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FUNCTIONAL AND SENSORY PROPERTIES OF COOKIES PREPARED FROM WHEAT FLOUR SUPPLEMENTED WITH CASSAVA STARCH

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Abstract- **Cassava (Manihot esculenta) is that the third largest carbohydrate food source within the tropical region, after rice and corn. Cassava roots are used as sources of carbohydrate, protein, vitamins and minerals. The starch content of the fresh cassava root was found to be about 30%. Cassava starches have some unique characteristics, like a bland taste and flavour, high paste clarity, and low amylase content. The developed cassava cookies with Bengal gram and Horse gram (T2) gained high scores for overall acceptability by sensory evaluation. The developed cassava cookies (T2) showed higher in fiber (5.04 ± 0.03%) and ash (2.55 ± 0.03%) whereas cassava cookies (T1) showed higher value for carbohydrate (70.09 ± 0.02%), fiber (2.04 ± 0.01%) and ash (1.53 ± 0.02%) as compared with control cookies had fiber (0.287 ± 0.02%), ash (0.97 ± 0.06%) and carbohydrate (62.743 ± 1.11%). On the index of physical characteristics spread ratio of cassava cookies (T1) was found to be higher (5.47 ± 0.028) and cassava cookies (T2) was found to be lower (3.75 ± 0.018) than that of control cookies (4.48 ± 0.024). On the index sensory evaluation, the overall acceptability of cassava cookies (T2) showed the quite acceptable having a hedonic rating (8.3 ± 0.03) than control cookies (8.00 ± 0.22). Cassava derived raw materials (flours and starches) were found to have various application in baking, edible film, syrup, glucose, alcohol and soups production. Cassava starch-based cookies were standardized as the main ingredient in this study, and sensory panels determined them to be acceptable in terms of nutritional value, storage stability, and physical quality.**

Keywords: **Cassava. Starch. Cookies. Horse gram. Bengal gram**

I. INTRODUCTION

Tapioca, often known as cassava, is a staple food crop for approximately 800 million people in South America and parts of Africa and Asia. It is scientifically known as Manihot esculenta. Cassava produces a starchy tuberous root that is high in carbohydrate (30 to 35%) and protein (1 to 2%). Vitamin C, riboflavin, thiamine, potassium, and manganese are all vital vitamins and minerals present in Cassava tubers. It also has a high level of dietary fibre, which aids in weight loss. Each of the 100 grams of cassava tuber contains double the calorific content and carbohydrate as sweet potatoes. Mature roots can range in starch content from as low as 15% to as high as 33%, depending on the climate and harvest time. Cassava, like potato, is a popular tuber vegetable, and as a result, it might be viewed not only as a source of carbohydrates but also as a source of protein. Crop that is suitable for both food and nutritional security. The flour, starch, pomace, and peel of the cassava tuber are used to make a variety of high-quality baked goods. In recent years, rising urbanisation, population, and changes in food preferences have resulted in a demand for wheat and wheat-based foods such as maida, which has been shown to have a negative impact on consumers, causing indigestion, obesity, diabetes, and hypertension. It is necessary to discover adequate alternatives to solve these health concerns in people of all ages, and cassava-based food items are one of such safe, nutritious, and cost-effective dietary components.

Tapioca flour is becoming more popular as a grain-free and gluten-free alternative. People have become more health conscious in recent years, focusing on concerns such as weight reduction, diabetes, and so on. As a result, those who avoid gluten-rich products can use cassava flour as a substitute for wheat flour in the baking sector. Cassava flour is made by simply peeling the whole root, drying it, and grinding it into a powder with a greater fibre content. This feature allows it to be employed as a thickening agent in the

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preparation of baked items. Cassava flour includes 0.56-1.1% resistant starch, which aids in the reduction of a variety of health problems.

Starch is one of the most significant functional food biopolymers (Mamat and Hill, 2018). It is one of the primary components of cassava that has been used in the food industry to help with processing and improve final food products. The fresh cassava root has a starch content of roughly 30% and produces the largest production of starch per unit area of any crop. It's a complex carbohydrate that's one of the most prevalent plant products, serving as a key nutrient and energy source.

Cassava starch, which has a high concentration of amylose and amyl pectin, can be used to thicken sauces, soups, and gravies. During the starch extraction process, the leftover waste is dried and ground into pomace, which is a good source of energy. Cassava peel, which is high in protein, is widely utilised in underdeveloped nations as a natural coagulant for waste water treatment, minimising the use of chemical coagulants.

Despite its low protein content and poor protein quality, as well as its cyanogenic glucoside content (Hahn and Keyser, 1985; Cooke and Coursey, 1981), Cassava is processed for human consumption, either directly as food or indirectly as livestock feed, and its food quality is generally improved through processing.

In the present study wheat is being replaced by the cassava flour in preparation of gluten free cassava cookies. This causes a condition called "Celiac Disease" because wheat contains gluten (a special protein commonly found in Triticale, Wheat and Barley). Celiac Disease (CD) is a chronic inflammatory disease of the small intestine caused by the intake of grains containing gluten. This is an immune disorder that primarily affects the gastrointestinal tract. According to NIDDK, the only cure for Celiac disease is a gluten-free diet.

Objectives

The study was carried out with the following objectives

- To extract starch from cassava.
- To develop reduced gluten content cookies by using cassava starch.
- To study the nutritional, sensory and textural analysis of developed cookies.
- To study the storage studies of developed cookies.

II. MATERIALS AND METHODS

Materials

The fresh Cassava root tubers used were obtained from the local market. Other ingredients such as Sugar, Butter, Baking soda, Bengal gram, Horse gram, Vanilla essence of standard manufacturers were procured from local departmental store.

Starch extraction and yield

Fresh Cassava tubers were washed, removed skin (outer layer), and sliced into small pieces before being processed for 5 minutes in a high-powered blender. The pulp was suspended in ten times its volume of water, agitated for five minutes, and then filtered through double-fold muslin cloth. The starch in the filtrate was allowed to settle for 2 hours and the top liquid was decanted and discarded. Water was added to the sediment, which was then agitated for another 5 minutes. The starch from the filtrate was allowed to settle after another round of filtration. The sediment (starch) was dried for one hour at 55°C after decanting the top liquid. It was shown in Fig.1.

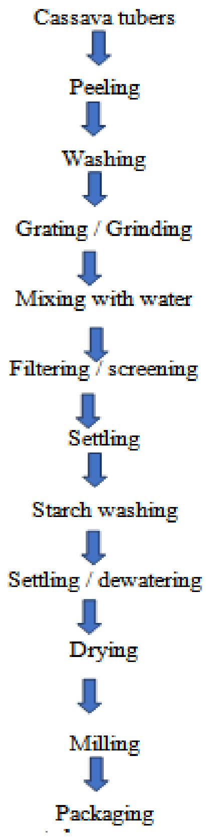

Fig. 1 Flow chart for extraction of starch from cassava tubers

Sample preparation

Standardization of the product was carried out by preparing two trails (T1 and T2) with the control sample (T0) as per standard recipe as given in the Fig. 2. Theingredients required for the preparation of cookies were weighed according to the formulation. Wheat flour, Cassava starch, Bengal gram flour, Horse gram flour, Powdered/Icing sugar, baking powder and pinch of salt was mixed and sieved by using wire mesh sieve. Creaming process was carried out with the addition of butter using beater for 5 minutes. Then the powdered sugar was mixed with the creamy butter.

Wheat flour, cassava starch, Bengal gram flour and Horse gram flour to the creamy mixture and beat for 30 seconds to 2 minutes. Then the vanilla essence was added to the flour mixture. Kneading process was carried out and dough was prepared. Sheeting process of the prepared dough carried out. Cutting was done with the help of the biscuits/cookies moulds for the desired shape and size. After baking the finished baking products were cooled at room temperature and packed in plastic pouches and sealed and stored at room temperature.

Weigh all the ingredients
↓
Beat butter for five minutes
↓
Add sugar and beat till light and fluffy
↓
Add the Refined wheat flour and beat well for 30 seconds
↓
Add Cassava flour and again beat well for 30 seconds
↓
Add Bengal gram, Horse gram flour, salt and baking powder & beat again
↓
Knead well to make a non-sticky dough
↓
Roll the dough on a pastry board in uniform thickness
↓
Cut the dough using a Cookie Cutter
↓
Line cookies on an oven try by placing them on a butter paper
↓
Bake at 180°C for 20 minutes
↓
Remove tray and cool for 30 minutes
↓
Packaging

Fig. 2 Flow chart for the preparation of cookies

Functional properties of starch

Functional properties of starch were determined by various methods. Water Absorption Capacity was determined using the centrifuge method, Water Solubility Index was determined using the supernatant obtained during Water Absorption Capacity estimation, Gelatinization temperature and Swelling power was determined using the decanted supernatant as per the method (Geetha et al., 2021). Water Binding Capacity was determined by the method given by Yamazaki et al., 1953. Bulk density and tap density were determined as per the method described by Danbaba et al., 2014.

Physical parameters
Average diameter (D) and thickness (T) of cookies were measured with the help of vernier calliper. Spread ration was then determined by dividing the diameter with thickness (D/T) as per the method of Shrestha and Noomhorm, 2002.

Physico-Chemical analysis of developed cookies
The cookies formulated with different formulations were subjected to chemical analysis using standard protocols. The samples were analysed for moisture content by air-oven drying method (AOAC, 2000). Crude protein content was estimated according to the Kjeldhal method as described in AOAC, 2006. Crude fat was estimated using Socsplus as described in standard method of AOAC, 2000. Crude fiber was estimated by Fibraplus as per the method of AOAC, 2006. Ash contents (%) were determined as per method of AOAC, 2000. Total carbohydrate content of the samples was determined as total carbohydrate by difference, calculated by subtracting the measured crude protein, crude fat, crude fibre and ash from 100. The calorific value was estimated based on the contents of crude protein (N*6.25), fats and carbohydrates using the Atwater factors (energy conversion factors) of 4.0, 9 and 4 Kcal/g each component respectively (AOAC, 2000).

Organoleptic evaluation of developed cookies
The organoleptic evaluation of products prepared by different formulations was conducted by a semi-trained panel (a panel consisting of people capable of discriminating differences and communicating their reactions though they may not have been formally trained) for appearance, aroma, colour, texture and taste by a semi-trained panel of 15 people. The judges scored quality characteristics as per 9-point hedonic scale.

Statistical analysis
Summary statistics (mean and standard deviation), graphs and were obtained using Microsoft® excel 2010.

III. RESULTS AND DISCUSSION

The starch was subjected to functional properties analysis and the developed cookies were subjected to physico-chemical, physical properties and organoleptic evaluation. The results obtained are presented under the following sub headings.

Functional characteristics of Cassava starch
The behavioral properties of starch in water include solubilization, swelling and gelatinization.

Table 1 Functional properties for Cassava starch

Parameters	Values
Water Absorption Capacity (%)	1.13 ± 0.02
Water Solubility Index (%)	37.2 ± 0.03
Water Binding Capacity (%)	113 ± 0.02
Bulk Density (g/ml)	0.56 ± 0.01
True Density (g/ml)	0.68 ± 0.002
Porosity	0.56 ± 0.02
Gelatinization temperature (℃)	76
Swelling Power (%)	40.0 ± 0.02

(@Average of 6 trials)

Water absorption capacity
Water absorption refers to the ability of material to absorb water when immersed in it and is represented with Water Absorbing Capacity. Water absorbing capacity is defined as the ratio of the weight of water absorbed by a material in saturated state over the weight of the dry material.
The Water absorption capacity is one of the important properties which determine the amount of water held by the sample. The Water Absorption Capacity of Cassava starch was recorded as 1.13 ± 0.023%.
Milling equipment and flour preparation methods, such as a milling time can affect some properties of the flour; for example, starch damage, which will result in high water absorption because water can penetrate into granules more easily than intact granules (Tulyathan et al., 2002).

Water solubility index
Water solubility index is an important property which is closely related to ratio of amorphous and crystalline components of granules. The water solubility index in this study was lower than that reported by Moorthy (2002). The water solubility index of cassava starch was found to be 37.20 ± 0.038%.
Moorthy, (2002) studied that the Cassava flour had high swelling power due to their higher amyl pectin in comparing with potatoes flour. Also reported that the swelling power of cassava starch was vary from 42-71 (g/g). It shows that cassava flour and cassava starch have a different value of swelling power.

Water binding capacity
The water binding capacity of food stuffs is an essential quality parameter, it is used to determines the product texture and palatability. In the present study, the water binding capacity of cassava starch was found to be 113 ± 0.024%.
Aryee et al., (2006) reported that the water binding capacity (WBC) of the cassava flour samples ranged from 113.66%

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to 201.99%. The relatively high WBC values obtained are indicative of weak associative forces between the starch granules, which allows for more molecular surfaces to be available for binding with water molecules (Rickard et al., 1991).

Bulk density and True density

Bulk density measures the compactness or heaviness of flour sample which is helps to determine the porosity of a product. In this present study, the bulk density of 0.56 ± 0.0178 g/ml was found for cassava starch comparatively other studies reported that the bulk density of cassava starch was found to be 0.72 ± 0.04 g/ml.

Bulk density is a measure of the degree of coarseness of the starch sample. The bulk properties describe the density, packing and flow of a powder mass. High density materials have high diluent power as they substantially reduce powder volume or bulk while improving consolidation and flow studied by Aulton, (2001).

Gelatinization temperature

The process of gelatinization of starch occurs by removal of excess water at particular temperature which it is called point of gelatinization. The gelatinization point of cassava starch was reached at 76℃.

During starch gelatinization, starch granules adsorb water and swell resulted in a disorder of crystalline region Hoover (2001). Udomrati et al., (2003) who stated that rice starch required a certain amount of minimum water for gelatinization. Aichayawanich et al., (2011) studied that the gelatinization temperature of cassava starch slightly decreased with increasing moisture content. Evans and Haisman (1982) proposed that increased amount of water facilitates the gelatinization by lowering the melting point of crystallite region. Therefore, aswater becomes limiting, gelatinization temperature increased.

Swelling power

Hoover, 2001 studies revealed that when starch with excessive amount of water is heated, the granules absorb water and swell, while starch components leach out of the granules and solubilize mostly in the form of amylose. With the increased temperature, the swelled granules disintegrate and break down eventually. This process is influenced by various factors, such as molecular structure of amylose and amylopectin, physical associations of chemical components in the granules, size distribution of granules, and presence of lipid–amylose complex and phosphorous groups. The swelling of granules in water during heating is usually quantified by swelling factor (SF) or swelling power (SP), whereas the granular solubilization is characterized by solubility (%) (S) or amylose leaching (AML) (%). SF relates to the inter- and intra-granular portion of water, and SP the intra-granular portion (Tester and Morrison, 1990).

In the present study the swelling capacity of the sample was studied on the temperature of 50℃ and 90℃ was found to be 40.0 ± 0.025%. As studies revealed that millet starch had lower swelling and solubilization values than potato at higher temperature range (e.g., ~90°C) studied by Hoover, 2001.

Physical parameters

The physical parameters like weight, diameter, thickness and spread ratio of cookies were evaluated and compared with control (Co) cookies prepared from whole wheat flour. The weight of cookies ranged from 7.33g to 8.33g. The diameter and thickness of cookies varied from respectively. The spread ratio of cookies was found in range of 3.75 ± 0.018 to 5.47 ± 0.028. Spread ratio of reduced gluten cookies was lower than control cookies prepared from wheat flour. It was mainly because of lack of gluten content, resulting in escape of CO_2 generated during baking process thereby, decreasing the spread ratio of reduced gluten cookies.

Table 2Physical properties of developed cookies

Parameter	**Treatment**		
	T_0	**T_1**	**T_2**
Spread ratio	4.48 ± 0.024	5.47 ± 0.028	3.75 ± 0.018

Physio-Chemical analysis of developed cookies

Reduced gluten cookies were subjected to chemical analysis for different parameters and results obtained are presented in Table 3. There were significant differences in chemical composition of different formulations of reduced gluten cookies. The moisture content ranged from 3.03 ± 0.02% to 4.83 ± 0.29%. The values for protein content varied significantly from 5.31 ± 0.01% to 6.83 ± 0.15% in different formulations. Due to incorporation of protein rich ingredients (Bengal gram + Horse gram), the protein content was highest in T_2 (5.54 ± 0.02%) as compared to T_1(5.31 ± 0.01%). Values for crude fibre were highest in T_1 (2.04 ± 0.01%) and lowest in control cookies (0.29 ± 0.02%). Crude fat contents were highest in T_0 (25.33 ± 0.76%) and lowest in T_1 (21.03 ± 0.02%). The ash content of cookies ranged from 0.97 ± 0.06% to 2.55 ± 0.03%. Values for carbohydrates ranged from 62.74 ± 1.11% to 70.09 ± 0.02%. Calorific values of cookies varied from 490.87 ± 0.03% to 514.35 ± 0.83% Kcal/100g. The values were highest for T_0 (514.35 ± 0.83%) and lowest for T_1 (490.87 ± 0.03%).

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Organoleptic evaluation of developed cookies

Organoleptic evaluation of reduced gluten cookies after processing is given in fig. 3Cookies were subjected to organoleptic evaluation by a semi-trained panel. The overall acceptability score for T_0, T_1, T_2 was 8 ± 0.22, 7.60 ± 0.02 and 8.30 ± 0.03 respectively. There was slight decrease in overall acceptability of reduced gluten cookies (T_1) as compared to control cookies. Cookies containing higher proportion of Cassava starch scored less for colour, flavour, taste and overall acceptability as compared to other formulation. The cookies with incorporation of Bengal gram and Horse gram had the distinct flavour and aroma as compared to other formulation. It was mainly due to the flavour and aroma of roasted Bengal gram and Horse gram. On the index of texture, scored lesser than other composition due to the improper sieving/fibrous content of Bengal gram and Horse gram. However, the cookies were highly acceptable on 9-point Hedonic rating scale.

Table 3Proximate composition of developed cookies

Test	Values			Method
	T_0	T_1	T_2	
Protein (%)	6.83 ± 0.15	5.31 ± 0.01	5.54 ± 0.02	Kjeldahl method
Fat (%)	25.33 ± 0.76	21.03 ± 0.02	23.4 ± 0.18	Socs plus apparatus
Fibre (%)	0.29 ± 0.02	2.04 ± 0.01	1.06 ± 0.02	Fibra plus
Ash (%)	0.97 ± 0.06	1.53 ± 0.02	2.55 ± 0.03	Muffle furnace
Moisture (%)	4.83 ± 0.29	3.03 ± 0.02	3.80 ± 0.03	Hot air oven
Carbohydrate (%)	62.74 ± 1.11	70.09 ± 0.02	67.45 ± 0.2	By Difference method

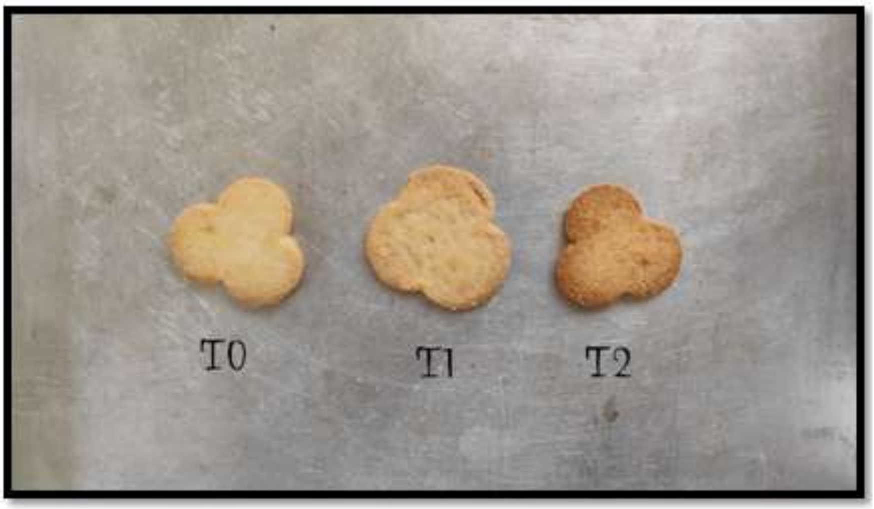

Fig. 3 Image of developed cookies

T_0 – Control sample,T_1 – 50% Cassava starch added,T_2 – 30% Cassava, 10% Bengal gram, 10% Horse gram

IV. CONCLUSION

Gluten free ingredients i.e., Cassava starch, Bengal gram and Horse gram flour were incorporated successfully for preparation of value-added reduced gluten food products like cookies. It has been observed that incorporation of nutritious gluten free ingredients in these products increased the contents of essential nutrients such as crude protein, crude fibre, crude fat and ash contents. All formulations were desirable as per results of sensory evaluation except for formulation containing higher proportion of Cassava starch and considered moderately desirable as per 9-point hedonic rating scale.

Gluten free-food products on the market are expensive and out of reach for the majority of people. Because of the incorporation of low-cost products, there can be afforded by people from all section of society. These food products can assist improve the nutritional status of celiac patients as well as other people suffering from various disorders by acting as a good carrier for transferring the essential nutritious components.

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