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PHYSICOCHEMICAL ANALYSIS OF STARCH EXTRACTED FROM SEEDS OF *Faidherbia albida*

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ABSTRACT

This paper examines the physicochemical properties of starch extracted from seeds of Faidherbia albida collected form different locations within Sokoto metropolis. After extraction by hot water method, the starch was subjected to physicochemical analysis. The results of the analysis showed that the starch yield was 39.2% while the starch pH was 7.2. Also, the moisture content, ash content, starch protein, starch lipid, and amylose content of the starch were 7.3%, 0.02%, 0.72%, 0.27% and 26.7% respectively. Equally, the results showed that the swelling power, solubility and extent of amylose leaching were 10.7g/g, 2.9% and 5.9% respectively. Thus, the study concludes that F. albida starch may require some modifications in order to serve as a raw material for industrial products.

Key words: Faidherbia albida, Starch, extraction, amylose

INTRODUCTION

Starch is a polysaccharide produced by all green plants as an energy store [1]. It is a carbohydrate which comprises of a large number of glucose units joined together by glycosidic bonds[2]. Gycosidic bonds are the type of covalent bonds that joined a carbohydrate sugar molecule to another group, which may or may not be carbohydrate[3]. Traditionally, starch has been extracted from staple foods such as potatoes, wheat, maize (corn), rice and cassava etc [1]. Basically, it is made up of two components: 10-25% Amylose and 75-90% Amylopectin. The Amylose consist of 250-300 D-glucopyranoside units connected by α-1,4 linkages in a linear chain. It is insoluble in water but soluble in hot water and gives a blue colour with iodine solution. The Amylopectin, is composed of 1000 or more D-glucopyranoside units connected by α-1,4 linkages in a branched chain [2]. Starch has numerous applications in both the food and non-food industry. Its uses in the food industry include: food additive, pudding, custards, salad dressing and to make noodle and pastas[4]. It is also used for the pharmaceutical industry as an excipient, as tablet disintegrant or as a binder[5]. Equally, it is used in paper making as cationic binder[4]. Other uses include: its application in laundering of clothes; in gypsum wall board as demulcent and adsorbent; in the manufacturing of anti-set off spray powder to avoid wet ink being set off; in the production of bioplastic; in making drilling fluid for petroleum extraction; in the making of dusting powder and as an antidote for iodine poisoning[2, 4, 6]. These applications notwithstanding, carbohydrate chemists have continued to develop numerous products that have greatly expanded starch use and utility [7]. This has led to high cost of starch sources such as rice, yam, cassava, maize and potatoes, hence the need for alternative sources. Researchers in Sokoto State of Nigeria have recently extracted starch with good yield and physicochemical properties from seeds of *M. indica* and *C. albidun* which are usually discarded[8, 9]. Another common plant in Sokoto State, whose seeds is usually discarded and could be explored for starch, is *Faidherbia albida.* Therefore, this research is aimed at extracting and analysing the physicochemical

properties of starch from seeds of *F. albida* in order to ascertain if it can be used as an alternative source of cheap starch for industrial applications.

MATERIALS AND METHODS

Description of the Plant

Faidherbia albida also known as Ana tree, Apple-ring Acacia or Winter Thorn is a species of *Faidherbia which is* native to Africa and the Middle East[10]. It has also been introduced to India and Pakistan[11]. The tree is thorny growing up to 6-30m tall and 2m in trunk diameter. Its deep penetrating tap root makes it highly resistant to drought. The bark is grey and fissured when old[12]; it has about 11000 seeds/1kg and it is not a threatened species [13]. It grows in areas with 250-600mm/yr of rain. All of the trees in a given grove are usually genetically identical and tend to multiply by vegetative propagation for thousands of year[14]. It serves as an important tree in the Sahel for raising bees, since it flowers provide bee forage at the close of raining season, when most other local plants do not[13]. The seed pods are important in raising livestock, and are used as camel fodder in Nigeria, and are relished by elephant, antelope, buffalo, buffoons and various browsers and grazers though strangely ignored by warthog and zebra[15]. Its wood is used for canoes, pestles, and for firewood. The wood has density of about 560kg/m^3 at a water content of 12%. The energy value of the wood as fuel is 19.741kj/kg[10]. It is also used for nitrogen fixation, erosion control for crops, for food, drink and medicine. It contains the psychoactive chemical compound dimethyltryptamine in its leaves. The extract is used to treat ocular infections in animals [12].

Collection and Preparation of Sample

Seeds of *F. albida* were collected from waste sites around Sokoto metropolis with the help of local people and identified at the Botany Unit, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto. The seeds were washed thoroughly with distilled water, dried and stored in an air-tight container before extraction of the starch. All reagents used were of analytical grade.

Analysis of Sample

Total starch content

Total starch content of the seeds was determined by first extracting soluble sugars with ethanol (95%) and the residual starch was hydrolysed with perchloric acid into monosaccharides. The sugar was colorimetrically determined with phenol-sulphuric acid by means of a UV-VIS spectrometer as described in literatures [16, 17, 18]. The total starch content obtained was used to determine the yield.

Extraction of Starch

The starch was extracted using hot water method. 100 g of seeds were soaked in 1000 cm^3 beakers in a thermostatic water bath at a constant temperature of 40 ^oC for about 24 hrs. One part of soaked seeds and three parts of distilled water were blended for 3 min at medium and high speed. The resultant slurry was passed through double layer of muslin cloth and then centrifuged at 5000 rpm for 20 min. The supernatant was discarded and the sediment resuspended in excess 0.02 % NaOH to remove any residual proteins and phenolic compounds. After standing for 4 hr the supernatant was discarded. This procedure was repeated 6-8 times until the supernatant becomes colourless. The final

sediment was suspended in distilled water and then subjected to filtration through 0.045 mm sieve, neutralized to pH 7.0, filtered on Buchner funnel and thoroughly washed with distilled water. The filtered cake was dried overnight at room temperature, ground to powder and stored in an air-tight glass bottle before further analysis[19, 20].

Amylose Content Determination

This was carried out as described in literature [8]. 5 cm^3 of 10 % w/v aqueous slurry of starch and 55 cm^3 of 0.16 M sodium hydroxide was introduced into a flask and swirled gently until the suspension clears. After 5minutes, 15 cm^3 of 5 % v/v sodium hydroxide in 0.6 M hydrochloric acid was added and mixed gently but thoroughly. The supernatant contained amylose, which was precipitated by saturating it with 1-butanol and letting it stand for a few hours. It was collected by centrifugation at 5, 000 rev. per min for 15 minutes. The precipitate was then dried in a Uniscope oven at 40 ^oC and weighed.

pH Determination

This was done by shaking 2g of the powdered material with 100ml of distilled water for 5 min and the pH of the supernatant liquid determined using a pH meter [21].

Proximate Analysis

(a). Moisture Content Determination

This was determined by drying the starch samples at 110^oC for at least 24 hours until the weight became constant [18, 22].

(b). Total Ash Determination

Ash content was estimated as the residue left after combustion of 2g of starch in a silica dish at 450 ^oC. The percentage of ash was calculated with reference to the starch[23].

(c). Starch Protein Determination

This was done by first determining nitrogen content by the standard micro-Kjeldahl method using a digestion apparatus (Kjeldatherm System KT 40) and a titration system [23]. Crude protein content was calculated as (N x 6.25).

(d). Starch Lipid Determination

This was assayed by extraction with petroleum ether in a soxhlet extractor as described in literature [18].

Gelatinization Temperature Determination

The gelatinization temperature of the starch samples was determined by making 0.29% w/v suspension of each sample in water in a 25 cm^3 beaker and heating in a thermostated water bath at 40^oC. The temperature was gradually raised by about 2^oC and samples were withdrawn and observed under a polarized microscope after each rise to ascertain the temperature at which the granules lost their polarization crosses totally [8].

Swelling Power and Solubility

Standard method was used in determining swelling power and solubility. Briefly, 0.4g of starch (dry basis) was weighed accurately in a centrifuge tube before adding 40 ml of distilled water. The slurry was heated at 0, 50, 60, 70, 80, 85 and 90^oC in a water bath for 30 min. After cooling samples to room temperature, the solution was centrifuged at

3000rpm for 15 min. The supernatant obtained was carefully removed, and the swollen starch sediment was weighed. The aliquot of supernatant was then evaporated overnight (110^{o}C) and swelling power and solubility were calculated as follows[24]:

Swelling power (g/g) = $\frac{\text{Weight of the wet sediment (g)}}{\text{Weight of the dry starch (g)}}$ .....Equation 1

Solubility (%) = $\frac{\text{Weight of dry supernatant(g)}}{\text{Weight of the dry starch (g)}}$ x 100 .....Equation 2

Extent of Amylose Leaching (AML)

This was determined using standard method. Various concentrations of starches (15-20 mg) in water were heated (0, 50-90°C) in volume-calibrated sealed tubes for 30 min. The tubes were cooled at ambient temperature and centrifuged at 2000 g for 10 min. The supematant liquid (1 cm^3) was withdrawn and its amylose content determined [25, 26].

RESULTS AND DISCUSSION

Starch Yield

The result for starch yield is presented in Table 1. It shows that the yield was 39.2%. The yield was greater than values obtained for horse gram starch (22 to 31%)[19] but less than values obtained for rye starch (42.2%)[27] and for sago, potato and corn starches, which were 93.6%, 93.4% and 86.5%, respectively[24]. It was also less than values obtained for *M. indica (70.1%)* and *C. albidun (58.3%)* starches [8, 9]. The low yield was possibly due to the composition and granular size of the starch which did not allow for easy extraction of the starch granule.

Starch pH

The result for starch pH showed that the starch had a normal pH which is in line with WHO value (6.8 – 7.2).

Proximate analysis

The results for proximate analysis showed that *F. albida* starch had low moisture, ash, lipid and protein contents (Table 1). The moisture content was less than values obtained for root, tuber and cereal crops (8 – 16.5%) [28]. The low moisture content suggests that the starch will not be prone to fungi and micro-organism infections and as such will have a long shelf life[28]. The lipid content was within the range of values obtained for rye starch (0.24 to 0.48) [22, 27]. The protein content was greater than values obtained for rye starch (0.09 to 0.47) [27] but was within the range of values obtained for root, tuber and cereal crops (0.47 to 6.58)[28]. It was however, greater than values obtained for *M. indica* and *C. albidun* starches, which was 0.06 and 0.08% respectively [8, 9]. The nitrogen content of the isolated starch represents the endosperm storage proteins, lysophospholipids and proteins located inside starch granules [19]. Thus, the results showed that the extracted starch had some protein and lysophospholipid contents, which could adversely affect the physicochemical properties of the starch and make starch extraction difficult [19, 29]. This may explain why the starch had a small yield and was off-white in colour.

Amylose Content

The amylose content was 26.7% which was higher than those reported for oat starches (22.5 to 25.2%) [26] and corn starches (16.9 to 21.3%) [30] but less than values reported for Horse Gram (34.00 to 36.30%) [19]. Also, they were within the range reported for pulse starches (11.6 to 88.0%)[31]. The amylose content of starch determines crystalinity and thus affects solubility [32], and this is very important in determining the applicability of the starch. It was however greater than values reported for *M. indica* starch [8].

Gelatinization Temperature

The results in Table 2 show that the starch had an onset temperature of 48.3^{o}C and a conclusion temperature of 62.3^{o}C, thus, showing a gelatinization range of 14.0^{o}C. This is in agreement with values reported for pulse starches[31]. The gelatinization temperature was however, less than values obtained for *M. indica* and *C. albidun* starches [8, 9]. The gelatinization property of starch is a determining factor in its functionality in food applications [33].

Swelling power of Starch

The results for swelling power are given in Figure 1. The swelling power of the starch increases as the temperature rises from 50 to 90^{o}C. There was however, no considerable increase in the swelling power between 80 to 90^{o}C. The results also show that the swelling power characteristic was less than those obtained for M. indica and *C. albidun* starches [8, 9]. This might be due to the higher amylose content. Different studies have equally shown that swelling power is well correlated to Amylose and it properties. Specifically, it has been postulated that the level of Amylose lipid complexation has a significant effect on the swelling power; as it is reduced by Amylose lipids complexes [34]. Swelling power in turn affects viscosity of starch, with low swelling power resulting into low break down of viscosity [32]. Thus, the swelling power should be given a serious consideration where starch is to be used for any application.

Solubility of Starch

Figure 1 also shows that the solubility of *F. albida* starch increases as the temperature rises from 50^{o}C, even though the increase is not as high as the swelling power. The figure equally, shows that the starch had a lower solubility when compared to starches from *M. indca* and *C. albidun* [8, 9] and purse starches [31]. This of course is due to the high amylose content of the starch. Also, the processes, such as heating and chemical treatment that lead to breakdown of starch and release of amylose into solution affect positively the solubility of starch. Whereas treatments, such as cooling that reinforce crystalline structure reduce the solubility of starch [35].

Extent of Amylose leaching

The extent of Amylose leaching for the starch is higher than values reported for pulse starch [31]; *M. indca* and *C. albidun* starches [8, 9]. This most likely is due to the higher amylose content in the starch [31].

CONCLUSION

The analyses have shown that even though some of the physicochemical properties of *F. albida* starch were comparable to values in literatures, a few of the properties still show

some variations from values obtained for *M.* indica, *C. albidun*, purses, sago, potato, corn and rye starches. Thus, the study concludes that *F. albida* starch may require some modifications in order to serve as a raw material for industrial products.

REFERENCES

1. A. M. Smith (2001).The Biosynthesis of Starch Granules. Biomacromolecles. 2(2): 335-41.
2. W. H. Brown and T. Poon, *Introduction to Organic Chemistry*, 3rd Edition, Wiley, London, 2005. Pp. 324 – 341.
3. B. Lubert; M. Jeremy; T. Stryer and L. John, *Biochemistry* (5th edition). W.H.Freeman, San Francisco, 2002. Pp. 43 – 132.
4. E. Madigan (2003). New Uses for Starch. HealthGuidance for Better Health. Retrieved on 20/1/2011 from: http://www.healthguidance.org/pages/Terms-of-Service
5. O. A. Odeku and A. Itiola (2007). Compaction Properties of Three Types of Starch. Iranian Journal of Pharmaceutical Research (IJPR), 6, (1): 17-23.
6. D. Schwartz and R. L. Whistler (2009). History and Future of Starch: Chapter 1 in BeMiller, J. and Whistler, R. (Ed). Starch: Chemistry and Technology*. (3rd ed),* Elsevier, Amsterdam. P. 5.
7. J. C. Shannon; D. L. Garwoodand C. D. Boyer (2009). Genetics and Physiology of Starch Development: Chapter 3. In BeMiller, J. and Whistler, R. (Ed). Starch: Chemistry and Technology*. (3rd ed),* Elsevier, Amsterdam. Pp. 24 – 25.
8. A. Uba; T. Izuagie; L. G. Hassan; M. Achor and D. M. Sahabi (2011a). *Isolation and Characterization of Starch from Seeds of Mangifera indica.* Nigerian Journal of Basic and Applied Science, 19 (2): 226-232
9. A. Uba; T. Izuagie; L. G. Hassan; M. Achor and D. M. Sahabi (2011b). Physicochemical Properties of Starch Isolated from Seeds of *Chrysophyllum albidun. International Journal of Chemical Sciences*, 4(2): 264 – 270.
10. G. E. Wickens (1969). A Study of *Acacia albidal Del*. (Minosoideae) Kew Bulletin, 23(2): 181-202
11. G. Edmund and C. Barrow (1996). *The Dry Land of Africa,* Local Participation in Tree Management Initiatives Publishers, Nairobi, Kenya. Pp. 11 - 142.
12. International Centre for Research in Agro Forestry (ICRAF), *the Apple Ring Agro-Forestry Today*, 1989. Pp. 11-12
13. C. Dancette and J. F. Poulian (1969). Influence of *Acacia albida* on Pedoclimate Factors and Crop Yields. Africa Soils 14(1): 143-184.
14. W. B. Van and W. P. Van, *Field Guide to Trees of Southern Africa.* Struik, 1997, Cape Town, Pp. 43 – 133.
15. M. C. Hogan, *Faidherbia albida.* Encyclopedia of Life, 2010, Pp. 1-18.
16. M. N. Duboise; K. A. Gruillies; J. K. Hamilton; P. A. Rogers and F. Smith (1956). Colorimetric Method for Determination of Sugars and Related Substances. Anal Chem 28 : 350-6.
17. K. Kalenga; L. F. Hood and P. J. Vansoest (1981). Characterisation of Starch and Fiber of Banana Fruit. J Food Sci. 46: 1885-90.
18. I. E. Ezeagu; C. C. Metges; J. Proll; K. J. Petzke and A. O. Akinsoyinu (2011). Chemical Composition and Nutritive Value of Some Wild-Gathered Tropical Plant Seeds. Retrieved on February 3 from: http//:www.chemcomandnutrient.

19. U. D. Chavan; B. G. Shinde; S. S. Kadam and A. Amarowicz (2010). Isolation and Characterization of Starch from Horse Gram. African Journal of Food Science and Technology, 1(3), 64-67.
20. B. N. Kevate; U. D. Chavan; S. S. Kadam; J. K. Chavan & R. Amarowicz (2010); Isolation and Characterization of Starch from Moth Bean. African Journal of Food Science and Technology, 1(3), 68-70.
21. G. Barry (2007). Isolation of Amylose and Amylopectin from Starch. (cited from: Method in Carbohydrate Chemistry, Vol. IV, Pp. 25 – 27).
22. H. C. Lee; A. K. Htoon and J. L. Paterson (2007). Alkaline Extraction of Starch from Australian Lentil Cultivars: Matilda and Digger Optimised for Starch Yield and Starch and Protein Quality. Food Chemistry, 102, 551–559.
23. AOAC (1990). Association of Official Analytical Chemists. Official Methods of Analysis. 12th ed. Washington, DC.
24. M. Z. N. Nadiha; A. Fazilah; R. Bhat and K. A. Karim (2010). Comparative Susceptibilities of Sago, Potato and Corn Starches to Alkali Treatment. Food Chemistry, (121), 1053–1059.
25. J. Chrastil (1987). Improved Calorimetric Determination of Amylose in Starches of Flours. Carbohydrate Research, 159: 154-158.
26. R. Hoover and S. P. J. N. Senanayake (1996). Composition and Physiochemical Properties of Oat Starch. Food Research International, 29 (1), 15–26.
27. T. Verwimp.; G. E. Vandeputte; K. Marrant and J. A. Delcour (2004). Isolation and Characterisation of Rye Starch. Journal of Cereal Science. 39, 85 – 90.
28. E. Nuwamanya.; Y. Baguma; E. Wembabazi and P. Rubaihayo (2011). A Comparative Study of the Physicochemical Properties of Starches from Root, Tuber and Cereal Crops. African Journal of Biotechnology. 10(56):12018-12030
29. R. F. Tester and W. R. Morrison (1990). Swelling and Gelatinization of Cereal Starches. Effect of Amylopectin, Amylose and Lipids. Cereal Chemistry. 67, 551 – 557.
30. K. S. Sandhu and N. Singh (2007). Some Properties of Corn Starches II: Physicochemical, Gelatinization, Retrogradation, Pasting and Gel Textural Properties. Food Chemistry. 101, 1499–1507
31. R. Hoover; T. Hughes; H. J. Chung and Q. Liu (2010). Composition, Molecular Structure, Properties, and Modification of Pulse Starches: A review. Food Research International. 43, 399–413.
32. Y. Yuan; L. Zhang; Y. Dai and J. Yu (2007). Physicochemical Properties of Starch obtained from *Dioscorea nipponica* Makino Comparison with Other Tuber Starches. Journal of Food Engineering. 82, 436 – 442.
33. J. D. Evans and D. R. Haismann (1982). The Effect of Solutes on the Gelatinization Temperature of Potato Starch. Starch/Staerke, 34, 224–231.
34. M. Zuluaja; Y. Baena; C. Mora; D. Ponce and L. Leon (2007). Physicochemical Characteristics and Application of Yam (*Discora caynsis-roundata)* Starch as a Pharmaceutical Excipient, Starch/Starke. 59: 307- 317.
35. A. Jyothi.; K. Kiran, K; Wilson, B.; Nwoththy, S. and Nambisan, B. (2007). Wet Storage of Cassava Starch: Use of Sodium Metabisulphite and Acetic Acid and their effect on starch properties, Starch/Starke 59:141-148.

Table 1: Physi-cochemical properties of *F. albida* starch

Parameter	Composition
Starch Yield (%)	39.2
Ph	7.2
Moisture content (%)	7.3
Ash content (%)	0.02
Starch protein (%)	0.72
Starch lipid (%)	0.27
Amylose content	26.7
Appearance	Off-White

Data were reported in means ± SD (n = 3)

Table 2: Gelatinization parameter of *F. albida* starch

Parameter	*F. albida* Starch
T_o(°C)	48.3±0.4
T_c(°C)	62.3±0.2
$T_c - T_o$(°C)	14.0 ± 0.3

Data were reported in means ± SD (n = 3)

Where T_o = onset Temperature, T_c = conclusion temperature and $T_c - T_o$= temperature range

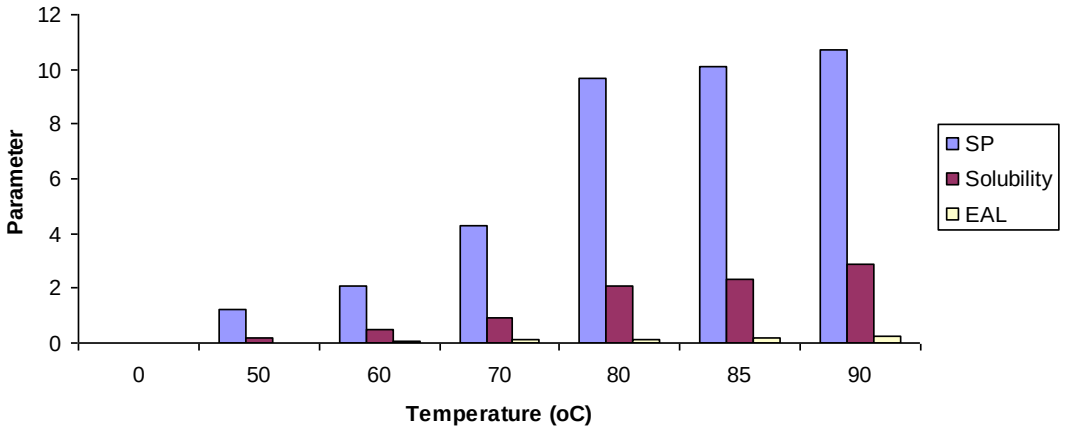

Fig. 2: SP, S and EAL of *F. albida* Starch over the ange of 50 to 90°C

Key: SP = Swelling Power, S = Solubility and EAL = Extent of Amylose Leaching