International Journal of Biological Macromolecules 92 (2016) 416–422

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

# Dual modification of taro starch by microwave and other heat moisture treatments

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ARTICLE INFO

*Article history:*
Received 31 March 2016
Received in revised form 27 June 2016
Accepted 12 July 2016
Available online 14 July 2016

*Keywords:*
Taro starch
Dual physical modification
Properties

ABSTRACT

Effect of heat moisture treatment on the physicochemical properties of taro starch with 25% moisture (w/w) modified by single treatments of microwave (HMT1), autoclave (HMT2) and hot air oven (HMT3), and dual treatments of microwave followed by autoclave (HMT4) and microwave followed by hot air oven (HMT5) were investigated. Amylose contents of the modified starches increased except for HMT3. A loss of physical integrity of the starch granules were observed for dual modified starches. The swelling and solubility of all the modified starches increased. The peak viscosities of starches modified by HMT1 and HMT5 were found to be higher whereas for other modified starches it was lower than that of native starch. The holding and final viscosities of all the modified starches except HMT4 were higher than native starch. The freeze-thaw stabilities of the modified starches were also found to be better than that of native starch.



## 1. Introduction

Starch is a semi-crystalline biopolymer, and is one of the most abundant carbohydrates present in nature. It is the chief reserve carbohydrate in many plants. It is widely distributed amongst the plant kingdom, including seeds, roots, tubers and cereals [1]. It has widespread application in paper, textile, food, pharmaceutical and cosmetics industries [1,2]. Worldwide starch is one of the most used food ingredients due to its diverse functionalities. It is a low cost ingredient and available throughout the year [3]. Corn, potato, cassava and wheat are the most common sources of industrial starch [4]. Tuber starches have specific functional characteristics which may be required to impart unique properties to the different processed food products [5].

Variety of starch sources are available in the tropic and subtropics regions of the world which are being used as food. Taro (*Colocasia esculenta*) tubers are among these starch rich sources which has potential as a source of starch for industrial use [6]. Taro starch has high swelling power and peak viscosity [7]. It also forms smooth textural gel owing to its small granule size [8].

Native starches have limited use in food processing since it has narrow peak viscosity range, poor process tolerance, lack of clarity, form a weak, cohesive and rubbery paste when heated, and undesirable gels when cooled or during storage due retrogradation and precipitation [9,10]. The functional properties of the native starches can be improved by modification through physical, chemical or enzymatic methods. In food processing applications, modified starches play a very important role due to their improved functional properties over their native counterparts.

In view of the increasing demand by consumers for safe and additive free foods, there is growing interest for physically modified starch over chemically or enzymatically modified starches because starch functionality can be improved without introducing any foreign substances [11]. Properties of starch can be altered by controlled application of heat and moisture which produces physical changes in the starch granules [12]. The modified starches increase the versatility of the starches for variety of food applications [10]. Heat-moisture treatment is one such technique for physical modification of native starch wherein starch granules with low moisture levels (<35%, w/w) are heated at a temperature above the glass transition (Tg) and gelatinization temperature for a specific period of time [13]. Studies have shown that physical modification by HMT method can modify starch properties [14]. HMT promotes changes in the arrangement of amylose and amylopectin chains within the granules which results in changes in granular swelling, crystallinity, amylose leaching, gelatinisation, retrogradation, thermal properties and pasting properties [15]. Traditionally, Heat-moisture treatment is carried out in hot air ovens. Many works have been reported on the effects HMT on the properties of starches from various sources by conventional method of

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http://dx.doi.org/10.1016/j.ijbiomac.2016.07.040
0141-8130/

heat-moisture treatment in hot air ovens [16–22], but there are very few reports of HMT of starch by other methods. Although, investigations on modification of starch using autoclave [23–25] and microwave [12,26–31] have been reported previously, there are no reports on dual modification of taro starch by heat moisture treatment using combination of microwave and other heat moisture treatment methods.

Microwaves are non-ionizing electromagnetic radiations capable of inducing changes in the properties of materials due to rapid alternations of the electromagnetic field at high frequency. Microwave processing is receiving wide attention because of higher yield and better qualities of products are obtained compared to conventional processing methods [29]. Processing with microwave is more efficient than the traditional heating processes due to its shorter processing time and ensures homogenous operation in the whole volume of substance [12]. Dual modified starch find application in food industries as emulsifiers, agglutinants and thickeners, and in non-food industries as adsorbent for heavy metals, carriers for controlled released of drugs and other bioactive compounds among other uses [32]. Therefore, the objectives of the present investigation were to examine the effect of heat moisture treatment by microwave technique and dual modification by combination of microwave and other heat moisture treatment techniques (Autoclave and hot air oven) on the physicochemical properties of taro starch.

## 2. Materials and methods

### 2.1. Starch isolation

Taro tubers locally known as *Panchamukhi* (*Colocasia esculenta* var. *antiquorum*) was collected from an agricultural farm near Tezpur University, Assam, India. Starch from taro tubers was extracted as per the method of Sit et al. [33]. Tubers were washed under tap water, peeled and cut into cubes of approximately 1 cm. The cubes were ground using a high speed laboratory blender (Philips HL 1632, India) for 2 min. The slurry was mixed with 10 times its volumes of distilled water. The suspension was filtered through double fold cheese cloth and the filtrate was kept for sedimentation for 6 h. The supernatant was discarded and the sediment thus obtained was washed with distilled water for two times. The final sediment was dried at 45 °C for 24 h in drying oven. The dried starch was ground and passed through 100 mesh sieve and kept in air tight plastic containers for further analysis.

### 2.2. Starch modification with microwave and other heat moisture treatments

The moisture content of the isolated taro starch was adjusted to 25% and equilibrated at 4 °C for 4 days with intermittent mixing. Heat moisture treatment of the taro starch was carried out by various methods using microwave, autoclave and hot air oven, and combination of microwave and other methods. Five treatments were performed as follows:

a 20 g of equilibrated starch sample was placed in an air tight microwavable and autoclavable polypropylene container and heated in a microwave oven for 5 min at power level 180 W (increasing the power level or time of heating in microwave caused burning of the starch sample). The treated starch sample was then dried at 45 °C for 24 h in a hot air oven (HMT1).
b 20 g of equilibrated starch sample was placed in an air tight microwavable and autoclavable polypropylene container and heated in an autoclave (LAC-5080S, Daihan Labtech Co. Ltd, Namyangju-city, South Korea) for 1 h at 110 °C. The treated starch sample was then dried at 45 °C for 24 h in a hot air oven (HMT2).
c 20 g of equilibrated starch sample was placed in an air tight microwavable and autoclavable polypropylene container and heated in a hot air oven (Shanghai Boxun Industry & Commerce Co. Ltd, China) for 1 h at 110 °C. The treated starch sample was then dried at 45 °C for 24 h in a hot air oven (HMT3).
d 20 g of equilibrated starch sample was treated in microwave and then dried. The dried sample was again equilibrated to 25% moisture content, treated in autoclave and again dried i.e. HMT1 followed by HMT2 (HMT4).
e 20 g of equilibrated starch sample was treated in microwave and then dried. The dried sample was again equilibrated to 25% moisture content, treated in hot air oven and again dried i.e. HMT1 followed by HMT3 (HMT5).

The dried samples were analyzed for various physicochemical and functional properties and compared with native taro starch.

### 2.3. Chemical composition and amylose content

The moisture, fat, ash and crude fibre content of the isolated starches were determined by AOAC methods [34]. Protein content (N × 6.5) was determined by Kjeldahl method [35]. The amylose content was determined by colorimetric method [36]. The standard curve was prepared using pure potato amylose type III (HiMedia, India).

### 2.4. Granule size and shape

Shape and size of starch granules were evaluated using scanning electron microscope (JEOL JSM 6390 LV, Singapore). A thin layer of starch granule was mounted on the aluminium specimen holder by double-sided tape. The samples were coated with platinum and examined under the microscope at an accelerating voltage of 15 kV with magnification of 4000X.

### 2.5. XRD analysis

XRD analysis of the starch samples were carried out using X-ray diffractometer (Miniflex, Japan). The dried samples (Moisture content 8% wet basis) were exposed to X-ray beam at 15 mA and 30 kV. Data were recorded over a diffraction angle (2θ) range of 5°–50° with a step angle of 0.05°. Relative crystallinity was determined by calculating the percentage ratio of diffraction peak area to the total diffraction area.

### 2.6. Colour of starch (dry powder)

Colour of starch (dry powder) was measured using colorimeter (Ultrascan VIS, Hunterlab, USA). L, a* and b* values were noted. L is for lightness, a* for redness and b* yellowness.

### 2.7. Swelling and solubility

Swelling power and solubility of the starches were determined by modified method of Torruco-Uco and Betancur-Ancona [37]. Starch (0.5 g) was dispersed in 20 ml distilled water in a pre-weighed 50 ml centrifuge tubes and kept in shaking water bath at 60, 70, 80 and 90 °C for 30 min. The suspension was then centrifuged at 12,000 × *g* for 10 min. The supernatant was carefully decanted in a Petri dish and dried at 103 °C for 12 h. After decantation the weight swollen granules were taken. The swelling power and percentage solubility were calculated using the following formulas: