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Study on modification of native potato starch by various techniques

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Abstract
The aim of this research was to modify native potato starch extracted by physical, enzymatic and alkaline method to improve the solubility and swelling power. The ultrasonic and heat moisture treatment techniques were used for native potato starch modification. In ultrasonic technique, the solubility was ranging from 2.32-12.03% and swelling power was ranging from 2.92 to 5.89%. The solubility and swelling power in moisture heat treatment was ranging from 1.98% to 4.70% and 5.17% to 6.02% correspondingly. The modified potato starch recovery in current study was ranging from 93.94-99.44% and 95.77-99.62% in ultrasonication and moisture heat treatment appropriately. The utrasonication was the best technique to improve the solubility and swelling power of native starch modification. Further study is proposed for other techniques for native starch modification to improve solubility and swelling power of native potato starch such as chemical (NaOH, NaOCl, acid, alcohol), annealing, microwave heating and enzymatic methods (cellulase, protease, lipase).

Keywords: Native potato starch modification, solubility, swelling power, utrasonication, moisture heat treatment

1. Introduction
Native starches from different sources are limited in industrial applications due to their inability to face up to processing conditions like warmth (has low thermal resistance), diverse pH and high shear rate (has low shear resistance) (Singh *et al*., 2007) [1], high ability to retrograde, loss of viscosity during cooling, syneresis tendency and thickening power upon cooking and storage particular at low pH. Native starch will be tailored by chemical, genetic, enzymatic and physical treatments to boost its specific and desired properties to enhance the physiochemical, morphological, rheological and functional properties of some native starch. The properties of native potato starch, however, might not be desirable for all applications due to high viscosity at low solids content i.e. difficulty in handling, lack of body), higher susceptibility to retrogradation (gel opacity, syneresis, and lack of freeze–thaw stability), and lack of process tolerance (Bertolini, 2010) [2]. Modification of potato starch can help in broad range of processing parameters like acidity, thermal conditions and mechanical shear. Modified starches have also been accustomed stabilize frozen foods by providing freeze-thaw stability and retrogradation. In dairy products, they supply types of alterations, like enhanced viscosity, mouth feel, cuttability and stability, e.g. utilized in yogurt and soured cream to regulate syneresis and enhance thickness. In puddings, soups, pie fillings, sauces and gravies starch enhances viscosity and smoothness coatings up to a maximum concentration of 0.5% by weight (Anonymous, 2015) [3]. Canned food products undergo treatment at higher temperature, therefore starch is generally used to thicken, stabilize and enhance the mouth feel. The shortcomings of native starch can be alleviated using modification by chemical (NaOH, NaOCl, acid, alcohol), physical (heat-moisture treatments, annealing, microwave heating), and enzymatic methods (cellulase, protease, lipase) (Neeraj and Bisht, 2018) [4]. In physical modification, changes the physicochemical properties of starch, without destroying its granule structure. Heat moisture treatment is expounded process within which the starch to moisture ratio, the temperature and heating time are critical parameters that require being controlled (Chung *et al*., 2009) [5]. It is dispensed under restricted moisture content (10 - 30%) and better temperatures (90-120 ºC) for a periods starting from 15 min to 16 h (Maache-Rezzoug *et al*., 2008) [6]. Application of power ultrasound has immense potential for a good kind of processes within the food industry which include extraction, crystallization, filtration, emulsification and more. Controlling the viscosity of starch (polysaccharide) solutions is one amongst the foremost promising processes to be developed. Power ultrasound can effectively gelatinize at high starch concentration (20-30%).

Starch gel will be liquidized by sonication (Lida *et al*., 2008) [7]. Multiple deep freezing and thawing of granular potato starch altered the water distribution within the granules (Szymonska *et al*., 2003) [8] and significantly increased the granule surface coarseness (Szymonska *et al*., 2000; Szymonska and Krok, 2003) [9-10]. The method of iterated synersis applied to modification of potato, tapioca, corn and wheat starches resulted in an exceedingly new style of physically modified starches that contained the resistant starch (RS) fraction of unique physicochemical properties (Lewandowicz and Soral-Smietana, 2004) [11]. Therefore, this study was meted out to switch native potato starch by physical method (heat-moisture treatment (HMT) and Ultrasonication.

2. Materials and Methods

2.1 Heat-moisture treatment (HMT)

Water was sprayed onto powdery native potato starch to adjust its moisture content to 20-25% as described by (Lim *et al*., 2001) [12] method. The starch/water mixture was extensively mixed with a blender and then the exact moisture content of the mixture was measured. The moisture adjusted starch (200g) was transferred to a glass beaker and conventionally heated in an electric oven at 120 ºC for 1h. After the HMT, the starch was dried to approximately 10% moisture content in a convection oven (40 ºC) overnight. The sample ground and sieved through a 60 mesh screen in aluminium pouches and stored at room temperature for further utilization.

2.2 Ultra sonication method

Native potato starch sample was modified by ultra-sonication method as described by (Lida *et al*., 2008) [13]. Six treatments (T_1-T_6) of known weight were sonicated by variation of time and temperature (Table 1). The known sample weight was dissolve in distilled water in ratio of (1:1) in beakers and mechanically mixed by glass rod to obtain starch slurries. The slurries were sonicated at different time and temperature. After sonication, supernatant was collected in measuring cylinder for weight records and transferred to the petri plated for oven drying. The starches were dried in the universal hot air oven at 40 ºC for 24 hours. The dried starches were homogenized in a 60 mesh screen and packed into aluminium pouches for further utilization. The solubility, swelling power and starch recovery was calculated for each method after modification.

2.3 Swelling power and solubility

The solubility and swelling power were determined using method as suggested by (Lauzon *et al*., 1995) [14] with some modification. The starch dispersion (0.5 g starch in 25 ml distilled water) was heated at different temperatures of 95°C for 1 h with continuous shaking followed by rapid cooling to room temperature. The solubility and swelling power was determined as follows:

$$\% \text{ Solubility} = \frac{(\text{weight of dried supernatant})}{\text{Initial weight of dry starch}} \times 100$$

The swelling power of modified potato starch calculated by using the follow formulae

$$\% \text{ Swelling power} = \frac{\text{Weight of wet sample x 100}}{\text{Sample weight x (100--\% solubility)}}$$

$$\%\text{Starch recovery after modification} = \frac{\text{Weight of modified starch in dry basis x100}}{\text{Weight of native starch in dry basis}}$$

Data Analysis Tool of Microsoft Excel (Mean and standard deviation) was used to calculated solubility, swelling power and starch recovery of modified starch.

3. Results and Discussion

Table 1: Ultra sonication method

Treatment	Initial weight of dry starch (g)	Temperature (ºC)	Time (min)	Weight of dried Supernatant (g)	Solubility (%)	Swelling power (%)	Starch recovery (%)
T_1	0.518	30	15	0.012	2.32 ± 0.01	2.94±0.01	97.37±0.01
T_2	0.511	40	15	0.013	2.54 ± 0.02	2.92±0.01	99.02±0.01
T_3	0.511	30	30	0.014	2.74 ± 0.01	3.15±0.01	99.44±0.01
T_4	0.502	40	30	0.020	3.98 ± 0.01	4.14±0.01	96.48±0.01
T_5	0.504	30	45	0.023	4.56 ± 0.01	5.37±0.01	98.69±0.01
T_6	0.532	40	45	0.064	12.03 ± 0.02	5.89±0.01	93.94±0.01

(Mean ± SD)

Table 2: Heat Moisture Treatment (HMT) method

Treatment	Initial weight of dry starch (g)	Temperature (ºC)	Time (min)	Weight of dried Supernatant (g)	Solubility (%)	Swelling power (%)	Starch recovery (%)
T_1	0.506	60	30	0.010	1.98 ± 0.01	4.43 ± 0.02	95.77 ± 0.02
T_2	0.511	70	30	0.011	1.99 ± 0.01	4.97 ± 0.02	95.82 ± 0.02
T_3	0.511	80	40	0.013	2.01 ± 0.01	5.36 ± 0.01	96.52 ± 0.01
T_4	0.502	95	40	0.012	2.03 ± 0.02	5.59 ± 0.02	97.43 ± 0.02
T_5	0.504	100	50	0.014	2.07 ± 0.01	5.62 ± 0.01	98.59 ± 0.01
T_6	0.532	120	50	0.011	2.09 ± 0.5	6.57 ± 0.2	99.62 ± 0.00

(Mean ± SD)

4. Discussion

Results in Table 1 and 2 indicate that as temperature increased, the solubility increased due to breaking of starch granules and exposure of hydrophilic groups to water (Eliasson and Gudmundsson, 1996) [15]. Swelling power indicates the water holding capacity of starch granules and is affected by the extent of chemical cross bonding within the granules (Chen *et al*., 2003) [16]. The increase in solubility and swelling is due to the effect of ultrasound and moisture heat treatment. This might be attributed to the destruction of starch granules at elevated temperature and subsequent release of all the amylose from the amylopectin network (Charles *et al*.,

2007) [17]. The swelling of the starch granules were more when the utrasonication and moisture heat treatment temperature increase from T_1-T_6. This may be attributed to higher breakdown of the starch structure with time thereby exposing more hydrophilic groups to water and leading to higher water uptake and retention (Tester and Morrison, 1990; Jambrak *et al*., 2010) [18-19]. Similar increase in starch swelling and solubility due to ultrasonication has been reported by (Chan *et al*., 2010) [20] for mung bean and sago starch and (Jambrak *et al*., 2010) [19] for corn starch. The modified potato starch recovery in current study was ranging from 93.94-99.44% and 95.77-99.62% in ultrasonication and moisture heat treatment respectively. These values are in accordance to (Lindhauer *et al*., 2003) [21] whose research suggested the optimum engineering results in starch recovery rates of at least 97–98 %. The concerning starch extraction, a minimum of 95% is reached in modern potato starch plants, but optimum engineering (rasping, decanting, sieving) gives recovery rates of 97 to 98 % (Bergthaller *et al*., 1999) [22]. These ranges were similar to the present study values of starch recovery 93.94-99.44% and 95.77-99.62% in ultrasonication and moisture heat treatment respectively.

5. Conclusions

Both ultrasound and moisture heat treatment increased the solubility and swelling power of potato starch during modification. Sonication was the best method compared to heat moisture treatment in starch modification as solubility and swelling power values are higher (Table 1) compared to (Table 2). Modified potato starch in current research can be utilized in food industry and food processors in different food products as thickening, preservation and quality enhancer in baked foods, confectioneries, pastas, yoghurt, soups, sauces, and mayonnaises. The modified starch recovery was higher in each method.

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