Valorization and Characterization of Spray-Dried Unsalable Ripe Papaya (Carica papaya L.) Puree as Potential Food Flavoring Powder

Anna Mae A. Apatan
Department of Agricultural and Biosystems Engineering, College of Engineering and Geosciences, Caraga State University

Dexter D. Pabatang
Department of Agricultural and Biosystems Engineering, College of Engineering and Geosciences, Caraga State University

Philip Donald C. Sanchez
Department of Agricultural and Biosystems Engineering, College of Engineering and Geosciences, Caraga State University

Genesis Jared A. Cutamora
Center for Resource Assessment, Analytics & Emerging Technologies (CReATe), Caraga State University

他

https://doi.org/10.5109/7323254

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp.135-141, 2024-10-17. International Exchange and Innovation Conference on Engineering & Sciences
バージョン：

Valorization and Characterization of Spray-dried Unsalable Ripe Papaya (*Carica papaya* L.) Puree as Potential Food Flavoring Powder

Anna Mae A. Apatan[1], Dexter D. Pabatang[1], Philip Donald C. Sanchez[1,2,3], Genesis Jared A. Cutamora[2], Marjun C. Alvarado[1,3]
[1]Department of Agricultural and Biosystems Engineering, College of Engineering and Geosciences, Caraga State University, Ampayon, Butuan City 8600, Philippines
[2]Center for Resource Assessment, Analytics & Emerging Technologies (CReATe), Caraga State University, Ampayon, Butuan City 8600, Philippines
[3]Caraga Food Innovation Center (FIC), Caraga State University, Ampayon, Butuan City 8600, Philippines
Corresponding author email: pcsanchez@carsu.edu.ph

Abstract: *This study aims to convert unsalable papaya puree into papaya powder using spray drying technology. Factors such as inlet temperatures (160°C and 180°C) and carrier agents (maltodextrin and gum arabic) both at 20% concentrations were investigated under four (4) different treatments. Hygroscopicity test, total soluble solids content, color, water activity, aerobic plate count (APC), proximate composition, and sensory properties were evaluated. Results revealed that the carrier agents and temperature had no significant impact on color, while all treatments exhibited low hygroscopicity, ensuring stable storage. Treatment 4 showed the highest process yield at 51.75%. APC results confirmed microbiological safety across all treatments. APC results ensured microbiological safety across all treatments. Moreover, Treatment 1 displayed desirable proximate composition, including low moisture (6.88%), ash (1.12%), high crude protein (10.50%), minimal crude fiber (0.02%), and moderate crude fat (2%). Hence, this research demonstrates the conversion of unsalable ripe papaya into a potential food flavoring powder, showcasing positive attributes in composition, sensory aspects, and microbial safety across different treatments.*

Keywords: Valorization; Spray Drying; Unsalable Papaya; Food flavoring.

1. INTRODUCTION

Papaya (*Carica papaya* L.), belonging to the family Caricaceae, is the most economically significant species in the genus Carica [1]. It is globally renowned for its sweet flavor and nutritional quality [2]. Papaya fruits are predominantly composed of water and carbohydrates, are low in calories, and are rich in essential vitamins and minerals, especially vitamins A and C, ascorbic acid, and potassium [3]. However, previous research has indicated that despite its health benefits, there are quality issues that can negatively impact its shelf life [4].

Papaya has a high moisture content and is highly perishable, which limits its preservation period and leads to significant losses [5]. Instead of discarding unsalable papayas, they can be converted into value-added commercial products such as fruit powder. Drying is an excellent method for preserving natural products as it reduces their moisture content. Various drying techniques have been studied for papaya, including foam-mat drying, freeze-drying, hot air oven drying, spray drying, and solar drying [5,6]. Among these methods, spray drying is the most economical for maintaining quality through rapid dehydration, offering lower operating and maintenance costs [7].

Recent studies on the spray drying of papaya have primarily focused on using a single carrier agent with varying concentrations and inlet temperatures. This study aims to valorize and characterize unsalable papaya by producing powder using spray drying technology with different carrier agents and inlet temperatures. The resulting powder was analyzed for its physicochemical properties, proximate composition, and sensory attributes. Spray-dried unsalable papaya powder offers an innovative solution to reduce fruit waste, benefiting both the commercial market and the food processing industry, particularly as a potential food flavoring agent.

2. MATERIALS AND METHODS

This study utilized unsalable (waste) red lady papaya. The papayas were collected from a local producer in Barangay Pinamanculan, Butuan City, Philippines, at maturity level 3, characterized by 50% orange-red coloration on the skin's surface [8]. These papayas were deemed unsalable by the farmers. After collection, the papayas were transported to the Caraga State University Food Innovation Center (FIC) Laboratory for pretreatment.

2.1 Process Flow

The overall process involved in this study is illustrated in Figure 1. It includes the preparation of unsalable papaya waste, followed by liquefaction, spray drying, characterization, and quality assessment.

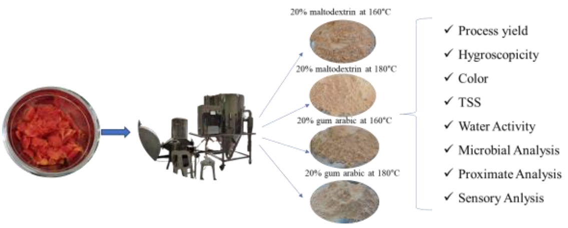

Fig. 1. The graphical representation of spray drying.

2.2 Pulp Liquefaction

The process started by homogenizing 500 g of pulp with 1 L of water at a ratio of 1:2 in a blender for 1 min at high speed. The blended pulp underwent manual water bathing (MWB) using [9] method with some modifications. The water-bathed puree was set aside and cooled down. The papaya purees were sieved using a cloth strainer filter (25 cm length × 30 cm depth × 12 cm diameter) three times to ensure a smooth consistency. The process was repeated several times until all the blended papaya pulp had sieved [2]. Then, the sieved papaya puree was weighed and divided into four containers for four treatments, and the physicochemical properties of the sieved papaya puree were investigated.

2.3 Feed Solution

For this study, the researchers prepared solutions with four different treatments (Table 1). Each treatment (T) consisted of 6.5 kg of liquefied papaya puree. T1 and T2 were prepared by placing 6.5 kg of liquefied papaya puree into two large casseroles (28 cm diameter), each containing 20% maltodextrin DE-10. The mixtures were stirred occasionally until the maltodextrin DE-10 was well combined with the liquefied papaya puree, then set aside. For T3 and T4, another two large casseroles were prepared, each containing 6.5 kg of liquefied papaya puree with 20% gum Arabic. Each treated papaya puree was stirred individually and then placed in the freezer overnight at -40 °C.

Table 1. Different treatments used in the study.

Treatment	Carrier Agent	Inlet Temperature (°C)
T1	Maltodextrin	160
T2	Maltodextrin	180
T3	Gum Arabic	160
T4	Gum Arabic	180

T1- treatment 1; **T2**- treatment 2; **T3**- treatment 3; and **T4**- treatment 4.

2.4 Spray Drying Process

The LPG-5 high-speed centrifugal spray dryer was used in this study. To start the spray drying process, a liter of distilled water was sprayed to warm up the spray dryer before the concentrated sample was added. The spray dryer's inlet temperature was set according to the treatment provided. For T1 to T4, the inlet temperature allocated were 160 ℃, 180 ℃, 160 ℃ and 180 ℃, respectively. After every spray drying of each treatment, a liter of distilled water was added to the spray dryer in order not to contaminate the next batch solution to be spray dried**.**

2.5 Quality Evaluation

2.5.1 Process Yield (%)

The process yield of spray-dried papaya powder was determined using a method adapted from [2]. It was calculated using the weight of the final product and the weight of the solution being fed into the spray dryer. Thus, the powdered papaya was measured on a dry matter basis and determined according to the formula displayed in Equation 1.

$$process\ yield\ (\%) = \frac{w_1}{(w_2)(w_3)} x100 \qquad \text{[Eq. 1]}$$

Where; W_1= weight of the spray-dried powder (g)
W_2= weight of the papaya solution(g)
W_3= weight of the maltodextrin added (g)

2.5.2 Hygroscopicity

Hygroscopicity was determined following the methods described by [10] with some adjustments. Specifically, 100 g of powder from each treatment was placed in a 500 mL microwavable container and stored at room temperature. After one week, the samples were observed and weighed. Each experiment was replicated three times to ensure reliability. Hygroscopicity was calculated using Equation 2, adapted from [2].

$$hygrocopicity\ (\%) = \frac{w_1 - w_2}{w_2} x100 \qquad \text{[Eq. 2]}$$

Where, W_1= weight of the samples after a week (g)
W_2= weight of the initial sample (g)

2.5.3 Color Values

The color of the raw papaya pulp, liquefied papaya with a 20% carrier agent, spray-dried papaya powder, and reconstituted powders was measured using a colorimeter (LS172, Linshang Technology) adopting the method of [11] with some modifications. The colorimeter was calibrated first through a white bond paper before use. The data collected was expressed in terms of L*, a*, and b* values, corresponding to the lightness to darkness, greenness to redness, and blueness to yellowness of the sample, respectively.

2.5.4 Total Soluble Solids (TSS) Content

The TSS of the papaya puree and reconstituted spray-dried papaya powder were measured using a refractometer (LC-DRI 94B). The solution used a mixture of 5 g of powder and 10 mL of distilled water in a 50 mL beaker. The solution was carefully mixed using a spatula until well blended and rested the solution for 1 hr [12]. Distilled water was used to calibrate the digital refractometer. The sample port of the refractometer was cleaned using distilled water before and after the sample was measured. The data gathered from the refractometer was expressed in °Brix.

2.5.5 Water Activity

Power TX Water Activity Meter was used to measure the powders' water activity. Initially, the device was turned on at least 1 hr before use to warm up. In measuring the Aw, the method from the study of Alissa et al. (2020) was adapted with slight modification. One (1) g of powder was utilized in every treatment and placed in the sample port of the water activity meter. Read the water activity meter under the room temperature of 25 °C, and each treatment underwent three (3) replications.

2.5.6 Microbial Analysis (Aerobic Plate Count)

To test the spray-dried papaya powder in terms of the number of bacteria present, the stated process from the study of [13] was utilized. The samples from different treatments were separately diluted with Ringer's solution (pH 70) and plated on MRS agar (pH 62). Spray-dried samples were previously rehydrated in Ringer's solution at a solid content of 20% (w/v), and the solution was used to measure cell survival after 48 hr of incubation at 37 °C under anaerobic conditions. The cell counts were then expressed in CFU/g.

2.5.7 Proximate Analysis

The spray-dried papaya powders were analyzed in terms of Moisture, Ash, Crude Protein, Crude Fat, Crude Fiber, Carbohydrates, and Calorie Content based on the method suggested by [14].

2.5.8 Proximate Analysis

A sample of spray-dried papaya powder from treatments T1, T2, T3, and T4 underwent acceptability and descriptive sensory evaluations. Two (2) products were included in the evaluation: the reconstituted powder and the powdered form itself. Qualified panelists were selected for the sensory evaluation, guided by a trained professional overseeing the sensory testing procedure. The evaluation took place in the Post-Harvest Processing Laboratory, under fluorescent lighting, and at a room temperature of 25 °C, located in the College of Agriculture and Agri-Industries Building on Caraga State University's main campus. The panelists were initially informed about the descriptions used in both the descriptive and acceptability evaluations. Necessary materials, such as water and spit cups, were provided to the panelists before presenting the samples. Each sample was placed in a white plastic cup, labeled with a 3-digit random number, and then given to the panelists along with the evaluation sheet for both the descriptive and acceptability evaluations. In the descriptive evaluation, four (4) attributes were assessed: color, texture, taste, and aroma, each with corresponding descriptions. For the acceptability evaluation, a 9-point hedonic scale was utilized to gauge the degree of liking for each sample, where a value of 9 represented 'like extremely' and 1 represented 'dislike extremely' [15].

2.6 Data Analysis

In this study, the collected data were statistically analyzed as a two-factor factorial design with three replications using the analysis of variance except for the process yield, aerobic plate count, and proximate analysis. Post hoc analysis was also employed to determine the significant differences between the means of the treatments using a Statistical Tool for Agricultural Research (STAR Software) at a significant level of $p \leq 0.05$ [35].

3. RESULTS AND DISCUSSION

3.1 The Developed Spray-dried Papaya Powder

The developed spray-dried papaya powder of different treatments is displayed in Figure 2.

Fig. 2. The spray-dried papaya puree turned powders.

3.2 Process Yield (%)

The process yields (Table 2) of the spray-dried papaya powder ranged from 46.9% to 51.75%. The spray-dried papaya powder that had gum arabic and spray-dried under 180 °C accumulated the highest process yield (51.75%) and was followed by T3, T1, and T2 with the corresponding values of 50, 47.60, and 46.90%, respectively. The descriptive values found that using gum arabic as a carrier agent produced much more powder than using maltodextrin. This result coincided with the study of [16] when they studied spray-dried sour cherry juice. In their study, they observed that using 20% concentration of gum arabic produced much more powder compared to using 20% maltodextrin, regardless of the inlet temperature. In addition, among all the treatments, T4 had the highest process yield compared to the rest of the other treatments. This finding was due to the use of high temperatures (180 °C), which could minimize the sticky powders attached to the wall of the spray dryer and could produce more powder [17].

Table 2. Process yield obtained under different treatments.

Treatment	Carrier Agent	Inlet Temperature (°C)	Process Yield (%)
T1	Maltodextrin	160	47.60
T2	Maltodextrin	180	46.90
T3	Gum Arabic	160	50.00
T4	Gum Arabic	180	51.75

T1- treatment 1; **T2**- treatment 2; **T3**- treatment 3; and **T4**- treatment 4.

3.3 Hygroscopicity (%)

As supported by Tukey's HSD test at $p \leq 0.05$, samples of all treatments were not statistically significant. Therefore, the varying carrier agent and inlet temperature have no significant effect on the hygroscopicity of the developed spray-dried papaya powder. However, as observed in Table 3, T2 exhibited the lowest hygroscopicity of 6.97%, and thus it is better compared to other treatments. Samples that exhibited low hygroscopicity were considered good powders since high hygroscopicity indicates a greater tendency to absorb water and cause stickiness [18, 19].

Table 3. Descriptive values of the hygroscopicity results.

Treatment	Carrier Agent	Inlet Temperature (°C)	Hygroscopicity (%) Mean ±SD
T1	Maltodextrin	160	7.47 ± 1.38[a]
T2	Maltodextrin	180	6.97 ± 2.75[a]
T3	Gum Arabic	160	9.55 ± 2.05[a]
T4	Gum Arabic	180	9.16 ± 2.10[a]

SD- standard deviation; **T1**- treatment 1; **T2**- treatment 2; **T3**- treatment 3; and **T4**- treatment 4.

According to [20] powder with less than 20% hygroscopicity was considered not very hygroscopic. Meanwhile, using maltodextrin and gum arabic carrier agent, the increase in inlet temperatures has slightly decreased the hygroscopicity of the powder. Moreira et al. [21] reported that the decrease in hygroscopicity produced at high temperatures is attributed to the powder's low moisture content. A similar observation was observed by Bakar et al. [22] and Goula and Adamopoulos [23], in which the increase in temperature resulted in a decreased powder's hygroscopicity of red pitaya peel and orange juice, respectively. Moreover, using maltodextrin as a carrier agent at different inlet temperatures resulted in a less hygroscopic powder compared to gum arabic. This could be because maltodextrin is a material that has low hygroscopicity, and thus, it is widely used as a carrier agent in spray drying [19]. This result was also observed in the study of Ferrari et al. [24] and Tran and Nguyen [25]. Hence, after spray-drying, the powder spray-dried with gum arabic was considered to absorb more water from surrounding environments faster than maltodextrin, resulting in a higher hygroscopic powder [26].

3.4 Color Values (*L*, a*, and b**)

The color properties of the developed powder reinforced with different inlet temperatures (160 °C and 180 °C) and carrier agents (maltodextrin and gum arabic). The lightness (L*), redness (a*) and yellowness (b*) ranged from 83.62±0.25 to 85.97±0.45, -0.26±1.55 to 1.14±2.12 and 7.19±1.09 to 9.60±1.91, respectively.

As supported by Tukey's HSD test at $p \leqslant 0.05$, no significant differences ($p>0.05$) were observed in L*, a*, and b* values, indicating that the addition of maltodextrin and gum arabic at different inlet temperatures did not affect the color of the powder. As to the reconstituted powder, as supported by Tukey's HSD test at $p \leqslant 0.05$, significant changes were observed in the obtained L* of papaya powder from different inlet temperatures and carrier agents used. Also, it was observed that using maltodextrin, the obtained L* increased as the temperature increased, indicating that the increase in temperature increased the lightness color of the powder. In terms of the a*, the obtained value was 4.72±0.11 to 6.39±0.15. Results revealed a significant difference ($p<0.05$) in the a* value of the reconstituted powder. It is observed that regardless of the carrier agent used, the increased inlet temperature has significantly increased the a* value. Furthermore, the obtained yellowness (b*) of the powder was between 19.39±0.51 to 20.96±0.23. A significant difference ($p<0.05$) was also observed in the b* values of the reconstituted powder. Results showed that regardless of the carrier agent used, the b* value decreased as temperature increased.

3.5 Total Soluble Solids (TSS) Content

To visualize the sweetness retained in the spray-dried powder, the TSS of the samples was measured, and the data results are listed in Table 4. The values of the reconstituted powder in terms of TSS using the maltodextrin have increased as the temperature increases.

On the other hand, the value of TSS using gum arabic has decreased as the temperature increases. Results revealed that the differences in the TSS powder from different treatments from the current study might be due to the sugar content of the raw papaya, the heat absorbed by the particles during spray drying, and the implications of carrier agents [27].

Table 4. Mean TSS values of the spray-dried powders.

Treatment	Carrier Agent	Inlet Temperature (°C)	TSS (°Brix) Mean ±SD
T1	Maltodextrin	160	16.66 ± 0.06[a]
T2	Maltodextrin	180	16.80 ± 0.00[a]
T3	Gum Arabic	160	16.43 ± 0.12[a]
T4	Gum Arabic	180	15.80 ± 0.10[a]

SD- standard deviation; **T1**- treatment 1; **T2**- treatment 2; **T3**- treatment 3; and **T4**- treatment 4.

Furthermore, regarding the inlet temperatures used during spray drying, the inlet temperatures being assessed were 160 °C and 180 °C. It was then observed that using 160°C inlet temperature significantly affected ($p<0.05$) the values of TSS whether the carrier agent used was maltodextrin or gum arabic, same way with the use of 180°C inlet temperature. Based on the results, the values gathered from using either 160°C or 180°C inlet temperature, the TSS using maltodextrin was higher than gum arabic. According to [28], they mentioned that before spray drying food, maltodextrin is added to increase the TSS and reduce the amount of water available for evaporation. Also, Nthimole et al. [29] mentioned that TSS might vary depending on the carrier agent used, and the differences in the powders' TSS value depend on the soluble components of the carrier agents.

3.6 Water Activity

The values for water activity of the spray-dried papaya powder ranged from 0.45±0.005 to 0.57 ± 0.01, which was denoted as microbiologically stable [30, 31].

As supported by Tukey's HSD test, the different carrier agents with different inlet temperatures have a significant effect ($p<0.05$) on the water activity values of the spray-dried papaya. Moreover, the results obtained from the observations associated with the use of maltodextrin were similar to those obtained in the study of Martins et al. [32] which explained that the increased heat transfer rate caused the powder's water activity to decrease. In addition, the result of the present study in terms of water activity using the gum arabic was in contrast to the study of Fazaeli et al. [33] and Arepally et al. [34] where they studied the black mulberry juice powder and encapsulation of probiotic. However, according to Alvarado et al. [35] this result may be due to the difference in products studied because some products can increase water activity with increasing temperature, and some are not.

3.7 Microbial analysis (Aerobic Plate Count)

Displayed in table 5 are the results of microbial analysis. It is evident that regardless of which of the two carrier agents with different temperatures were used, the value of APC was still the same. All treatments gathered a value of 10 CFU/g, indicating that all treatments were safe to consume [36].

Table 5. Mean TSS values of the spray-dried powders.

Treatment	Carrier Agent	Inlet Temperature (°C)	Aerobic Plate Count (CFU/g)
T1	Maltodextrin	160	10
T2	Maltodextrin	180	<10
T3	Gum Arabic	160	10
T4	Gum Arabic	180	10

APC- aerobic plate count; **CFU** – colony forming unit; **T1**- treatment 1; **T2**- treatment 2; **T3**- treatment 3; and **T4**- treatment 4.

3.8 Proximate Analysis

Based on the results as summarized in Table 6, T1 obtained a powder with good properties. The treatment obtained a favorable low moisture content (6.88), low ash content (1.12), high crude protein (10.50), low crude fiber (0.02) and crude fat (2.00), high carbohydrate (79.5), and high-calorie content (378).

Table 6. Proximate values of the spray-dried powders.

Test Parameters	T1	T2	T3	T4
Moisture (%)	6.88	11.58	9.28	7.93
Ash content (%)	1.12	1.76	1.15	1.80
Crude Protein (%)	10.50	8.75	8.75	7.95
Crude Fat (%)	2.00	1.90	1.26	1.19
Crude Fiber (%)	0.02	0.05	0.17	0.18
Carbohydrates (%)	79.50	76.01	76.56	81.13
Calorie Content	378.00	356.00	364.00	367.00

3.9 Sensory Evaluation

Based on the results displayed in Figure 3, the panelists observed that there was not much difference in color among all the treatments. However, among all the treatments, T4 obtained the highest percentage that the panelists liked. T4 powder was spray-dried at an inlet temperature of 180 °C and composed of a 20% concentration of gum arabic carrier agent. For the descriptive evaluation of color, most of the panelists viewed the colors T1, T2, T3, and T4 as light orange to orange. For the taste, the average of the reconstituted papaya was 5.53, 5.40, 5.27, and 5.67 for T1, T2, T3, and T4, respectively. These values gathered from the result of taste for its general acceptability fell into the "like slightly" scale. For the descriptive evaluation, T1 and T2 accumulated the highest taste and aftertaste scores that distinguished a slightly sweet taste from the reconstituted papaya powder. This result was justifiable since during spray drying, there was no sugar added, and the solution was added with only 20% maltodextrin carrier agent concentration. Based on these results, the treatments being applied had a positive outcome because the powders from these treatments detected a small amount of sweetness perceived by most of the panelists.

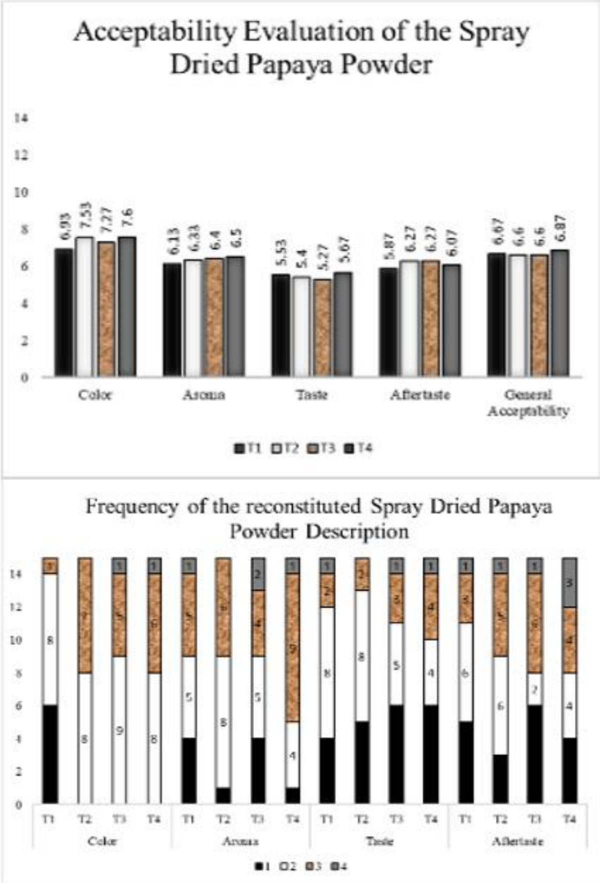

Fig. 3. General acceptability evaluation (top) and descriptive evaluation (bottom) of the reconstituted spray-dried papaya powder.

4. CONCLUSION

Spray drying technology is an effective method to value-add unsalable papaya into food flavoring powder. Good results were observed in T2 with optimal TSS, hygroscopicity, and water activity values. Aerobic Plate Count (APC) and proximate analysis were also evaluated in this study. APC of all the treatments has the same value of 10 CFU/g, which indicates that the products are safe to consume. Moreover, for the proximate analysis of the powders, T1 obtained a powder with good properties. The treatments are composed of low moisture content, low ash content, high crude protein, low crude fiber and crude fat, high carbohydrate, and high-calorie content. Also, the acceptability and descriptive sensory evaluation of powder in terms of aroma and taste showed that the use of maltodextrin spray-dried under different temperatures retained its flavor even after spray drying. Thus, this study concluded that the incorporation of different carrier agents and inlet temperatures contributes to the potential of spray-dried papaya as a food flavoring powder.

The present study has shown that spray-dried powder from unsalable ripe papaya has the potential to be used as a food flavoring. The incorporation of different carrier agents and inlet temperatures with two (2) corresponding levels affected the physicochemical characteristics, proximate analysis, and sensory properties of spray-dried papaya. Although the result from the characterization indicates good properties of the powder, the researchers would like to recommend the addition of levels of inlet temperatures and different concentrations of carrier agents to fully analyze the trend and the possible changes in the results after spray drying. Additionally, the researchers suggested applying the produced powder to a specific product and conducting a thorough sensory evaluation.

5. ACKNOWLEDGMENT

The authors are grateful to the Department of Agricultural & Biosystems Engineering, College of Engineering and Geosciences, the Center for Resource Assessment, Analytics, and Emerging Technologies (CSU-CReATe) and the Caraga Food Innovation Center (FIC) for the facilities and technical expertise afforded during the entire conduct of the study. Special acknowledgment is given to the Department of Budget and Management for funding the research project (RS - Valorization of Agricultural Waste into Potential Utilization) under the CSU-GAA-FY 2022 led by Assoc. Prof. Engr. Philip Donald C. Sanchez.

6. REFERENCES

[1] I. Hewaljulige and S. Dhekney, Papayas, Encyclopedia of Food and Health, 2016.

[2] L. S. Chang, Y. L. Tan and L. P. Pui, "Production of spray-dried enzyme-liquefied papaya (Carica papaya L.) powder," Brazilian Journal of Food Technology, vol. 23, 2020.

[3] J. D. Silva, Z. Rashid, D. T. Nhut, D. Sivakumar, A. Gera, M. T. Souza and P. Tennant, "Papaya (Carica papaya L.) biology and biotechnology," Tree and Forestry Science and Biotechnology, vol. 1, no. 1, pp. 47-73, 2007.

[4] J. G. De Oliveira and A. P. Vitória, "Papaya: Nutritional and pharmacological characterization, and quality loss due to physiological disorders. An overview.," Food Research International, vol. 44, no. 5, pp. 1306-1313, 2011.

[5] P. Kandasamy, N. Varadharaju, S. Kalemullah and R. Moitra, "Production of papaya powder under foam-mat drying using methyl cellulose as foaming agent.," Asian Journal of Food and Agro-Industry, vol. 5, no. 5, pp. 374-387, 2012.

[6] C. A. Chopda and D. M. Barrett, "Optimization of Guava Juice and Powder Production. Journal of Food Processing and Preservation," Journal of Food processing and Preservation, vol. 25, no. 6, pp. 411-430, 2001.

[7] N. Phisut, "Spray drying technique of fruit juice powder: some factors influencing the properties of product," International food research journal, vol. 19, no. 4, p. 1297, 2012.

[8] J. Barragán-Iglesias, L. L. Méndez-Lagunas and J. Rodríguez-Ramírez, "Ripeness indexes and physicochemical changes of papaya (*Carica papaya* L. cv. Maradol) during ripening on-tree," Scientia Horticulturae, vol. 236, pp. 272-278, 2018.

[9] K. W. Saw and L. P. Pui, "Pproduction and characterization of ‘sekaki’ papaya fruit puree and powder," Carpathian Journal of Food Science and Technology, pp. 140-149, 2021.

[10] G. W. Shuen, L. Y. Yi, T. S. Ying, G. C. Y. Von, Y. a. B. Yusof and P. L. Phing, "Effects of drying methods on the physicochemical properties and antioxidant capacity of Kuini powder," Brazilian Journal of Food Technology, vol. 24, 2021.

[11] J. Du, Z.-Z. Ge, Z. Xu, B. Zou, Y. Zhang and C.-M. Li, "Comparison of the Efficiency of Five Different Drying Carriers on the Spray Drying of Persimmon Pulp Powders," Drying Technology, vol. 32, no. 10, pp. 1157-1166, 2014.

[12] A. Gbadegesin, S. Gbadamosi and T. Odunlade, "Physicochemical and sensory properties of pineapple flavored roselle powders," Cogent Food & Amp; Agriculture, vol. 3, no. 1, p. 129283, 2017.

[13] M. Jantzen, A. Göpel and C. Beermann, "Direct spray drying and microencapsulation of probiotic Lactobacillus reuteri from slurry fermentation with whey," Journal of Applied Microbiology, vol. 115, no. 4, pp. 1029-1036, 2013.

[14] K. N. Sindol, A. S. T. Gadat, J. J. J. Sanchez, P. D. C. Sanchez, Development and Characterization of Briquettes made from Unsalable Banana Peels: A Preliminary Evaluation, International Exchange and Innovation Conference on Engineering and Sciences (IEICES), vol. 8, pp. 265-270, 2022.

[15] M. Everitt, Consumer-Targeted Sensory Quality, Elsevier EBooks, 2009.

[16] I. E. Garofulić, Z. Zorić, S. Pedisić and V. Dragović-Uzelac, "Optimization of Sour Cherry Juice Spray Drying as Affected by Carrier Material and Temperature," Food Technology and Biotechnology, vol. 54, no. 4, 2016.

[17] T. Laokuldilok and N. Kanha, "Effects of processing conditions on powder properties of black glutinous rice (Oryza sativa L.) bran anthocyanins produced by spray drying and freeze drying.," LWT - Food Science and Technology, vol. 64, no. 1, pp. 405-411, 2015.

[18] S. Bhusari, K. Muzaffar and P. Kumar, "Effect of carrier agents on physical and microstructural properties of spray dried tamarind pulp powder," Powder Technology, vol. 266, pp. 354-364, 2014.

[19] R. V. Tonon, S. Freitas and M. D. Hubinger, "Spray drying of açai (*Euterpe oleraceae* mart.) juice: effect of inlet air temperature and type of carrier agent," Journal of Food Processing and Preservation, vol. 35, no. 5, pp. 691-700, 2011.

[20] B. Nurhadi, R. M. Andoyo and R. Indiarto, "Study the properties of honey powder produced from spray drying and vacuum drying method," International Food Research Journal, vol. 19, no. 3, pp. 907-912, 2012.

[21] G. É. G. Moreira, M. G. M. Costa, A. S. Souza, E. S. De Brito, M. De Fátima Dantas De Medeiros and H. M. Azeredo, "Physical properties of spray dried acerola pomace extract as affected by temperature and drying aids," Lebensmittel-Wissenschaft & Technologie, vol. 42, no. 2, pp. 641-645, 2009.

[22] J. Bakar, S. C. Ee, K. Muhammad, D. M. Hashim and N. M. Adzahan, "Spray-Drying Optimization for Red Pitaya Peel (Hylocereus polyrhizus)," Food and

Bioprocess Technology, vol. 6, no. 5, pp. 1332-1342, 2013.
[23] A. M. Goula and K. G. Adamopoulos, "A new technique for spray drying orange juice concentrate," Innovative Food Science and Emerging Technologies, vol. 11, no. 2, pp. 342-351, 2010.
[24] C. C. Ferrari, S. P. M. Germer, I. D. Alvim, F. Z. Vissotto and J. M. Aguirre, "Influence of carrier agents on the physicochemical properties of blackberry powder produced by spray drying," International Journal of Food Science and Technology, vol. 47, no. 6, pp. 1237-1245, 2012.
[25] T. N. Tran and H. H. Nguyen, "Effects of Spray-Drying Temperatures and Carriers on Physical and Antioxidant Properties of Lemongrass Leaf Extract Powder," Beverages, vol. 4, no. 4, p. 84, 2018.
[26] I. Tontul and A. Topuz, "Spray-drying of fruit and vegetable juices: Effect of drying conditions on the product yield and physical properties," Trends in Food Science &Amp; Technology, vol. 63, pp. 91-102, 2017.
[27] S. F. Z. M. Fuzi and N. S. Ramli, "Effect of Spray Drying Conditions on the Physical Properties of Sugarcane (*Saccharum officinarum*) Powder," Enhanced Knowledge in Sciences and Technology, vol. 2, no. 1, pp. 94-102, 2022.
[28] D. E. Jimenez-Sánchez, M. Calderón-Santoyo, R. I. Ortiz-Basurto, P. U. Bautista-Rosales and J. A. Ragazzo-Sánchez, "Effect of maltodextrin reduction and native agave fructans addition on the physicochemical properties of spray-dried mango and pineapple juices," Food Science and Technology International, vol. 24, no. 6, pp. 519-532, 2018.
[29] C. T. Nthimole, T. Kaseke and O. A. Fawole, "Micro-Encapsulation and Characterization of Anthocyanin-Rich Raspberry Juice Powder for Potential Applications in the Food Industry," Processes, vol. 10, no. 5, p. 1038, 2022.
[30] S. Y. Quek, N. K. Chok and P. J. Swedlund, "The physicochemical properties of spray-dried watermelon powders," Chemical Engineering and Processing, vol. 46, no. 5, pp. 386-392, 2007.
[31] D. Dantas, M. A. Pasquali, M. Cavalcanti-Mata, M. E. Duarte and H. M. Lisboa, "Influence of spray drying conditions on the properties of avocado powder drink.," Food Chemistry, vol. 266, pp. 284-291, 2018.
[32] E. Martins, D. C. Cnossen, C. R. J. Silva, J. C. Junior, L. A. Nero, I. T. Perrone and A. F. Carvalho, "Determination of ideal water activity and powder temperature after spray drying to reduce Lactococcus lactis cell viability loss," Journal of dairy science, vol. 102, no. 7, pp. 6013-6022, 2019.
[33] M. Fazaeli, Z. Emam-Djomeh, A. Kalbasi Ashtari and M. Omid, "Effect of spray drying conditions and feed composition on the physical properties of black mulberry juice powder," Food and Bioproducts Processing, vol. 90, no. 4, p. 667, 2012.
[34] D. Arepally and T. K. Goswami, "Effect of inlet air temperature and gum Arabic concentration on encapsulation of probiotics by spray drying," LWT, vol. 99, pp. 583-593, 2019.
[35] M. C. Alvarado, S. G. N. Polongasa, P. D. C. Sanchez, A Preliminary Evaluation on the Development of Edible Drinking Straw from Guso (*Eucheuma cottonii*) Seaweeds, International Exchange and Innovation Conference on Engineering and Sciences (IEICES), vol. 9, pp. 51-58, 2023.
[36] C. f. F. Safety, Microbiological Guidelines for Food, 2014.