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Original Article

MANGO STARCH: ITS USE AND FUTURE PROSPECTS

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ABSTRACT

Mango (*Mangifera indica* L.) is tropical fruit with high nutritional value. The aim of present work was to isolate the starch from black variety of mango and evaluate the physicochemical as well as functional properties. Starch is widely used in the food and pharmaceutical industries for various applications. These industries depend on crops that are also the traditional sources of food resulting high demands with consequence economic implications. The results showed that the moisture content (14.93%) was higher while ash content (0.12%) was low. Amylose content was 35.06%. It was observed that the onset gelatinization temperature of the starch ranged from 50°C whereas, the conclusion gelatinization temperature was from 91-92.5°C. The starch show adequate properties and could be alternative source for the production of industrial products that may require starch.

Keywords: Mango (*Mangifera indica* L.), 'Kala amba' or 'Black mango'.

INTRODUCTION

Mango belongs to family Anacardiaceae. It is one of the most favoured commercially valuable fruit growing throughout the tropics and used in variety of food products. Starch is predominant food reserve substance in plants. It is greatly in abundance and is readily converted into useful chemicals and products (Madigan, 2003). Thus, it finds various applications in many industries. Mango starches have not been extensively studied. Kaur *et .al*, 2007 studied starch isolated from mango kernels (seeds) from five varieties and they reported the physicochemical and morphological properties. Extensive research has been conducted on the structure and functional properties of the main starches of commerce, such as wheat, corn, potato, and rice, due to their ready availability and their extensive utilization in food and non-food applications (Singh, Singh, Kaur, Sodhi, & Gill, 2003).

Among fruits, mango occupies top position in India, covering an area of roughly 1.28 million hectares (Srivastva, 1998). India is the largest producer of mangoes in the world (11,500,000 Mt; FAO, 2002), the total world production being 25,760,848 Mt (FAO, 2002). For present study the variety 'Black mango' is selected for starch isolation and characterization.

Starch, as a renewable and biodegradable natural resource, is an important polysaccharide reserved in higher plants. Up to now, the conventional starches from corn, rice, potato, wheat, and their derivatives have not been sufficient to satisfy people' demands, with the developments of society and technology (Kaur, Singh, Sandhu, Guraya, 2004). Therefore, identification of new starch source with novel properties is of great importance, in order to select the most adequate starch for specific application.

Material and Methods

Collection & preparation of plant material

The variety of mango locally called 'Kala amba' or 'Black mango' were collected from Sindhudurg district of West Coast of Maharashtra. The unripe mature mangoes of same size were selected, peel off and pulp was collected. The pulp was dried and ground to a fine powder. Powder was used for starch isolation.

Methods

Starch isolation

Starch was extracted using the method of Badenhuizen (1964). Unripe green mangoes were peeled off and pulp was obtained and with distilled water grind by using blender. The homogenate was consecutively sieved and again washed in distilled water. The mixture keeps overnight for sedimentation. Discard the supernatant and crude starch was repeatedly washed with 70% ethanol. Starch powder was dried and stored at room temperature.

Physicochemical properties of starch

Moisture content (%)

Moisture content was determined by the AOAC (1990).5g of starch sample was weighed in pre-weighed crucible (W_1). The sample was dried for 24 hours at 105°C, cooled in desiccators and weighed (W_2). Moisture content was calculated using following equation. Average of three trials was taken.

Moisture content (%) =100 - W_2/W_1 X 100

Ash content (%)

Ash content was determined by the AOAC (1990). 5 g of starch sample was weighed accurately in the pre-weighed crucible (W_1). The crucible is heated in a furnace at 900°C for 5 hours. Cooled in desiccators and weighed (W_2). Ash content was calculated using following equation. Average of three trials was taken.

Ash content (%) =W_2/W_1 X 100

pH

The method reported by Benesi *et al.* (2004) was used for pH determination. Approximately 5 g of starch sample was added to 20 ml of distilled water in a beaker. The contents were stirred for 5 min. Starch was allowed to settle and the pH of the water phase was measured using a calibrated pH meter.

Amylose content (%)

Amylose content of the isolated starch was determined by using the method of Williams, Kuzina and Hlynka (1990). A starch sample (20mg) was taken and 10ml of 0.5N KOH was added to it. The suspension was thoroughly mixed. Then the sample was transferred to 100ml volumetric flask and makes the final volume to the mark with distilled water. 10ml of test starch solution was pipette out into 50ml volumetric flask and 5ml of 0.1N HCl was added followed by 0.5ml of iodine reagent. The volume was diluted to 50ml and the absorbance (A) was measured at 625 nm.

Amylose content (%) = (85.24 x A) - 13.19

Amylopectin (%) = 100 - % Amylose

Foaming capacity (%)

Foaming capacity was determined by the method of Onwuka (2005). 2g of starch sample homogenized in 100 ml distilled water by using vortex mixer for 5 min. The homogenate was poured into 250 ml of measuring cylinder and the volume occupied after 30 s was noted. The foam capacity was expressed as the percent increase in volume. The mean of three replicate determinations is presented.

Paste Clarity

Paste clarity was determined by Nand, Charan, Rohindra and Khurma (2008). Starch samples were suspended in distilled water to yield 1% (w/v) slurries in screwcap tubes. pH of the slurries were adjusted to 2, 4, 6, 8, 10 and 12 by the addition of 0.1M HCl or NaOH as required. The tubes were then heated in boiling water bath (with occasional shaking) for 30 min. After cooling to ambient temperature, the percent transmittance (%T) at 650 nm was determined against water as blank.

Emulsion capacity (%)

Emulsion capacity of each starch was determined by the method of Solulski (1962). A 2g starch powder dispersed in 25 ml of distilled water and vortexes for 30 s. 25 ml of vegetable oil was then added gradually and then mixing continued for another 30 s. The suspension was centrifuged at 1600 rpm for 5 min. The volume of oil separated from the sample was read directly from the tube. Emulsion capacity is the amount of oil emulsified and held per gram of sample.

Water binding capacity (WBC)

WBC of the starches from propagules of mangroves was determined using the method of Yamazaki (1953), as modified by Medcalf and Gilles (1965). A suspension of 5g starch (dry weight) in 75 ml distilled water was agitated for 1 h and centrifuged for 10 min. The free water was removed from the wet starch, which was then drained for 10 min. The wet starch was then weighed.

X-ray Diffraction

An x-ray diffraction pattern of mango starch was analyzed using X-ray diffractometer (Philips Analytical diffractometer-PW 710).

Thermal characteristics

The thermal characteristic of the isolated starch was studied by using a differential scanning calorimeter (DSC, SDT Q600 V20.9 Build 20). Starch (~6mg dry weight) was loaded into DSC pan . An empty pan was used as a reference. The scanning temperature range and heating rate were 25-200°C and 10°C /min., respectively. Onset (T_0), peak (T_p) and conclusion (T_c) temperatures (°c) and enthalpy change (ΔH, J/g of dry starch) were determined. The gelatinization temperature range (R) and peak height index (PHI) was calculated as 2 (T_p- T_0) and ΔH /(T_p- T_0), as described by Krueger, Knutson, Inglett and Walker (1987).

To study the retrogradation of starch, gelatinized starch was stored at 4°C for 2 days then at 37°C for 7 days. The DSC parameters of the retrograded starch were calculated as described above. The percentage of retrogradation was calculated as,

% R = (enthalpy of retrogradation / enthalpy of gelatinization) × 100

Granular morphology:

Granular morphology was determined by using Biological research Microscope.

RESULT AND DISCUSSION

The isolation of starch from mango was very easy and settling was not hampered by the presence of non-starch materials which remained suspended and floating, and was easily decanted off (Meyer, 1982). The obtained starch powder is off-white in colour and amorphous in nature. The isolated starch was confirmed through starch-I_2KI test, which gives intense deep blue colored reaction. The starch granules were observed by biological research microscope and microphotography was carried out (Fig. 1).

Fig.1: Isolated starch from Mango pulp, I_2KI reaction and starch granules

Physicochemical characteristics

Physicochemical properties of isolated mango starch are depicted in Table1. Mango starch had a slightly lower pH. Ash content was found to be lower while moisture content was higher.

Table 1: Physicochemical properties of isolated mango starch

Sample	pH	Moisture content (%)	Ash content (%)	Amylose content (%)	Foaming capacity (%)	Emulsion capacity (%)
Mango starch	5.27±0.03	14.93±0.1	0.12±0.02	35.06	52.33±1.33	3.93±0.12

According to their difference in botanical source, the shape of starch granules could be generally divided into four classes: spherical, elliptic, polygonal, and irregular. Granule microstructure is the inherent feature of botanical starch, which is often the basic underlying factor affecting its physicochemical and functional properties.

The difference in properties may result in the different application in the industry. In present study, granules of mango starch were elliptic to oval in shape and having a slit on the surface of the granule (Fig.

2). Average diameter of starch granules was ranges from 12-22µm. The amylose content observed for mango starch was found to be 35.06%, which is quite higher. Emulsion capacity as well as foaming capacity of mango starch was found to be higher, which was 52.33% and 3.93% respectively, which are higher than the maize starch.

The past clarity of mango starch at different pH values is presented in Fig.3. Mango starch had moderate paste clarity at all pH values. The paste clarity was found to be high at pH 2, which decreased sharply up to pH 4. In very acidic solutions, negatively charged phosphate groups are neutralized and the ionization of hydroxyl groups is suppressed. Therefore, lysophospholipid complexed amylose chains contain only electropositive nitrogens. Colulombic repulsion between these positive nitrogens on adjacent amylose chains decreased the compactness of the amorphous region, thus increasing the transmission. However, the light transmission decreased from pH 4. Mango starch showed lower light transmission, this may be due to higher amylose content. According to Wang *et al*. (1993), starches containing high amylose show relatively lower light transmission.

The isolated starch with water when heated to a high temperature it forms gel, which means that the isolated starch is useful in various industries as a solidifying agent (Fig.4). Thus, it may be used in preparation of jellies in chocolate industries.

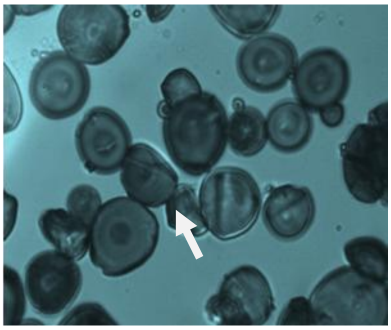


Fig.1 Starch granules showing slit on the surface

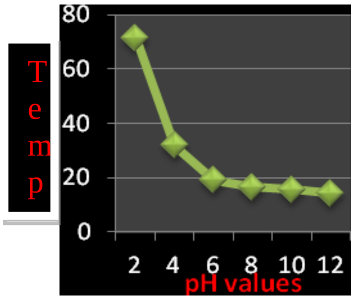


Fig. 2 Paste clarity of mango starch

WBC of starch from mango starch was 89.5%, which is lower than those reported for different potato cultivars (Kaur *et al.,* 2002). Loose association of amylose and amylopectin molecules in the starches has been reported to affect the WBC (Soni, Sharma, Bisen, Srivastava, & Gharia, 1987).

Fig. 3 Gel like mass formation

Native starch granules exhibit two main types of XRD, the A type cereal starches and the B type for tuber and amylose rich starches (Katz, 1930; Zobel, 1988; & Colonna, 1982). Another C type, which has been shown to be a mixture of A & B type (Biliaderis, 1992). The X-ray diffractogram of the mango starch is shown in Fig. 4. Mango starch showed A-type X-ray diffraction pattern, which is typically found in many cereal starches. Millan-Testa *et al*. (2005) reported A-type X-ray diffraction patterns for mango starch. Mango starch showed strong reflections at 22° and 33° (2θ). It showed an additional peak at 38° (2θ).

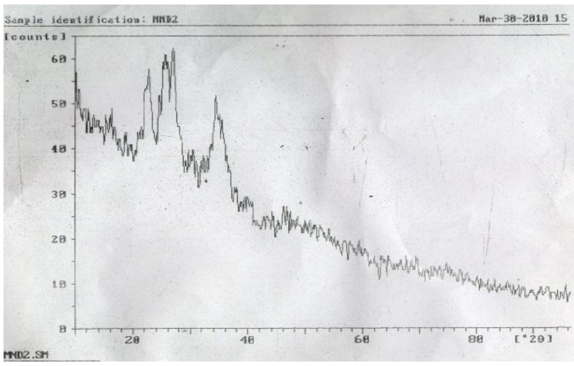


Fig. 4: X-ray diffractogram of mango starch

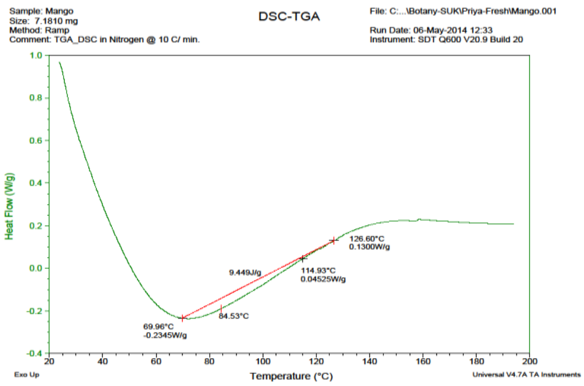
Differential scanning calorimetry was used to study the gelatinization behavior of the mango starch. Table 2 represents the gelatinization temperature namely, onset temperature (T_{0G}), Peak temperature (T_{PG}) and Conclusion temperature (T_{CG}) as well as gelatinization enthalpy on a dry starch basis (ΔH_G). Gelatinization temperature is a measurement of perfectness of starch crystallites (Tester & Morrison, 1990). Gelatinization temperatures were noticed in starch of mango (T_{0G}, T_{PG}, & T_{CG}). The range of ΔH_G value is (ΔH, J/g). The results of DSC further support the large variation in the crystalline nature of starch.

PHI, a measure of uniformity in gelatinization, was found to be lower in isolated mango starch (0.649). The value of R_g was 29.14, which is high. The high value of R in mango starch suggests the presence of crystallites of varying stability within the crystalline domains of its granule (Hoover, Li, Hynes & Senanayake, 1997).

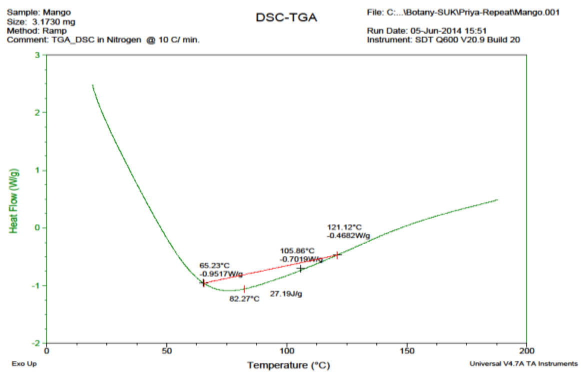
Table 2: Gelatinization properties of Mango starch:

Source	Gelatinization						
	T_{0G} (˚C)	T_{PG} (˚C)	T_{CG} (˚C)	T_{PG} - T_{0G} (˚C)	ΔH_G (J/g)	R_g	PHI
Mango starch	69.96	84.53	114.93	14.57	9.449	29.14	0.649

T_{0G}, onset temperature, T_{PG}, peak temperature, T_{CG}, conclusion temperature, ΔH_G, enthalpy of gelatinization, R_g gelatinization range 2(T_{PG} - T_{0G}); PHI, peak height index ΔH_G / (T_{PG} - T_{0G}).



A



B

Fig. 5: DSC thermograms of Mango starch, A: Gelatinization; B: Retrogradation

Table 3: Retrogradation properties of Mango starch:

Source	Retrogradation						
	T_{OR} (°C)	T_{PR} (°C)	T_{CR} (°C)	T_{PR} - T_{OR} (°C)	ΔH_R (J/g)	R_r	%R
Mango starch	65.23	82.27	105.86	17.04	27.19	34.08	34.75

$T_{0R,}$ onset temperature, $T_{PR,}$ peak temperature, T_{CR}, conclusion temperature, $\Delta H_{R,}$ enthalpy of retrogradation, R_r retrogradation range $2(T_{PR} - T_{0R})$;; %R, ratio of enthalpy of retrogradation to enthalpy of gelatinization × 100.

Retrogradation is the molecular interaction that is hydrogen bonding between starch chains that occur after cooling of the gelatinized starch (Hoover, 2000). The retrogradation properties of mango starch are depicted in Table 3. The gelatinization temperature of retrograded starch was lower than that of native starch. This might result from improper alignment of the starch chains during re-association. Percentage of retrogradation (%R) was 34.75. According to DSC parameters, the re-crystallization degree of mango starch was found to be very small.

CONCLUSION

All the researchers suggested that, the physicochemical as well as functional properties of the different starches could directly result in different utilization both in food and non-food uses. The starch show adequate properties and could be alternative source for the production of industrial products. The thermal properties of starch are much complex. This is because of the multiple transitions and instability of water contained in starch. DSC is an important technique which will determine the thermal behavior of starch. The need to harness underutilized crop such as 'Black mango' for industrial raw materials cannot be overemphasized since this will enhance food security. The results obtained are suggestive of the potential of black mango as a source of starch and also a source of functional ingredient for various food products.

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