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Physical Characteristics and Nutritional Analysis of Native and Chemically Modified Starches Obtained From *Yam (Dioscorea Rotundata) and Cassava (Manihot Esculeta) Tubers*

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Abstract

Starch is a white tasteless powder that is insoluble in cold water, alcohol, or other solvents, due to some poor physical characteristic like its low oil absorption ability and high ability to retrograde .Starch modification had to be carried out in order to meet the demands from the industry, this work focuses on the comparison of physical characteristics and nutritional analysis of native and chemically modified starch of cassava and yam tubers. Starch was extracted using the wet as described by Benesi. The percentage yield of the starch extracted from the tubers were as follows: 20.00% for cassava and 10.00% for yam The starch obtained from each tuber was divided into three parts where a portion was chemically modified with an acid and another portion was modified with an acetate while the portion left was not modified (native starch).

Native yam starch had a higher quantity of crude protein than the native cassava starch and it was noticed that the yam starch had higher oil absorption ability than the cassava starch. The ether extract was seen to be higher in native starches than in the chemical modified starches which showed that the native starch samples contained more oil than the chemically modified samples. The acetate modified samples contained less oil than the acid modified samples. Starch modified with acetate is an effective emulsifier used in the food, pharmaceutical and cosmetic industries. Chemical modification has improved the quality of starch making it a valuable raw material in industries.

Keywords: Cassava, Yam, Chemical Modification, Starch

Introduction

Starch is a white organic substance that is obtained from green plants. It is a natural and inexpensive material used on a wide scale [1]. It is used by plants as source of carbon and energy [2] It could also be described as a polysaccharide of vegetable origin composed of two fractions: amylose and amylopectin. Starch is also an important ingredient for the food industries, whereas starches with specific properties when modified are necessary to impart functionality desirable attributes to foods. It could be used in bread making, as a meat binder, in confectionary and also as an additive in most food and beverages. This is in addition to its use in textiles, paper and plywood industries, as filler in biodegradable plastics and in the mining and construction industry [3]. Modified starch is a natural starch in which, by suitable treatment, one or more of its initial physical or chemical properties has been changed. Modifying the starch has an aim to improve its functional properties or give it new features [4]. Modification of starch changes the structure of starch, as a result of which its properties change, which allows expanding the possibilities of practical application [5]. However, in recent years, the literature on this subject included information about new research on the development of technologies involving adhesives mostly based on unmodified starch locally occurring in Africa starch from tubers of plants such as yam or cassava [6]. There have been several researches that have been focused on the modification of starches but this research focuses on the comparison of physical characteristic and nutritional analysis on native and chemically modified starch of cassava and yam tubers.

Materials and Methods Sample Collection

Fresh tubers of yam and cassava were purchased from Oje market in Ibadan, Oyo state. Starch was extracted using the wet method described Benesi [7]. 2 kg of each tuber was washed, peeled, chopped and then pulverized in a high-speed blender for 5 minutes. The pulp was suspended in ten times its volume of water, stirred for 5 minutes and filtered with a sieve of mesh 212 nm. The filtrate was allowed to stand for 2 hours, then the supernatant was discarded. The residue was dissolved in 2 L of water and stirred for 5 minutes. The filtration process was repeated. After decanting the supernatant, the residue (starch) was sun dried for 24 hours, then blended and stored.

Modification of Starch using dilute acid

The starch was modified based on the proposed method of Caglarirmak and Cakmakl,1993 [8]. 50ml of 0.1M HCl was added to 100g starch and 150 mL deionized water and mixed for 30mins. Then pH was adjusted to 7.0 with 1M NaOH. The Neutralized starch was dried at room temperature for 24 h after washing three times with deionized water and filtered with filter paper.

Modification of Starch using Acetic anhydride

The modification of starch using Acetic anhydride was carried out based on Sandhu et al., 2007[9]. Starch (100g) was dispersed in distilled water (225ml) and stirred for 1hr at 30^0C. The pH of the slurry was adjusted to 8.0 using sodium hydroxide (3%) solution. Acetic anhydride (8g) was added drowse to the stirred slurry, while painting the pH within the range of 8.0684 using 3% NaOH solution. The reaction was allowed to proceed for 10mins after the completion of acetic anhydride addition. The slurry was then adjusted to pH 4.5 with 0.5m HCl. The slurry was washed twice with distilled water once with 95% ethanol filtered and oven dried at 40^0C .

Physical Analysis Bulk Density

Bulk density was determined using the method of Nwanekezi et al, 2001[10] and Maninder et al., (2007) [11]

Water Absorption Capacity (WAC)

WAC was measured using the method of Sathe and Salunkhe (1981) [12].

Oil Absorption Capacity (OAC)

OAC was measured using the method of Sathe and Salunkhe (1981) [12].

Proximate Analysis

Standard methods by Association of official analytical chemists (AOAC) [13] were used to determine the carbohydrate content, crude fats, crude fibres, protein, ash and moisture content of the sample.

Results and Discussion

The starch industry is in constant expansion, and modification processes will increase its versatility. When starch is physically or chemically modified, it can be adapted for different purposes in food and or non-food industries. The oldest chemical modification technique is acid modification. Products of acid modification have several applications and uses in the food, paper, textile and pharmaceutical industries [14].

Percentage yield of starch extracted from yam and cassava tubers

SAMPLE (tubers)	MASS OF SAMPLE (g)	MASS OF STARCH (g)	PERCENTAGE YIELD (%)
YAM	2000	210	10.50
POTATO	2000	400	20.00

Table 1: Percentage yield of starc

From the percentage starch yield of the two tubers under consideration as reflected on table 1, cassava had a higher starch yield of 20.00 % when compared with yam that had a percentage starch yield of 10.50 %. The yield of cassava almost doubles that of yam showing that starch produced from cassava is more economical and will bring in more profit to the industries than the ones produced from yam as shown on the table above.

Bulk density of foods increases with increase in starch content [15]. Cassava had a higher bulk density than yam. When comparing native starch and modified starch the bulk density of the chemically modified starch was higher than that of native starch for the tubers. Bulk density is defined as weight of fiber per unit volume, often expressed as g ml−1 and is a good index of structural changes [16]. The bulk density of the chemically modified starch was higher than that of native starch for the tubers, showing that with the modification of the native starch, the bulk density was enhanced ie the weight of fibre per unit volume was increased. Acid modifications can change the structure and physicochemical properties of starch, such as molar mass, crystallinity, viscosity,gelatinization temperature, and gel rigidity[14].The starch used for this analysis were milled to a mesh size of 212 nm. Huang et al. (2009) [17] demonstrated that smaller fiber particles are shown to have a higher bulk density and may lower the ability of the fiber to absorb water and oil. The water absorption capacity was seen to be higher in native yam starch as compared to the modified

Physical Characteristics of Native and Modified Starches

PHYSICAL PROPERTIES	NATIVE STARCH		ACID MODIFIED STARCH		ACETATE MODIFIED STARCH	
	Cassava	**Yam**	**Cassava**	**Yam**	**Cassava**	**Yam**
Bulk density (g/ml)	3.88±0.03	3.05±0.07	4.52±0.05	4.71±0.11	4.15±0.08	4.99±0.04
Water absorption capacity (%)	64.44±2.17	68.06±0.34	66.13±0.14	65.34±0.64	66.12±0.16	64.67±0.58
Oil absorption capacity (%)	16.60±0.34	16.85±0.64	17.42±o.62	17.71±0.01	30.29±0.08	34.17±0.24

Table 2: Physical Characteristics of Native and Modified Starch of Yam and Cassava Tubers

starch of yam while the reverse was noticed for cassava starch. The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics [18]. The increase in water absorption capacity has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure. The starch with high water absorption may have more hydrophilic constituents such as polysaccharides. The ability of starch to absorb water is an indication of its moisture stability that is very important for food industry [19]. According to Ravi & Susheelamma (2005) [20], oil absorption is the ability to nonpolar sites of protein chains to entrap oil, so that the content and type of protein in the product determine the oil absorption capacity. Low oil absorption capacity leads to low protein content. Yam had the lowest absorption capacity in modified starch and native starch while cassava has the highest in acetate modified starch. The oil absorption capacity of the acetate modified starches for both cassava and yam increased tremendously when compared to the native and acid modified starches. The oil absorption capacities suggest that they may be useful in food preparation that involve mixing like bakery products where oil is an important ingredient [21]. The oil absorption capacities of the composite flours tended to increase with increase in protein content since the protein in foods influences fat absorption. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods [22]. The acetate modified starch showed the ability to absorb oil more than the native and acid modified starch. Due to the oil absorption ability of acetate modified starch, it could be used in the food, pharmaceutical and cosmetic industries; The introduction of acetyl groups reduces the resistance of bonds between the starch molecules. Acetylated starch increases the swelling capacity and solubility compared to native starch [23].

Nutritional Analysis of Native and Modified Starch

NUTRITIONAL COMPONENT	NATIVE STARCH		ACID MODIFIED STARCH		ACETATE MODIFIED STARCH	
	Cassava	**Yam**	**Cassava**	**Yam**	**Cassava**	**Yam**
Moisture content	13.75±0.07	12.45±0.07	13.90±0.03	12.58±0.04	13.28±0.04	12.33±0.04
Dry matter	86.25±0.07	87.55±0.07	86.10±0.03	87.43±0.04	86.73±0.04	87.68±0.04
Crude protein	1.28±0.01	1.50±0.28	1.12±0.03	1.61±0.03	1.21±0.01	1.68±0.04
Ether extract	0.42±0.01	0.40±0.00	0.39±0.01	0.34±0.02	0.37±0.02	0.32±0.01
Crude fibre	2.15±0.07	1.25±0.07	2.07±0.02	1.14±0.06	2.06±0.01	1.17±0.02
Ash content	0.20±0.00	0.35±0.07	0.44±0.01	0.11±0.01	0.47±0.02	0.11±0.01
Carbohydrate	84.10±0.11	85.25±0.07	84.15±0.06	85.38±0.08	84.69±0.06	85.54±0.01

Table 3: Nutritional Analysis of Native and Modified Starch Obtained from Yam and Cassava Tubers

The results of nutritional analysis for native, acid modified starch and acetate modified starch of cassava and yam is on table above. The moisture content was noticed to be higher in acid modified starch of yam and cassava than in the native and acetate modified starch. Acid modification encourages hydrolysis of the starch structure, Acid modifications can change the structure and physicochemical properties of starch, such as molar mass, crystallinity, viscosity, gelatinization temperature, and gel rigidity [14]. The crude protein was higher in native yam starch than in native cassava starch, with chemical modification, the crude protein for yam starch increased while that of cassava starch decreased. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods [22] Oil absorption is the ability of nonpolar sites of protein chains to entrap oil, so that the content and type of protein in the product determine the oil absorption capacity. Low oil absorption capacity leads to low protein content. Native yam starch had a higher quantity of crude protein than the native cassava starch and it was noticed that the yam starch had higher oil absorption ability than the cassava starch. The ether extract was seen to be higher in native starches than in the chemical modified starch which showed that the native starch samples contained more oil than the chemically modified samples. The acetate modified samples contained less oil than the acid modified samples. Starch modified with acetate is an effective emulsifier used in the food, pharmaceutical and cosmetic industries [24]. Crude fibre was lower in yam starch than in cassava and with the chemical modification, there was a downward trend in both yam and cassava starch. Diets with low dietary fibre contain more soluble carbohydrates which would be digested before reaching the caecumin of rabbits [25].The ash content for native cassava starch was low when compared to yam starch but with chemical modification , the ash content of cassava starch increased when that of yam starch decreased, The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics [18]. Chemical modification involves the introduction of functional groups on the starch molecule without affecting the morphology or size distribution of the granules. Chemical modifications generate significant changes in starch behavior, gelatinization capacity, retrogradation and paste properties [26].

Conclusion

Chemical Modification has improved the quality of starch making it a valuable raw material in the food, pharmaceutical and cosmetic industries. The yield of cassava starch almost doubles that of yam starch but yam starch contains more crude protein and better oil absorbing capacity than cassava starch. The acetate modified starch contained less oil than the acid modified starch which makes it an effective emulsifier in the food, pharmaceutical and cosmetic industries Modified starches are valuable assets in Food and Cosmetic industries.

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