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Chemical modification of grain starch: Proximate and physiochemical analyses

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ABSTRACT

In this study, starches were extracted from selected grains such as rice, wheat, beans and corn. Starches from the grains were extracted using cold extraction and modified using acetate and hydrochloric acid. The physical, chemical and nutritive values of the modified and unmodified starches were carried out. The percentage yield of starches from wheat, beans, rice and corn were 30.5, 30.0, 15.0 and 10.5 (%), respectively. The water and oil absorption capacities of the unmodified starches were 63.65 & 18.00 % (wheat), 65.00 & 15.35 % (rice), 67.15 & 19.55 % (corn) and 62.25 & 19.55 % (beans). The acid modified starches had the following water and oil absorption capacities 67.30 & 29.65 % (wheat), 69.65 & 20.90 % (rice), 69.10 & 28.75 % (corn) and 67.15& 19.80 % (beans). Acetate modified starches had the following water & oil absorption capacities 65.70 & 16.35 % (wheat), 68.75& 23.90 % (rice), 65.90 & 34.50 % (corn) and 67.30 & 19.80 % (beans). The high-water absorption capacity of the acid modified rice starch shows that it can withstand higher temperature than unmodified rice starch, which is an advantage for its use in cooking**.** The high oil absorption capacity of the acetate modified corn starches can earn it a place in the cosmetic industries. From this finding, it shows that acid and acetate modified starches would be a better composition of talcum powder.

Capsule Summary: The starches were extracted from some selected grains such as rice, wheat, beans and corn and modified starches were studied on the basis of proximate composition and physiochemical properties.

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INTRODUCTION

Starch is the most important polysaccharide in the human diet. It is the second most abundance organic compounds in the biosphere after cellulose (Ashogbon, 2017). The attractiveness of starch usage in the food and non-food industries is attributed to its cheapness, abundance, biodegradability and non-toxic nature. Starches are easily obtained from various botanical sources, e.g., cereal, legume, root and tuber and green fruit (Ashogbon and Akintayo, 2014). It is used industrially as coatings and sizing in paper, textiles and carpets, as binders, as adhesives, as absorbents, encapsulant bone replacement implants, bone cements, drug delivery systems, and tissue engineering scaffolds (Ashogbon and Akintayo, 2014).

Native starch has some shortcomings such as poor solubility and high hydrophilicity, inability to withstand

extreme temperature, diverse pH, and high shear rate, high ability to retrograde, loss of viscosity, thickening power upon cooking and poor stability. Starch modification is aimed at correcting one or some of the above-mentioned shortcomings, which will enhance its versatility and satisfy consumer demand. Starches from different sources have been reported to be useful for many industrial applications but their physiochemical properties have been a limiting factor, hence the needs for this study.

MATERIAL AND METHODS

Extraction of starch

Extraction of (rice, beans, wheat, and corn) was carried out according to the method of Singh and Singh with minor modification. 2000 g of grains was blended, soaked in distilled water at room temperature for 8 hrs and stirred constantly. The slurry was filtered through 212 mesh sieve and residue were washed with distilled water three times. The filtrates were left for 12 hrs, supernatant was discarded and the crude starch was cleaned with distilled water. This step was repeated thrice and the starch cake was sun dried. The starch was packed in an air-tight container.

Modification of starch with diluted Acid

A 75 mL 0.1 N HCl was added to 150 g starch with 75 mL deionized water mixed for 30 mins. The pH was adjusted to 7.0 with 1N NaOH. Neutralized starch was dried at room temperature for 24 hrs. The dried starch was washed thrice and filtration.

Modification of starch with acetic anhydride

A 100 g of Starch was dispersed in distilled water (225 mL) and stirred for 1 hr at 30°C. The pH of the slurry was adjusted to 8.0 using sodium hydroxide (3 %) solution. 8 g acetic anhydride was added to the slurry which was continuously stirred, the pH was adjusted 8.0684 using 3% NaOH solution, the reaction was allowed to stand for 10 mins. The slurry was then adjusted to pH 4.5 with 0.5 M HCl. The slurry was washed twice with distilled water and with 95 % ethanol, filtered and oven dried at 40 °C.

Proximate analysis

Native starch and modified starches were analyzed for nutritional composition such as carbohydrate, crude fats, protein, moisture content, crude fibre and ash content according to the official method of the Association of Analytical Chemists (A.O.A.C), 2000. The carbohydrate content was determined by following the method of James and Friday (2010), given as: Carbohydrate content = [100–

Table 1: Percentage yield of starches obtained from grains

Samples (grain)	Mass of sample (g)	Mass of starch (g)	Percentage yield (%)
Beans	2000	600	30.0
Corn	2000	210	10.5
Rice	2000	300	15.0
Wheat	2000	610	30.5

Table 2: Proximate analysis of unmodified and modified starches obtained grains

Sample	Moisture content	Dry matter	Crude protein	Ether extract	Crude fibre	Ash content	Carbohydrate
Unmodified starches							
Beans	10.30 ± 0.14	89.90 ± 0.14	22.43 ± 0.04	1.15 ± 0.07	3.30 ± 0.00	0.55 ± 0.07	65.58 ± 0.11
Wheat	10.60 ± 0.14	89.15 ± 0.21	10.15 ± 0.21	1.60 ± 0.00	1.10 ± 0.00	0.50 ± 0.00	77.25 ± 0.35
Rice	9.45 ± 0.07	90.25 ± 0.35	6.15 ± 0.07	0.70 ± 0.00	1.15 ± 0.07	0.20 ± 0.00	83.50 ± 0.00
Corn	8.85 ± 0.07	91.15 ± 0.07	8.85 ± 0.07	3.25 ± 0.07	2.45 ± 0.07	0.35 ± 0.07	78.70 ± 0.00
Acid modified starches							
Beans	13.65 ± 0.14	86.35 ± 0.14	19.68 ± 0.14	2.10 ± 0.07	1.68 ± 0.18	0.28 ± 0.04	64.30 ± 0.35
Wheat	10.65 ± 0.07	89.35 ± 0.07	10.26 ± 0.21	1.63 ± 0.11	1.30 ± 0.07	0.34 ± 0.02	77.14 ± 0.40
Rice	9.76 ± 0.06	90.24 ± 0.06	6.63 ± 0.11	0.94 ± 0.02	1.18 ± 0.04	0.25 ± 0.07	82.47 ± 0.31
Corn	9.66 ± 0.20	90.34 ± 0.20	9.05 ± 0.08	2.95 ± 0.21	8.96 ± 0.08	0.30 ± 0.03	78.05 ± 0.04
Acetic anhydride modified starches							
Beans	11.90 ± 0.21	88.10 ± 0.21	18.64 ± 0.16	2.09 ± 0.05	1.63 ± 0.11	0.41 ± 0.01	66.97 ± 0.01
Wheat	10.86 ± 0.08	89.14 ± 0.08	9.82 ± 0.09	1.56 ± 0.15	1.29 ± 0.05	0.30 ± 0.03	77.47 ± 0.35
Rice	9.35 ± 0.07	90.65 ± 0.07	6.45 ± 0.07	0.90 ± 0.03	1.17 ± 0.10	0.24 ± 0.03	83.06 ± 0.14
Corn	8.98 ± 0.04	91.02 ± 0.42	8.65 ± 0.07	3.09 ± 0.05	2.25 ± 0.07	0.34 ± 0.02	78.95 ± 0.14

(protein + fat + moisture + ash + crude fibre)]. The proximate analysis was carried out in triplicates and all values reported in percentage.

Physiochemical Analysis

Native starch and modified starches were analyzed for physiochemical analysis such as pH, bulk density, water absorption capacity and oil absorption capacity.

RESULTS AND DISCUSSION

Table1 shows the mass of starches and the percentage yield (Eq. 1) of the starches obtained from grains. The proximate analysis of the unmodified starches and modified starches are given in Table 2. The physiochemical analysis such as pH, bulk density, water absorption capacity and oil absorption capacity were reported for unmodified and modified starches was revealed in Table 3.

$$Yied\ (\%) = \frac{Final\ mass}{Initial\ mass} * 100 \qquad (1)$$

The starch obtained were white and faint color, tasteless and odorless. The yield was (30.0 %, 10.5 %, 15.0 %, and 30.5 %) for beans, corn, rice and wheat respectively (Table 2). The yield is considered to be appreciable especially when compared with starches from other sources. The purity of the starches is considerable high with or no shaft residue. The yield of beans and wheat starches are high and would be good source of starches for industrial use. The results of proximate analyses (crude protein, moisture, crude fibre, ash content, dry matter, ether extract and carbohydrate content) shows modification affected the proximate analyses of starches obtained from beans, wheat, rice and corn (Table 2), but are within the range of values obtained for starches from other sources. Wheat, rice and corn plants are non-leguminous plants and are therefore expected to have minimal amounts of fat and protein content (Builders et al., 2004, Kunle et al., 2003 and Carcea and Acquistucci, 1997).

The pH of 6.53, 4.46, 4.70, and 4.60 was obtained for unmodified starches from beans, wheat, rice and corn respectively. The pH for acid modified was 7.25, 6.36, 6.70, and 6.80 for beans, wheat, rice and corn respectively (Table 3). The values obtained for acetate modified starches of beans, wheat, rice and corn are pH of 6.80, 5.70, 5.60 and 5.80 respectively (Table 3). ThepHrangeof3-9obtained for most starches used in the pharmaceutical, cosmetics and food industries (Omojola et al., 2010).

The water absorption capacity for unmodified starches of beans, wheat, rice and corn were (62.25, 63.65, 65.00 and 67.15) Table 3). The acid modified starches possess water absorption capacity of 67.15, 67.30, 69.65 and 69.10 for beans, wheat, rice and corn respectively (Table 3). Acetate modified starches also revealed water absorption capacity of beans, wheat, rice and corn as 67.30, 65.70, 68.75 and 68.70 respectively. The higher moisture content of modified rice and corn confirms that the granules are not tightly packed compared wheat and beans. The water holding capacities of modified rice and corn starches are very high when compared to the unmodified starches, this is possibly due to the higher amylose content in rice and cornstarch. It has been reported that the degree of water absorption of a starch is directly related to its amylose content and starches with high amylose content generally have high water absorption capacities, the modification has been found to improve the capacity of starch granules to expand in volume without collapsing (Ihegwuagu et al., 2009). The oil absorption capacity of unmodified starches of beans, wheat, rice and corn are 17.00, 18.00, 15.35 and 19.55, respectively (Table 3). The

Table 3: Physiochemical analysis of unmodified and modified starches obtained grains

	Appearance	Ph	Bulk density (g/ml)	Water absorption capacity (%)	Oil absorption capacity (%)
Unmodified starches					
Beans	Light brown	6.53 ± 0.04	3.20 ± 0.00	62.25 ± 3.32	17.00 ± 3.68
Wheat	Ash	4.46 ± 0.02	3.15 ± 0.70	63.65 ± 4.60	18.00 ± 5.37
Rice	White	4.70 ± 0.03	3.05 ± 0.21	65.00 ± 2.97	15.35 ± 3.61
Corn	Off-white	4.60 ± 0.11	3.45 ± 0.07	67.15 ± 2.47	19.55 ± 0.92
Acid modified starches					
Beans	Light brown	7.25 ± 0.04	4.80 ± 0.00	67.15 ± 0.07	19.80 ± 0.14
Wheat	Ash	6.36 ± 0.02	3.85 ± 0.07	67.30 ± 0.28	29.65 ± 0.21
Rice	White	6.70 ± 0.03	7.05 ± 0.07	69.65 ± 0.35	20.90 ± 0.14
Corn	Off-white	6.80 ± 0.11	3.40 ± 0.00	69.10 ± 0.14	28.75 ± 0.35
Acetic anhydride modified starches					
Beans	Light brown	6.80 ± 0.11	3.95 ± 0.21	67.30 ± 0.28	19.80 ± 0.14
Wheat	Ash	5.70 ± 0.11	3.7 ± 0.00	65.70 ± 0.42	16.35 ± 0.35
Rice	White	5.60 ± 0.11	5.55 ± 0.07	68.75 ± 0.35	23.90 ± 0.14
Corn	Off-white	5.80 ± 0.11	4.75 ± 0.07	68.70 ± 0.42	34.50 ± 0.57

oil absorption capacity results of acid modified starches of beans, wheat, rice and corn for revealed 19.80, 29.65, 20.90 and 28.75, respectively (Table 3). Acetate modified starches possesses oil absorption capacity for beans, wheat, rice and corn (19.80, 16.35, 23.90 and 34.50), respectively. The modified wheat, rice and corn starches have higher oil absorption capacity than unmodified. Modification increases the packing of the starches thereby increasing the oil absorption capacity (Ihegwuagu et al., 2009).

CONCLUSIONS

The high-water absorption capacity of the acid modified rice starch shows that it can withstand higher temperature than unmodified rice starch, which is an advantage for its use in cooking**.** The high oil absorption capacity of the acetate modified corn starches can earn it a place in the cosmetic industries. From this finding, it shows that acid and acetate modified starches would be a better composition of talcum powder.

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