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Research Article

Isolation and Characterization of *Digitaria exilis* Seed Starch as Raw Material for Noodles Making

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ABSTRACT

Digitaria exilis (Fonio) seed starch was isolated using wet milling process with a yield of 35.8% on dry weight basis. A pale white starch obtained was dried and selected and physicochemical properties were determined. The following results were obtained; granule sizes 0.003-0.005, 0.007-0.009, and 0.013-0.016 mm for small, medium and large respectively. The granules were comparable to other cereal types with a high amylose content of 25.41%, so it could be classed as a non-waxy starch. Mean specific gravity was 1.05, ash 0.2% and moisture contents 4.48%. Paste stability was 4.5 h, adhesive strength 3.21 KN/m^2, clarity 1·0 and line-spread 7·48 at 50^{o}C. Noodles from the starch were prepared and the quality assessed. Tensile strength was 17.5 KN/m^2 and there was a negligible solid loss during cooking. Also the tensile strength of yarns sized with the starch was 83·48 KN/m^2 and was compared with textile-sizing solution formulated with cassava starch and industrial yarn. Solutions showed fairly good adhesive strength and line-spread. The qualities of the starch noodles and the sized yarns are comparable to standards. The Fonio grain starch can be employed industrially for noodle production and as textile sizing solution.

Key words: Fonio, *Digitaria exilis*, Seed starch, Starch properties, Noodles textile yarns

INTRODUCTION

Fonio (*Digitaria exilis*, Stapt) commonly called 'acha' in Hausa tribe of Nigeria belongs to the grass family, Gramineae (Dutta, 1995). It originated from Africa and probably one of the oldest grains in Africa (Musa *et al.,* 2008). It grows well as a cereal grain throughout the savanna zones of West Africa including Nigeria. *Digitaria exilis (D. exilis)* gives abundant yield of grains as it grows in both fertile and infertile soil. It thrives well in sandy and rocky soil of the Sahel and survives in drought and flood where other plants fail to thrive. It grows so fast and can be harvested two or three times in one season.

Fonio is one of the staple foods in some parts of Nigeria and across fifteen North West African countries (Jideani, 1999; Musa *et al.,* 2008). The dehusked Fonio grain is known to be rich in carbohydrates particularly starch (Morales, 2003). It also contains some essential elements that are good in body building such as protein, magnesium, zinc, manganese and sulphur (Jideani, 1999).

Starch finds domestic applications in the production of different dishes. They can be used for baking breads, cakes and different other snacks. Starch is also used in the production of noodles, a traditional food in China (Wheatley *et al*., 1997; Lii and Chang, 1981,; Umerie and Ezeuzo, 2000) which is now consumed in other parts of the World, including Nigeria.

In Latin America, naturally sour cassava starch is used for the preparation of traditional cheese breads (Zakhia *et al*., 1996). The largest part of the world starch is used in the food industry while the rest finds applications in chemical, paper and textile industries (Shewry *et al*., 1987; Umerie and Ezeuzo, 2000). Utilization of starch in other industries will depend on availability of starch with desired qualities such as uniform granular size and proportions of amylose and amylopectin (Shewry *et al*., 1987; Umerie and Ezeuzo, 2000).

Due to the abundance of the Fonio grains, this study looks into the isolation and characterization of its starch and its suitability for various applications including textile sizing and noodles preparations.

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MATERIALS AND METHODS

Samples of Fonio (*Digitaria exilis)* grains, sized and unsized yarns

Dried Fonio grains were purchased from a local market in Awka, Anambra State of Nigeria. The grains were sorted and cleaned to rid them of shafts, sand and stones. Unsized and sized yarns were donated by ASABATEX, Asaba, Delta State, Nigeria.

Isolation of fonio starch

Starch was extracted from the grains using the method of Moorthy *et al* (1994) as reported by (Umeria and Ezeuzo, 2000). One hundred gram of the grains was weighed and steeped in 1 liter on water containing 0·813 g of Potassium metabisulphite solution at 30±1ºC for 48 h. The grains were then removed from the steeping water and milled using a Moulinex Type electric 276 mill to slurry. The slurry was suspended in 0·03 M ammonia solution, stirred and allowed to stand for 5 minutes. Afterwards the crude starch was passed through a 100-mesh sieve cloth for coarse sieving. The suspension was allowed too stand for another 6 h and the supernatant decanted. The remaining impure starch sediment was resuspended in ammonia solution stirred and allowed to stand for another 12 h. The supernatant was decanted and the starch solution passed through a 200- mesh sieve cloth for fine sieving. The suspension was allowed to settle for 8 h, excess solution decanted and the resulting starch solution slurried in 200ml of pure water and allowed to sediment twice. The recovered starch was dried for 24 h in a tray in an oven set at 40 ºC. The starch was crushed manually and oven dried again at 50 ºC for 3 h. The process was repeated to obtain a good quantity of the crude starch.

Starch solution preparation

The method of Campbell *et al*.,(1979) as used by Umerie *et al*., (1999) was used to prepare the starch solutions. Suspensions containing 2 % and 5% starch were separately heated slowly with constant stirring to 97 ºC and held at that temperature for 15 min.

Characterization of the starch

Amylose content of the starch was determined using the method of Chrastil (1987) while the specific gravity was by the method of Moss (1980). Granule size of the isolated starch was checked using iodine-stained suspensions of the granules under an optical microscope at 100x magnification using a Neubauer counting chamber. Moisture and ash contents were determined by the method of AOAC (2000). Clarity of the starch and paste stability was checked on 2% starch solution and adhesive strength and gelatinizing temperature of the 5% starch solution using the method of Moorthy *et al*., (1994) as reported by Umerie and Ezeuzo, (2000). The method of Umerie and Ezeuzo, (2000) was also used to determine the soluble extracts. The method of Campbell *et al*., (1979) was used to determine the consistency of the starch. The line spread test in terms of the distance they spread on a flat surface in a given time was performed for the time-scale of 2 minutes. Viscosity of the 2% starch solution was evaluated using the Haake (Hoppler-type) falling – ball viscometer at 20ºC (Umerie and Ezeuzo, 2000).

Formulation of the sizing solution and the sizing yarns

The sizing solution was prepared using 5 % of the starch solution produced. Calculated amount of binder (Top Bond brand) and vegetable oil (0·9% olive oil), which acts as a softner to soften the yarns and make them absorb the starch, were added and stirred until a smooth gel was obtained ((Umerie and Ezeuzo, 2000). Cassava starch-sizing solution was also prepared in the same manner. The industrial unsized yarns were dipped into the different starch solutions (*Digitaria exilis* and cassava starch) for 30 sec and excess starch wiped-off. They were air dried and then oven dried at 70ºC for 10 min after which they were packed in clean sterile dry polythene bags and kept.

Preparation of the noodle

The method of Lii and Chang (1981) was modified and used in the preparation of the noodles. The starch solution (9 %) was mixed with 5% gelatinized starch and stirred to form dough with smooth consistency. The dough was introduced into a 10 ml syringe and extruded directly into a water bath set at 90ºC for 20 sec. the hot water was decanted immediately and the noodles cooled with cold water for 5 min. The noodles were frozen over night, allowed to thaw and cooled with cold water for 2 h. They were air-dried for 3 h and oven-dried at 45 ºC for another 2 h. The dried noodles were also packed in clean polythene bag and stored.

Analysis of the noodles and the sized yarns

Tensile strength of the noodles: The noodles were cooked in boiling de-ionized water and removed after 5 and 10 min and cooled at room temperature. The tensile strength of the noodles and the yarns were checked using the method of Lii and Chang (1981) as described by Umerie and Ezeuzo (2000).

Solid loss during cooking: The method of Lii and Chang (1981) was used to determine the solid loss during cooking after cooking the noodles for 30 min.

Strength of yarns: The tensile strength of the yarns of the sized yarns (ASABATEX) and unsized yarns were determined using the method of (Umerie and Ezeuzo, 2000).

RESULTS AND DISCUSSION

The isolation of the *Digitaria exilis* starch was easy. Settling was not disturbed by the presence of no-starch materials which remained suspended and were easily decanted off as also reported by Meyer (1982). The 24 h standing of the starch milk after coarse sieving was advantageous as it afforded the lactic acid bacteria enough time to utilize the sugars present in the grains and corroborates the findings of Trease and Evans (2000). After the decantation and sieving procedures which removed the non starch materials, a pale white coloured starch that was substantially pure was obtained.

Table 1 shows the yield and physicochemical properties of the *Digitaria exilis* starch. Table 2 compares the colloidal properties of *D. exilis* starch to that of cassava and corn starches. Table 3 presents the cooking properties and solid loss of the produced noodles and noodle bought from the market while Table 4 compares the tensile strength of the sized and warps yarns.

From the results obtained *D. exilis* grains yielded a pale white starch with a low ash value indicating to a greater extent that the starch is of a fine purity grade. This was in conformity with the findings of Musa *et al*., (2008) who extracted the grain starch and used it as a Paracetamol binder. The moisture content value was low showing that the starch can be stored for a longer time hence a long shelf life. The amylose content appeared to be in the upper boundary of the range (15 – 31 %) given for other grain starches (Parmeter, 1969; Umerie and Ezeuzo, 2000). This showed that the starch can easily form complexes. The starch granules of *D. exilis* were teragonal in shape and occurred in three classes of small, medium and large. The range of the granule sizes fall within the range recorded for cereal grains (3-30µm) (Umerie and Ezeuzo, 2000; Musa *et al*., 2008). The small and medium sized granules have a higher predominance than larger ones.

The colloidal properties of *D. exilis* starch compared well with other popular starch samples. The starch solution appeared cloudy, more fluidly and jellies-like in texture, typical of cereal-type starches. The paste stability of the starch was less than that of corn starch but their gelatinization/ pasting temperatures were somewhat similar. Line-spread value was higher than that of corn and cassava starches indicating that the starch can be suitable for baking and brewing purposes (Parmeter, 1969).

Digitaria exilis starch noodles, after cooking under different temperatures, had tensile strength comparable with a commercial brand. Hence, Fonio starch can be seen as one suitable for noodle production since it has a little or no solid loss during cooking and its tensile strength lessens gradually. The *D. exilis* starch can also be used in sizing of textile yarns since its sizing solution showed an appreciable yarn sizing effect indicating a good interaction between the yarn fibres and the starch (Umerie and Ezeuzo, 2000). The tensile strength values when compared with cassava starch and industrial grade sized yarns, it was seen that the values almost tallied with that of the industrial grade while cassava starch has the highest value. *Digitaria exilis* starch sized yarn together with its high tensile strength can make a strong associative interaction between the yarn fibers and the starch. This starch also had a higher adhesive strength when compared with other plant starches like corn and tuber, showing that the starch had a good bonding capacity and can be used in adhesive formulation.

Table 1: Yield and physicochemical properties of the *Digitaria exilis* starch

Parameters	Observations
Color	Pale white
Shape	Teragonal (12 sides)
Yield (%)	35·8
Granular size (mm):	
Small	0·003 - 0·005
Medium	0·007 - 0·009
Large	0·013 - 0·016
Mean specific gravity	1·50
Moisture content (%)	4·84
Ash content (%)	0·2
Amylose content (%)	25·41

NB: All values are mean of two replicates.

Table 2: Comparison of the colloidal properties of *D. exilis* starch and other plant starch

Colloidal properties	*D. exilis* starch	Cassava starch	Corn starch
Clarity	1·00	0·17	1·17
Adhesive strength (KN/M^2)	3·21	2.53	3·11
Pasting temperature ºC	65 – 70	68 – 78	62 - 72
Line spread test (cm)	7·48	7·15	5·90
Paste stability (hrs)	4·5	6·5	5·0
Viscosity	4·77	-	-

Table 3: Comparison of the tensile strength of the *D. exilis* Starch noodles with noodles purchased from the market during cooking

Cooking time (mins)	Tensile Strength (KN/m^2)			
	D. exilis noodles	Solid loss (%)	Commercial noodles	Solid loss (%)
3	77·92	-	80·03	-
5	53·99	-	60·00	-
10	17·5	16·0	19·02	18·0

Table 4: Comparison of the tensile strength of the sized and unsized yarns

Types of Yarn (5 %)	Tensile strength (KN/m^2)
D· exilis sized yarn	83·48
Cassava sized yarn	111·29
ASABATEX sized yarn	79·66
Unsized yarn	16·63

Conclusion

Digitaria exilis (Fonio) grains is found to be a good source of starch that can be used in industrial production of different materials such as noodles, adhesives and as an industrial starch for sizing yarns. It is recommended that the starch be isolated in large scale to replace imported starch and be introduced even for baking and brewing.

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