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Development of Cookies Incorporated with Tannia Cocoyam (*Xanthosoma sagittifolium*)

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Abstract- This research study examines the potential of Tannia Cocoyam (Xanthosoma sagittifolium) as a valuable ingredient, particularly in the bakery industry, to benefit a wider audience. The study involves the development of tannia cocoyam-based flour through a process that includes selection of high-quality yam, blanching, drying and milling. Various mixtures of wheat flour and cocoyam flour in different ratios (100%, 25%, 50%, 75% and 100%) were used to make cookies, which were then evaluated by a group of 30 untrained people using a 9-point hedonic scale for evaluating sensory characteristics such as texture, color, smell, appearance, taste, mouthfeel and overall acceptability. Statistical analysis using SPSS revealed significant differences (P<0.05) in the sensory quality parameters between the different treatments, except for odor. Cookies with a higher proportion of cocoyam flour showed a darker color, and cookies with more than 25% cocoyam flour had a slightly bitter taste and an undesirable mouthfeel. The results suggest that replacing up to 25% wheat flour with cocoyam flour can result in delicious cookies, while higher percentages can negatively affect the physical properties of the cookies by increasing parameters such as diameter, thickness, and distribution ratio. Ultimately, cookies with a cocoyam flour to wheat flour ratio of 25% received higher preference. This research shows the potential of using underutilized cocoyam in baked goods to produce products with reduced gluten content and offers new possibilities for this traditional product.

Keywords: *Bakery product, Tannia cocoyam, cookies, sensory, physical properties*

I. INTRODUCTION

Tannia, also known as *Xanthosoma sagittifolium*, is a starchy vegetable crop belonging to the Araceae family. Within this category, there are two main species: Taro and Tannia. Of these, Tannia, specifically Xanthosoma sagittifolium, is the most prominent and is referred to as "ISURU" variety (HORDI CROP) (Hettiarachchi *et al*., 2020).

Tannia cocoyam has long been a staple food for millions of people living in tropical and subtropical regions. This fruit not only provides easily digestible starch but also essential nutrients such as protein, fiber, vitamin C, thiamine, riboflavin, potassium, salt, phosphorus, magnesium, and calcium (Hettiarachchi *et al*., 2020). The finely granulated starch in tannia cocoyam flour is known for its ability to improve binding and reduce breakage of snacks (Igbabul *et al*., 2015). This underutilized crop has the potential to provide nutritional benefits to a growing population.

The basic structure of bakery products is largely determined by the properties of wheat flour, particularly its high gluten content. Wheat, the preferred grain for baking, is not grown in tropical regions. Therefore, regions with limited access to wheat flour must either import it or find alternatives to produce baked goods (Igbabul *et al*., 2015).

In recent years, cookies have gained tremendous popularity due to their ready-to-eat nature, affordability, convenience, shelf life, and nutritional content (Ho *et al*., 2016). With increasing urbanization and higher consumption of processed foods and baked goods, the demand for wheat imports increases, leading to higher production costs (Hettiarachchi *et al*., 2020).

Yam flour has found diverse uses, both domestically and in the food industry, particularly in biscuit making. Its low fat content, high fiber content, abundant vitamins and minerals, and protein content of 6 to 12% make it an effective substitute for wheat flour in biscuit production (Seevaratnam *et al*., 2012).

Processing Tannia Cocoyam into flour is a crucial step that extends the shelf life of the product and makes it available all year round (Bolarin *et al*., 2018). Understanding the physical, chemical, functional, and microbiological properties of tannia cocoyam corn flour is crucial for its successful application in the food industry. In this way, cocoyam become a value-added product, that provides economic benefits to local cocoyam growers in the West African region.

In Sri Lanka, consumption of foods primarily based on wheat flour has increased since the introduction of wheat flour in the late 1970s. As a result, a wide range of convenience products are now available, including bread, buns, biscuits and cakes, all made from wheat flour. However, the country relies heavily on wheat imports and exchange rate fluctuations can have a significant impact on the cost of these products. Therefore, exploring alternative sources to replace wheat flour is crucial to conserve foreign exchange and maximize local resources. The aim of this research focuses on the application of tannia cocoyam in the bakery industry, particularly in the development of tannia cocoyam-based flour.

II. MATERIALS AND METHODOLOGY

A. Study Location

The research was conducted at the Food Technology Laboratory, Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, during the period May to November 2022.

B. Collection of Materials

The primary material used for the study was Tannia Cocoyam (*Xanthosoma sagittifolium*) obtained from a farm in Galaha, in the Kandy district of Sri Lanka and was grown there according to prescribed standards. Other ingredients such as wheat flour, sugar, butter, baking powder, salt, and vanilla flavor, were purchased from the local market.

C. Method of Preparation Tannia cocoyam flour preparation

The following method was used to prepare Tannia Cocoyam flour:

The yams was harvested, sorted by removing the damaged portions and selected, cleaned. The cocoyam was then peeled and the remaining yam was cut into small pieces with a stainless-steel knife. The yam pieces were blanched by immersing them in boiling water at a temperature between 80°C and 85°C for a period of 4-5 minutes (Coursey & Ferber, 2019). After blanching, the yam pieces were spread out on parchment paper to facilitate drying. The drying process was carried out in a food dryer (Model 30 – 160) at a temperature of 65°C (Igbabul *et al*., 2015). After drying, the cocoyam pieces were ground with a grinder (Model – GRT 1500B) and then sieved through 100 mesh sieves (Shebabaw, 2013).

D. Development and standardization of the recipe

The study involved creating a cookie recipe using common ingredients such as wheat flour, sugar, salt, margarine and vanilla flavor. Tannia cocoyam flour was added to different wheat flour to obtain a composite flour, leaving all other ingredients unchanged as shown in Table 1.

Table 1: Ingredients used for cocoyam cookies.

Ingredient	**Amount (per 100g)**
Cocoyam flour	Vary according to bellow ratio
Wheat flour	Vary according to bellow ratio
Margarine	65g
Sugar	50g
Salt	1g
Baking Powder	2g
Vanilla Flavor	1 ml

E. Composite flour incorporation Ratio

Composite flour samples were prepared based on specific ratios. During the experiment, the 100% tannia cocoyam sample (Treatment 5) was eliminated due to cookie breakage. Consequently, the final experiment continued with the remaining four samples.

1. Treatment 1 - 100% Wheat flour
2. Treatment 2 - Wheat flour 75%: Tannia cocoyam flour 25%
3. Treatment 3 - Wheat flour 50%: Tannia cocoyam flour 50%
4. Treatment 4 - Wheat flour 25%: Tannia cocoyam flour 75%
5. Treatment 5 - 100% Tannia cocoyam flour

F. Preparation of Cookies

The cookies were prepared in several steps. First, a mixture of flour, baking powder, salt and sugar was thoroughly mixed in a medium-sized bowl with a mixer. Then vanilla syrup was added and mixed until a homogeneous mass was obtained. This mixture was gradually mixed with the flour mixture to form the cookie dough. The cookies were shaped with a cookie cutter and arranged 2 cm apart on a parchment paper sheet lined sheet. Baking was done in an oven (model 30-1060) at 160°C for 15 minutes. After baking, the cookies were cooled to room temperature in a desiccator. Finally, the cooled cookies were packaged in standard polypropylene bags and stored at room temperature.

G. Sensory evaluation

The four cookie samples were presented for evaluation and the following attributes were evaluated: color, flavor, texture, taste, odor, and overall acceptability. Panelists were asked to rate their preference and overall acceptability using a 9-point hedonic scale.

H. Proximate analysis

Moisture, ash, and protein contents were analysed according to AOAC (2000) methods. Nitrogen content was estimated using the semi-micro Kjeldahl method and converted to protein by a factor of 6.25. The dietary fiber content was determined using the method described by the AOAC (2005).

I. Energy value

In a crucible, 1g of the dried sample was taken and a cotton thread was attached to the fuse wire that was in contact with the dried sample. The crucible loaded with the sample was placed in the bomb along with 15ml of distilled water. The bomb was then placed in the bomb calorimeter (IKA C6000, India). Then the bomb calorimeter started operation by selecting appropriate set orders. The results were determined by the calorimeter as Kcal/100g values.

J. Physical characteristics of formulated cookies

The thickness and diameter of the cookies were measured with a Vernier caliper. The thickness was measured at three locations on the cookies and the diameters were determined by measuring at different 90° angles. The arithmetic means were measured and the results are given in mm. The dispersion ratio was determined using the following equation:

Spread Ratio = Diameter/Thickness

Volume was calculated using the following equation (AOAC, 2000).

Volume = (3.14 ×HD^2)/4

K. Textural analysis of cookies

The hardness of the cookies, the adhesion of cookies, the springiness of the cookies and the cohesiveness of cookies were measured by the texture analyzer (Model-CT3 50 K).

L. Statistical analysis

The results were subjected to analysis of variance (ANOVA) and the means were compared by the test of Tukey's HSD at p = 0.05 using the SPSS statistical package (SPSS 20.0, IBM, New York, NY, USA).

III. RESULTS AND DISCUSSION

A. Physical Analysis of cocoyam Cookie Composited with wheat Flour

All determinations were done in triplicate and the results were reported as average value. Mean ± Standard error (SE).

Table 2: Physical analysis of cocoyam cookies

Treatment	Diameter (mm)	Thickness (mm)	Spread ratio	Volume (g/ml)
T1 (Control)	38.95 ± 0.315^{a}	6.28 ± 0.078^{a}	6.28 ± 0.103^{ab}	73.74 ± 0.564^{a}
T2	38.90 ± 0.185^{a}	4.98 ± 0.312^{ab}	7.85 ± 0.478^{a}	59.27 ± 4.049^{a}
T3	38.48 ± 0.140^{a}	5.44 ± 0.259^{a}	7.09 ± 0.363^{a}	63.26 ± 3.011^{bc}
T4	39.49 ± 0.310^{a}	5.16 ± 0.265^{a}	7.68 ± 0.362^{a}	63.22 ± 3.673^{a}

All determinations were performed in triplicate and the results were reported as average, Mean ± standard error (SE). Mean with different superscripts within the same column differ significantly ($P<0.05$).

The diameter of the cookies ranged from 38.90±0.185 mm to 39.49±0.310 mm, with no significant difference ($p > 0.05$) observed between samples. The largest diameter was in treatment T4, the smallest in treatment T3. This variation in cookie diameter is attributed to the speed at which the dough spreads as the margarine melts in the oven.

As for the thickness, increasing in the proportion of cocoyam flour had a significant impact on the thickness. The control had the highest thickness at 6.28±0.078 mm, while the lowest thickness was observed at T2 at 4.98±0.312 mm. Furthermore, the change in thickness can be attributed to the higher moisture absorption of cocoyam flour compared to wheat flour.

The spread ratio of cookies ranged from 7.85±0.478 mm to 7.68±0.362 mm, with no significant difference ($p > 0.05$) between cookies made with different proportions of cocoyam flour and wheat flour. The highest spread ratio was in treatment T2, and the lowest in treatment T1.

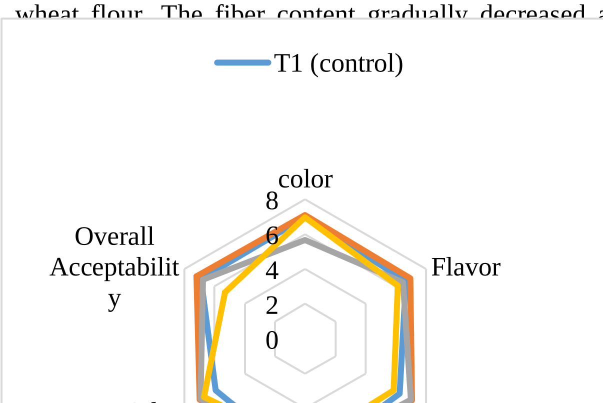
The mean volume of cookies varied between 59.27±4.049 g/ml to 63.26±3.011 g/ml, with a significant difference ($p < 0.05$) between cookies prepared with different proportions of cocoyam flour and wheat flour. Treatment T1 had the highest volume, while treatment T2 had the lowest volume (Table 2).

B. *Nutritional Parameters Analysis of Cocoyam Cookie Composited with Wheat Flour*

Table 3: Chemical analysis of cocoyam cookies

Treatment	Moisture (	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Energy (J)
T1 (Control)	0.316 ± 0.26^{a}	4.416 ± 0.32^{a}	6.033 ± 1.10^{ab}	23.443 ± 2.80^{a}	0.00 ± 0^{a}	5983.00 ± 133.0^{a}
T2	0.653 ± 0.06^{ab}	4.566 ± 0.45^{a}	3.613 ± 0.21^{a}	19.776 ± 0.90^{b}	12.626 ± 2.02^{a}	6211.00 ± 119.9^{a}
T3	0.646 ± 0.06^{ab}	3.933 ± 0.59^{ab}	2.600 ± 0.12^{a}	21.776 ± 2.146^{c}	12.316 ± 1.77^{b}	6124.33 ± 26.08^{ab}
T4	0.920 ± 0.23^{a}	4.850 ± 0.03^{c}	1.453 ± 0.14^{b}	20.553 ± 5.14^{c}	10.986 ± 3.07^{ab}	5981.00 ± 134.0^{a}

The data presented in the paper indicate that increasing the proportion of cocoyam flour in the cookies resulted in higher moisture, ash, protein, fiber, fat, and energy contents compared to cookies made from pure wheat flour (Treatment 1). Notably, the moisture content was lower in the 100% wheat flour-based cookies compared to the 75% cocoyam cookies. In contrast, the ash content was higher in the 75% cocoyam cookies was higher than in the 100% wheat flour cookies. Additionally, the protein content of the cookies containing 75% cocoyam cookies was lower than the cookies containing 100% wheat flour. The fiber content gradually decreased as ... at ... e ... e ... e



The results further reveal that the control sample had the lowest energy content, while the cookies in sample T2 had the highest energy content. This indicates an increase in energy content by replacing cocoyam flour, which is known for its relatively higher energy content. Moisture content is of particular importance to cookie quality, especially when it comes to texture. Notably, the 100% wheat flour-based cookies had lower moisture content, while sample T4 had significantly higher moisture content compared to the available literature. Specifically, T4 recorded 0.92% higher moisture content compared to reference data.

C. *Texture analysis of cocoyam*

A texture analysis was performed on the cookies, which included attributes such as hardness, cohesion, elasticity and adhesion. It is noteworthy that the hardness of the 75% cocoyam cookies (T4) exceeded that of the 100% wheat flour cookies (T1). As the cocoyam flour content in the cookies increased, the cohesion gradually decreased. Furthermore, the elasticity of the cookies containing 75% cocoyam flour (T4) was higher compared to the cookies containing 25% cocoyam flour (T2). Interestingly, the adhesive properties of the 25%, 50% and 75% cocoyam cookies (T2, T3, T4) were found to be similar to those of the 100% wheat flour cookies (T1).

Table 4: Texture analysis of cocoyam

Treatment	Hardness (N)	Cohesiveness	Springiness	Adhesion
T1 (Control)	18.740 ± 3.41^{a}	7.596 ± 6.85^{a}	3.366 ± 0.24^{a}	1.166 ± 0.72^{ab}
T2	35.033 ± 21.8^{ab}	-15.653 ± 16.12^{c}	3.233 ± 0.29^{a}	0.166 ± 0.16^{a}
T3	68.800 ± 16.8^{a}	0.9733 ± 0.38^{a}	3.500 ± 0.36^{b}	0.166 ± 0.16^{a}
T4	69.700 ± 2.02^{a}	-1.4033 ± 2.03^{c}	3.666 ± 0.23^{a}	0.166 ± 0.16^{a}

All determinations were done in triplicate and the results were reported as average value. Mean ± Standard error (SE). Mean values with different superscripts within the same column are significantly different (P<0.05).

D. *Sensory Analysis of Cocoyam Cookie Composited with wheat Flour*

Figure 1: Radar diagram for four samples in sensory evaluation

Abbreviations:

T1- Wheat flour (100), T2- Wheat flour + cocoyam flour (75:25),

T3- Wheat flour + cocoyam flour (50:50),

T4- Wheat flour + cocoyam flour (25:75).

The sensory evaluation of cocoyam cookies considered attributes such as color, aroma, texture, taste, mouthfeel, and overall acceptability. Cookies prepared with different proportions of wheat and cocoyam flour showed similar mean values for these properties. Statistical analysis using SPSS reveals significant differences ($P<0.05$) between different treatments for all sensory quality parameters, except for odor. Notably, cookies with higher amounts of cocoyam flour have a darker color, and those with more than 25% cocoyam flour tend to have a slightly bitter taste and an undesirable mouthfeel, according to the panelists' feedback.

However, it should be noted that a higher proportion of cocoyam flour can negatively affect sensory properties such as mouthfeel, taste, and color, resulting in darker cookies with poor taste perception. The cookies in T2 had the highest color and odor acceptability, probably due to the pleasant vanilla flavor. As the amount of cocoyam flour increased the odor perception also increased.

Among all parameters tested, overall acceptability was highest in T2, indicating that it was the preferred treatment with the greatest deviation from the center. Appearance preference was also highest in T2, which contributed to the overall high level of acceptance.

IV. CONCLUSION

The study involved the preparation of cookies using a combination of cocoyam flour, wheat flour and margarine based on a four-component mixture design. By analyzing of their chemical composition and physical properties, the composite cookies were found to outperform cocoyam cookies in parameters such as crude fat, crude fiber, crude ash, crude protein, and calculated energy content, particularly in the ratio of 75:25 cocoyam: wheat flour (T4) sample. Overall, the composite cookies had better nutritional content compared to the control. In sensory evaluations, these cookies showed different flavor profiles, with more intense flavors than wheat or Cocoyam cookies. Notably, the cookies with a cocoyam flour to wheat flour (T2) ration of 25:75 received the highest preference in sensory evaluations. Considering the physicochemical and sensory properties, the cookies prepared with cocoyam flour to wheat flour ratio of 25:75 were found to be the preferred option, indicating their potential for consumer acceptance and increasing nutritional value. This research demonstrates the potential of using underutilized cocoyam in baked goods, provides the opportunity to produce items with reduced gluten content, and offers a novel approach to incorporating this traditional ingredient.

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