Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

RV Kale
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

DM Shere
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Sontakke MD
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Gadhe KS
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Effect of isolation methods on physicochemical and functional properties of sweet potato (*Ipomoea batatas L.*) starch

RV Kale, DM Shere, Sontakke MD and Gadhe KS

Abstract
The present investigation aimed to study the isolation of sweet potato starch by different methods were carried out using viz., sodium chloride (0.5%) and sodium metabisulfite (0.01%). Yield and recovery of starch isolated by sodium chloride (NaCl) was highest 26.80 and 59.86 percent respectively. The highest whiteness value was observed in case of treatment T_1 (i.e. 92.63). Further the isolated sweet potato starch were investigated for various physiochemical and functional properties includes water absorption capacity, solubility, swelling power and paste clarity. Results showed water absorption capacity (WAC) of sweet potato starches was ranged from 0.65 to 0.74 g/g and there was not significant variations observed in solubility, swelling power and paste clarity of isolated starch. Results concluded that the sweet potato starch can be isolated with good functional properties with potential to exploration in different food products.

Keywords: Sweet potato, Isolation, Starch, Functional properties, Amysose, Amylpectin.

1. Introduction

Sweet potato (*Ipomoea batatas L.*) belongs to the morning glory family *Convolvulaceae.* Large, fleshy, edible storage roots are formed on the underground stem nodes. It is cultivated as a perennial in tropical and subtropical low land agro-ecologies, although it is well adapted to other zones and can be grown over widely different environments. There are two broad categories of sweet potato: the staple type with white flesh and white or purple skin has a high starch and dry-matter content. The dessert type with orange flesh and orange skin with a high sugar and beta-carotene content.

India produces about one million tonnes of Sweet potato and different varieties are grown in various parts of the country. Sweet potato is considered as a 'poor man's rich food in many parts of India. Sweet potatoes are ranked seventh in world staple food production (expressed on a dry matter basis), after wheat, maize, rice, potato, barley and cassava (FAO, 2014) [11].

Sweet potatoes are rich in starch (58-76% on a dry basis) and its starch has properties rather similar to potato starch and has been widely used in starch noodles, bakery foods, snack foods and confectionary products (Gunaratne and Corke, 2007) [13]. Sweet potato starch has two major components: amylose and amylopectin. These polymers are very different structurally. Amylose is a relatively long linear polymer α-glucan containing 99% α (1→4) and 1% α(1→6)linkages while amylopectin is a much larger molecule and a heavily branched structure built from about 95% α (1→4) and 5% α(1→6) linkages. The structures of these polymers play a critical role in the functionality of native and modified starches (Mweta *et al.*, 2008) [18]. Viscosity, shear resistance, gelatinization, solubility, gel stability and retrogradation are some of the functional properties that depend on the amylose/amylopectin ratio of the starches. In foodstuffs, starch is used to influence or control such characteristics as aesthetics, moisture, consistency and shelf stability. It can be used to bind, expand, densify, clarify or opacify, attract or inhibit moisture.

The major biochemical component of the dry matter in sweet potato is starch (58-76% on a dry basis) and its starch has properties rather similar to potato starch and has been widely used in starch noodles, bakery foods, snack foods and confectionary products (Gunaratne and Corke, 2007) [13].

This present investigation focused on the isolation and modification of sweet potato starch by different methods and evaluation of its physicochemical and functional properties.

Correspondence
RV Kale
Department of Food Science and Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Materials and Methods
Materials
Raw Materials
The good quality pink skin coloured sweet potatoes (*Ipomoea batatas L.*) were purchased from local market of Parbhani, Maharashtra.

Chemicals
All the chemicals, organic solvents and acids used were of analytical grade and other chemical (Fine, LOBA, BDH, Merck and Glaxo chemicals) for present investigation were obtained from Department of Food Science and Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

Processing Equipments
The equipment and machineries required in the present investigation were utilized from Department of Food Science and Technology and Niche area laboratory, Department of Food chemistry and nutrition, Niche area laboratory, Department of Horticulture and the other Departments of College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

Methods
Physical properties of isolated sweet potato starch
Bulk density was determined as given by Chegini and Ghobadian, (2005) [8], The color measurements of the starches were carried out using a Color Measuring System (Model Lab Scan-XE, Hunter Associates Laboratory Inc. USA),

Whiteness
The whiteness of starches was determined as per method described by Thao and Noomhorm, (2011) [24]. According to him the whiteness of starch was calculated by using following formula.

$$\text{Whiteness} = 100 - [(100-L)^2 + a^2 + b^2]^{1/2}$$

Functional properties of isolated sweet potato starch
The various functional properties viz., Water Absorption Capacity (WAC) of sweet potato starches were analyzed according to the method described by Abbey and Ibeh (1988) [2], Swelling Power and Solubility of sweet potato starches were studied by the method of Yuan *et al.* (2007) [29], Swelling Power and Solubility of sweet potato starches were studied by the method of Yuan *et al.* (2007) [29], Swelling Power and Solubility of sweet potato starches were studied by the method of Yuan *et al.* (2007) [29] and Sphericity of gulabjamun were investigated.

Methods of isolation of starch from sweet potato
Starches were isolated from the edible portion by three different methods and the isolated starches were analysed for functional, chemical, pasting and structural properties.

Starch isolation using sodium metabisulfite
Starch was extracted from the sweet potato by following the method of with slight modification as suggested by Vasanthan (2001). Blending of sweet potato with water was done at a ratio of 1:10 until smooth slurry was formed. Sodium metabisulfite of 0.01% (w/v) was added during slurring. After slurring, the filtration was done with double-layered cheesecloth and centrifuged for 20 min at 5000 × g at 20 °C. Starch settled at the bottom of centrifuge tube was washed with toluene; oven dried at 30° to 40 °C and packed in airtight polyethylene pouch.

Starch isolation using sodium chloride
Starch was isolated using sodium chloride as per method given Riley *et al.* (2006) [22]. The edible portion of sweet potato was cut into small pieces and homogenized with 1 M NaCl solution using a blender. The mixture was filtered through triple layered cheesecloth; starch was washed with distilled water. The granules were allowed to settle and water was decanted. The sediment was centrifuged at 3,000 x g for 10 min. Starch was removed, allowed to dry overnight at room temperature and the dried starch was ground with mortar and pestle into fine powder.

Proximate Composition
The proximate composition such as moisture, protein, fat, carbohydrates, crude fibre and total ash content was determined according to method given by A.A.C.C., (2000) [1].

Amylose Content
Amylose was determined by the method of given by Williams *et al.* (1958) [28].

Amylopectin
Amylopectin was calculated by difference method as follows:

$$\text{Amylopectin} = (100 - \text{Amylose})$$

Statistical Analysis
The data of the all experimental treatments were statistically analyzed by Completely Randomized Design (CRD) using analysis of variance (ANOVA). The analysis of variance revealed at the significance of S.E. and C.D. at 5 per cent level is mentioned wherever required (Panse and Shukhatame, 1984) [20].

Result and Discussion
Effect of different isolation treatment on yield and recovery of starch
Starch was isolated from sweet potato using, Sodium chloride (T₁) and Sodium metabisulphate (T₂) and these starches were compared for percent yield and recovery. The results pertaining to the recovery and yield of starch is as presented in table 1.

Table 1: Yield and recovery of starch from sweet potato

Treatment	Yield (%)	Recovery (%)
T₁	21.59	48.22
T₂	26.80	59.86

*Each value represents the average of three determinations
T1= Isolation of starch by using Sodium chloride (0.5 per cent) and
T2= Isolation of starch by using Sodium metabisulphate (0.01 per cent)

The highest yield and recovery was obtained by treatment T₂ (26.80 and 59.86%) respectively. There was no correlation between total starch and starch yield. This was because starch extraction was not 100 per cent efficient in any case. Extraction was said to depend on softness of the roots on harvest. According to Rahman *et al.,* (2003) [21], higher starch content does not necessarily mean higher percent of extractable starch. So, extractability of the starch is a more important criterion in the choice of variety for starch extraction rather than starch content and he found that the average starch recovery was found to be 80.2 per cent and 65.8 per cent in dry and wet seasons respectively.

Effect of different isolation treatment on physical properties of sweet potato starches

The physical properties *viz.,* bulk density; color and whiteness of starch isolated by different treatment are shown in table 2.

Table 2: Physical properties of starch obtained by different treatments

Treatment	Bulk Density (g/ml)	Color			Whiteness
		L	A	B	
T_1	0.89	93.01	-0.08	2.91	92.63
T_2	0.88	91.49	-0.07	4.35	90.27
SE±	0.001	0.006	0.003	0.004	0.001
CD @5%	0.004	0.018	0.007	0.011	0.004

*Each value is average of three determinations
T_1= Isolation of starch by using Sodium chloride (0.5 per cent) and
T_2= Isolation of starch by using Sodium metabisulphate (0.01 per cent)

Data presented in table 2 reported that there was not much variation observed for true density values among the both starches ranged from 0.88 to 0.99g/ml. Similar results were obtained by Sindhu and Khatkar, (2016) [23] for buckwheat starch. The bulk density of starch from T_2 (0.89g/ml) showed highest value followed by T_1 (0.88g/ml). The increased in bulk density of T_2 starch was due to decreased in particle size of starch as particle size is inversely proportional to bulk density. Also similar result was obtained by Eleazu and Ironua (2013) [10]. According to Oladebeye *et al.*, (2009) [19], bulk density of the granules of sweet potato starch was (0.76 g/ cm³). Bulk density is a function of particle size; particle size is inversely proportional to bulk density. Higher value bulk density of sweet potato suggests its suitability as drug binder and disintegrant in pharmaceuticals and have the more is the resistance for flow of powders.

Color and clarity are the most important characteristics that can decide successful applications of functional ingredients in different food products. The colour of starch due to the presence of polyphenolic compounds, ascorbic acid and carotene has impact on its quality. Some pigmentation in the starch is carried over to the final product which reduces the quality, hence acceptability of starch product (Glavez and Resurreccion, 1993) [12]. There was no significant difference observed for color of starches isolated by using T_1 and T_2 treatments in terms of lightness (L*), yellowness (b*). However, due to slight difference in greenness (a*) resulted in small difference in whiteness. However starch of the treatment T_1 found to be more lightness followed by T_2. The increase in lightness could be attributed to low ash content of starch (Kaur and Singh, 2007) [16], and effect of NaCl for isolation that deagglomeration of protein-starch agglomerates. Starch-protein agglomerates disintegrated resulting in protein floating to the top and being removed during separation. This resulted in reduction of the residual protein content of the isolated starch (Guraya *et al.*, 2003) [14]. Treatment T_1 and T_2 showed the satisfactory whiteness for starch purity as L* values were close to 90 or greater than 90 (Boundries *et al.*, (2009) [7]. The results of color obtained in present studies were in close agreement with Chen, (2003). According to him different starch from different variety of sweet potato had values of L*, a* (negative) and b* were ranged from 93.25-93.66, 0.35-0.55 and 2.91-4.27 respectively. Also similar results were obtained by Thao and Noomhorm, (2011) [24].

The whiteness of starches was ranged from 88.15 to 92.63. The highest value for whiteness of starch for treatment T_1 (92.63) followed by T_2 (90.27). There was no significant difference observed in starch of T_1 and T_2. The increased

whiteness of T1 and T_2 was due to purity of starch. This could be attributed by maximum removal of protein and other fractions from slurry during isolation. Also there was inverse relation in between paste clarity and whiteness. As the paste clarity increased there was decrease in whiteness. In present investigation as shown in table 2. Hence results justify the positive relation among whiteness and paste clarity as reported by Bello-Perez and lrapuato, (1996) [6].

Effect of different isolation treatment on chemical composition of sweet potato starch

The proximate compositions of sweet potato starches obtained by different treatment are as presented in table 3.

Table 3: Chemical composition of sweet potato starch

Treatments	Composition (%)					
	Moisture	Protein	Fat	Ash	Starch	Amylose
T_1	12.13	0.24	0.09	0.26	91.88	17.93
T_2	12.57	0.31	0.11	0.13	87.51	18.23
SE±	0.002	0.002	0.001	0.003	0.070	0.045
CD@ 5%	0.006	0.007	0.004	0.008	0.208	0.132

*Each value is average of three determinations
T_1= Isolation of starch by using Sodium chloride (0.5 per cent) and
T_2= Isolation of starch by using Sodium metabisulphate (0.01 per cent)

It was revealed that extracted starch appears to be in pure form and free from other components, it is invariably accompanied by various other components *viz,* proteins, lipids, fibers and minerals depending on a number of factors like method of extraction, maturity of crop, environmental conditions etc. Some of these impart desirable qualities to the starch, while others have detrimental effect on quality.

Moisture content of starches ranged from 12.13 to 12.57 per cent similar to the results of Tsakama *et al.,* (2010) [26], and it was within the range of 10 to 20 per cent that is recommended for commercial starches. Difference in moisture content may be due to the starch granule structures of the sweet potato starch. According to Lawal, (2004) [17], the moisture content of a powder plays a significant role in the flow and other mechanical properties of the food.

From table 3 it was cleared that the protein content of starches varied from 0.24 to 0.31 per cent. In method of extraction of starch (T_1) the protein content found to be 0.24 per cent, varied significantly from T_2 because addition of NaCl during isolation removed the protein fraction which adhered with starch material up to some extent. Higher amount of protein present in starches of treatment T_1 and T_2 could be due to less removal of protein during extraction of starch from sweet potato. Fat content was found to be 0.09 to 0.11 per cent.

Ash content of sweet potato starches ranged from 0.13 to 0.26 per cent and the similar results were reported by Abegunde *et al.,* (2012) [3]. The variation in the values of ash and fat content could be attributed to extraction method and degree of homogenization for isolation of starch.

Amylose and total starch content of starch samples were ranged between 17.93 to 18.23 per cent respectively. These results are at par with Tsakama *et al.,* (2011) [25] and Aina *et al.,* 2012 [4]. The percent starch in treatment T_1 was highest (91.88%) than followed by T_1 (87.51%) and that means the purity of starch isolated by T_1 was highest. It could be due use of NaCl for isolation that deagglomeration of protein-starch agglomerates. Starch-protein agglomerates disintegrated resulting in protein floating to the top and being removed during separation. This resulted in reduction of the residual protein content of the isolated starch (Guraya *et al.*, 2003) [14].

Effect of different isolation treatment on functional properties of sweet potato starch

The results of functional properties like Water absorption capacity, solubility, swelling power and paste clarity of sweet potato starch extracted by the two methods are given in Table 4

Table 4: Functional properties of starch from sweet potato

Treatment	Functional Properties			
	WAC (g/g)	Solubility (%)	Swelling Power (%)	Paste Clarity (%)
T₁	0.74	2.19	4.28	33.77
T₂	0.65	2.37	4.83	33.26
SE±	0.016	0.001	0.002	0.008
CD@ 5%	0.046	0.006	0.006	0.022

*Each value is average of three determinations
T_1= Isolation of starch by using Sodium chloride (0.5 per cent)
T_2= Isolation of starch by using Sodium metabisulphate (0.01 per cent)

Water Absorption Capacity (WAC) of sweet potato starches was ranged from 0.65 to 0.74 g/g. WAC is related to the interactive forces among starch components, weak interactive forces results in high WAC (Riley *et al.,* 2006) [22]. It could be due to greater hydrophobic tendency than hydrophilic tendency of isolated starches.

Shine and color of a product were influenced by the paste clarity of starch and paste clarity is a much desirable functionality of starches for its utilization in food industries since it directly influences brightness and opacity in foods that contain it as thickener. From table 4 the paste clarity of sweet potato starch ranged from 33.26 to 33.77 per cent which was similar to results obtained by Iheagwara, (2013) [15]. There was not much variations was found in paste clarity of both the starches. The reduction in paste clarity which could be attributed due to the different methods used for starch isolation, starch paste preparation and the interaction between phosphates group and sodium ions (in T_1 and T_2) that produce a collapsed structure decreasing light transmittance (Bello-Perez and Irapuato, 1996) [6]. The swelling power of isolated starches at 60^0C ranged from 4.28 to 4.83 per cent. This results were similar with the results reported by who reported that the swelling power of sweet potato starches was found to be 5.23-16.38 percent with temperature range of 65-95ºC. Swelling power of a starch can be associated with starch and its minor components (e.g., proteins and lipids), pre-treatment and processing conditions. Strong bonded micellar network of starch polymer was the primary factor in influencing the swelling property. Low swelling power starches might be due to the existence of huge number of crystallites formed by the association between long amylopectin chains. According to starch granular stability was increased as a result of crystallite formation and swelling decreases. Solubility values were ranged from 2.19 to 2.37 per cent at 60^0C. Similar range of solubility for sweet potato starch was reported by Abegunde *et al.,* (2012) [3].

Conclusion

It is concluded from the study that isolation of sweet potato starch using Sodium metabisulphate (0.01 per cent) obtained more yield and percent recovery with desirable functional properties which indicates the potential use of starch in different food product.

References

1. AACC. Approved Methods of the American Association of Cereal Chemists, 10th Ed. 2000.
2. Abbey BW, Ibe CO. Functional properties of raw and heated processed cowpea (*Vigna unguiculata* Walp) flour. Journal of Food Science. 1988; 53**:**1775-1777.
3. Abegunde OK, Mu T, Arogundade LA, Deng F, Chen J. Physicochemical characterization of starches from some Nigerian and Chinese roots and tubers. African Journal of Food Science. 2012; 6(11):317-329.
4. Aina JA, Falade OK, Akingbala OJ, Titus P. Physicochemical Properties of Caribbean Sweet Potato (*Ipomoea batatas* (L) Lam) Starches. Food Bioprocess Technol. 2012; 5:576-583.
5. Babu SA, Parimalavalli R. Functional and chemical properties of starch isolated from tubers. International Journal of Agricultural and Food Science. 2012; 2(3):77-80.
6. Bello-Perez LA, Irapuato 0. Paredes-Ldpez. Starch and Amylopectin- Effect Solutes on Clarity of paste. Starch-Starke. 1996; 48(6):205-207.
7. Boudries N, Belhaneche NN, Deroanne C, Mathlouthi M, Roger B, Sindic M. Physicochemical and functional properties of starches from sorghum cultivated in the Sahara of Algeria. Carbohydrate Polymers. 2009; 78:475-480.
8. Chegini GR, Ghobadian B. Effect of spray-drying conditions on physical properties of orange juice powder. Dairying Technol. 2005; 23:657-668.
9. Chen Z, Schols HA, Voragen AGJ. Physicochemical properties of starches obtained from three varieties of chinese sweet potatoes. Journal of Food Science. 2003; 64(2):431-437.
10. Eleazu CO, Ironua C. Physicochemical composition and antioxidant properties of a sweet potato variety (*Ipomoea batatas* L) commercially sold in South Eastern Nigeria. African Journal of Biotechnology. 2013; 12(7):720-727.
11. FAO. Food and Agricultural Organizations of UN Statistics. 2014. Link: http://www.fao.org/faostat/en as on [26th December 2016].
12. Glavez FCF, Resureccion AVA. The effects of decortications and method of extraction on the physical and chemical properties of starch from mung bean (*Vigna radiate* L. Wilcze). Journal of Food Process Preservation. 1993; 17:93-107.
13. Gunaratne A, Corke H. Functional Properties of Hydroxypropylated, Cross-Linked, and Hydroxypropylated Cross-Linked Tuber and Root Starches. Cereal Chemistry. 2007; 84:30-37.
14. Guraya HS, James C, Champagne ET. Physical basis for separation of rice starch using various density gradient systems and its effect on starch recovery, purity, and pasting properties. Starch/Stärke. 2003; 55:450-456.
15. Iheagwara MC. Isolation, modification and characterization of sweet potato (*Ipomoea batatas* L (Lam)) starch. J. Food Process Technol. 2013; 4(1):1-7.
16. Kaur A, Singh N, Ezekiel R, Singh HG. Physicochemical, thermal and pasting properties of starches separated from different potato cultivars grown at different locations. Food Chemistry. 2007; 101:643-651.
17. Lawal OS. Composition, physicochemical properties and retrogradation characteristics of native, oxidized, acetylated and acid thinned new cocoyam (*Xanthosoma sagittifolium*) starch. Food Chem. 2004; 87:205-218.
18. Mweta DE, Labuschagne MT, Koen E, Benesi IRM, Saka

JDK. Some properties of starches from cocoyam (*Colocasia esculenta*) and cassava (*Manihot esculenta Crantz*) grown in Malawi. African J. Food Sci. 2008; 2:102-111.

19. Oladebeye AO, Oshodi AA, Oladebeye AA. Physicochemical Properties of Starches of Sweet Potato (*Ipomea batata*) and Red Cocoyam (*Colocasia esculenta*) Cormels. Pakistan Journal of Nutrition. 2009; 8(4):313-315.

20. Panse VS, Sukhatme PV. Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi. 1984, 70-72.

21. Rahman SMM, Wheatley C, Rakshit SK. Selection of Sweet Potato Variety for High Starch Extraction. International Journal of Food Properties. 2003; 6(3):419-430.

22. Riley CK, Wheatley AO, Asemota HN. Isolation and characterization of starches from eight *Dioscoreaalata*cultivars grown in Jamaica. African Journal of Biotechnology. 2006; 5(17):1 528-1536.

23. Sindhu R, Khatkar BS. Composition and functional properties of common buckwheat (*Fagopyrum Esculentum Moench*) flour and starch. International Journal of Innovative Research and Advanced Studies. 2016; 3(7):154-159.

24. Thao HM, Noomhorm A. Physiochemical Properties of Sweet Potato and Mung Bean Starch and Their Blends for Noodle Production. J. Food Process Technol. 2011; 2(1):2-9.

25. Tsakama M, Mwangwela AM, Manani TA, Mahungu NM. Effect of heat moisture treatment on physicochemical and pasting properties of starch extracted from eleven sweet potato varieties. International Research Journal of Agricultural Science and Soil Science. 2011; 1(7):254-260.

26. Tsakama M, Mwangwela AM, Manani TA, Mahungu NM. Physicochemical and pasting properties of starch extracted from eleven sweet potato varieties, African Journal Food Science Technology. 2010; 1:90-98.

27. Vasanthan T. Overview of laboratory isolation of starch from plant materials. Food Anal. Chem. 2001, Unit E2.1.1-E2.1.6.

28. Williams VR, Wu W, Tsai HY, Bates HG. Varietal differences in amylose content of rice starch. Journal of Agriculture and Food Chemistry. 1958; 6:47-48.

29. Yuan Y, Zhang LM, Dai YJ, Yu JG. Physicochemical properties of starch obtained from Dioscorea nipponica Makino comparison with other tuber starches. Journal of Food Engineering. 2007; 82:436-442.