

SCOPE FOR FOOD PROCESSING INDUSTRIES TO BOOST GLOBAL ECONOMY BY MEANS OF POTATO VALUE ADDITION: A REVIEW

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ABSTRACT: Potato, an important agricultural crop grown mainly for domestic consumption as well as for variety of uses. The consumption of fresh potato accounts for 50% in worldwide, and the remaining is being processed into variety of food products as well as food ingredients for its use in food processing industries. The waste generated from potato processing industries, which is being fed to various livestock's and poultry, it can also be used for production of starch. Value added products produced from potato, which is being highly liked and consumed to a greater extent especially frozen potatoes like crisp and French fries especially in UK restaurants. The fuel grade ethanol can also be even manufactured by fermenting the liquid extract obtained from potato processing waste, so there is an ample scope for the various food processing industries to add value to this crop in order to boost the economy of the nation.

KEYWORDS: Potato, chips, French fries, flour, starch

INTRODUCTION

Potato, one of the essential agricultural crops, which are being cultivated in several countries. India stands second place in the production of potato after China, both the countries significantly lead to produce around 38% of total global potato production. The consumption of potato at global level accounts to around greater than a billion (FAO, 2008). By using this crop, several processed products can be prepared, which can further enhance the economic potential of the country. The crop had significant level of protein, which possesses more biological value, when compared to cereals and dairy products and therefore, it can be considered as a major vegetable ascribed to the source of energy as well as protein (King and Slavin, 2013). Potato and its processed products

were consumed widely, which form the part of breakfast, lunch as well as dinner. With respect to production aspects, more amount of dry matter cum nutrients like starch as well as proteins was produced in minimum duration, when compared to production of other agricultural crops like cereals (Rajiv and Kavar, 2016). The nation's nutritional security can be achieved by growing potato at huge extent.

The technology is widely available for exploring postharvest handling and value addition of potato in tropical parts of the world (Dhumal *et al.*, 1991). There is a lot of demand for value added products from potato viz. French fries, especially in fast food industries. In the early hood years, the usage of potato products has tremendously enhanced because of scientific existence of

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new innovative products, to name a few which includes potato flour, flakes, French fried products and also extraction of chemical components like chaconine, lactic acid, and solanine and many more products (Salunkhe and Kadam, 1991).

In UK, most of the fast food outlets and restaurants serve frozen potatoes in the form of French fries, which is deeply fried in oil, and it will be liked by most of the consumers. The global scenario is changing from utilizing potatoes in the fresh form to several value added products (FAO, 2008). Globally around 7 million tons of French fries were processed annually to cater the need of a consumer at global level (DHC, 2016). The global market growth of popularly consumed potato products were given in Table 1. The U.S manufactured and marketed potato crisp in the form of chips, which is also produced by several other developed countries. The starch obtained from potato is being used by multisector industries like paper, pharmaceutical, textile etc. Its usage in respective industries seems to be more, it can be used as a filling, binding, texturing and adhesive agents (Stearns *et al.*, 1994). One can use the starch obtained from potato as an alternative for manufacturing plastics and polystyrene products, it can be used in biodegradable cups, dishes, plates etc.

Good quality alcohol can be produced by using waste product obtained from peels of potato. Starch from these wastes can be effectively utilized for fermentation to further

yield alcohol (Dimitrios *et al.*,2010). Therefore, the global economy can be boosted by adding value to this crop into the form of various innovative processed potato products.

Therefore, in this review the various processing techniques adopted for manufacturing several potato based products were highlighted, which may further help the entrepreneur to start the industry, which can provide employment generation on one side and income generation on another side, which may help in boosting the global economy to a greater extent.

Potato value addition

French fries

Frozen potatoes in the form of French fries were the popular processed product consumed widely irrespective of the age. Majority of the consumption goes to this product only. The consumer choice for this product is long fry, which is being fried in vegetable oils, for this purpose long variety potatoes should be used for processing (Stearns *et al.*, 1994). It occupies not only as the evening snacks but also used as a startup during dinner in most of the hotel food industries. The color quality of the potatoes can be enhanced by choosing the potato varieties with lesser reducing sugar content, so that browning can be reduced during frying (Tzia *et al.*, 2016). The crop is of course seasonal in nature; therefore proper post-harvest handling and storage practices should be adopted to cater the need

Table 1. Market growth of popularly consumed potato products.

Name of the product	Maket size (2019) US Billion \$	Forecasted market size (2019-2024) US Billion \$	Top leading manufacturers	Challenges faced by firms
Potato Chips	30	35	PepsiCo, Kraft Foods, Nestle, Diamond, General Mills	Low fat, Low calorie
Frozen Potato Products	52	72	MccainFoods, Nomad Foods, Aviko Group, Kraft Heinz, Lamb Weston	Low fat

of consumer demand (Talburt *et al.*, 1987; Kadam *et al.*, 1991). To manufacture frozen fries, one has to consider selecting tubers with higher solids content with good texture; this is because the higher solid content has lesser moisture content compared to potato varieties of lesser solids (Stearns *et al.*, 1994). Selection of species with greater specific gravity also produces crispy, mealy with reduced oil absorption capacity. More specific gravity potato variety yields richer taste with slight tenderness (Kadam *et al.*, 1991).

Manufacturing of French fries

Receiving of raw materials, washing and peeling

The flow sheet for production of French fries was given in Fig.1. The potato is received, screened for its defect; malformed, greenish and infected potatoes were removed and send for washing. The potatoes were subjected to washing with the help of drum washer, during washing the solid particles

adhere to the potato get dissolved in water and they were washed, after that they were send to the peeling section. The potatoes were peeled by steam peeling process, the potatoes were subjected to steam pressure, the product surface layer is exposed to steam and after some minutes the pressure is quickly released, during this time the potato cell moisture begins boiling and the cell wall is being rubbed, making the skin looser, so that peeling can be effectively carried out and the adhering microorganisms will be killed during the steaming process, which render the product devoid of microbes for further processing. The loose peels were removed by using brush machines and this waste is utilized as an efficient feed for various cattle's. Once again the peeled potatoes were subjected for washing to remove the last traces of starch dirt's followed by manual inspection for efficient and quality processing.

Cutting, sorting and blanching

The slices were prepared with the help of hydro cutting system, especially for producing the French fries; one has to assure that slices should be of either square shape with straight cuts. The major advantages of this cutting are slice damage that will be minimized during cutting with reduced oil uptake during frying. Then the slices enter into blanching process in two stages, in first stage, where the blanching is done by treating cut slices with hot water around 90°C for a time period of 2 min, wherein the second stage the slices were exposed to a lesser temperature of 70°C with exposing time duration of 40 min.

Drying

The product quality sounds well if it has uniform color, for this the slices needs to be dipped in hot water at 80°C for a period of 45-60 sec. The slices were drained

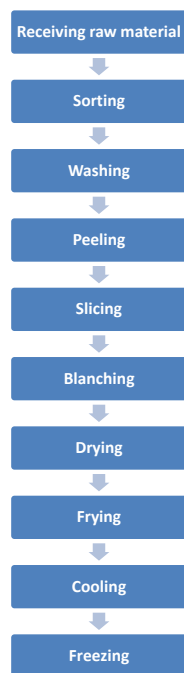


Fig. 1. Flow sheet for production of French fries.

and spread on the dryer belt for removal of some moisture before frying, which will definitely enhance the crispiness of the final product, on the other side it will reduce the oil absorption capacity during frying process and frying time will also be minimized to a greater extent. During drying the hot air will be travelling in upward as well as downward direction, which efficiently removes the moisture content by reducing the weight to 20%. The assurance of internal moisture equilibrium is very much important before frying process.

Frying

Frying is carried out in fryer equipment with filled oil. The oil is filled with the help of pump circulatory system; it also contains heat exchanger system for controlling heat with belt filter for removing dirt's. The pan is maintained at temperature of 180 °C during frying process with the exposure time duration of 1-2 min. De-fatting vibrator is placed near fryer to remove surface fat from the product.

Cooling and freezing

The cool air is blown from cooling tunnel towards the product for reducing the temperature from 90°C to 5°C, in this tunnel the products were exposed for 4 min after that the products were send for freezing with the help of freezer belt. The freezing is carried out rapidly with the help of commercial freezer by maintaining the temperature of -18°C for 10 min time duration.

Potato chips

This product, which is quiet popular snack product in US and it is also consumed by different age groups. The major challenges attached with this product are incorporation of spicy flavor, which has significant effect towards organoleptic characteristics.

This is a typical product served to the different sorts of people (McMath, 1990). It's a widely consumed food product especially among youngsters. The product, which is highly preferred because of its crispness texture, salt taste and fat mouth feel.

Production of potato chips

The potatoes were received in the manufacturing industries, they were stored properly preferably under cold atmosphere, if the processing time delays or immediately it can be washed to remove the adhering surface microorganism, and also to remove stones, dirt and they were peeled with the help of potato peeling machine assuring that without causing any damage to the potatoes. The pleasant color and chips texture will be affected if we utilize damaged tubers. After peeling once again the peeled one is again washed with potable water to prevent discoloration. One has to evaluate the quality checks during peeling like evaluation of potato for identification of green and dark patches, contaminated parts, bruises if any and also for trimming of eyes in order to assure the sound quality product. The very larger potatoes were chopped before the process of slicing, as they crumble as a result of frying. Slicing is an important operation to ensure crispiness quality because of uniform texture and it should be in the range of 0.7 to 1.8 mm. Sliced potatoes were also further washed to remove adhering carbohydrates like starch, sugars in order to prevent them from browning during frying (Tzia *et al.*, 2016). The uniform and consistent colored product can be retained by washing slices.

It was observed that for improving the color appearance the slices were blanched using plain potable water or by adding salt or chemical like sodium bisulfite at temperature of 65°C–95°C for time duration

of 1 min has significantly improved the color appeal (Tzia *et al.*, 2016). The slices should be partially dried before frying and after blanching period to reduce more oil absorption capacity.

After blanching and before frying, partial drying of slices should occur to avoid excessive oil absorption by the product. In bigger and continuous potato processing unit the chips were continuously dried before frying, the temperature utilized during frying is around 175°C- 190°C with a frying time of less than 3 min to achieve good quality product. Once the product is fried, the adhering oil can be easily removed from chips with incorporation of salt cum desired flavors (Tzia *et al.*, 2016). The products were cooled as such and send to the packaging section through conveyor. In the meantime, broken and burnt chips were removed, packed in laminated films, heat sealed and transported to the storage go downs until marketing (Vorria *et al.*, 2004).

Fried potato skin

It's a product, which can be prepared from Russet potatoes, peels can be easily fried or baked. The product will have minimum oil absorption capacity.

Mashes potatoes

The potatoes can be sorted, washed, steam blanched, peeled, mashed and seasoned with garlic and onion to be marketed as seasoned mashed potatoes, which is a quiet popular product in United States.

Potato cuisine microwaveable mini potatoes

In Canada, a product known as Potato Cuisine Microwaveable Mini Potatoes, which are being marketed with 5 different kinds of spices viz. garlic, smoked paprika, sundried

tomato, Maple Butter, Caribbean Jerk. This product were packed in trays and they can be easily cooked less than 7 min in microwave

Precooked frozen potato specialities

It's a product from Agristo firm; a Belgium based company successfully produces this product. The frozen potato specialities can be precooked using virgin sunflower oil, which is s source for 90% monounsaturated and polyunsaturated fatty acids. Precooking the products in such oil may remove bad cholesterol in the body, due to low oil intake during deep fat frying of such product, thereby preventing lifestyle diseases especially heart related diseases. The precooked, frozen and fried potato products taste well as like deep fat fried potato products

Potato flakes

It is one of the dehydrated potato products, which are available in the form of pellets, granules, powder, shredded and sliced forms. It is prepared by subjecting cooked potatoes into a drum drier to give a thin sheet, which is further grounded into a specific form of a product (NPCS, 2012; Milan *et al.*, 2023). During processing the cells were disintegrated, which will yield a mealy textured product ascribed to addition of monoglyceride as an emulsifier and as well as cooking of potatoes (Willard *et al.*, 1987). The short potato pieces during production of French fries can also be used for manufacturing potato flakes by means of grading as per the size (Willard *et al.*, 1987). It has got excellent application; it can be used in manufacturing other products on large scale like pasta, croquettes, instant mashed potatoes etc. It can be used as a thickening agent in chocolate milk, gravies and frozen desserts (NPCS, 2012).

Potato flour

It is one of the widely used potato products and it is being commercially used in bakery industries especially bread (Ezekiel and Singh, 2011). The incorporation of solids from source of potato may enhance organoleptic qualities especially product fresh appeal, pleasant flavor as well as for improvement of toasting qualities. The flour can be obtained by feeding the dehydrated and cooked potatoes into drum drier with applicator rolls attachment. Desired product fineness can be achieved by pulverizing sheets of potato solids (NPCS, 2012).

Snack kind of crackers can be prepared with the help of this flour, fabricated potato chips as well as frankfurters can also be manufactured by using potato flour (Ezekiel and Singh, 2011). The potato processed product industry can be further extended by adopting various new techniques and processes (Willard and Hix, 1987).

Minor Products

There are several commercial by products that can be manufactured by using potato (Milan *et al.*, 2023). The waste generated from potato industries can be utilized as cattle feed and even it's a source for extraction of various chemical components (Kadam *et al.*, 1991).

Potato starch

Starch is a major carbohydrate and it's a precious raw material for several food processing industries (Carvalho, 2008). It is being utilized for either food or feed purpose. The sub quality potatoes accounts for around 10% of the entire crop production, it will be difficult to further process such produce because of either damaged or malformed or any other defects, such crop can be utilized for manufacturing of starch. The starch can also be even manufactured from culled as

well as potatoes which are meant for cattle feed (Treadway, 1987).

The industrial demand stands in the production of starch from especially corn sources, which has got wide utility, production cost is also less for starch obtained from corn sources compared to potato (ERS, 1993). Even though the corn starch price is low, but potato starch is widely used in industries because of its functional properties (Phadnis and Jadhav, 1991). The functional properties for potato starch are excellent binding capacity, film forming ability, higher consistency etc.

Potato starch applications

For most of the products usage, the starch needs to be modified and they can be modified either by physically or chemically or enzymatically to cater specific use (Phadnis and Jadhav, 1991). The applications of starch for various industries obtained from source of potato are given in Fig.2.

Paper industry

The application of starch in paper industry is surface coating for manufacturing paper of high quality, for sizing of beater, here the fibres i.e. cellulose fibres, which can be

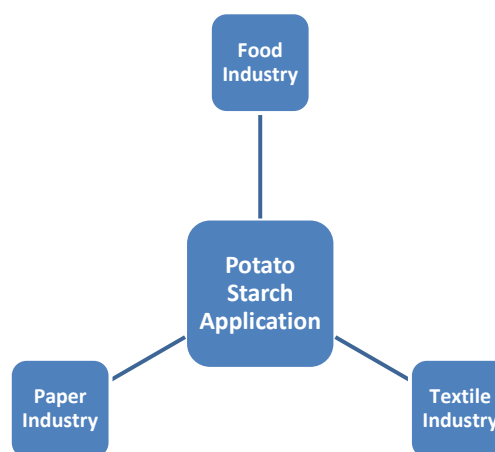


Fig.2. Application of starch obtained from potato.

cemented jointly ahead of forming sheets; tub sizing, here the sheet is send through dilute solution and finally calendar sizing, here the glossy finishing is obtained. The dextrin's and starches obtained from the source of potatoes were used for fabrication of boxes especially for fabricating laminated and corrugated fibre boxes (Treadway, 1987; Phadnis and Jadhav, 1991).

Textile industry

In textile industry the starch can be utilized for cotton sizing, as well as for spun rayon warps (Stearns *et al.*, 1994). The loose fibers can be binded by means of warp sizing, which can further prevent the warp during weaving process by means of abrasion. The greater flexibility and toughness can be obtained when potato starch is especially used, which further permit the sized warps from potato can be woven at lesser humidity when compared to wraps sized by using corn starch (Stearns *et al.*, 1994).

Food industry

In food industry, the starch obtained from potato is being used for baking industry (Stearns *et al.*, 1994). Its utility as a soup and gravy thickener, the pellets were used in the preparation of instant puddings, ascribed to jellying consistency (Stearns *et al.*, 1994). In confectionery processing, it can be utilized for molding purpose especially during processing cast candies. It can be a bodying agent, which can add softness to marshmallows and caramels, as a thickener in jellies, as a dusting ingredient along with crushed sugars for chewing gums (Treadway, 1987).

A product known as Perfect amyI Gel MB, which is a starch derived product from potato, which can be used for substituting casein protein @ of 20% in imitation cheese formulations with reduced product

production cost to 10 to 15%. The starch can be used successfully as a ingredient in various food processing industries because of its various properties like good viscosity and clarity with clean taste, lower gelatinization temperature etc. (Dairy Foods, 1991).

Adhesives

The dextrans can be manufactured by roasting of starch with the acid as a catalytic agent. The films made out of potato starch are having more flexibility with greater resistance power compared to dextrans obtained from cereal starch. They can be further used as a binding agent in manufacturing sandpaper, manufacturing abrasive cloth, for binding books etc. (Stearns *et al.*, 1994). The United States were using lot of adhesives which accounts for greater than 40%, which are from the source of potatoes (Morris and Ahmed, 1992).

Minor uses

The starch obtained from potato can be utilized as a additives in baking powder, for fermentation of raw materials, as a tablet binder, sausage extender, soap builder, dry cell battery separator, one of the raw material source for manufacturing nitro-starch, insecticidal attractant mixers, as a treating agent in boiler feed water, water clarifiers in mining industries, as a drilling muds in oil well etc. (Stearns *et al.*, 1994).

Waste products

There are two different kinds of wastes that can be obtained from potato processing first one is liquid waste ascribed to total soluble solids and other one is solid waste obtained as a result of potato tissues. On the other side the enormous volume of water used for frying potatoes, especially during washing raw material as well as during production of

starch powders enhance the generation of more liquid waste, which can be effectively recycled for further use (Anbuselvi and Reji, 2018). The other solid waste like immature potatoes, culled one can be recycled for manufacturing several byproducts (Natu *et al.*, 1991).

Recovery of proteins

The protein present in potato is lysine and the limiting amino acids in potato were cysteine and methionine. The protein of potato source is quite well comparable with animal protein i.e. egg, ascribed to its quality (Friedman, 1996). Therefore, the waste obtained from potato processing plants can be used as a food, feed and several useful by products. The European starch processing plants were manufacturing protein concentrates from potato, which can be used as an animal feed (Natu *et al.*, 1991).

Animal feed

Animal feed can be manufactured by efficiently utilizing peels obtained from potato source, culled potatoes and other waste obtained during potato processing can be recycled for manufacturing excellent animal feed. It's an excellent feed for especially ruminant animals because of plenty of nitrogen sources. It was estimated that around processing waste obtained from potatoes accounts for around 1.3 million tons in United States (Natu *et al.*, 1991).

The composite livestock feed can be prepared by using potato protein sources, which is a quite common practice. The meal prepared from potato waste can be used for feeding broiler chicken and other livestock's and it's one of the main carbohydrate sources for such livestock animals (Natu *et al.*, 1991).

Other applications

The waste obtained from potato processing plant is biodegradable (Stearns *et al.*, 1994).

It contains low phosphorus content and it can be used for efficient cleaning and washing purposes. The waste residues can be prepared in either granular or bar form for various specific applications. The waste can be further incorporated with wheat starch milk and used as an adhesive (Stearns *et al.*, 1994). The treatment of potato waste residues with hot water to remove residual starch, which can be further treated with enzyme glucoamylase to yield pectin, which has got extensive industrial applications. From potato peels the phenolic component like Chromogenic acid can be manufactured, which is a good antioxidant as like butylated hydroxyanisole (BHA), which has got good health properties (Rodriguez de Sotillo *et al.*, 1994). As like Chromogenic acid, L-ascorbic acid can be obtained from potato processing waste and it is widely used in agar gel. The starch obtained from potato can be transformed into glucose, further to lactic and citric acids, which can help in biodegradable plastic construction (Coleman, 1990; ERS, 1993).

Potato peel

It's a byproduct of potato processing industry, which is one of the cheap source for developing several value added by products like biopolymers, dietary fibres, antioxidants and food additives (Chiellini *et al.*, 2004). The method of peeling plays a significant role with respect to its application, adopting steam method of peeling exerted higher dietary fibre content with lesser starch content during production of dehydrated potato products and its better compared to abrasion method of peeling, usually the chips producing industries adopt (Camire *et al.*, 1997).

The dietary fibre obtained from source of potato exhibited hypocholesterolemic effect

demonstrated in animal model (Lazarov and Werman, 1996). The feeding of potato peel along with routine diet had significantly reduced cholesterol content in the plasma to 40% and while hepatic fat cholesterol was reduced to 30% pronouncing significant hypocholesterolemic activities, it also further minimized the glucose content in blood.

For bakery products development the dietary fibre obtained from potato peel can be incorporated to exert health benefits for the consumers (Table 2). The peel obtained from potato processing accounts for around 50%, when it is incorporated into flour, it exhibited good water holding capacity with lesser starch content, only issue is during incorporation it will produce end product with musty odour, which can be nullified by utilizing potato peel obtained by using extrusion process (Alonso *et al.*, 2006). Incorporation of potato peel during biscuit preparation @ of 5-10% lead to produce good quality acceptable product with smaller stack weight (Abd-El-Magied, 1991; Al-Weshahy and Rao, 2012).

The peel as a substrate can be successfully employed for producing variety of enzymes (Shukla and Kar, 2006). The peel obtained from potato serves as a carbon source for mannase production by utilizing microorganisms i.e. *Bacillus amyloliquefaciens*. As like mannase, and other enzymes like amylase, cellulose can also be prepared by using potato peel, and these enzymes have wide food industrial applications.

Table 2. Proximate composition of potato peel.

Parameter	Content (%)
Moisture	82.34
Carbohydrate	57.20
Protein	7.16
Fat	2.20
Ash	6.13

Potato peel, a rich source of antioxidants especially polyphenols, which exert preservative effects in various food applications. The freeze dried extract obtained from potato peel can be used @ of 1000 ppm for preserving beef patties as a substitute for synthetic antioxidants, the use of such peel extracts pronounced more antioxidant power, noticed at selective pH of 5-6 (Mansour and Khalil, 2000). It is also used in oil products to control rancidity (Rommi *et al.*, 2016).

CONFLICT OF INTERESTS

The author declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by the author

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