

Review Article

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Potato Starch: Novel Ingredient for Food Industry

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ABSTRACT

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Potato is a crop cultivated worldwide and starch extracted from potato had superior properties than their cereal starches. The limitations of native potato starch can be overcome by physical, chemical, enzymatic modifications. In fact, potato starch can easily be tailored to the requirements of the final product and can give superior techno-functional properties to the food than traditionally available cereal starches. It has larger granule size, high purity, longer amylose and amylopectin chains with phosphate ester groups on amylopectin, and form thick, clear visco-elastic gels. These properties make potato starch suitable for use in range of food products and pharmaceutical application.

Introduction

Among carbohydrate polymers, starch is currently enjoying an increased attention owing to the beneficial properties it imparts in food products. Approximately, 60 million tonnes starch is extracted annually worldwide from cereals, tubers and root crops, of which roughly 60% is used in foods and 40% in pharmaceuticals and non-edible purposes (Burrell, 2003). Starch acts as texturizer in food products and has applications as thickener, colloidal stabilizer, gelling agent, bulking agent and water retention agent.

Property of starch depends on its source. Starches extracted from cereals will differ in techno-functional properties than those extracted from vegetables. The major differences in starch properties are attributes to amylose/amylopectin ratio, granule size distribution, mean granule size, mineral content and presence of naturally occurring non-carbohydrate impurities (Aina *et al.*, 2010; Neeraj, 2017).

Starch is synthesized by plant cells and is made up of two polymers: amylose and amylopectin. Amylopectin consists of linear chains of

glucose units linked by α -1,4 glycosidic bonds and is highly branched at the α -1,6 positions by small glucose chains at intervals of 10 nm along the molecule's axis. Amylose, on the other hand, is essentially a linear chain of α -1,4 glucans with limited branching points at the α -1,6 positions. The relative amounts of amylose and amylopectin are known to influence both nutritional and technological properties of starch such as susceptibility to enzymatic hydrolysis, gelling and pasting behavior, which could be of biotechnological importance (Gerard *et al.*, 2002).

Starch Distribution around the world

Maize or corn starch makes up more than 80% of the world market for starch with most of this produced in the USA. Europe is the major producer of wheat and potato starches, whereas cassava or tapioca starch is produced mainly in Asia. Corn and potato starches are widely used commercially. Tuber or root starches have both larger granules and lower protein and lipid contents than cereal starches. Upon processing, tuber and root starches form clear pastes that have a bland taste, which have advantages in many food applications. Generally, root and tuber crops are rich sources of starch containing 70- 80% of water, 16-24% starch (85-87% dry matter), trace quantities (< 4%) of protein and lipids besides other minerals and vitamins (Hoover, 2001). Although a wide range of tuber crops are grown worldwide, only five species account for almost 99% of the total world production. These are potato (*Solanum tuberosum*, 46%), cassava (*Manihot esculenta*, 28%), sweet potato (*Ipomea batatas*, 18%), yams (*Dioscorea* spp., 6%) and taro (*Colocassia*, *Cytosperma*, *Xanthosoma* spp., 1%). UNESCO (United Nations Educational, Scientific and Cultural Organization) declared potato as the food of future during the 'International Year of Potato 2008' and stated potato as the 3rd most important World food crop. Being a short

duration crop, it produces more quantity of dry matter, edible energy and edible protein in lesser duration of time than cereals like rice and wheat. Industrial uses of potatoes include products like frozen fries, flakes, snacks, flour and starch (Gómez-Castillo, 2013).

Properties of potato starch

High content of phosphorus esterified with some of the glucose units of the amylopectin is a specific property of potato starch. Potato starch contained less protein, lipid and ash contents as compared to corn and tapioca starch. Potato starch is unique compared to cereal starches (corn, wheat, rice, etc), because of its larger granule size and purity, longer amylose and amylopectin chain length, presence of phosphate ester groups on amylopectin, ability to exchange certain cations with corresponding effects on viscosity behaviour, ability to form a thick visco-elastic gel (Singh *et al.*, 2003). Potato starch had certain limitations such as low shear resistance, thermal resistance, thermal decomposition and high tendency towards retrogradation. This limits its use in some industrial food applications.

Potato starch extraction methods

Starch can be extracted using different methods, depending on the plant source and end use of the starch. Extraction procedures affect both the chemical composition and the physical properties of starch. Potato starch can be isolated by various extraction methods using different steeping times, extraction temperatures, concentration and nature of chemicals, enzymes, etc. have been used by different workers to isolate starch from different sources. So combined method required for starch extraction having all the desirable qualitative properties so that it can be used in different food products (Neeraj, 2017).

Table.1 Method of extraction of potato starch and its effect on starch properties

Extraction Methods	Extraction treatment	Changes in potato starch	References
Physical	Heat-moisture treatment	Modified starch showed decreased relative crystallinity exhibiting A+B X-ray pattern. It also had lower amylose leaching, lower swelling factor, and higher enzymatic hydrolysis.	Gunaratne and Hoover, (2002)
	Microwave and ultrasound irradiation	Improved emulsifying and surfactant properties	Cízová <i>et al.</i> , 2008
	Pulsed Electric Field	Intra-granular molecular rearrangement of starch granules which resulted into changes related different physico-chemical properties of treated starch inducing some new characteristics and functions	Han <i>et al.</i> , 2009
	High Hydrostatic pressure	Distorted molecular integrity, crystallinity was preserved, demonstrated limited swelling	Błaszczak <i>et al.</i> , 2005; Stute <i>et al.</i> , 1996
Chemical	Epichlorohydrin and Phosphoryl Chloride	Solubility of cross-linked starch decreased with increasing degree of cross-linking at all temperatures when compared to native starch	Kaur <i>et al.</i> , 2006
	Alkali (NaOH)	higher swelling power and solubility; lower protein content, higher starch purity, higher peak viscosity, final viscosity, lower paste stability and higher gelatinization temperature as compared to distilled water extraction methods.	Uthumporn <i>et al.</i> , (2012); Neeraj (2017)
	Sodium dodecylsulphate: Mercaptoethanol solution	Swelling power and solubility increased, increased peak viscosity, starch protein content decreased, purity increased; amylose content, swelling power and peak viscosity were significantly increased, peak time and peak temperature decreased for starches.	Singh & Kaur, 2004; Blake <i>et al.</i> , (2015); Neeraj (2017)
	N-propanol: water	Pasting viscosity decreased, thermal stability of starch decreased, syneresis increased, starch lipid content decreased	Neeraj (2017)
	Sodium hypochlorite and hydrochloric acid	Modified starch had higher concentration of larger granules, higher swelling power, solubility, water holding capacity with better paste clarity and improved pasting characteristics than native starch	Khan <i>et al.</i> , (2014); Neeraj and Bisht (2018)
Enzymatic	Cellulase	Starch yield increased, freeze thaw stability, pasting temperature, paste clarity and swelling of the starch granules increased	Sit <i>et al.</i> , (2015) ; Neeraj (2017)
	Protease	Protein content decreased, high amylose and resistant starch contents and produced strong, elastic and stable gels	Correia and Beirão-da-Costa, (2012)

Table.2 Application of potato starch in food products according to its functional properties

Food application	Desired quality	Starch Properties
Bread making	Improve bread crumb characteristics and baking performance	High amylose starch, high gelling strength, as thickeners, high water absorption capacity, Increased stability in the hot paste, paste stability
Gelling and thickening agent in pie and salad dressing	Formation of clear or opaque based on desired product	High paste viscosity, high breakdown viscosity and low setback viscosity
Cantonese noodles, Fish paste products	Desirable color and texture	Highly swelled starch increase smoothness and tendency to reduce firmness and elasticity
Frozen food products, canned products	Better uniformity, stability and texture of product. Product has better freeze thaw stability	Lower setback viscosity, Low paste temperature, low gelling point and lower amylose content and low retrograding tendency
High temperature cooked food	Stabilizing agent- the texture of the product doesn't change on heating	Resistance to heat treatment lowest swelling index, formed very viscous, firm gel after cooling
Jellies and fruit	Increased paste clarity greater stability of the starch structure, improvement of inter and intramolecular bonding	
UHT food products	Canned products	Higher stability ratio, high resistance of starch paste to viscosity breakdown as shear applied, stability against high temperature degradation
Dairy products	As texturizers	Low viscosity, high clarity and low-temperature stability

Extraction procedures affect both the chemical composition and the physical properties of starch and this is presented in Table 1 (Neeraj, 2017). Selecting an appropriate starch extracting method is restricted to obtain a pure product with maximum yield and recovery, lowest cost, and application of a series of interrelated stages allowing the non-starchy fraction to be removed without affecting the granule native structure and minimal incidence on its physico-chemical and mechanical properties (Correia and Beirao-da-Costa, 2012).

Modification of native potato starch

Native starches irrespective of their source are undesirable for many industrial applications because of their inability to withstand processing conditions such as extreme temperature (has low thermal resistance), diverse pH and high shear rate (has low shear resistance) (Singh *et al.*, 2007), high ability to retrograde, loss of viscosity, syneresis tendency and thickening power upon cooking and storage particular at low pH. Native starch can be tailored by chemical, genetic,

enzymatic and physical treatments to enhance its specific and desired properties, and these can be used to improve the physiochemical, morphological, rheological and functional properties of some native starch.

The properties of native potato starch, however, may not be desirable for all applications. Modification of potato starch can help in this respect. So to these shortcomings may be overcome by starch modification by chemical (NaOH, NaOCl, acid, alcohol), physical (heat-moisture treatments, annealing, microwave heating), and enzymatic methods (cellulase, protease, lipase) (Neeraj, 2018).

Application of potato starch

Food is multi-component, multi-phase system that contains complex mixture of water, polysaccharides, proteins, lipids and numerous minor constituents. Potato starch is most commonly used to thicken, stabilize and enhance the mouthfeel of canned foods such as puddings, pie- fillings, soups, sauces and gravies. In puddings, starch is used to enhance viscosity and smoothness. When starch is added into surimi seafood, it modifies texture, improves freeze-thaw stability, and decreases the product cost (with the addition of water). Also, starch gives a whiter and glossier appearance to surimi gel. Surimi solubilized by salt and water forms a continuous matrix. Starch can be entrapped within this matrix and therefore fill the gel. Starch acts as filler within the matrix. Starch granules absorb water and expand themselves on heating until they are limited by the gel matrix. The expansion of the starch granules results in a reinforcing or pressuring effect on the gel matrix and also in a higher gel strength (Liu *et al.*, 2014). Starch having freeze-thaw stability, low syneresis and resistant to retrogradation are used in frozen foods. High amylose starches can be processed into 'resistant

starch', which has nutritional benefits. Unlike normal starch, resistant starch is not digested in the small intestine but is fermented in the large intestine by gut bacteria, producing short-chain fatty acids such as butyrate that are beneficial for colon health. Starch having different qualitative properties can be utilized in a range of food products (Table 2). Potato starch has the highest level of phosphate among commercial starches, and this is in part responsible for the high swelling power and stable-paste properties of this starch. The high viscosity of potato starch can be utilized to have an advantage in instant soups and sauces (Singh *et al.*, 2003).

In conclusion, potato is grown as a vegetable for consumption, and is processed into snacks. Starch can be extracted from potatoes can be stored for a longer time. Starch is present as a macro-constituent in many foods and its properties and interactions with other constituents, particularly water and lipids, are of interest to the food industry and for human nutrition. Potato starch has superior functional properties than other cereal based starches. The way forward is to engage in more studies regarding the modification of potato starch to make it suitable for the end product and use it to the consumer's and manufacturer's advantage.

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