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Transforming Milk Tea: Harnessing *Nypa fruticans* Mesocarp Flour as an Alternative for Tapioca Pearl for Sustainable Product Development and Innovation

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Nypa fruticans, known as nypa, is a fast fruit-bearing mangrove palm with immeasurable potential. This dissertation used the mature fruit mesocarp, a byproduct of the Nypa palm. Thus, the byproduct is underrated for some reason, and mostly, they are neglected due to a lack of public knowledge of its most potential. This research used the Nypa Fruitican Mesocarp fruit from Brgy. Sabang, Surigao City. The quest for sustainable alternatives in exploring mesocarp flour as a potential substitute for traditional tapioca pearls in milk tea beverages. Begins with a comprehensive determination of mesocarp flour's functional properties using the ANNOVA ONE WAY test $p>0.05$. The result of all the data is 0.098; therefore, Pearl made from Mesocarp flour is a sustainable innovation. The functional properties of pearls made from cassava and mesocarps

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have no significant difference. Further, practical application forms a core component of this study, involving mesocarp flour formulations to replicate tapioca pearls. The cooking process and consumer acceptance are rigorously analyzed to determine their compatibility and desirability in this popular beverage. Analysis of variants showed that Pearls, once made from Mesocarp of *Nypa fruticans* incorporated into the milk tea beverage, have 4.3 overall acceptance, and the best organoleptic test with texture, aroma, and color is 4.3 (likes). Additionally, this research contributes a nuanced understanding of mesocarp flour's potential against traditional tapioca pearls, considering cost-effectiveness, scalability, and consumer preferences, thereby fostering innovation in sustainable beverage production.

Keywords: Mesocarp flour; tapioca pearl; beverage; swelling power; solubility; water absorption capacity; functional properties.

1. INTRODUCTION

Nipa, scientifically known as *Nypa fruticans*, is a truly classified mangrove palm that grows dominantly in coastal regions and can mostly be found in Asia [1]. Several South and Southeast Asian countries are rampaged by *Nypa fruticans*, which can be observed in rural brackish water swamps and tidal muddy banks in some rural areas, particularly in the Philippines [2]. According to DENR National Capital Region Philippines, through its Conservation and Development Division (CDD) and West Field Office (WFO) [3], World Agroforestry Philippines added that a kind of palm (Nipa) that grows along the waterlines could be one possible alternative to the problem of the food scarcity that the country will soon be facing [4].

Nipa thrives in Mangrove areas in Surigao City [5], particularly in Brgy Villafranca Gigaquit and some parts of Brgy. Sabang, Surigao City [6], and utilizing its immense potential for being a major solution for food insecurity [7], its immeasurable uses from leaves to sap are viral in the economy today [8]. Husk and shell have a promising contribution to biofuel and chemicals [9], while the Mesocarp is to be exploited as food. Despite its potential [10], the utilization of Mesocarp has been neglected and almost forgotten and has been underrated because of the lack of public knowledge about its countless functional properties [11].

The mature fruit of Mesocarp contains a considerable amount of carbohydrates 51. 89%, a very low-fat content of 0.48% to 1.16% [12] and a low protein content of 0.7% to 2.4% [13]. These unique chemical compositions offer the potential for Nypa mesocarp to be processed into Flour [14]. Though not familiarly used [15], Nypa flour has evidence that Flour from Nypa has been used for human consumption and in countless bakery products [16]. This research was conducted to replicate tapioca pearl using the starch concocted in Nypa Flour as the exemplary ingredient in Milk Tea beverages [17], which is one of the beverages that are concentrated in metropolitan around the globe [18]. Evidence of its popularity has expanded to other areas across the Philippines [19]. Despite these excellent traits and delights brought by traditional tapioca pearls [20], the tillage and output production is slow-growing and environmentally taxing [21].

In the advent of the growing concern for sustainability, section twelve (12) of the Sustainable Development Goal (SDG) highlighted the reduction of ecological footprints in the food and beverage industry [22]. Proponents have turned their attention to potential alternative ingredients [23]. One gifted candidate is the Mesocarp, a byproduct of the Nypa palm, which has shown the potential to be processed into Flour that would serve as a sustainable alternative for tapioca pearls [24]. This research is rooted in exploring Mesocarp as a viable and eco-friendly option to meet the tapioca pearl demand in milk tea beverages to expand the utilization of the underutilized byproduct of Nypa palm sustainability to economy and agronomy [25].

2. REVIEW OF RELATED LITERATURE

The early exploration of alternative starch sources dates back several decades when researchers began investigating diverse plant-based starches for various industrial applications [26]. Initial studies primarily focused on the potential of traditional starch sources like corn, wheat, and potatoes [27]. However, by the late 20th century, attention shifted towards more sustainable and underutilized starch sources [28]. This shift was driven by environmental concerns and the need for more cost-effective

raw materials [29]. The exploration was not just confined to food but expanded to other sectors like bioplastics, pharmaceuticals, and textiles [30].

In the early 2000s, the focus of research expanded to include tropical and subtropical plants, particularly in regions like Asia, Africa, and South America [31]. These studies uncovered the potential of various native plants [32], such as cassava, sweet potatoes, and yams, as alternative starch sources [33]. The appeal of these plants was their low cultivation cost, high starch yield [34] and adaptability to different climates [35]. This period also marked the beginning of integrating sustainability into the starch industry, with studies exploring the environmental impact of starch extraction and processing [36].

The last decade has seen a significant increase in the study of non-conventional starch sources [37]. Researchers worldwide have been evaluating the functional properties of starches from plants like *Nypa fruticans* [38], lotus seeds, and breadfruit [39]. These studies are not only focused on the starch's culinary applications but also on its nutritional benefits [40], digestibility, and potential health impacts [41]. This period also witnessed a growing interest in using alternative starches in gluten-free products, responding to the increasing demand from consumers with dietary restrictions [42].

Recently, the focus has shifted towards a more holistic approach, considering not only the functional properties of these alternative starches but also their role in supporting local economies [43] and promoting biodiversity. Studies are increasingly looking at the full life cycle of these starch sources, from cultivation to processing and end-use [44]. This contemporary research is crucial in shaping future food sustainability [45], particularly in the context of climate change and global food security challenges [44]. The ongoing research into alternative starch sources like *Nypa fruticans* is a testament to this evolving and dynamic field [46].

3. MATERIALS AND METHODS

This section presents the materials and methods of transforming milk tea: harnessing *nypa fruticans* mesocarp flour as an alternative for tapioca pearl for sustainable product development and innovation.

3.1 Materials

The researcher used mature Mesocarp of *Nypa fruticans* (Fig. 1), which were obtained from the mangrove area in Brgy. Sabang, Surigao City. Its dark brown skin color characterizes mature Nypa. The rendering for Mature Mesocarp of Nypa in making Flour was 20-40% ration of fruit weight. The tools used in this research are knives, grinders, mixers, analytic scales, sieves, pans, and basins.

3.2 Methods

Flour and Tapioca are considered in the section for transforming milk tea: harnessing *nypa fruticans* mesocarp flour as an alternative for tapioca pearl for sustainable product development and innovation.

3.2.1 For flour

Tapioca pearls are made from the starch of cassava flour. This research will use the underrated Mesocarp, a byproduct of *nypa fruticans*, to process into Flour and replicate tapioca pearls made from the starch of cassava. The Nypa Flour, the endocarp of each matured Mesocarp (MM) was scraped using knives, after which washed, cut, and dried below the solar for 6-8 hours to lessen the water content, with the use of a grinder dried-MM was grounded and sieved with 200 To support this action, Ulyarti et al. in their study on the functional properties of *Nypa fruticans* Flour, concluded that the Mesocarp of Nypa can be processed into Flour. Therefore, Nypa flour is a promising substitute for common Flour such as wheat and rice, especially for producing low-calorie or high-fiber food that satisfies dietary health concerns. Mesh sieve size to gain Flour.

To evaluate the functional properties of Nypa Flour, such as Swelling Power (SP), Solubility (Sol), Water Absorption Capacity (WAC), Swelling Capacity (SC), Bulk Density (BD), and Viscosity, two sets of treatments were conducted. The traditional method of starch extraction involves sieving the ground and drying the Mature Endosperm of *Nypa fruticans* (Mesocarp), resulting in the Un-bleached Mature Mesocarp Flour (MMF).

In contrast, the Bleached treatment involved soaking the mature mesocarp flour (MMF) in sodium metabisulphite (0.4%) and

stirring the mixture. After 15 minutes, the mixture was filtered and rinsed twice with water, and the precipitates were sun-dried. Both treatments involved sieving through a 200-mesh sieve. Consequently, the Unbleached Nypa Flour was found to be more acceptable and suitable as a flourfor use.

Fig. 1. (a) Cross section of *Nypa fruticans*, (b) Bunches of *Nypa fruticans*

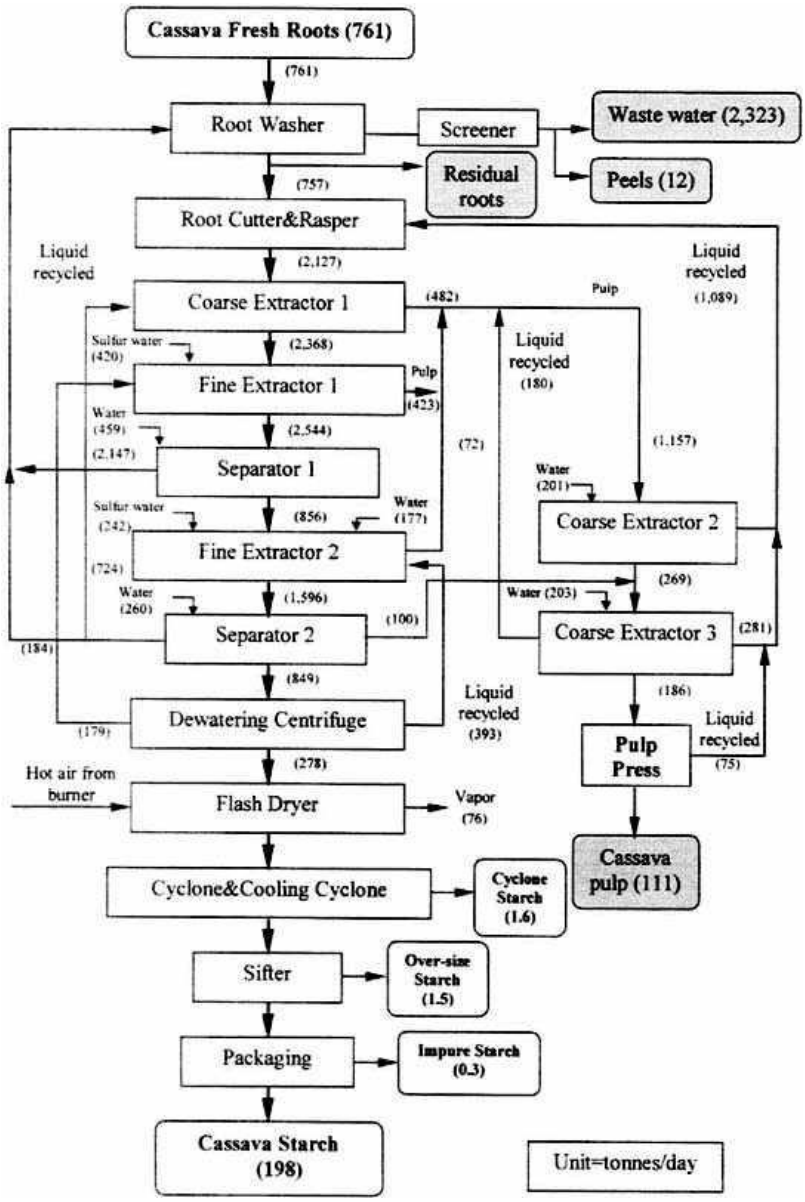


Fig. 2. Diagram for Cassava Starch Extraction

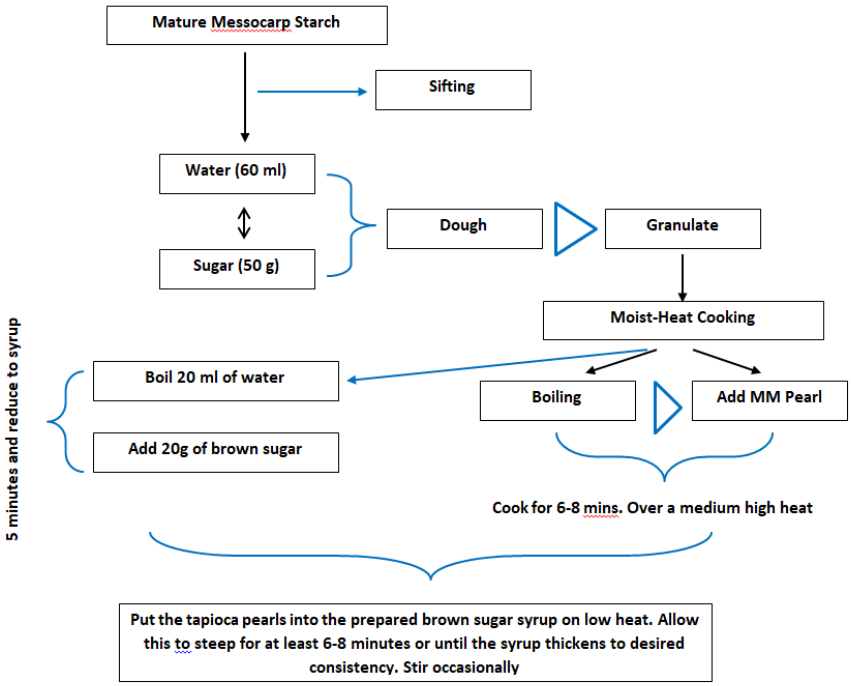


Fig. 3. Diagram for Nypa flour/starch extraction

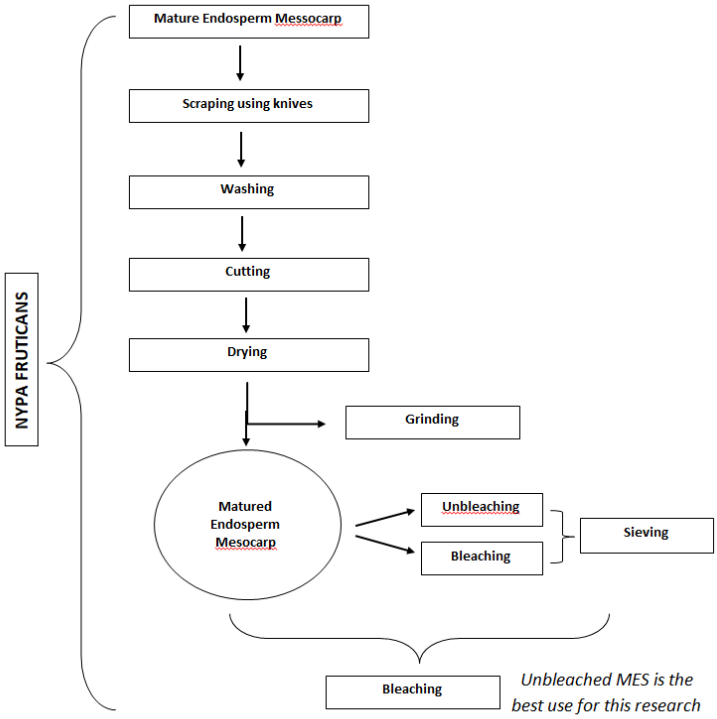


Fig. 4. Diagram for Making Pearl from MM starch

WAC is the amount of water absorbed in food circumstances to achieve the desired consistency in food items. Additionally, it can be utilized to explain the consistency, bulking, crystallinity, and integrity of starch in aqueous dispersion and bulking of the product. The starch granule's associative force is linked to the starch's capacity to absorb water and swell, a property known as the swelling index (SI). The primary classifications of SC include particle size, chemical content, and processing techniques. It can serve as a foundation for excellent bakery product standards.

The SC value of the UONFEF was both noticeably longer and greater than that of the BONFEF. The approach outlined by Okaka and Potter (Okaka & Potter, 1977; Chandra et al., 2015) was used to determine SC. SP data indicates how Flour, particularly starch granules, can bind water to demonstrate its expansion or hydration ability to generate swollen starch granules. Bleaching may break the hydrogen bonds that hold starch granules together, causing water to be absorbed by the hydrogen bonds, proteins, and non-starch polysaccharides.

The capacity of food that produces gas, liquid, or solid to dissolve in a liquid, gas, or solid solvent is known as sol in the food system. Flour solubility is the amount of Flour that dissolves in water or other solutions. The BD parameter, sometimes referred to as the total solid content (TSC) parameter, is crucial for determining the weight of solid samples and the specifications for packing. Particle size, moisture content, starch or Flour surface characteristics, and food material handling all impact BD value. The greater the BD value, the bigger the particle size; a agent can raise viscosity is called a viscosifier. This ingredient is necessary in food to stabilize items like foam, emulsion, and frozen dairy. Because of the enlargement of the starch granules and the increased amount of β-glucan that results from the breakdown of starch molecules, Flour can be employed as a viscosifier agent.

3.2.2 For Tapioca Pearl Application

Tapioca pearls, which are mainly made from cassava starch, were the popular main ingredients for the globally known Milk Tea in the beverage industry. The pearls were shaped into spherical with gelatinized and un-gelatinized starch produced by heat-moisture treatment. The undeniable property of the tapioca pearl is irreplaceable. Still, with the aim of sustainable innovation, this research will bring forth and revolutionize tapioca pearl by utilizing the underrated Mesocarp, a byproduct of *Nypa fruticans* and convert it to Nypa flour/starch used to replicate the pearl made from cassava/tapioca starch. With this goal in mind, this research will serve its purpose to give public knowledge about the wide potential of the neglected Mesocarp of *Nypa fruticans*.

The starch is wetted to 50% moisture content when producing tapioca pearls with cassava flour. The moist starch is putrefied and shaped into spherical particles by continuous mechanical shaking. The formed pearls are then sent to dry heat processing or roasting at 250–300°C. The pearls are allowed to cool before undergoing a secondary drying treatment at temperatures ranging from 50–80°C, a process that helps reduce the finished products' moisture content. In this research, we utilize a modified flour/starch extraction method to produce pearls from Nypa flour. The same process and treatment are also applied in the production of Tapioca using the Mature Mesocarp (MM) Flour.

4. RESULTS AND DISCUSSION

A Completely Randomized Design (CRD) will be used to evaluate Table 1, which involves two different conditions. The methodology will vary according to the duration of the experiment. We will use both Tapioca made from cassava starch and mesocarp starch, each weighing 100g, prepared using the moist-heat method. This method will maintain a consistent temperature of 200°C and include the addition of 60 ml of water. The only variable in this experiment is the duration. For each 100g of starch under each condition, the process will produce 50 medium-sized pearls, like the size of tapioca pearls commonly sold in the market for Milk Tea.

Beverages, not including some additives like sugar and milk. The 50 pieces were subjected to 4 treatments and three replications so that 12 experimental units were obtained. The treatments were given to know the best use of Pearl made from MM starch, and each piece reacted in different periods when it was cooked.

4.1 Texture

With the same moist heat method, 50 pieces of Tapioca were diluted and boiled to the same amount of water and subjected to experiment at different times with the same temperature. The result is significantly not different; therefore, Pearl from Mesocarp has the same texture in terms of chewiness, hardiness, and gumminess Table 1.

Table 1. Average Value of Texture Swelling Capacity, Solubility, and Water Absorption Capacity

Time	Temperature	MS:CS	Texture (GF)	SPC %	SOL %	WAC %
5 mins	200^{0}C	12:18	8.33,5.56	31.58,56.25	24,36	481.42,320.94
10 mins	200^{0}C	15:23	6.67,4.35	42.86,85.19	30,46	385.13,251.17
15 mins	200^{0}C	18:28	5.56,3.57	56.25,127.27	36,56	320.94,206.32
20 mins	200^{0}C	24:33	4.17,3.03	92.31,194.12	48,66	240.71,175.06
30 mins	200^{0}C	36:38	2.78,2.63	257.14,316.67	72,76	160.47,152.03

Note: The numbers presented are the average of two conditions, and the deviations means were not significantly different (p>0.05)

4.2 SPC

The 50 pieces of the pearl were cooked under the same volume of water and amount of heat but differed in time or duration Table 1. The result is not significantly different; therefore, regarding swelling capacity concerning time, Tapioca pearls made from cassava and Pearls made from Mesocarp have a common factor.

4.3 Solubility

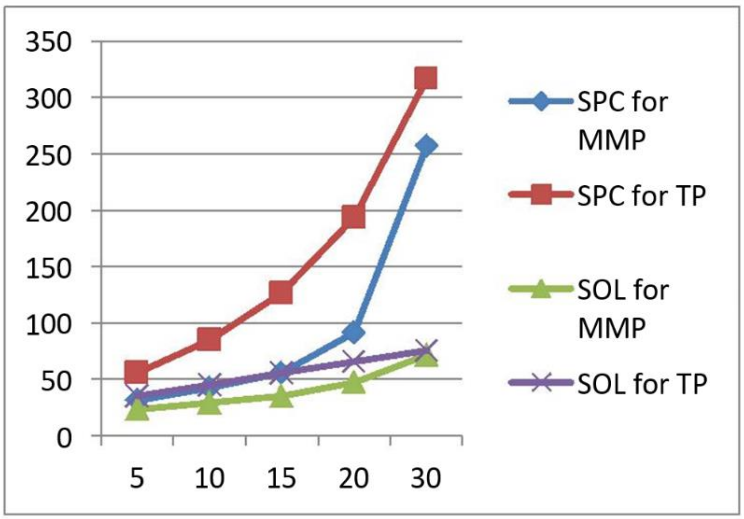
This was carried out by getting the percentage from the number of pieces that reacted respectively in different durations to the total number of pieces experimented, and the result of both has no significant difference Table 1.

4.4 WAC

WAC was determined based on Anderson et al. (Anderson et al., SPC for TP 1970; Bamigbola, Awolu, & Oluwalana, 2016). Both Tapioca (50 pieces) were resuspended with 60 ml of distilled water, stirred, cooked at different times or durations, and then centrifuged at 1.731 x no. Pieces react in time respectively. The result is significantly no different from each other Table 1.

The swelling Power Capacity (SPC) of a Pearl made of Mesocarp Flour (Table 2) relates to amylose content, water holding capacity of starch molecules, hydrogen bond, and degree crystallinity of the pearl under different experiment times.

Different pearl condition processing in the same SOL study exhibited a significant difference (p>0.05). One of the factors that contributes to solubility is particle size. The smaller the particle size, the quicker the dissolution. The other factor is chemical composition, mainly lipids and amylopectin. Lipids and amylopectin in Flour can contribute to reducing SOL, SC, and WAC.



Below (5, 10, 15, 20, 30) is the time duration; left (0, 50, 100-350) is the percentage

Fig. 5. Swelling Power Capacity and Solution of Mesocarp Pearl

Table 2. Sensory Evaluation Texture, Aroma, and Colour

Sample	Texture	Aroma	Color	Overall Acceptance
Milk Tea with Tapioca Pearl	4.5	4.1	4.3	4.3
Milk Tea with Mesocarp Pearl	4.3	4.3	4.14	4.25
Difference	0.2	-0.2	0.0	

Note: For the scale: (1) Strongly dislike, (2) Dislike, (3) Somewhat likes, (4) Likes, (5) Very Likes

For the overall acceptant (Table 3), with sensory evaluation using a nine-point hedonic scale (Likert Scale), the pearls made from mesocarp starch were added to the Milk tea beverages together with some additives like sugar, chocolate, and milk with the original milk both in the market. The evaluation was done in the eye of the needle from the taste, aroma, texture, and color.

After gathering the results from the 50 respondents and using the 5-point Likert Scale to interpret the data for the sensory evaluation texture, aroma, and color for the Milk Tea with Tapioca Pearl and Milk Tea with Mesocartp Pearl, for the Texture evaluation result, Milk Tea with Tapioca Pearl has a 4.5 rating. In contrast, Milk Tea with Mesocarp Pearl has a 4.3 rating with only 0.2 differences. Milk Tea with Tapioca Pearl has a 4.1 rating for the Aroma evaluation result. In comparison, Milk Tea with Mesocarp Pearl has a 4.3 rating with only -0.2 differences. Milk Tea with Tapioca Pearl has a 4.3 rating for color evaluation results. In comparison, Milk Tea with Mesocarp Pearl has a 4.3 rating with only 0.0 differences. Overall, Milk Tea with Tapioca Pearl and Milk Tea with Mesocarp Pearl have the same rating of 4.3

5. CONCLUSION

Using the ANNOVA ONE WAY test was p>0.05, the result of all the data is 0.098; therefore, Pearl made from Mesocarp flour is a sustainable innovation. The functional properties of both pearls made from cassava and mesocarps have no significant difference. Analysis of the variant showed that Pearl, once made from Mesocarp of *Nypa fruticans* incorporated into the milk tea beverage, has a 4.3 overall acceptance. The best organoleptic test with texture, aroma, and color is 4.3 (likes).

This study successfully established the potential of *Nypa fruticans* mesocarp flour as an alternative to traditional tapioca pearls in milk tea, showcasing similar functional and sensory properties. Our findings indicate that this substitution could have a positive environmental impact, underscoring the sustainable nature of *Nypa fruticans* as a resource. Consumer acceptance testing revealed a favorable response to milk tea made with Nypa flour pearls, suggesting its potential in the market. These results make a significant contribution to sustainable food innovation, particularly in the Philippine context. Future research could focus on scaling production methods and expanding the application of Nypa flour in other food products, further supporting sustainable development initiatives.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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