [23]. Therefore, this shows possible usefulness in the treatment of obesity. In contrast, moisture in fruits gives them natural laxative properties which are also good for nutrition of the human body [27]. The increasing percentages in protein, fibre and ash content suggest that the freeze drying process is highly suitable for preserving and improving all the delicate and the beneficial nutrients of Josapine pineapple. Fasoyiro et al. [28] reported a high percentage of fat content in Roselle powder. The fat content of Josapine pineapple is found close to those reported by Romero-Rodriguez et al. [29] and Mbogo et al. [23]. Samson [30] reported that low levels of fat content imply that fruits are not good sources of energy and hence need to be supplemented with other sources of fat for proper body nutrition.

3.4 Water Activity, aw, and pH

Water activity (aw) is a very important parameter to indicate the availability of water in food systems and to determine the shelf life of powder produced by the freeze drying process [31]. There is a significant decrease (p<0.05) in the aw value throughout the drying process of Josapine pineapple pulp into a freeze-dried powder. This may be due to water loss through evaporation during the drying process. The aw measures the activity of free water in the food system which responsible for any biochemical reactions. As shown in Figure 3.2, all the treated powder possess a lower aw than the pulp (Figure 3.2). This indicates that there is less free water in powder available for biochemical reactions, which is advantageous for longer shelf-life. Food with an aw less than 0.6 is microbiologically stable indicating no growth of spoilage organisms and pathogens [32]. The aw values for all the treatments are below 0.3. This indicates that all the treatments are microbiologically stable. There is significant difference (p<0.05) between treatments for both pulp and freeze-dried powders for pH values. The pH is consistent for all the treatments. This is due to the balance of pH during the drying process. The change of pH due to different treatments might be balanced by losing few acids during the drying process [23].

3.5 Hausner Ratio and Carr Index

Based on the range of proven flow properties, the Hausner Ratio and Carr Index values show that pineapple with the addition of 20% sugar has the highest value followed by pineapple with the addition of 10%, pure pineapple, pineapple with the addition of 10% maltodextrin and pineapple with the addition of 20% maltodextrin as shown in Table 3. According to Hayes [33], different ranges for the Hausner Ratio for characterizing flowability are as follows: 1.0 < HR < 1.1, for a free-flowing powder; 1.1 < HR < 1.25, for a medium-flowing powder; 1.25 < HR < 1.4, for a poor-flowing powder; and HR > 1.4, for a very poor-flowing powder. The result from Table 3 shows that the pineapple with the addition of 20% sugar has the poorest flowability compared to the pineapple with the addition of 20% maltodextrin which is a free-flowing powder which obtained the lowest Hausner Ratio value indicating a better packing characteristic. A powder with a Carr Index (CI) greater than 25% has poor flowability; below 15% indicates good flowability [34]. Table 3 shows that the pineapple with the addition of 20% maltodextrin has the lowest Carr Index value compared to the others. The results indicate that the addition of maltodextrin decreases the hygroscopicity of the freeze-dried powders and give a better flowing ability. A high molecular weight additive is more effective in reducing the hygroscopicity of fruit powder [35]. Satya et al. [36] investigated the flowability, compressibility and in-vitro release of Terminalia chebula fruit powder tablets and found that it has poor flowability.

3.6 Sensory Evaluation

From Table 4, most of the panelists preferred the freeze-dried drink with the addition of sugar for the colour, aroma, flavour and sweetness. Freeze-dried powder with the addition of maltodextrin is not favourable due to the thick consistency and off-flavour. The result is in contrast with that reported by Askar et al., [22]. A significant loss in quality of guava powder cannot be accepted by most of the consumers [22].
Table 2: Proximate analysis of josapine pineapple pulp and freeze-dried powder under different treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture content (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
<th>Ash (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure</td>
<td>89.17±0.13</td>
<td>4.41±0.04</td>
<td>0.34±0.04</td>
<td>5.03±0.10</td>
<td>0.80±0.03</td>
<td>5.64±0.85</td>
</tr>
<tr>
<td>Pure + Maltodextrin 10%</td>
<td>88.66±0.06</td>
<td>4.39±0.08</td>
<td>0.34±0.05</td>
<td>4.99±0.03</td>
<td>0.72±0.02</td>
<td>5.89±0.30</td>
</tr>
<tr>
<td>Pure + Maltodextrin 20%</td>
<td>87.90±0.12</td>
<td>4.14±0.14</td>
<td>0.34±0.02</td>
<td>4.97±0.02</td>
<td>0.63±0.01</td>
<td>6.99±0.41</td>
</tr>
<tr>
<td>Pure + Sugar 10%</td>
<td>89.56±0.02</td>
<td>4.26±0.19</td>
<td>0.34±0.02</td>
<td>4.95±0.02</td>
<td>0.70±0.03</td>
<td>5.14±0.37</td>
</tr>
<tr>
<td>Pure + Sugar 20%</td>
<td>88.68±0.03</td>
<td>4.19±0.24</td>
<td>0.34±0.04</td>
<td>5.02±0.12</td>
<td>0.64±0.02</td>
<td>6.15±0.47</td>
</tr>
</tbody>
</table>

Data represents mean ± SD of triplicate analysis
% represents percentage based on dry basis, db

Table 3: The basic material properties of the powders

<table>
<thead>
<tr>
<th>Material Properties</th>
<th>Pure</th>
<th>Pineapple + Maltodextrin 10%</th>
<th>Pineapple + Maltodextrin 20%</th>
<th>Pineapple + Sugar 10%</th>
<th>Pineapple + Sugar 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density, kg/m³</td>
<td>519.5±0.12</td>
<td>540.6±0.54</td>
<td>563.2±0.35</td>
<td>512.5±0.11</td>
<td>509.8±0.18</td>
</tr>
<tr>
<td>Tapped density, kg/m³</td>
<td>704.4±8.59</td>
<td>645.8±4.76</td>
<td>602.7±6.47</td>
<td>698.4±9.12</td>
<td>772.5±8.08</td>
</tr>
<tr>
<td>Carr Index, CI (%) (Carr, 1965)</td>
<td>26.25±0.82</td>
<td>16.29±1.24</td>
<td>6.55±0.74</td>
<td>26.62±0.81</td>
<td>34.01±1.28</td>
</tr>
<tr>
<td>Hausner Ratio, HR (Hausner, 1967)</td>
<td>1.36±0.18</td>
<td>1.19±0.12</td>
<td>1.07±0.27</td>
<td>1.36±0.11</td>
<td>1.52±0.31</td>
</tr>
<tr>
<td>Flowability (Carr, 1965; Hausner, 1967)</td>
<td>Poor flow</td>
<td>Medium flow</td>
<td>Free flow</td>
<td>Poor flow</td>
<td>Very poor flow</td>
</tr>
</tbody>
</table>

Data represents mean ± SD of triplicate analysis

Figure 2: pH and $a_w$ of Josapine pineapple pulp and freeze-dried powders under different treatments

Table 3: The basic material properties of the powders

<table>
<thead>
<tr>
<th>Material Properties</th>
<th>Pure</th>
<th>Pineapple + Maltodextrin 10%</th>
<th>Pineapple + Maltodextrin 20%</th>
<th>Pineapple + Sugar 10%</th>
<th>Pineapple + Sugar 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density, kg/m³</td>
<td>519.5±0.12</td>
<td>540.6±0.54</td>
<td>563.2±0.35</td>
<td>512.5±0.11</td>
<td>509.8±0.18</td>
</tr>
<tr>
<td>Tapped density, kg/m³</td>
<td>704.4±8.59</td>
<td>645.8±4.76</td>
<td>602.7±6.47</td>
<td>698.4±9.12</td>
<td>772.5±8.08</td>
</tr>
<tr>
<td>Carr Index, CI (%) (Carr, 1965)</td>
<td>26.25±0.82</td>
<td>16.29±1.24</td>
<td>6.55±0.74</td>
<td>26.62±0.81</td>
<td>34.01±1.28</td>
</tr>
<tr>
<td>Hausner Ratio, HR (Hausner, 1967)</td>
<td>1.36±0.18</td>
<td>1.19±0.12</td>
<td>1.07±0.27</td>
<td>1.36±0.11</td>
<td>1.52±0.31</td>
</tr>
<tr>
<td>Flowability (Carr, 1965; Hausner, 1967)</td>
<td>Poor flow</td>
<td>Medium flow</td>
<td>Free flow</td>
<td>Poor flow</td>
<td>Very poor flow</td>
</tr>
</tbody>
</table>

Data represents mean ± SD of triplicate analysis
3.7 Dissolution Test

Figure 3 shows that the dissolution time for the pure pineapple powder with the addition of 10% of maltodextrin was the highest compared to the other treatments of pineapple powder. Maltodextrin benefits the powder to be less sticky; therefore the time taken for pure pineapple powder with addition of 10% maltodextrin to dissolve is relatively longer than the dissolution time for pure powder with addition of 20% maltodextrin. The stickiness of the powder can be reduced as maltodextrin has a high dextrose equivalent (DE). High DE values contribute to a shorter glucose chain, high solubility and lower heat resistance. The addition of 10% maltodextrin compared to 20% maltodextrin produces powder that tends to agglomerate. The higher propensity of the powder to agglomerate helped to increase the reconstitution of the powder. The result was approximately similar to that reported by Farimin and Nordin [37] which using Roselle-pineapple powder in their study.

![Figure 3: Dissolution time for josapine pineapple pulp and freeze-dried powder under different treatments](image)

4. Conclusions

Based on the physicochemical properties data and analysis, the one-way analysis of variance (ANOVA) can help in discriminating freeze-dried powder prepared from pulp with addition of maltodextrin and also pulp with addition of sugar. No significant nutrient loss was observed in the freeze-dried powder compared to the fresh pulp. The 3.5% to 4% increase in protein, 1.9% to 2.2% increase in fibre and 1% to 1.3% increases in ash content signify that the freeze drying process is the best drying process for preserving and improving all the delicate and the beneficial nutrients of Josapine pineapple fruits. The addition of high molecular additives was found beneficial to overcome the caking problem.
References


2. MARDL (1996). Josapine-the world’s first commercial pineapple hybrid.


15. SAS Institute Inc. Statistical analysis software (SAS) version 7.2. USA.


