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Comparative studies on extraction of starch through physical, enzymatic and alkaline method

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Abstract
The aim of this research was to extract starch from potatoes using physical, enzymatic and alkaline method and to compare the best method on starch yield and recovery. The different parameters were investigated in both raw potatoes and starch. The physico-chemical characteristics were weight (281g), size (5.21cm), edible portion (93.59%), volume (63.33ml), height (4.92cm), moisture content (79.44%), fibre content (0.55%), starch yield (7.12%) and starch recovery (38%), the edible portion of potatoes was 88.80 to 89.70% in both methods. The moisture content of starch was 15.77-15.87%, Starch yield 11.16-13.67%, starch recovery was 7.12% alkaline, enzymatic (6.66%) and physical (6.18%). Water solubility was 1.01%, 0.76% and 2.12% in each method respectively. Swelling power was 1.01%, 1.01% and 1.03% in each method. The native starch in current study has low solubility and swelling power. Therefore another research is proposed to increase the solubility and swelling power through modification.

Keywords: extraction methods, potato starch, solubility, swelling power, starch yield, starch recovery

Introduction

Potato is the most significant food crop in the world after wheat, rice and maize. Its production and utilization is being increased in developing countries due to fast industrial growth and urbanization. Major sources of starch are cereals (40 - 90%) especially in endosperm, tubers (65 - 85%), roots (30 - 70%), legumes (25 - 50%) and other immature fruits like bananas or mangoes, constituting about 70% starch on dry weight basis (Santana and Meireles, 2014) [4]. Starch consists of amylose (straight chain) and branched chain amylopectin molecules in molar ratios of 15% - 25% and 85% - 75%, respectively (Tako *et al*., 1986) [11]. The amylose, composed of D-glucose units linked through α–D–(1–4) glycosidic linkage and amylopectin (branched polymer) composed of α–D–(1–4) linked glucose segments branched with α–D-(1–6) linked glucose units. Amylose is present as a hydrophobic helix therefore, has ability to form complex with volatile compounds such free fatty glycerides, of some alcohols, and iodine (Thomas and Atwell, 1999) [13]. Therefore, starch used as encapsulation of volatile compounds in food industries. Amylopectin exclusively contribute as a crystalline molecule due to its ordered packaging arrangement. Regarding chain length, amylose possesses small chain than amylopectin, with average degree of polymerization (DP) of about 15, and large chains, with DP > 45 respectively. Granular starch is universally abundant, relatively low cost and has an ability to impart a broad range of functional properties to food and non-food products (Whistler, 1984; Jane, 1995; Be Miller, 2007) [14, 5, 2]. Starch is used in food, cosmetics, paper, textile, and certain industries, as adhesive, thickening, stabilizing, stiffening, and gelling (pasting) agents (Wischmann *et al*., 2007) [1]. Potato starch has a large starch granules size than other cereal and tuber starches (Tester *et al*., 2005) [12]. In large scale production of potato starch, mechanical separation method is used in most industries worldwide for releasing starch from tuber and cereal crops, after mechanically disintegration, washing is taken with water for maximum recovery of starch (Byg *et al*., 2012) [3]. Starch can be separated by physical, enzymatic and alkaline methods from cereals, tubers, roots and other sources like bananas or mangoes. The present research work was carried out to find out best method of extraction of starch out of physical, enzymatic and alkaline method.

Material and Methods

Raw material

Five (5kg) of raw potatoes were procured from local market and immediately bring to product development laboratory under the Department of Food Science and Technology at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, India. The potatoes were washed to remove extraneous materials and drained overnight. Random sampling was done to select potato tubers from lot for physico-chemical estimation of different parameters and starch content. The remaining roots were weighed using weighing electronic balance and divided into three for extraction of starch using physical, enzymatic and alkaline method.

Preparation of materials for starch extraction in physical, enzymatic and alkaline method

In physical, enzymatic and alkaline process, one and half (1.5kg) were used. The potatoes were washes, drained, peeled with potato peeler and weighed using weighing electronic balance scale. The peeled potato were cut into small pieces and soaked in 0.1% potassium metabisulphite ($K_2S_2O_5$) for 15-20 minutes to prevent enzymatic browning. The extraction of starch in each method was done according to standard procedures as shown in figure 1, 2 and 3 below. The edible portion (%), moisture content (%), starch yield (%), starch recovery (%), water solubility (%) and swelling power (%) were also estimated.

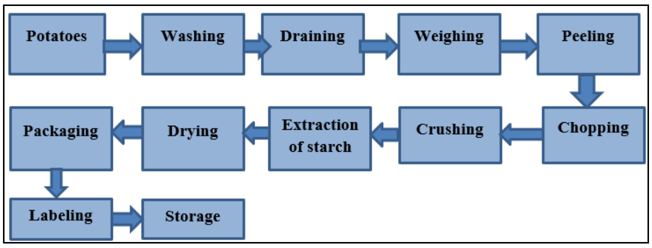

Fig 1: The process flow sheet for potato starch extraction by physical method

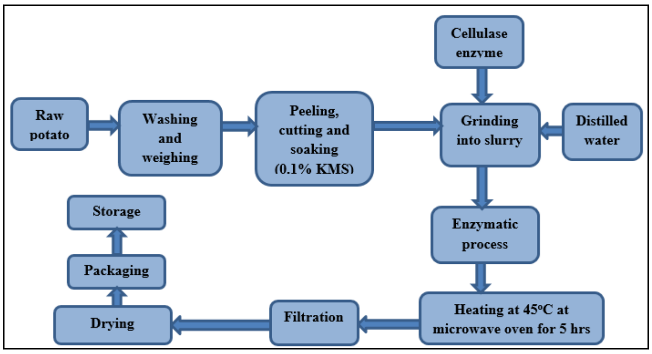

Fig 2: Flow sheet for extraction of starch by enzymatic process

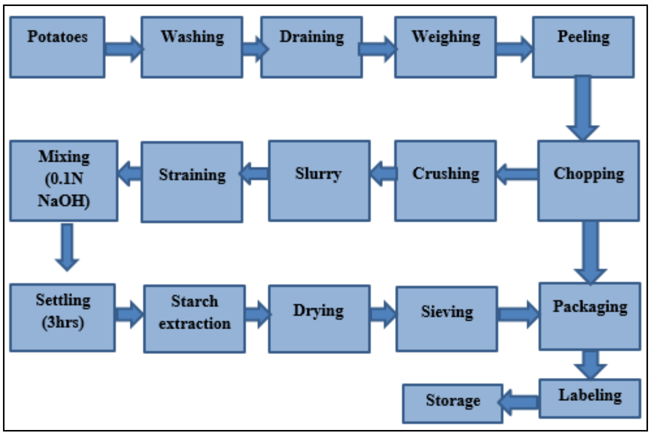

Fig 3: Flow sheet for extraction of starch by alkaline process

The estimation of physico-chemical characteristics of raw potato and extracted starch

Determination of weigh of potato (g)

The randomly selected potatoes were weighed in digital weighing scale and weight was recorded in gram.

Size of potato (cm)

The size of potatoes was determined by using vernier caliper in mm and the value obtained converted into cm.

Height of potato (cm)

The height of potatoes were determined by using vernier caliper in mm and converted to cm.

Volume of potato (ml)

The potatoes were immersed into a beaker of known volume of distilled water as initial volume which was recorded as (V_1), after that the potatoes were immersed in the beaker and an increase in volume was recorded as final volume (V_2). The volume calculated as following:-

$$\text{Volume of potato (ml)} = (V_2 - V_1)$$

Edible portion (%)

The edible portion of potatoes sample was determined by dividing peeled roots weight (g) by whole roots weight (g). The value was calculated on percentage basis.

$$\text{Edible portion (\%)} = \frac{\text{weight of peeled potato roots}}{\text{Weight of whole potato roots}} \times 100$$

Moisture content (%)

The five (5g) of potatoes sample on wet basis weighed to determine the actual weight then dried at 105 °C in universal hot air oven for 12 hours. The pre-dried crucibles containing the dried samples cooled in desiccators for 20 minutes and re-weighed to determine the amount of moisture lost.

$$\text{\% Moisture} = \frac{(\text{wt of wet sample + pan}) - (\text{wt of dried sample + pan})}{(\text{wt of wet sample + pan}) - (\text{wt of pan})} \times 100$$

Crude fiber determination (%)

For the estimation of crude fiber Fibtron instrument was used.1g sample was first digested by dilute sulphuric acid (1.25N, H_2SO_4) for 30 minutes and washed three times with hot distilled water. Residues neutralized by diluted alkali (1.25N, NaOH) for 30 minutes and then washed by hot distilled water three times. Digested residues were dried in universal hot air oven at 100 °C for 12 hours then were cooled in desiccators for 20 minutes and weighed.

$$\text{Fibre content (\%)} = \frac{W_1 \times 100}{W}$$

Whereby:-
W_1 = loss in weight (g)
W = weight of sample (g)

$$\text{Starch yield (\%)} = \frac{\text{Extracted starch after drying (g)}}{\text{Amount of potatoes (g)}} \times 100$$

$$\text{Starch recovery (\%)} = \frac{\text{Starch yield (\%)}}{\text{Weigh of extracted starch after drying}} \times 100$$

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

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

Statistical analysis

Mean and Standard deviation was used to calculate raw data and starch extract from potatoes

Results and Discussion

Table 1: physico-chemical parameters for raw potato

Parameter	Amount
Weigh of potato (g)	281 ± 1
Size of potato (cm)	5.21 ± 0.01
Edible portion (%)	93.59 ± 0.6
Volume of potato (ml)	63.33 ± 0.4
Height of potato in (cm)	4.92 ± 0.02
Moisture content of potato (%)	79.44 ± 0.9
Fibre content (%)	0.55 ± 0.01
Starch yield (%)	7.12 ± 0.01
Starch recovery (%)	38 ± 0.8

Table 2: Different parameters of native potato starch (%)

Parameter	Physical method	Enzymatic method	Alkaline method
Edible portion (%)	88.80 ± 0.01	89.70 ± 0.01	89.20 ± 0.01
Moisture content (%)	15.77 ± 0.01	15.87 ± 0.01	15.77 ± 0.01
Starch yield (%)	11.16 ± 0.02	12.61 ± 0.02	13.67 ± 0.01
Starch recovery (%)	6.18 ± 0.03	6.66 ± 0.01	7.12 ± 0.01
Water solubility (%)	1.01 ± 0.01	0.76 ± 0.01	2.13 ± 0.02
Swelling power (%)	1.03 ± 0.02	1.01 ± 0.01	1.02 ± 0.01

Discussion

Table 1 summarizes the physico-chemical parameters of raw potato and starch. The weight of raw potato samples were weight (281 g), size (5.21 cm), edible portion (93.59%), volume (63.33 ml), height (4.92cm), moisture content (79.44%), fibre content (0.55%), starch yield (7.12%) and starch recovery (38%). The starch yield was (7.12%) in current study. It shows that starch yield is low. This value differs with Rahman *et al*. (2011) [6] which obtained the yield value of 14.49%. This different may be attributed by several factors such as amount of potato used for starch extraction, methods used, location and varieties of potato used. The present study however conducted in north India at Dr YSP University of Horticulture and Forestry, Nauni, Solan, India with 100g of potatoes while the another study was conducted in Bangladesh at University of Dhaka with unmentioned amount of potatoes. The fibre content in the current study is 0.55% which is similar to Sit (2012) [8] and Castaño *et al*. (2016) they obtained fibre content of 0.1±0.09% and 0.16%, respectively. The starch recovery was 38%. There are no research findings which have done physico chemical characteristics for raw potatoes like weight, size, edible portion, volume and height of potato.

The results in Table 2 above indicated highest edible portion of potato ranging from (88.80% to 89.70% whereas moisture content of native starch were 15.77%, 15.87% and 15.77 in physical, enzymatic and alkaline methods respectively. These values are similar to Yadav *et al*. (2016) [15] which obtained moisture content of native potato starch (15.35 ± 0.72%) and Sonia *et al*., 2015 [9] who obtained the moisture content ranging from 15.23% to 18.82% in native starch from different varieties of potato. According to Castaño *et al.* (2017) [4] the moisture content of native potato starch was 18.81% which is higher compared to the value (15.77% - 15.87%) in present study. This difference may be due to varietal type and location in which present study conducted in India while another study conducted in Colombia. The starch yields were ranging from 11.16% to 13.67% in current study. It shows that starch yield was low (11.16%) in physical method while there was no significance difference in starch yield in enzymatic and alkaline methods. The low value observed in physical method is due to washing procedures which does not allow maximum recovery of starch compared to other methods. The starch yields were ranging from 6.68% -7.12%. These ranges differ with Rahman *et al*. (2011) [6] which obtained the yield value of 14.49%. This different may be attributed by several factors such as amount of potato used for starch extraction, methods used, location and varieties of potato used. The present study however conducted in north India at Dr YSP University of Horticulture and Forestry with 1.5 kg of potatoes in each method while the another study was conducted in Bangladesh at University of Dhaka with unmentioned amount of potatoes. The starch recovery was 6.88%, 6.66% and 7.12% in physical, enzymatic and alkaline processes respectively. The solubility (%) of starches ranged between 0.76% to 2.13%. The lowest solubility observed in these starches is due to the fact that the starches were in native form. Many reaches revealed the higher starch solubility in modified starch. Swelling power of starches observed to be low (ranging from 1.01% to 1.03%) in both methods of extraction. The low swelling power may be attributed by presence of lipids (Swinkels, 1985) [10] which affects the swelling power of starches in the current study.

Conclusion

The starch yield and recovery observed to be higher in alkaline method followed by enzymatic process and lastly physical method. These starches can be uses as a thickener in food industries for stabilizing emulsions in dairy products, vegetable products, soups, mayonnaise, confectionaries, binding agent in meat products, fat replacers to control overweight and obesity etc. The native starch can be used in foods as mentioned above with low performance in solubility and swelling power if it is in native form. Therefore modification is very important to improve native starch solubility and swelling power before utilization in various food products. Therefore, another research is proposed to carry out the modification of native starch obtained in this study to improve its solubility and swelling power so as to improve its utilization in various food products.

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