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Morphological, structural and Physico-chemical properties of starch extracted from Banana pseudo stem: A Novel Starch

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Abstract: The objective of the current study is to separate the starch from banana pseudostem of kokan local variety Velachi and characterize the isolated starch in order to investigate their functional qualities, granule morphology, crystalline pattern, amylose content and physical as well as chemical compositions. For characterization, a variety of methods were employed, including scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FT-IR). The amylose concentration of the banana pseudo-stem starch was determined to be 11.94 g/100g. According to SEM measurements, banana pseudo-stem starch had smooth surfaces and uniform, elongated, circular ridges between 15 to 65 µm in length. According to the data gathered from this study, the kokan local banana pseudo-stem isolated starch has a variety of applications, particularly in the food, drug, and cosmetics industries where they can be utilized as thickeners, edible coatings, fat substitutes, and other similar applications. Additionally, functional foods containing banana starch may be suggested for those with diabetes.

Keywords: Banana, Pseudo-stem, starch, food, amylose

Introduction:

The banana (*Musa paradisiaca* L.) is one of the important tropical fruit crops. India ranks second in banana production in the world, occupying about 3, 25858 ha. area under cultivation (Anonymous, 1992). The majority of the solid ingredients in grains and tubers are starch, which is found in nature as food that has been stored in the tissues of higher plants. Throughout the world, food grains, tubers and roots and sago are frequently utilized as raw materials for the production of starch. The interior soft core of banana is eaten as a cooked vegetable, and the stems are used to make fiber ropes and low-quality paper to some extent, but no significant industrial use for the stem has yet to be documented. The production of starch in this country has greatly decreased. Because there is a potential market for starch in the country, the novel starch - banana pseudo stem starch can be utilized advantageously to execute starch production.

When the plant reaches its maximum height, the lower portion of the midrib undergoes alteration, causing the tightly packed leaf sheaths that make up the pseudostem of a banana to thicken. It began at the onset of the reproductive organs formation. A delicate core that resembles a tube is located in the center of the pseudostem (Figure 1) with a diameter of roughly 5–6 cm.

Figure 1: Cross section of Banana Pseudo-stem

Raw material commonly used for the manufacture of starch in different parts of worlds is: food grain (maize, wheat, jowar) tubers and roots (potato, sweet potato, tapioca) and sago. In countries suffering from shortage of food, the availability of these materials for starch manufacture is limited. The starch is present in the form of granules and can be demonstrated by pouring iodine solution over the cut stem. Banana stem is used to some extent in the preparation of fibre ropes and cheap quality paper, and the inner soft core is consumed as a cooked vegetable, but no important industrial use of the stem has so far been reported. The production of starch in this country has greatly decreased. Thus, the new starch, *viz.:* Banana stem starch can be used with advantages for implementing the production of starch in this country for which there is potential demand.

After harvesting the fruit, the felled plant is generally allowed to rot in the field. The stem is used to some extent in the preparation of fibre ropes and cheap quality paper, and the inner soft core is consumed as a cooked vegetable, but no important industrial use of the stem

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has so far been reported. The estimated output capacity of all the starch factories located in the country is about 73,000 tons per annum, but it is reported that these factories could hardly produce 1350 tons in 1947 and 3599 tons in 1998. This was because of the irregular supplies of maize, which occurred due to food shortage in the country and also its poor quality of as obtained by the manufactures. As a result, in comparison to the real demand, the production has been extremely low. This has led to the enormous increase in the imports of starch from foreign source from 1946- 47 onwards. According to figures available in seaborne trade for the year 1948-49, total quantity import of all starches amounted to about 8,76,000 cwts i.e. about 43,800 tons (Gholap *et .al.*, 2011).

Though several researches are available where isolation of starch from banana and their functional properties were investigated but there is very few reports are available on isolation of starch from banana pseudo-stem starch and their potential use. Therefore, the present investigation is aimed to accomplish isolation of starch from banana pseudo-stem from Konkan variety 'Velachi' and to characterize isolated starch with their physico-chemical and micro-structural properties.

Material and Methods:

Sample Collection: Locally cultivated banana pseudo-stems were collected from Konkan region of Maharashtra.

Preparation of a sample: Banana Pseudo-stems with higher initial moisture content were selected. The whole pseudo-stem was cut into longitudinal pieces, which is suitable for crushing.

METHODS:

Starch Isolation: Starch was isolated from pseudo-stem of banana following the simple method. The Fresh banana pseudo-stems cut into pieces and these pieces were crushed into sugarcane crusher in presence of water. After crushing, liquid containing starch was obtained. It was kept for sedimentation for 10 hrs. Starch was allowed to settle at the bottom then upper liquid was removed and starch was separated. Starch granules were allowed to repeat washing of 70% ethanol to attain maximum purity. After evaporation drying to form starch powder.

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ESTIMATION OD STARCH:

The extracted starch content was estimated by the method of Benesi *et al.,* (2004). The estimated starch was measured as follows:

Starch content = Weight of isolated starch / Weight of dry powder × 100

CONFIRMATION OF STARCH:

Starch- I_2KI Test: Isolated starch was confirmed by potassium iodide (I_2KI) test, which is given by Daniel (1954). 1g starch sample was mixed with 5 ml of distilled water in a test tube. The mixture was heated in boiling water bath for 2-3 min. After heating, it was cooled and settles the starch powder for 6-8 hours. Neutralized the solution with 0.1% HCL drop by drop and then phenolphthalein indicator was added one drop extra. The solution was mixed properly and then 0.2% I_2KI solution was added drop by drop until the blue colour develops.

Fourier transform infrared spectroscopy (FT-IR) Study:

In order to determine the structure of both the starches, the FT-IR spectra were obtained using FT-IR (ALPHA, Bruker, Germany). The spectra were recorded in transmission mode from 5,000 to 400 cm^{-1}.

GRANULE MORPHOLOGY:

Photomicrography: Photomicrography of each starch was done by using compound microscope (10X & 40 X).

Scanning Electron Microscopy (SEM):

SEM analysis was done by using JEOL JSM-6360A Analytical Scanning Electron Microscope**.** A starch sample was mounted on a scanning electron microscope stub with a double-sided adhesive tape, and coated with gold by using an EDT-2000 ion sputter (2×10^{-4} MPa, 25 mA) for 30 s. Then, the coated samples were put into the SEM chamber and scanning electron micrographs were taken at 500 × magnifications with the signal electron type of SE1 and an accelerating voltage of 10 kV.

Physico-chemical properties of starch:

Starch sample was analysed for their physic-chemical properties (moisture, ash, protein, fat and fibre content) by Official Analytical Chemist (AOAC, 2005) standard procedures. A micro-Kjeldahl method was used to determine the crude protein contents.

Analysis of amylose and amylopectin:

A 40 mg mangrove flour was put in a tube, and then 1.0 ml 95 % ethanol and 9 ml 1 N NaOH were added. The next step was to heat the solution in a water bath at 100 ^{o}C for 10 min and cool it down for 1 h. The solution was diluted with distilled water to 100 ml. About 5 ml of the solution was placed into a 100 ml volumetric flask containing 60 ml of distilled water, then added with 1.0 ml of 1 N acetic acid and 2.0 ml of 2 % iodine solution, respectively. The final volume was shaken and allowed to stand for 20 min, and the absorbance was monitored using a spectrophotometer at a wavelength of 625 nm (Apriyantono *et al.*, 1989). Amylopectin content was obtained as follows:

Amylopectin content = Starch content - Amylose content

RESULTS AND DISCUSSIONS:

The starch obtained from banana pseudo-stem was white, crystalline, non-hygroscopic powder and a yield of about 36.96%, which is considered to be appreciable. Isolated starch was further confirmed by I_2KI test and microphotography (Fig. 2). The intrinsic quality of botanical starch is its granule microstructure, which is frequently the fundamental element influencing its physicochemical and functional characteristics.

A **B**

Figure 2: A- Isolated banana pseudo stem starch, B- Starch-I_2KI

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FOURIER TRANSFORM INFRARED (FT-IR) SPECTROSCOPIC ANALYSIS:

Fourier transform infrared (FT-IR) offers quantitative and qualitative analysis for organic and inorganic samples. FT-IR identifies chemical bonds in a molecule by producing an infrared absorption spectrum (Chavan & Patil, 2019). The FT-IR spectrum for isolated starch was shown in figure 4. The information obtained from this technique is related to the short-range order in the starch molecule (Sevenou *et al.*, 2002)

The infrared (IR) spectrum of starch samples was described by seven main modes, with maximum absorbance peaks near 3,500, 3000, 1,600, 1,400, 1,000, 800 and 500 cm^{-1} (Koksel *et al.*, 2008; Sitohy *et al.*, 2000). In present investigation, FT-IR spectra showed similar pattern for the isolated starch, with seven main modes with maximum absorbance peaks near to 3,500, 3000, 1,600, 1,400, 1,000, 800 and 500 cm^{-1}(Fig. 3). The study was confirmed the observed spectra by FT-IR spectroscopy of starch sample. The peaks at 3389.77 cm^{-1}, 2925.67 cm^{-1} in starch of *H. littoralis* could be attributed to O-H and C-H bond stretching. The ratio between the absorbance obtained at a wavenumber of 1022 cm^{-1}, related to the amorphous component (Van *et al.*, 1995) and that obtained at 1016.60 cm^{-1} related to the ordered component (Smits *et al.*, 1998). The characteristic angular O-H bending vibration was found in the range of 1639.70 cm^{-1}. The band at 1,080 cm^{-1} in isolated starch was associated with the amorphous structures of starch. The bands at 928~8 cm^{-1} were attributed to D-glucopyranosyl ring vibrational modes and 766 ± 10 cm^{-1} were attributed to D-glucopyranosyl ring stretching. The isolated starch was slightly less ordered in the external region of the granule.

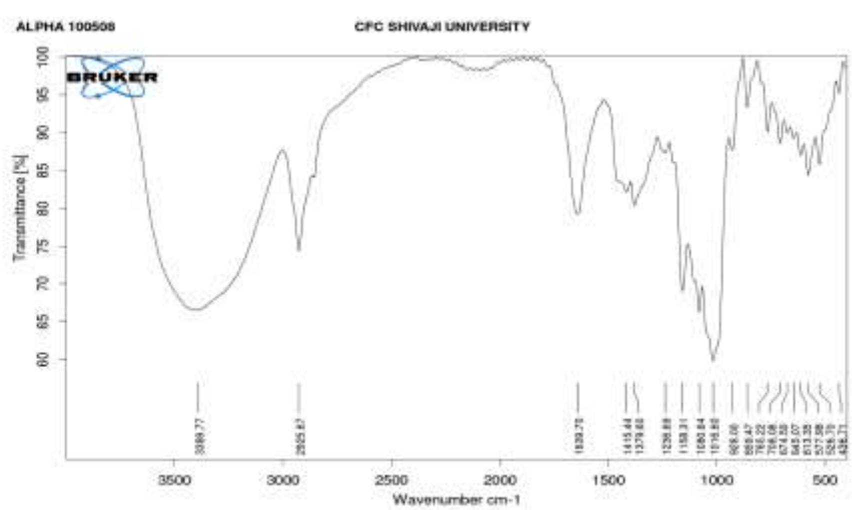

Figure 3: FT-IR Spectra of Banana Pseudo-stem Starch

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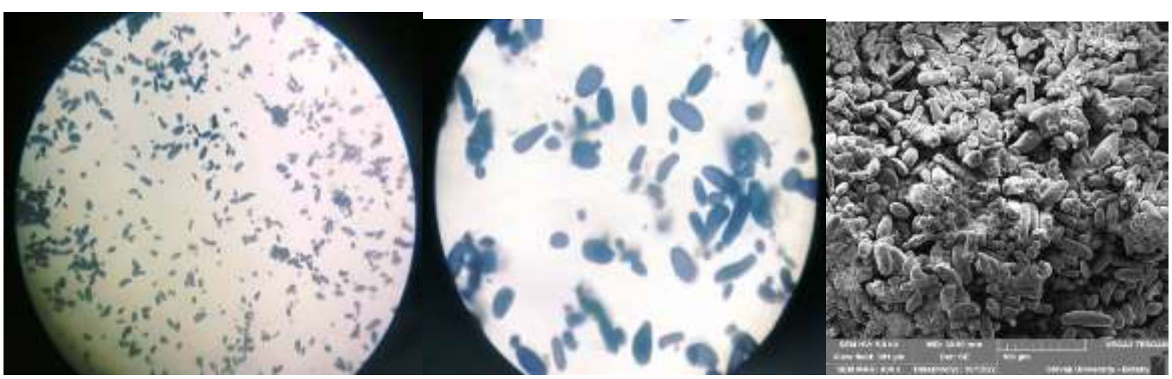
Granule Morphology:

Generally, banana starch granules from various banana varieties are irregular, elongated, and round/spheroidal in shape (Pelissari *et .al*, 2012). Variety affects the granule shape of banana starch (Marta *et .al,* 2016). Furthermore, the elongated shape is mainly found in the granules of Kapas cultivars, while the round shape is mostly found in the granules of Kepok, Ambon, and Nangka cultivars (Marta *et .al*, 2022). For present study, granule size was expressed as average length for oval and elongated shape of starch granules. The granule size of banana starch depends on the cultivar and the ripening state (Chávez-Salazar *et al.*, 2017). Based on the results of analysis using SEM, the size of starch granules from banana pseudo-stem starch average length of starch granules of was in between 15-65µm which showed small to medium granules. SEM analysis was performed to determine the granule shape and shown in Fig. 4 (C). The magnification was used 450X to 500X. Starch granules of banana pseudo-stem were found in regular elongated with smooth surface. The results showed that granules were larger in size and shape. Previous studies reported that starch granule size has been affecting the physico-chemical properties of starch. The granule size of banana starch is larger than other starch, such as breadfruit starch (<10 µm) (Tan *et .al,* 2017), wheat starch (2–20 µm) (Wei *et .al*, 2017) and sorghum starch (4–35 µm) (Zhu, 2014).



A B C

Figure 4: Granule morphology of banana pseudo-stem starch A) Starch granules at 10X B) Starch granules at 40X C) SEM image of starch granules

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Physico-chemical Properties of banana pseudo-stem starch:

The chemical composition of starch extracted from banana pseudo stem is represented in Table 1. Starch extracted from banana pseudo-stem has 6.96% moisture content and 1.02% ash. It also contains 1.26% and 0.37% lipid and protein, respectively. The crude fiber content of banana pseudo-stem starch was found 2.47% .

Variety	Moisture (%)	Ash (%)	Lipid (%)	Protein (%)	Fiber (%)
Musa Var. Velachi Pseudo-stem starch	6.96	1.02	1.26	0.37	2.47

Table 1: Physico-chemical properties of isolated starch

Variety	Amylose (g/100g)	Amylopectin (g/100g)	Starch (%)
Musa Var. Velachi Pseudo-stem starch	11.94	25.02	36.96

Table 2: Amylose and amylopection analysis of isolated starch

Forming a gel will be more challenging the higher the amylose level. Due to the fact that, the amorphous structure that forms will raise the temperature during gelatinization, slowing down the process. Since, the amorphous structure that forms will raise the temperature during gelatinization, gelatinization process will run slowly.

CONCLUSION:

The isolated starch of banana pseudo-stem had oval to elongated shaped and large sized granules showed prominent structure showed in light as well as scanning electron microscopy, indicating that the isolation procedure yielded intact granules. Isolated starch contained similar amount of short-range order which could influence on some other physico-chemical properties.

The results obtained in structural characterization provide information about the possible behaviour of the starch when being used in certain applications. The physico-chemical properties of the starch indicate their potential applications as thickener, stabilizer, emulsifier, and de-foaming agent in the food (confectionery, sauces, edible films, etc.), pharmaceutical (excipient, tablet/capsule disintegrant, binder, etc.).

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