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Development and Evaluation of Nipa (*Nypa Fruticans)* Vinegar Powder

MARIO A. DE CASTRO JR.
http://orcid.org 0000-0002-7412-5725
mariodecastro787@gmail.com
MIMAROPA Food Innovation Center
Mindoro State College of Agriculture and Technology, Calapan City Campus
Masipit, Calapan City, Oriental Mindoro, Philippines

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ABSTRACT

Due to emerging technologies, the improvization of products is a new trend. Spray drying is a new technology that transforms a product in liquid phase into a dry particulate powder. This study investigated the possibility of developing powder out of nipa vinegar with ideal physicochemical properties and high recovery percentage. A single process schedule design was applied in the nipa vinegar during spray drying. Three formulations of the added carrier were applied (F1- 50%, F2- 25% and F3-12.50%). The sensory characteristics of the spray-dried nipa vinegar in three formulations were analyzed and compared using organoleptic evaluation score card utilized by food experts. The pH level, total soluble solids (TSS) and solubility test of the three samples were also measured. Results showed that nipa vinegar with 12.50% of the added carrier is the preferred sample by the respondents and has the fastest solubility rate. However, it has the lowest recovery percentage. On the other hand, the nipa vinegar with 50% added carrier has the highest recovery percentage. The three samples have consistent pH value and changes were only observed in Nipa Vinegar with 50% added carrier. Further studies should be conducted to optimize the production quality of spray-dried nipa vinegar.

***Keywords* —** Food processing, nipa vinegar, pH level, quality attributes, recovery percentage, total soluble solids (TSS), spray drying, MIMAROPA Food Innovation Center, Philippines

INTRODUCTION

Commonly, vinegar is processed through alcoholic and subsequent acetic fermentation of several sugary and starchy materials such as fruits, malt, and sugar cane juice. Vinegar has been used for antiseptic purposes and acts as medicine for aches and gastric problems. Traditionally, it also acts as a preservative or condiment for food that provides a good market for it. Domestic utilization is limited, but it is used in large quantities in restaurants, clubs, and canteens, and by the caterers (Mokhtar, Zakaria, Soon, Ariff, Latiff, & Campus, 2016).

Nipa (*Nypa fruticans Wurmb*) is a high sugar-yielding palm that can be found along coastal areas, river estuaries and mangrove forests with brackish water environments. By removing the infructescence of this plant, it is possible to collect a sugar-rich sap from its stalk on a daily basis for a minimum of 60 days in the Philippines and up to 340 days in Malaysia. Moreover, nipa sap production ranges from 0.5 to 2.5 L/palm/day with an average sugar content of 16.4 w/v%. Traditionally, production of nipa sap vinegar involves fermentation of alcohol using yeast and consequently transforming it to acetic acid by the presence of aerobic bacteria (Nguyen, Sethapokin, Rabemanolontsoa, Minami, Kawamoto, & Saka, 2016).

Nipa (*Nypa fruticans*) is a monoecious palm with special characteristics. Contrast to usual palms like coconut (*Cocos nucifera*) and oil palm (*Elaeis guineensis*), it thrives in river estuaries and brackish water environment in which salt and fresh water mingle. Nipa lacks an upright stem, trunks and becomes fully developed at the height of about 1m. Nipa palms abundantly grow in Southeast Asia, northward to the Philippines, Ryukyu Islands and southward to north Queensland. The largest natural nipa stands are found in Indonesia (700 000 ha), Papua New Guinea (500 000 ha) and Philippines (8 000 ha) (Tamunaidu, Matsui, Okimori, & Saka, 2013).

Nipa Palm Vinegar (NPV) is produced by the fermentation of "nira," a nipa palm alcoholic beverage. It is commonly consumed throughout East Asia and usually taken before meals and at bedtime by adding to drinking water (Yusoff, *et al.,* 2015). Chemical components of nipa sap include sucrose, glucose, fructose, and minor amounts of organic and inorganic compounds. These constituents were used for various purposes but the juice is collected limitedly by local communities for their traditional use without many industrial applications. The underutilized nipa sap could, thus, be a good raw material for acetic acid production (Nguyen *et al.,* 2016).

Spray drying is the process of transformation of a product in liquid phase into a dry particulate powder. The liquid is atomized into droplets, subjected to a high temperature and dried through contact with air. During this process, the solvent is evaporated, and droplets are reduced. Ensuring the shelf-life of the product, reducing biological degradation, easy handling and low transportation costs, are the advantages of spray-drying. Obtaining a product with appropriate properties in terms of pH, water activity, solubility, moisture content, nutritional composition, hygroscopicity, glass transition temperature, color and fluidity and others, etc. is the principle of spray drying technology (Patel, Chen, Lin, & Adhikari, 2009).

The development of new products undergoes a series of procedures. Sensory aims to characterize and measure sensory attributes and differences among the products. It may be defined as the examination of the organoleptic characteristics of a product by the sense organs and, hence, its importance in the evaluation of the final product (Guiné, Almeida, Correia, & Gonçalves, 2015).

OBJECTIVES OF THE STUDY

The study aimed to produce and evaluate spray-dried nipa vinegar in three formulations in terms of the physicochemical properties and quality attributes prior to the set process schedule. Specifically, it aimed to evaluate the pH level, solubility test and total soluble solids (TSS) of the three formulations of spray-dried nipa vinegar before and after spray drying; To describe and compare the quality attributes in terms of taste and aroma of the three formulations; To determine and compare the recovery percentage of the three formulations using a single process schedule design.

MATERIALS AND METHODS

I. Product Preparation - *Initial checking of pH and TSS of Nipa vinegar:*

a. Raw materials: Nipa Vinegar

b. Tools and equipment: casserole, mixing bowl and weighing scale, pH meter, and refractometer

c. Procedure

1. Transfer the nipa vinegar in a clean container and filtered using a fine
mesh sifter to eliminate other unwanted residue or material
2. With the use of a pH meter check the acidity level of the pure nipa vinegar.
3. Using a refractometer check the TSS value of the pure nipa vinegar.
4. Record all the gathered data in the production report form.

II. *Product Formulation and Spray drying*

a. Raw materials: Pure Nipa Vinegar and maltodextrin

b. Equipment: Spray Dryer

Ten Liters of pure nipa vinegar were added with certain percentage of maltodextrin. Three formulations were made in each sample before subjected to spray drying using a single process schedule design.

Table 1. Three formulations of Nipa vinegar and maltodextrin using as single process schedule design

	Formulation 1	**Formulation 2**	**Formulation 3**
Added carrier	50%	25%	12.50%
Inlet Temperature	200 C	200 C	200 C
Outlet Temperature	150 C	150 C	150 C
Pressure setting	500 psi	500 psi	500 psi

III. Product assessment

- *Research Design*

A. Production Analysis and physicochemical analyses

Spray-dried *nipa vinegar* in three formulations were made to assess the production performance in terms of percentage of recovery and solubility test. Basic physicochemical analyses were conducted to test the pH level and TSS value of the three formulations.

B. Sensorial Analysis

Sensory evaluation is the process of using our senses (taste, smell, touch, sight) and applying them to determine the acceptability of foods. The three formulations of spray-dried *nipa vinegar* (F1, F2, F3) was subjected to sensory evaluation. In this study, purposive sampling technique was adopted to choose the panelists. Thirty (30) evaluators who are food experts were chosen to evaluate the products. Each evaluator was subjected to allergy test and their consent was assured before the conduct of the product evaluation in accordance to the ethical procedures being observed by the center.

Figure. 1 Obtained Nipa Vinegar powder in three formulations, F1- 50% added carrier, F2- 25% of the added carrier and F3- 12.50% of added carrier

Figure. 2 Utilization of the three formulations of Nipa Vinegar powder for sensory evaluation

Table 2. Organoleptic Score Card for the characteristics of spray-dried *Nipa Vinegar*

Rating	Description	
	Aroma	**Taste**
5	*Nipa vinegar* Like	*Nipa vinegar* Like
4	Slightly *Nipa vinegar* Like	Slightly *Nipa vinegar* Like
3	Average *Nipa vinegar* like	Average *Nipa vinegar* like
2	Slightly not *Nipa vinegar* Like	Slightly not *Nipa vinegar* Like
1	Not *Nipa vinegar* Like	Not *Nipa vinegar* Like

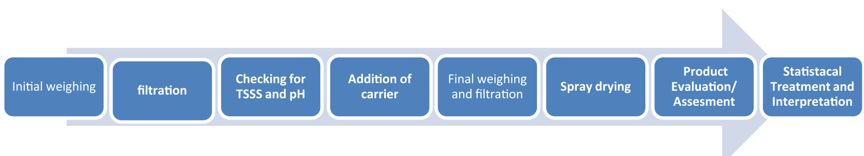

Figure. 3 Spray-dried Nipa Vinegar Development and Evaluation Framework

Figure 3 shows the development and evaluation framework of spray-dried nipa vinegar in three formulations.

RESULTS AND DISCUSSION

A. *Production Analysis*

Table 3. Recovery percentage of Spray-dried Nipa Vinegar in Three Formulations using a single process schedule design

Formula	Inlet	Outlet	Pressure	Recovery percentage
F1	200 C	150C	500 psi	43.20%
F2	200 C	150C	500 psi	25%
F3	200 C	150C	500 psi	10%

Table 3 shows the recovery percentage of the three formulations of spray-dried nipa vinegar in a single process schedule design.

It can be noted in table 3 that there are differences in the percentage of recovery in each formulation. ***Formulation 1*** with 50% of the added carrier had the highest recovery percentage of 43.20%, followed by ***formulation 2*** with 25% of added maltodextrin got 25% of recovery. On the other hand, ***formulation 3*** with 12.50% carrier got the lowest percentage of recovery with 10% value.

This implies that the amount of added maltodextrin and inlet temperature setting in each sample affects the yield quality of the final product. These findings support the study of Koç and Kaymak-Ertekin (2014) which reveals that atomizing airflow and inlet air temperature had more effect than feed temperature and feed flow rate on the physical properties of spray-dried maltodextrin. It also conforms to the findings of Jittanit, Niti-att and Techanuntachaikul (2010) reveals that the drying air temperature and MD (maltodextrin) content had significant influence on the product quality in terms of recovery.

Table 4. Solubility test of spray-dried nipa vinegar in three formulations

Temperatures	F1		F2		F3	
	Time suspended	Remarks	Time suspended	Remarks	Time suspended	Remarks
90 C	58 sec.	**slowest**	53 sec	**average**	49 sec.	**fastest**
28 C	1 min. and 3 sec.	**average**	1 min. and 5 sec.	**slowest**	59 sec	**fastest**
10 C	2 min. and 32 sec.	**average**	2 min and 49 sec	**slowest**	2 min and 20 sec	**fastest**

The solubility rates of each sample were determined by measuring the time of suspension of a 10-gram spray-dried sample of (F1, F2, and F3) in a 125 ml of water with three different temperatures (warm, cold and hot).

The data in table 4, reveals that ***F3*** sample has the fastest solubility rate in three temperatures of water under constant stirring as evidenced by its recorded time of suspension with 49 seconds at 90˚ C, 59 seconds at 28 C and 2 minutes and 20 seconds at 10 C.

Average suspension rate was recorded for ***F1*** sample in both colder and warmer temperatures with 1 minute and 3 seconds at 28 C and 2 minutes and 32 seconds of time suspension for 10 C. On the other hand ***F2*** is at its average suspension rate at 90 C with 53 seconds of time dissolution.

However, the slowest suspension rate was observed in F2 and F3 samples. For the warmer temperature, F2 was recorded at 1 minute and 5 seconds while in the colder temperature it was recorded at 2 minutes and 49 seconds of suspension rate. On the other hand, F1 was determined slowest suspension with the recorded time of 58 seconds at the water temperature of 90˚ C.

This implies that the hotter the water temperature, the faster the suspension rate of spray-dried products. It was also found out that F3 sample having 12.50% of the added carrier has the fastest dissolution performance in three different temperatures as compared to F2 with 25% and F1 with 50% of added carrier.

The findings conform to the citation of Phisut (2012) that an increased maltodextrin concentration did not cause a reduction in powder solubility. This variation may be attributed to the fact that maltodextrin has a superior water solubility. Similar to the study of Chuaychan and Benjakul in 2016 reveals that with the increasing maltodextrin proportions, the resulting powders showed an increase in yields.

According to Cano-Chauca, Stringheta, Ramos, and Cal-Vidal (2005), high solubility in water is one of the good physical properties of maltodextrin which makes it a good carrier for spray drying. Grabowski, Truong, and Daubert (2006) also reported that as the amount of maltodextrin increases the water solubility index of sweet potato powder also increases.

B. *Physicochemical Analysis*

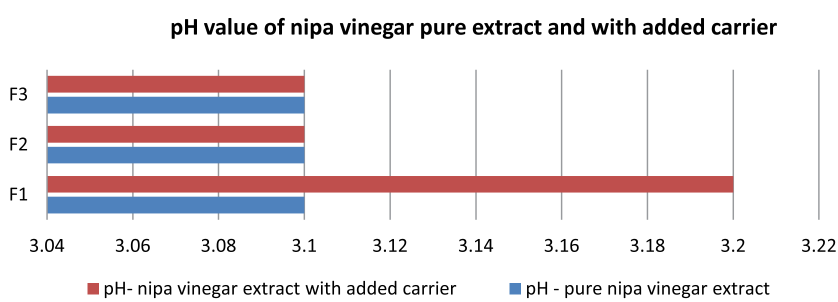

Figure. 4 pH level of Nipa Vinegar in pure extract and with added carrier

Differences in terms of the pH level of the three samples were determined by measuring the initial temperatures of pure nipa vinegar. Two trials of pH measurement were conducted in each sample to get the average pH levels using Milwaukee pH 600.

It can be gleaned in Figure 3 that, changes in the pH level of formulations 2 and 3 in both pure extracts and with added carrier was not observed. As evidenced by its same pH value of 3.1 respectively both described as *strongly acidic*. On the other hand changes in the acidity level was observed in formulation 1 as evidenced by its pH value of 3.1 in the pure extract, while 3.2 pH was obtained after the addition of carrier.

This implies that the pure extracts of the three samples had a consistent pH value before it was added with maltodextrin. A change in the level of acidity was only observed in formulation 1 with 50% added carrier. Formula 2 with 25% and Formula 3 with 12.50% of the added carrier does not affect the pH level as compared to its value in its pure extract form.

This finding can be explained by the study of Kothakota, Kumar, Kumar, Juvvi, Rao, and Kautkar (2014) entitled, "Characteristics of spray-dried dahi powder with maltodextrin as an adjunct." The study reveals that the moisture content, acidity, and hygroscopicity decreases with increasing maltodextrin (MD) aid in spray-dried dahi powder but the values of pH and acidity remain constant during spray drying process by increasing maltodextrin (MD) aid.

Similarly, in the study of Ekpong, Phomkong, and Onsaard (2016) stated that increasing the maltodextrin content resulted in a lighter color, with a decrease in redness and yellowness. Likewise, the total acidity decreased with increasing maltodextrin.

Table 5. Total Soluble Solids (TSS) value of Nipa Vinegar

Formulations	Nipa Vinegar Pure extract	Nipa vinegar with added carrier
F1	4.53 ºBx	37.6 ºBx
F2	4.40 ºBx	24 ºBx
F3	4.48 ºBx	16 ºBx

It can be noted in Table 5 that changes in the total soluble solids was observed after each addition of maltodextrin. Formulation 1 has the highest TSS value of 37.6 ºBx after the addition of 50% of carrier. Followed by Formulation 2 with 25% added carrier with its TSS value of 24 ºBx on the other hand Formulation 3 had the weakest changes after adding 12.50% of maltodextrin with its TSS value of 16 ºBx. It implies that the amount of the added carrier affects the natural TSS value of the nipa vinegar.

C. *Sensorial Evaluation*

Fig. 5 presents the sensorial profiles of the three formulations of the product tested: F1 –Nipa vinegar with 50% carrier, F2 nipa vinegar with 25% carrier and F3 Nipa vinegar with 12.50% of added carrier.

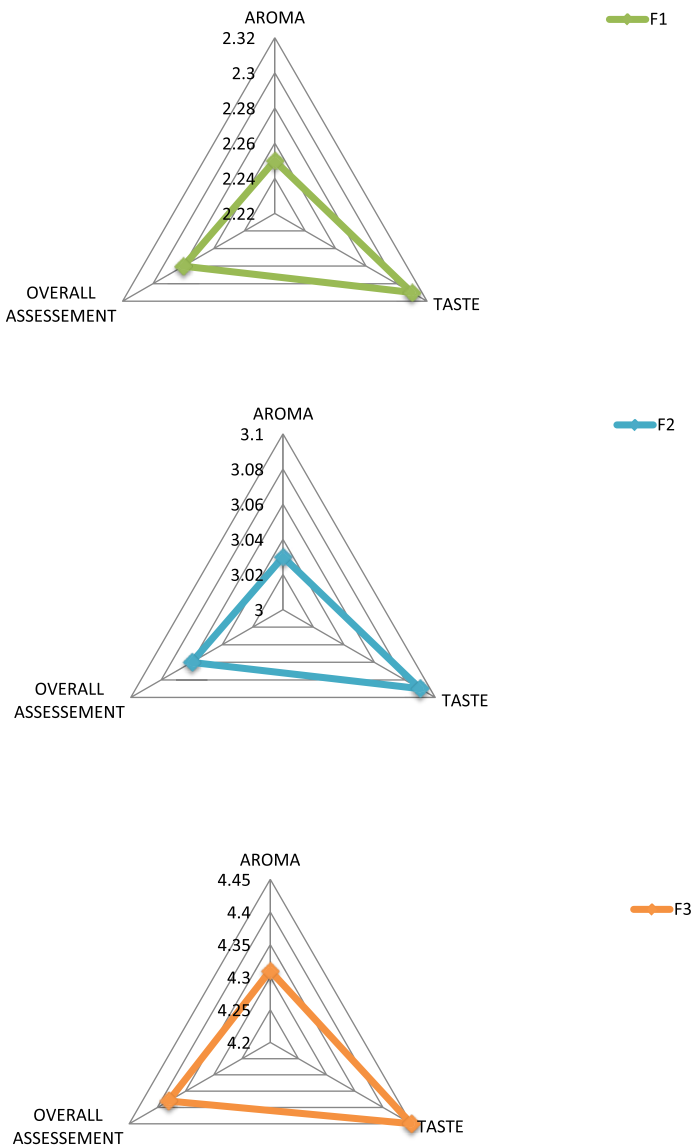

Figure 5. Sensorial profiles of the evaluated spray-dried nipa vinegar in three formulations

The results in Figure 5 confirm that formulation 3 (nipa vinegar with 12.50% of added carrier) is the preferred sample by the respondents. ***F3*** got the highest mean scores of 4.31 and 4.45 respectively both described as slightly nipa vinegar like in terms of its aroma and taste. However, ***F2*** (nipa vinegar with 25% added carrier) got the higher scores in terms of its aroma and taste as evidenced by its mean scores of 3.03 and 3.09 respectively, both described as average nipa vinegar. On the other hand, ***F1*** (nipa vinegar with 50% added carrier) was confirmed as less valued with the lowest scores in all the attributes evaluated as evidenced by its mean scores of 2.25 and 2.31, respectively both described as slightly not vinegar like.

Comparing the three formulations in regards to the overall assessment of the developed product, ***F3 sample*** *(nipa vinegar with12.50% added carrier)* is the most acceptable among the three formulations with the mean score of 4.38 respectively described as slightly nipa vinegar like. It was followed by F2 (nipa vinegar with 25% maltodextrin) with a score of 3.06 described as average nipa vinegar like.

This implies that the lower the amount of the added carrier in the nipa vinegar retains much of the quality attributes such as taste and aroma. This conforms to the findings of that MD (maltodextrin) also facilitates retention of some food properties such as nutrients, color, anthocyanin, and flavor during drying and storage process.

TRANSLATIONAL RESEARCH

The findings of this study could be translated into a food processing utility model that can be adopted by the MSMES (Micro, Small, and Medium Enterprises) in the food processing sector specifically to those who are engaged in nipa vinegar production in the MIMAROPA region and other parts of the Philippines.

CONCLUSION

With the utilization of the three formulations and the application of the established single process schedule design, the production and evaluation of spray-dried nipa vinegar has become possible in this investigation. The developed nipa vinegar powder using formulation 3 is of good aroma and taste and acidity level that is comparable to the pure nipa vinegar in liquid form, the dissolution performance was also excellent for hot, warm and cold temperature. However, the percentage of recovery is at its minimum level among the three formulations.

It is believed that this study will be able to contribute to the innovative utilization of our locally produced nipa vinegar for product development and agri-product promotion through value adding. The study could help the local nipa farmers and nipa vinegar producers in the different parts of the Philippines specifically in the MIMAROPA Region to increase their profit out of innovative nipa vinegar production, likewise the micro, small and medium enterprises or small food processors may engage themselves in value adding product by utilizing indigenous material in the region with the use of the DOST High Impact Technology Solutions – Food Processing Equipment namely: spray dryer, vacuum fryer, water retort and freeze dryer through MIMAROPA Food Innovation Center.

It is recommended that further study should be conducted to optimize the production quality of spray-dried nipa vinegar. Nutrients analysis and other laboratory tests should be taken into consideration in the optimization process to develop marketable quality of spray-dried products. Consumer acceptability test in a wide range of dishes is also encouraged to create a quality market opportunity for the product.

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