Utilization and Development of Libas (*Spondias Pinnata*) Spray-Dried Powder

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ABSTRACT

In this study, the effect of maltodextrin concentration on the physico-chemical, sensory and storage characteristics of Libas (Spondias pinnata) powder produced by spray drying was investigated. Initially, fresh Libas leaf extracts were drawn out in distilled water heated at 100°C for 30 minutes. 10, 20 and 30% maltodextrin was added to the solution prior to sieving. These solutions were then atomized in a pilot scale centrifugal spray dryer at an inlet temperature of 180°C, material cooling temperature of 70°C, fan operation frequency of 60 Hz, atomizer operation frequency of 300 Hz and mean outlet temperature of 125°C. Spray dried Libas leaf powder was analyzed for product yield, pH, moisture content, ash content and solubility time. The level of acceptability of the spray dried Libas leaf powder was also assessed in terms of appearance, taste, aroma, mouthfeel and overall acceptability using a 9-point hedonic scale conducted on thirty (30) sensory panelists. Findings of the study revealed that maltodextrin concentration significantly affected various physico-chemical, sensory and storage characteristics of spray dried Libas leaf powder. Product yield, solubility and residual moisture content were found to be significantly improved by an increase in maltodextrin concentration. However, it was also found that there is a decrease in the ash content and level of acceptability of the spray dried samples with an increase in maltodextrin concentration. Storage of the spray dried Libas leaf powder for six (6) months significantly affected pH and moisture content. No significant difference in sensory characteristics was detected among treatments indicating that powder quality is still acceptable during the six (6) months storage period.

Keywords-- *Spondias Pinnata*, Spray Drying, Maltodextrin Concentration, Physico-Chemical Characteristics, Sensory, Shelf Life

I. INTRODUCTION

Spondias pinnata, locally known as “Libas” is a tree that is about 25 meters in height and about 60 centimeters in diameter. The surface of its bark is smooth, with irregular cracks, grey to pale reddish brown in color, exuding a clear, sticky sap with turpentine smell. Its leaves are alternate, pinnately compound, 20 centimeters or more in length. Its leaflets are pointed at the tip, rounded or abruptly pointed at the bottom, and 7 to 14 centimeters in length. Its flowers are minute and in panicles while its fruits are rounded, yellow, a one-seeded drupe, with a finely flavored, edible pulp. It is sometimes planted as a shade in some places. In culinary, the young leaves, fruits and even flowers are edible. In medicine, it is used as an anthelmintic, anti-inflammatory, anti-pyretic, anti-tumor, anti-bacterial and is used to regulate menstruation. It is also used as treatment for burns, sores and wounds.

Spray drying is the transformation of a liquid system (solutions, dispersions, emulsions) into a dry particulate powder. The liquid system is atomized into droplets, which are dried through contact with a drying medium, usually air, at a high temperature. During the spray drying process, the droplets are reduced and the solvent (often water) is evaporated. Spray drying is commonly employed in the food industry to ensure microbiological stability of the product, reducing biological deterioration and storage and transportation costs, obtaining a spray-dried powder with appropriate properties in terms of water activity, moisture content, pH, solubility, hygroscopicity, nutritional composition, glass transition temperature, color and fluidity. Fruit and vegetable food powders with the quality attributes required by the commercial sector can be manufactured using spray drying technology. This can be achieved through experimental optimizations, evaluating the effects of independent variables such as formulation and processing on dependent variables. In designing experiments, optimizing formulations such as variation in the level of encapsulating agent used in the product can be an effective way to attain the desired quality of the finished product.

Libas (*Spondias pinnata*) is underutilized and is deemed to have little economic importance. However, recent studies have proven that *Libas* can be promising in improving food security through research, resulting in food product development (jams, jellies, seasoning mix, etc.). The development of Libas spray dried powder will promote increase use of the tree species. This can result to rural development in the provinces where the tree species is abundant, by creating job opportunities to local farmers, improving the lives of locals in rural areas. Expanded utilization of Libas (*Spondias pinnata*) will encourage production (harvesting) resulting in trade of the plant material to other parts of the country, improving our country's economy by opening up new investment opportunities and markets. Results of the study can also provide technical knowledge to food processors, researchers and academicians, introducing them on the use of spray drying technology on food processing.

Specifically, the aim of this study is to assess the effect of using different concentrations of maltodextrin in the production of Libas (*Spondias pinnata*) spray-dried powder.

II. METHODOLOGY

This study employed developmental, quantitative and experimental method of research. It involved three (3) different treatments. Treatment 1 employed 10% concentration of maltodextrin in the formulation. Treatment 2 utilized 20% concentration of maltodextrin while Treatment 3 used 30% maltodextrin concentration.

The Bicol Regional Food Innovation and Commercialization Center (BRFICC), BU East Campus, Legaspi City, Albay was the site of the experiment. However, mature leaves of Libas (*Spondias pinnata*) were harvested at Catanduanes State University, Calatagan, Virac, Catanduanes. Collected leaves were washed in running tap water for removal of dirt. They were then soaked in 1% saline solution (NaCl) for 5 minutes to remove microorganisms. Libas (*Spondias pinnata*) leaves were heated with distilled water at 100°C for 30 minutes. Once done, the mixture was strained to separate the extract from the leaves. The leaf extract was then subjected to the spray dryer (MachineLab Technology Inc. High Speed Centrifugal Spray Dryer) to produce a fine soluble powder. Powdered finished product was packed in PET-MET films and sealed using a heat sealer to prevent contact with oxygen, light and moisture.

Biological specimen samples of Libas were sent to DOST FPRDI for species identification. Physico-chemical characteristics of the spray-dried product were analyzed in terms of product yield, pH, moisture content, ash content and solubility time. Analyses were done in triplicates. Sensory evaluation was also conducted to determine the level of acceptability of the different treatments in terms of appearance, taste, aroma and overall acceptability. Shelf-life characteristics of the treatments were assessed for six (6) months to determine if there were significant changes in the product's physico-chemical and sensory characteristics.

III. RESULTS AND DISCUSSION

Spray drying is a technique commonly used in the food industry to make food powder due to its effectiveness under optimum conditions. Spray drying parameters such as maltodextrin concentration, drying air temperature and feed rate are influential regarding the attributes of spray-dried powder like appearance, moisture content, nutrient retention, solubility time and the amount of insoluble solids. Due to the lack of research on the spray drying of Libas, this study was carried out. The feed materials were prepared by adding the specified amount of maltodextrin into the concentrated Libas leaf extract samples and then sieving. The concentrations of maltodextrin used in this study were 10%, 20% and 30% w/v.

Samples were then fed to a small-scale spray dryer to convert the liquid extract to a fine powder. A schematic diagram of a small-scale spray dryer is shown in Figure 1.

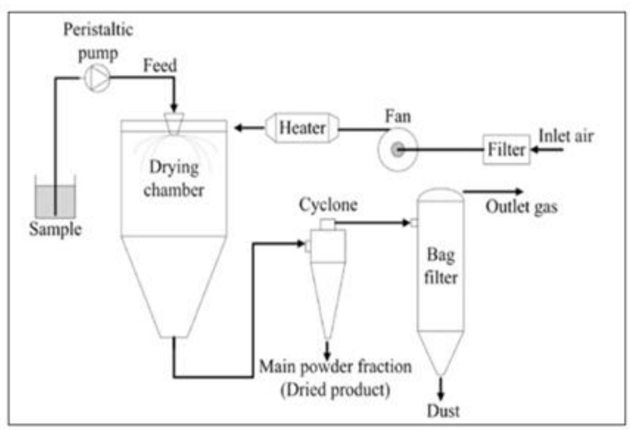

Figure 1: Schematic diagram of a small scale spray dryer

3.1. Physico-Chemical Analysis

3.1.1. Product Yield

Product yield was expressed as the ratio between the total weight of powder collected and the total weight of extract with maltodextrin as shown in the formula below:

Product Yield= [Final weight of spray dried powder (g)/(Weight of extract + Maltodextrin)] * 100

Product yield was calculated as the percent of the mass of solids collected after spray drying to the amount of solids in feed solution. While computing yield, total weight of powder obtained from drying chamber and cyclone were added.

The product yield for Treatment 1, 2 & 3 was observed to have increased with increase in maltodextrin concentration. Treatment 1, 2 and 3 differ significantly from each other in terms of product yield (see Table 1).

Table 1: Initial product yield (%) results of spray-dried Libas powder at different maltodextrin concentrations

	Product Yield (%)		
Trial No.	**Treatment 1**	**Treatment 2**	**Treatment 3**
Trial 1	35	40	50
Trial 2	32	39	47
Trial 3	31	42	45
Mean	**32.67[a]**	**40.33[b]**	**47.33[c]**

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

No significant difference in terms of product yield was observed for Treatment 1, 2 and 3 from 0-6 months of storage.

The results showed that maltodextrin improved product yield and served the purpose as the drying agent in spray drying of the *Libas* powder. Similar trends were reported by Bazaria and Kumar (2016), Fazaeli et al. (2012) and Quek et al. (2007) in spray drying of beetroot, black mulberry and watermelon powders, respectively. A small amount of CAL powder was recovered (12.60±0.14 %) without the addition of the drying agent. The findings were similar with Quek et al. (2007) and Ibrahim et al. (2015) studies in watermelon and kafir lime leaves spray drying, respectively. There were hardly any powder produced without the presence of maltodextrin and the sticky particle mainly deposited on the wall chamber. This shows the importance of maltodextrin as a drying agent to encapsulate the active compound and improve the properties of the powder, hence, increase the spray drying recovery.

At a constant inlet air temperature, increase in concentration of maltodextrin increased product yield and vice versa. At lower maltodextrin concentration, feed has lower total solids causing lower viscosity and this might lead to shearing action between high velocity compressed air and low velocity feed producing high velocity atomized spray droplets colliding with internal walls of the drying chamber at greater speed and intensity, generating increased wall deposits and thus, decrease the product yield.

3.1.2. pH

pH indicates the acidity or basicity of a solution. pH of the reconstituted *Libas* leaf powder was determined using a digital pH meter (Mettler Toledo 51343054).

The pH measurements were almost the same in all treatments. The pH of samples upon reconstitution ranged between 2.10 and 2.37 (Table 2); therefore, the reconstituted powdered samples are classified as high acid food.

Table 2: pH of spray-dried Libas powder at different maltodextrin concentrations

	pH		
Trial No.	**Treatment 1**	**Treatment 2**	**Treatment 3**
Trial 1	2.08	2.32	2.37
Trial 2	2.10	2.35	2.36
Trial 3	2.12	2.37	2.38
Mean	**2.10[a]**	**2.35[b]**	**2.37[b]**

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

The pH of Libas powder with 10% maltodextrin is significantly lower than the spray dried powder with 20% and 30% maltodextrin. Increasing the concentration of maltodextrin dilutes the amount of organic acids that may be present in the mixture, thus, an increase in pH is observed with an increase in maltodextrin concentration. During storage, there was observed significant decrease in pH among treatments due to the production of acetic acid and lactic acid.

3.1.3. Moisture Content

The moisture content of *Libas* powder was obtained by drying an empty dish and lid in the oven at 105°C for 3 hours and putting in a desiccator to cool. Upon cooling, the empty dish and lid were weighed using an analytical balance. About 3g sample was weighed on the dish and the sample was spread evenly with a spatula. The dish with the sample was put in the oven for 3 hours at 105°C. After drying, the dish with partially covered lid was transferred to the desiccator to cool. The dish and the dried sample were reweighed to obtain the moisture content of the sample. Moisture content for each treatment was calculated based on the formula:

$$\text{Moisture (\%)} = \frac{(W1-W2) \times 100}{W1}$$

where: W1 = weight (g) of sample before drying

W2 = weight (g) of sample after drying

The presence of residual moisture in the powders is a result of the limitations of the spray-drying process since the process alone could not remove the water content from the samples completely. For food and pharmaceutical applications, this must be kept at its minimum because it can usher in spoilage and enzymatic degradation of the product. The residual moisture content of the *Libas* spray-dried powders was found to range from 3.70-4.70% (Table 3).

Table 1. Product Yield (%) of *Libas* spray-dried powder at different maltodextrin concentrations

Table 3: Moisture content (%) of spray-dried Libas powder at different maltodextrin concentrations

Trial No.	Moisture content (%)		
	Treatment 1	Treatment 2	Treatment 3
Trial 1	4.7	4	3.7
Trial 2	4.8	4.2	3.6
Trial 3	4.6	4.4	3.8
Mean	**4.70**[a]	**4.20**[b]	**3.70**[c]

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

There is significant difference among treatments in moisture content; with a decrease in moisture content observed when maltodextrin concentration was increased. This trend was consistent with the work of Lee et al. (2022) whereby increasing maltodextrin concentration led to reduction in moisture content in honeydew melon powder. Quek et al. (2007) found a similar pattern where increase in maltodextrin concentration led to an increase in total solids content and reduced the amount of water for evaporation which in turn reduced the moisture content of the spray-dried powder.

3.1.4. Ash Content

Ash content of samples was analyzed using gravimetric method (AOAC, 2000). Crucible and lid were put in the furnace overnight at 550°C to ensure that impurities are scorched. The crucible was then cooled at the desiccator for 30 minutes and crucible and lid were weighed using an analytical balance. Five (5) grams of test sample was weighed into the crucible. Crucible was heated over low Bunsen flame with lid half covered. When fumes were no longer produced, crucible and lid were placed in the furnace and heated at 550°C overnight. Lid was not covered during heating. Lid was only placed upon complete heating to prevent loss of fluffy ash. The crucible with the sample was then placed in the desiccator to cool down. The crucible and lid together with the sample was weighed when the sample turned gray. Ash content was calculated using the formula below:

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Ash denotes the inorganic residue comprised mostly of the minerals present in the feedstock. The ash content of the *Libas* spray-dried powders ranged from 0.97% to 2.01% with a significant decrease in ash content among treatments when maltodextrin concentration is increased (Table 4).

Table 4: Ash content (g/100g) of spray-dried Libas powder at different maltodextrin concentrations

Trial No.	Ash content (%)		
	Treatment 1	Treatment 2	Treatment 3
Trial 1	2.01	1.54	0.96
Trial 2	2.03	1.53	0.97
Trial 3	1.98	1.55	0.98
Mean	**2.01**[a]	**1.54**[b]	**0.97**[c]

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

This would mean that minerals, and probably vitamins, initially present in the feedstock were most likely preserved during spray drying, but concentrations are likely diminished by an increase in the amount of maltodextrin present in the spray dried powder. During storage for six (6) months, there was no observed significant difference in the ash content among treatments.

3.1.5. Solubility Time

The solubility time of the powder was determined by dissolving 2g of the *Libas* powder to 50 mL distilled water at 26 °C. The solution was mixed homogeneously in a 100 mL glass beaker with magnetic stirrer at 892 rpm using a stirrer bar of size 22×7 mm. The time required to dissolve the powder completely was recorded.

The most desirable property of a powder is its ability to dissolve in water in quick time since they are intended for rehydration. Hence, an ideal spray dried powder should wet quickly, thoroughly, disperse and dissolve without lumps, sink rather than float in the solution in only a matter of seconds. Solubility time is described as the time of dissolution. Solubility time for spray dried *Libas* leaf powder ranged from 40.0 to 58.67 seconds. Concentration of maltodextrin can influence the solubility of the spray dried powder. Increase in maltodextrin concentration can reduce solubility time as maltodextrin had superior water solubility and was mainly used in the process of spray drying due to its high solubility in water. Many researchers had reported similar trends in solubility time for fruit powders of ginger, pineapple and grapes. Solubility time of Treatment 1, 2 and 3 varied significantly with lowest solubility time recorded from Treatment 3 (Table 5). However, no significant difference was noted on solubility time of all treatments upon 6 months of storage.

Table 5: Solubility time (in seconds) of spray-dried Libas powder at different maltodextrin concentrations

Trial No.	Solubility Time (seconds)		
	Treatment 1	Treatment 2	Treatment 3
Trial 1	60	50	40
Trial 2	57	52	39
Trial 3	59	55	41
Mean	59^{a}	52^{b}	40^{c}

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

3.2 Sensory Evaluation

A 9-point hedonic scale was used to assess the level of acceptability of the treatments in terms of appearance, taste, aroma, mouthfeel and overall acceptability. Finished product was assessed by ten (10) experienced food technologists and twenty (20) respondents from the general population aged 15-50 years old. Sensory evaluation forms were used by panelists to assess the product. Informed consent form was also given to panelists prior to the conduct of the activity.

Libas powder samples using 10%, 20% and 30% maltodextrin concentration were evaluated in terms of appearance, taste, aroma, mouthfeel, and overall acceptability. A summary of the results of the sensory evaluation is shown in Table 6. This depicts that maltodextrin concentration can affect the level of acceptability of the product.

Table 6: Mean sensory rating of spray-dried Libas powder at different maltodextrin concentrations in terms of appearance, taste, aroma, mouthfeel and overall acceptability

Treatments	Mean sensory rating				
	Appearance	Taste	Aroma	Mouthfeel	Overall Acceptability
T1	7.17^{a}	7.43^{a}	7.07^{a}	6.13^{a}	7.53^{a}
T2	7.13^{a}	7.40^{a}	7.00^{a}	6.37^{a}	7.47^{a}
T3	6.77^{a}	6.53^{b}	6.80^{a}	6.67^{b}	6.50^{b}

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

Mean sensory rating of for appearance obtained were 6.13, 7.13 and 7.17 for Treatment 1, 2 and 3, respectively, which can be interpreted as moderate liking of sensory panelists to the product. Panelists detected no significant difference among treatments in terms of appearance. Libas spray dried powder can be described as fine, soft, and slightly sticky, with a pale yellow color powder. Other studies claim that increasing maltodextrin concentratiom resulted in a lighter colour.

In terms of taste, mean sensory ratings obtained are 7.43, 7.40 and 6.53 for Treatment 1, 2 and 3. Significant difference has been detected on Treatment 3 in comparison with Treatment 1 & 2. This can be attributed to high maltodextrin concentration present in Treatment 3 which may have imparted a bland taste on the product.

Mean sensory ratings of 7.07, 7.00 and 6.80 were obtained for Treatment 1, 2 and 3, respectively, for aroma. No significant difference was detected among treatments in terms of aroma.

In terms of mouthfeel, 6.13, 6.37 and 6.67 mean sensory ratings were obtained. Treatment 3 was noted to be significantly different than the other two treatments. This can be attributed to the high maltodextrin concentration present in Treatment 3 causing a less puckering mouthfeel from the product.

Treatment 1, 2 and 3 obtained a mean sensory rating of 7.53, 7.47 and 6.50, respectively, for overall acceptability. This means that the sensory panelists judged Treatment 1 as the most acceptable among treatments. This can be attributed to the noticeable mango-like taste present in Treatment 1 due to its low maltodextrin concentration.

3.3. Shelf-Life Evaluation

3.3.1. Changes in Physico-Chemical Properties

Table 7: Changes in product yield (%) of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Trial No.	Product Yield (%)								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Trial 1	35	40	50	36	41	51	36	42	52
Trial 2	32	39	47	33	40	47	34	40	47
Trial 3	31	42	45	32	42	45	32	43	46
Mean	32.67^{a}	40.33^{a}	47.33^{a}	33.67^{a}	41.00^{a}	47.67^{a}	34.00^{a}	41.67^{a}	48.33^{a}

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

There was a slight increase in product yield from 32.67% to 34.00% from 0 to 6 months of storage of *Libas* powder using 10% maltodextrin (Treatment 1); from 40.33% to 41.67% on powdered samples using 20% maltodextrin (Treatment 2); and from 47.33% to 48.33% on powdered samples using 30% maltodextrin (Treatment 3).

Table 8: Changes in pH of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Trial No.	pH								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Trial 1	2.08	2.32	2.37	2.05	2.29	2.31	2.02	2.25	2.28
Trial 2	2.10	2.35	2.36	2.06	2.31	2.32	2.01	2.25	2.29
Trial 3	2.12	2.37	2.38	2.08	2.32	2.33	2.04	2.27	2.28
Mean	2.10^{a}	2.35^{a}	2.37^{a}	2.06^{a}	2.31^{a}	2.32^{a}	2.02^{b}	2.26^{b}	2.28^{b}

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

Libas powder samples using Treatment 1, 2 and 3 were observed to be more acidic from 0 to 6 months storage. There was a decrease in pH from 2.10 to 2.02 in a period of

6 months in Treatment 1, from 2.35 to 2.26 in Treatment 2; and from 2.37 to 2.28 in Treatment 3.

Table 9: Changes in ash content (g/100g) of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Trial No.	Ash (g/100g)								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Trial 1	2.01	1.54	0.96	2.02	1.53	0.98	2.02	1.55	0.98
Trial 2	2.03	1.53	0.97	2.04	1.54	0.97	2.04	1.56	0.99
Trial 3	1.98	1.55	0.98	2.03	1.56	0.96	2.05	1.57	0.98
Mean	**2.01^{a}**	**1.54^{a}**	**0.97^{a}**	**2.03^{a}**	**1.54^{a}**	**0.97^{a}**	**2.04^{a}**	**1.56^{a}**	**0.98^{a}**

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

There was a slight increase in ash content from 2.01 g/100g to 2.04 g/100g during 0 to 6 months of storage of *Libas* powder using 10% maltodextrin (Treatment 1); from 1.54 g/100g to 1.56 g/100g on powdered samples using 20% maltodextrin (Treatment 2); and from 0.97 g/100g to 0.98 g/100g on powdered samples using 30% maltodextrin (Treatment 3).

Table 10: Changes in moisture content (%) of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Trial No.	Moisture content (%)								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Trial 1	4.7	4	3.7	4.8	4.3	3.9	5.2	4.6	4.3
Trial 2	4.8	4.2	3.6	4.9	4.5	4	5.3	4.7	4.4
Trial 3	4.6	4.4	3.8	4.9	4.7	4.1	5.4	4.9	4.4
Mean	**4.70^{a}**	**4.20^{a}**	**3.70^{a}**	**4.87^{a}**	**4.50^{a}**	**4.00^{b}**	**5.30^{b}**	**4.73^{b}**	**4.37^{c}**

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

There was also a slight increase in moisture content from 4.70% to 5.30%during 0 to 6 months of storage of *Libas* powder using 10% maltodextrin (Treatment 1); from 4.20% to 4.73%on powdered samples using 20% maltodextrin (Treatment 2); and from 3.70% to 4.37% on powdered samples using 30% maltodextrin (Treatment 3).

Table 11: Changes in solubility time (seconds) of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Trial No.	Solubility Time (seconds)								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Trial 1	60	50	40	60	53	42	58	52	41
Trial 2	57	52	39	59	49	39	60	49	39
Trial 3	59	55	41	60	51	40	60	50	42
Mean	**58.67^{a}**	**52.33^{a}**	**40.00^{a}**	**59.67^{a}**	**51.00^{a}**	**40.33^{a}**	**59.33^{a}**	**50.33^{a}**	**40.67^{a}**

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

An increase in solubility (shorter solubility time) with an increase in maltodextrin concentration was observed on *Libasas* spray-dried powder in Treatment 1, 2 & 3. During storage from 0 to 6 months, it was recorded that the solubility time of powdered samples of Treatment 1 ranges from 58.67 seconds to 59.33 seconds; Treatment 2 solubility time ranges from 52.33 seconds to 50.33 seconds; and Treatment 3 ranges from 40.00 seconds to 40.67 seconds.

3.3.2. Changes in Sensory Characteristics

Table 12: Changes in sensory characteristics of spray-dried Libas powder using different levels of maltodextrin at 0, 3 and 6 months of storage

Sensory characteristics	Mean sensory rating								
	0 months			3 months			6 months		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
Appearance	7.17^{a}	7.13^{a}	6.77^{a}	7.10^{a}	7.07^{a}	6.73^{a}	6.97^{a}	6.93^{a}	6.60^{a}
Taste	7.43^{a}	7.40^{a}	6.53^{a}	7.30^{a}	7.33^{a}	6.43^{a}	7.17^{a}	7.13^{a}	6.33^{a}
Aroma	7.07^{a}	7.00^{a}	6.80^{a}	7.00^{a}	6.93^{a}	6.73^{a}	6.87^{a}	6.80^{a}	6.60^{a}
Mouthfeel	6.13^{a}	6.37^{a}	6.67^{a}	6.07^{a}	6.30^{a}	6.60^{a}	5.97^{a}	6.20^{a}	6.47^{a}
Overall acceptability	7.53^{a}	7.47^{a}	6.50^{a}	7.47^{a}	7.37^{a}	6.30^{a}	7.33^{a}	7.27^{a}	6.17^{a}

** Mean values followed by the same superscript are not significantly different at p≤0.05.*

Treatment 1, 2 and 3 had a decrease in mean sensory ratings in terms of appearance, taste, aroma, mouthfeel and overall acceptability during their six (6) months storage period. In terms of appearance, Treatment 1 mean sensory rating decreased from 7.17 to 6.97; Treatment 2 declined from 7.13 to 6.93; and Treatment 3 diminished from 6.77 to 6.60upon 0-6 months of storage. In terms of taste, Treatment 1 mean sensory rating lowered from 7.43 to 7.17; Treatment 2 decreased from 7.40 to 7.13; and Treatment 3 dropped from 6.53 to 6.33 upon 0-6 months of storage. In terms of aroma, mean sensory rating of Treatment 1 decreased from 7.07 to 6.87; Treatment 2 reduced from 7.00 to 6.80; and Treatment 3 lowered from 6.80 to 6.60 upon 0-6 months of storage. In terms of mouthfeel, Treatment 1 declined from6.13 to 5.97; Treatment 2 from 6.37 to 6.20; and Treatment 3 from 6.67 to 6.47 upon 0-6 months of storage. In terms of overall acceptability, mean sensory rating of Treatment 1 decreased from 7.53 to 7.33; Treatment 2 from 7.47 to 7.27; and Treatment 3 from 6.50 to 6.17 upon 0-6 months of storage.

IV. CONCLUSION

The findings of this study demonstrated that *Libas* leaf powder can be successfully manufactured using the spray drying technique. Maltodextrin concentration has significantly affected various physico-chemical, sensory and storage properties of *Libas* leaf powder. Product yield was enhanced by increase in maltodextrin concentration. Solubility was improved with increase in maltodextrin concentration. Increasing maltodextrin concentration also significantly reduced moisture content which may improve the shelf stability of the product. However, pH of the product increased (became less acidic) and its ash content decreased (signifying lower mineral content) with an increase in maltodextrin concentration. During sensory evaluation, product obtained a mean sensory rating for overall acceptability of 6.50, 7.47 and 7.53 on Treatment 1, 2 and 3, respectively, which can be interpreted as moderate liking for the product. Treatment 1 (10% maltodextrin) obtained the highest rating for overall acceptability while Treatment 3 (30% maltodextrin) has the least. Storage of the powders for six (6) months significantly affected pH and moisture content of the product which may lower the product's shelf life. However, results of the sensory evaluation during the six (6) months storage period did not show significant differences in terms of appearance, aroma, taste, mouthfeel and overall acceptability among treatments, which means that the product has not yet deteriorated and is still acceptable during the six (6) months observation period.

Based on the results of the study, the following are recommended:

1. Other organic encapsulating agents may be considered to make the product a healthier option for the consumers.

2. Other studies may be conducted to test the effect of other process parameters such as inlet temperature and infeed concentration on the physico-chemical properties of the spray-dried *Libas* powder.

3. Cost benefit analysis research may be performed as a follow up study to determine benefits and costs of adapting the technology.

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