INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 26, No. 4, p. 153-162, 2025

RESEARCH PAPER OPEN ACCESS

Effects of drying time and sizes to the physical and sensory properties of giant swamp taro (*Cyrtosperma merkusii*) flour

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Key words: Giant swamp taro, Flour, *Cyrtosperma merkusii*

http://dx.doi.org/10.12692/ijb/26.4.153-162 Article published on April 10, 2025

Abstract

In the Philippines, especially in Bohol, Giant Swamp Taro are not given much value as food and only eaten if there is no other food to eat. The main thrust of the study was to determine the effects of different drying time and sizes on the physical and sensory properties of giant swamp taro flour in terms of color, aroma, texture, and general acceptability in different treatments namely: 6 hours: 6mm, 6 hours: 8mm, 12 hours: 6mm, 12 hours: 8mm, 18 hours: 6mm and 18 hours: 8mm. Based on the physical properties, it shows that all treatments of GST flour has low in pH or acidic. In terms of gluten, all treatments have no gluten. In the average of Gelatinization Temperature, Giant swamp taro flours ranged 91°C to 94°C. Also in viscosity, GST flour has low viscosity. Moreover, the giant swamp taro flour with 12 hours: 8mm appears to be consistently acceptable among the experimental treatments across color, aroma, texture, and general acceptability. It was also found that the drying time and size does not significantly affect the physical properties of giant swamp taro flour. This implies that the different drying time and size of giant swamp taro flour does not affect the judgment of the respondents. All treatments are acceptable in all terms based on color, aroma, texture and general acceptability.

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Introduction

Flour is the powdery substance created when a dry grain is pulverized. This is referred to as the milling process. It serves as the base ingredient and the starting point in all baked goods. The main function of flour in baking is to build structure. When the proteins found in wheat flour are hydrated, they interact with each other forming what is known as gluten. This gluten network stretches to contain the leavening gasses in the baked good (Bettie, 2018).

One of the starchy plants that has lot of benefits in our body is Giant swamp taro (GST), *Cyrtosperma merkusii*. Giant swamp taro is a very big type of taro with an edible tuber called a corm. It grows in swamps and can get very large with big glossy leaves. It has traditionally been an important emergency crop in times of natural disaster and food scarcity. The harvested corm is cooked and eaten. As a tuber it is a carbohydrate – a staple food that provides energy.

In the Philippines, especially in Bohol, Giant Swamp Taro are not given much value as food and only eaten if there is no other food to eat. Lots of Giant Swamp Taro in our province are dying since it is not consumed and forgotten.

There are only few recipes and products are produced from Giant Swamp Taro. Traditionally, it's been an important emergency crop in times of natural disaster and food scarcity. The researchers want to add value and give potential of giant swamp taro in forming a new product. Since, there is lack of study of giant swamp taro and we only seen few products that are made in giant swamp taro.

The current situation of giant swamp taro is that people is not acquainted of what are the products they can produce from giant swamp taro. They don't know the potential benefits they get in consuming giant swamp taro. Especially nowadays, the people are exposed to the production of synthetic foods, such as processed foods which are unhealthy and much more dangerous to our health. In our product which is the giant swamp taro flour, it can be used by bakers to mix in their ingredients for baking.

Statement of the problem

The main purpose of this study was to determine the effects of drying time and sizes of giant swamp taro to the physical and sensory properties produced Giant Swamp Taro flour as basis for proposed extension program during the school year 2022-2023 in Bohol Island State University Calape, Bohol.

Specifically, this study sought to answer the following questions:

1. What are the physical properties of giant swamp taro flour produced from different drying time and size in terms of?
   1. pH;
   2. Gluten;
   3. Gelatinization temperature; and
   4. Viscosity?

2. What is the sensory properties of Giant swamp taro flour produced from different drying time and sizes in terms of?
   1. Color;
   2. Aroma;
   3. Texture; and
   4. General acceptability?

3. Is there a significant difference in the physical properties of Giant Swamp Taro Flour produced from different drying time and sizes?

4. Is there a significant interaction between drying time and size as it affects sensory properties?

5. What extension program can be proposed?

Statement of null hypothesis

There is no significant interaction between drying time and size as it affects sensory properties of giant swamp taro flour in terms of color, aroma, texture and overall sensory evaluation among the six treatments.

Materials and methods

Design

The researchers used the descriptive survey and experimental design in conducting the study. Descriptive survey uses rating sheet in gathering the data and describes the effects of drying time and sizes to the physical and sensory properties of giant swamp taro flour. An experimental design was also used in the study where different treatments was manipulated in six (6) treatments namely: Treatment 1- 6 hours:6mm, Treatment 2- 6 hours:8mm, Treatment 3- 12 hours: 6mm, Treatment 4 - 12 hours:8mm, Treatment 5- 18 hours:6mm and Treatment 6- 18 hours:8mm. Respondents acceptability was collected which were on terms of sensory attributes such as color, aroma, texture and general acceptability. They used questionnaires to record sensory evaluation of the respondents in order to get the results, which served as the basic condition of the study.

Environment and respondents

This study was conducted in the Municipality of Calape, Bohol, Philippines. The researchers used purposive sampling in identifying the respondents. There were thirty (30) respondents in the study composed of two (2) Food Technology Instructors, two (2) OJTS, twenty-two (22) Students of BSIT-Food Technology and four (4) Bakers who have the capacity to give exact and precise information regarding the study.

Instrument

In order to make this research work possible, the researcher used the constructed rating sheet to determine the rater's sensory perception on the color, aroma, texture and general acceptability of Giant swamp taro flour. Coding description such as: in terms of color 3 is Off-white, 2 is Light brown and 3 is Brown. Moreover, in terms of aroma 3 is Very perceptible of giant swamp taro flour aroma, 2 is slightly perceptible giant swamp taro flour aroma and 1 is no distinct giant swamp taro flour aroma. Lastly, in terms of texture 3 is Very fine giant swamp taro flour, 2 is fine giant swamp taro flour and 1 is medium fine giant swamp taro flour. The constructed were provided using a 9-Point Hedonic Scale. Rating sheet interpretations such as (9) Extremely acceptable, (8) Very much acceptable, (7) Moderately acceptable, (6) Slightly acceptable, (5) Neither like nor dislike, (4) Slightly Inacceptable, (3) Moderately inacceptable, (2) Very much inacceptable and (1) Extremely inacceptable.

Procedures

Approval of the study and preparation of questionnaires to be used

The researchers asked the permission of the Dean of the College of Technology and Allied Sciences (CTAS), Campus Director of Bohol Island State University and to the bakers before conducting this study. Researchers prepared the rating sheet before the sensory activity.

The researchers started their study as soon as possible, create their studies and plan their actions to be done in the right place and at the right time.

Preparation of the ingredients

The basic ingredients for the six (6) treatments were prepared by the researchers which were the giant swamp taro for producing flour. In each treatment all of the ingredients are all the same in making giant swamp taro flour.

Preparation of tools and equipment

The tools and equipment was prepared in making the flour for the six treatments. The following tools and equipment that used includes: blender, sifter, grater, bowl, knife, bolo, tray and chopping board.

Steps in making giant swamp taro flour

Treatment 1:

1. Gather the giant swamp taro
2. Wash thoroughly the giant swamp taro
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 6mm size of grater

6. After shredding the giant swamp taro, dry it in the mechanical dryer for 6 hours with a temperature of 60°C.
7. When it is done drying for six (6) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Treatment 2

1. Gather the giant swamp taro
2. Wash thoroughly the giant swamp taro
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 8mm size of grater
6. After shredding the giant swamp taro, dry it in the mechanical dryer for 6 hours with a temperature of 60°C.
7. When it is done drying for six (6) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Treatment 3

1. Gather the giant swamp taro
2. Wash thoroughly the giant swamp taro
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 6mm size of grater.
6. After shredding the giant swamp taro, dry it in the mechanical dryer for 12 hours with a temperature of 60°C.
7. When it is done drying for twelve (12) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Treatment 4

1. Gather the giant swamp taro.
2. Wash thoroughly the giant swamp taro.
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 8mm size of grater
6. After shredding the giant swamp taro, dry it in the mechanical dryer for 12 hours with a temperature of 60°C.
7. When it is done drying for twelve (12) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Treatment 5

1. Gather the giant swamp taro
2. Wash thoroughly the giant swamp taro
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 6mm size of grater
6. After shredding the giant swamp taro, dry it in the mechanical dryer for 18 hours with a temperature of 60°C.
7. When it is done drying for eighteen (18) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Treatment 6

1. Gather the giant swamp taro
2. Wash thoroughly the giant swamp taro
3. Peel then cut the giant swamp taro into small pieces so that it will be shredded easily.
4. Wash again the giant swamp taro to completely remove dirt.
5. Shred the giant swamp taro using the 8mm size of grater
6. After shredding the giant swamp taro, dry it in the mechanical dryer for 18 hours with a temperature of 60°C.
7. When it is done drying for eighteen (18) hours, blend it to produce flour.
8. Lastly, sift it to produce more refined flour.

Testing the product for the development and acceptability

After the food preparation of treatments, the researchers distributed the products and questionnaires to the respondents for testing; they have to answer the sensory properties of GST flour. Each participant was asked to determine the differences of giant swamp taro flour in the six (6) treatments. Researchers made sure that the respondents answer all the questions by the given time. The researchers gathered the answered questionnaires personally. The information gathered served as data in gathering the effects of drying time and sizes to the physical and sensory properties of giant swamp taro in making flour.

Statistical treatment

Mean was computed to generally describe the effects of drying time and size to the sensory properties of giant swamp taro flour in terms of color, aroma, texture and general acceptability. It is interpreted as follows (Table 1).

Table 1. The 9-point hedonic interpretation guide

Range	Descriptive rating
8.12 – 9.00	Extremely acceptable
7.23 – 8.11	Very much acceptable
6.34 – 7.22	Moderately acceptable
5.45 – 6.33	Slightly acceptable
4.56 – 5.44	Neither like nor dislike
3.67 – 4.55	Slightly inacceptable
2.78 – 3.66	Moderately inacceptable
1.89 – 2.77	Very much inacceptable
1.00 – 1.88	Extremely inacceptable

Kruskall-Wallis H test was used to test if there is significant difference on the physical properties in terms of pH, gluten content, gelatinization temperature, and viscosity of flour as affected by drying time and size of the giant swamp taro.

Two-way factorial Analysis of Variance (ANOVA) applying bootstrapping with 95% Bias corrected was used to test if there is significant difference on the effects of different drying time and sizes to the sensory properties of giant swamp taro flour in terms of color, aroma, texture and general acceptability with respect to different drying time and sizes of grater, as well as, to test if there is a significant interaction between the different drying time and the sizes of grater in effect to the acceptability of the giant swamp taro flour in terms of color, aroma texture and general acceptability. IBM SPSS Statistics Trial Version was used with probability values are compared at 0.05 level of significance. Bootstrapping is robust estimation method for reducing bias associated with normality and sampling. The sample data are treated as a population from which smaller samples (called bootstrap samples) are taken, putting each score back before a new one is drawn from the sample available (Duncan, 1955; Bower, 2013; Field, 2020; Vaughan and Corballis, 1969; Kirk, 1996; Tabachnick and Fidell, 2018; Field, 2020; Denis, 2021; IBM Corp, 2022).

Results and discussion

pH determination

The pH scale usually ranges from 0 to 14. Aqueous solutions at 25°C with a pH less than 7 are acidic, while those with a pH greater than 7 are basic or alkaline. A pH level of 7.0 at 25°C is defined as "neutral" because the concentration of H_3O^+ equals the concentration of OH^- in pure water (Helmenstine, 2019).

The Table 2 shows that treatment 4 has the highest average pH of 6.1; treatment 5 got an average of 6.0; treatment 3 and 6 have the same average pH of 5.8; and treatment 1 and 2 have the lowest average pH of 5.7. Moreover, the table further shows that the six treatments are low in pH, or acidic, since pH describes how acidic or basic an aqueous solution is, where a pH below 7 is acidic (Helminstine, 2019).

The GST flour samples were mixed with 100 ml of distilled water, and the mixture was left at room temperature for 30 minutes. The values range from 5.7 to 6.1. Low pH values were reported to be caused by the distilled water being mixed with GST flour samples. In the middle of the scale is pure distilled water with a neutral pH of 7 (Johnson, 2023). However, in contact with the atmosphere, carbon dioxide is absorbed, and the pH falls. Of this dissolved CO_2, about 0.1% converts to carbonic acid, which dissociates to hydrogen and bicarbonate ions (Reddi, 2013). The presence of carbonic acid will make the solution acidic and influence the pH of GST flour samples.

Table 2. Physical properties of giant swamp taro flour in terms of pH

Drying time	Size	Potential of hydrogen (pH)				
		1st replicate	2nd replicate	3rd replicate	Average	Description
6 hours	6mm	5.8	6.0	5.5	5.8	Acidic
	8mm	5.6	5.8	5.8	5.7	Acidic
12 hours	6mm	5.8	5.9	5.8	5.8	Acidic
	8mm	5.9	6.3	6.2	6.1	Acidic
18 hours	6mm	6.2	6.2	5.7	6.0	Acidic
	8mm	5.6	6.0	6.0	5.9	Acidic

Legend: pH=7, neutral pH>7, basic pH<7, acidic

Table 3. Physical properties of giant swamp taro flour in terms of gluten

Drying time	Size	Gluten (mg/kg)				
		1st replicate	2nd replicate	3rd replicate	Average	Description
6 hours	6mm	0	0	0	0	No gluten
	8mm	0	0	0	0	No gluten
12 hours	6mm	0	0	0	0	No gluten
	8mm	0	0	0	0	No gluten
18 hours	6mm	0	0	0	0	No gluten
	8mm	0	0	0	0	No gluten

Legend: Standard gluten= 20 mg/kg

Gluten

Gluten is a complex mixture of hundreds of related but distinct proteins, mainly gliadin and glutenin. Similar storage proteins exist in rye, hordein in barley, and avenins in oats and are collectively referred to as "gluten" (Biesiekierski, 2017). The standard level for gluten-free products is 20 mg/kg (Choi *et al.*, 2021).

The gluten content of giant swamp taro flour is shown in Table 3. It shows that all treatments of GST flour have no gluten content. Giant swamp taro flour's lack of gluten lies in its protein composition. The protein found in giant swamp taro is arabinogalactan-protein (5.30–8.83 g/kg) and contains mainly arabinose and galactose (in a 1:1 proportion) and also significant amounts of rhamnose, xylose, glucuronic acid, and mannose (Nguimbou *et al.*, 2014). Arabinogalactan proteins (AGPs) play important roles in many cellular processes during plant development, such as reproduction, cell proliferation, pattern formation and growth, and plant-microbe interaction (Dilokpimol *et al.*, 2014). It contains different types of proteins that do not form gluten when mixed with water. As a result, giant swamp taro flour is naturally gluten-free, making it suitable for individuals with gluten sensitivity or celiac disease. Since the results of gluten content in giant swamp taro flour is 0, it is too weak for bread production.

Gelatinization temperature

Gelatinization temperature is regarded as the temperature at which the phase transition of starch granules from an ordered state to a disorder state occur (Hermansson and Svegmark, 1996). The gelatinization temperature of starch depends on the plant type and amount of water present, pH, salt concentration and types, sugar, protein, and fat in the recipe, as well as the starch derivatization technology used. Some type of unmodified native starches begin swelling at 55°C, some other types at 85°C (Hans-Dieter *et al.*, 2004).

Gelatinization Temperature of Giant swamp taro flours ranged 90°C to 94°C. Highest Gelatinization Temperature was found for Treatment 2 (6 hours: 8mm) with a GT of 94°C across 1st test to 3rd test. Lowest Gelatinization temperature was found on Treatment 6 (18 hours: 8mm), GT of 90°C on 1st test and 2nd test, 92°C on 3rd test. According to Yeh and Li (1996), the disruption of starch granules occurs mainly at temperatures between 70 and 77.5°C and almost no starch granules are disintegrated below 55°C (Table 4).

Table 4. Physical properties of giant swamp taro flour in terms of gelatinization temperature

Drying time	Size	Gelatinization temperature (°C)				
		1st test	2nd test	3rd test	Average	Description
6 hours	6mm	90	94	92	92	High GT
	8mm	94	94	94	94	High GT
12 hours	6mm	92	94	94	93	High GT
	8mm	90	92	92	91	High GT
18 hours	6mm	94	94	92	93	High GT
	8mm	90	90	92	91	High GT

Table 5. Physical properties of giant swamp taro flour in terms of viscosity

Drying time	Size	Viscosity (cP)				
		1st test	2nd test	3rd test	Average	Description
6 hours	6mm	12.9	33.9	6.0	17.6	Low in viscosity
	8mm	7.1	6.3	8.1	7.2	Low in viscosity
12 hours	6mm	5.5	6.0	34.7	15.4	Low in viscosity
	8mm	35.7	8.4	7.5	17.2	Low in viscosity
18 hours	6mm	5.9	7.0	7.0	6.6	Low in viscosity
	8mm	35.3	6.9	6.0	16.1	Low in viscosity

Legend: cP < 1154, Low cP 1154-2000, Moderate cP > 3521, High

Table 6. Acceptability of giant swamp taro flour (n=30)

Sensory attributes	Treatment											
	1 6hrs:6mm		2 6hrs:8mm		3 12hrs:6mm		4 12hrs:8mm		5 18hrs:6mm		6 18hrs:8mm	
	Acceptability		Acceptability		Acceptability		Acceptability		Acceptability		Acceptability	
	M	Inter.	M	Inter.	M	Inter.	M	Inter.	M	Inter.	M	Inter.
Color	7.23	LV	7.20	LM	7.23	LV	7.43	LV	7.23	LV	7.57	LV
Aroma	7.20	LM	7.37	LV	7.37	LV	7.47	LV	7.20	LM	7.13	LM
Texture	7.23	LV	7.27	LV	7.23	LV	7.37	LV	7.50	LV	7.40	LV
General	7.30	LV	7.20	LM	7.27	LV	7.57	LV	7.43	LV	7.50	LV

The gelatinization temperature of giant swamp taro flour is high, since a study reported that rice and maize starches displayed gelatinization temperatures ranging between 58.9 and 72.4°C (rice) and 64.3 and 77.2°C (maize). Further, starch that has been pre-treated with heat–water will have an increased gelatinization temperature. It was reported that the degree and temperature of gelatinization of 5% (w/w) tapioca, corn, potato, and wheat starch suspensions increased with an increase in treatment temperature in the range between 25°C (Bauer and Knorr, 2005).

Viscosity

Viscosity describes a fluids internal resistance to flow. In the baking industry, viscosity plays a very important role. It will impact the chance of phase separation, affecting the products made from batter and dough (Vessele, 2019).

Table 5 shows that the six treatments are low in viscosity. In 1st test Treatment 4 has the highest viscosity of 35.7 cP while treatment 3 has the lowest viscosity of 5.5 cP. In 2nd test, treatment 1 has the highest viscosity of 33.9 cP and the treatment 3 also got the lowest viscosity of 6.0 cP. In 3rd test, treatment 3 has the highest viscosity while the Treatment 1 and treatment 6 has the lowest viscosity of 6.0. The giant swamp taro flour are low in viscosity since some flours like native rice flour had maximum viscosity (3521 cp) and wheat flour had least viscosity (1154 cp) (Kaur *et al.*, 2016). According to Nascimento *et al.* (2007), raw Flours have initial low viscosity values because raw starches are insoluble in cold water, while thermally treated starches show an initial viscosity value due to irreversible tumescence of starch granules, reflecting their degree of pre-gelatinization. This implies that Giant swamp taro flour has low of viscosity, since it is raw flour.

General acceptability

Among the six (6) treatments in terms of color, the Treatment 6 (18 hours: 8mm) got the highest mean acceptability of 7.57 interpretation of "Like Very Much" (Table 6). Moreover, the Treatment 2 (6 hours: 8mm) was the least acceptable with a mean acceptability of 7.20 interpretation of "Like Moderately". In terms of Aroma, the treatment 4 (12 hours: 8 mm) got the highest mean acceptability of 7.47 described as "Like Very Much" while treatment 6 (18 hours: 8mm) got the lowest mean acceptability of 7.13 interpretation of "Like Moderately". In terms of texture, Treatment 5 (18 hours: 6mm) got the highest mean of 7.50 described as "like very much" while treatment 1 (6 hours: 6mm) and the treatment 3 (12 hours: 6mm) were the least acceptable of all treatments, with a mean acceptability of 7.23 and the interpretation of "Like very much." In the General acceptability, treatment 4 (12 hours: 8mm) got the highest mean 7.57 described as "like very much" while Treatment 2 (6 hours: 8mm) got the lowest mean acceptability of 7.20 "like moderately".

Conclusion

As a result obtained in physical properties, among the six treatments there is no significant difference between the drying time and size of giant swamp taro flour. Also, among the six treatments there is no significant interaction between the drying time and size of giant swamp taro flour. This implies that the different drying time and sizes of giant swamp taro flour do not affect the acceptability in terms of Sensory and physical properties of flour.

Recommendations

1. Although that the six treatments have no significant difference, the researchers recommend Treatment 2 to be used in making giant swamp taro flour since treatment 2 do not require long time in drying and it produce more yield.
2. Future researchers may conduct future related studies to develop and enhance the GST flour.
3. Future researchers may conduct a further study on the Physicochemical and Functional Properties of GST flour.
4. Conduct a study about the nutrition facts of the Giant swamp taro flour.

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