

Scope of Value- addition in Potato

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Abstract— Since after the introduction of the potato in India in the early seventeenth century by the Portuguese traders, the potato has been widely grown and consumed in the country. These tuberous nutritious crops known as the king of vegetables is ranked as the fourth largest food crop in the world. A variety of processed products can be achieved that enhances the market value, marketability, and desirability of the product. In this review, we will discuss on the potato, current global and Indian scenario, scope and potential of processing market, health-related issues of potato. And discuss popular potato processed products and future outlook to improve the processing industry.

Keywords— *Potato processing; Global processing scenario; Indian processing potential; Processed products; Processing industry.*

I. INTRODUCTION

The potato (*Solanum tuberosum*) is a starchy, tuberous herbaceous annual (surviving only one growing season) belonging to Solanaceae family (“Potato – Definition of potato by Merriam-Webster,”). Being the world’s fourth-largest food crop after maize, wheat and rice, the potato also known as the king of vegetables, is staple food in many parts of the world grown for its edible tubers and contributes substantially in the world’s caloric intake (“PotatoPro,” 2017) contributing around 2% of the world’s dietary energy supply. Present-day southern Peru and extreme northwestern Bolivia, where domestication of potato was commenced approximately 7,000-10,000 years ago (between 8000 and 5000 BC), were considered the place of its origin (Spooner et. al, 2005).

Morphologically the potato (refers to the plant itself, but can also refer to the edible tuber) are herbaceous about 60 cm high bearing white, pink, red, blue or purple flowers with yellow stamens and bears white or pink skinned edible tubers that grow underground generally 25 cm in the soil (generally the white flowers bearing plants tend to have white skinned tuber while those possessing colorful flowers have pink skinned tubers) (Winch, 2006). The plant has a branched stem with alternately arranged oval to oblong green leaflets of unequal shape and size (Kesaulya, et. al, 2015). Under the cool and wet condition, the fertile plants may even produce small, green tomato alike potato berries. Though they look like a tomato, due to high glycoalkaloids content (in between 177 mg/kg to 1350 mg/kg or more with

the permissible range being 200mg/kg) they are unfit for human consumption (Machado et. al, 2007). The berries possess the seeds called “true potato seeds” or TPS and are botanical potato seed. These seeds are viable and used for virus-free seed production and also for the production of new varieties (the common practice of potato cultivation is via tubers which are the clones of the parents) (Wiersema, 1986).

Status of Potato in India:

Out of total horticulture production (including fruits, vegetables, spices, plantation crops, and flowers), the fruits and vegetables account 90% of share in India. The country is the major contributor of global fruits and vegetable production ranking second largest producer only next to China while being a leader in several crops, like mango, banana, papaya, cashew-nuts, areca nut, potato, and okra. The country has made a significant improvement in the total horticulture production from a meager 191.8 million tonnes in 2006-07 to whopping 299.8 million tonnes in 2016-17 surpassing the production of food grains in India (*Horticultural Statistics at a Glance 2017*). Potato plays an important fraction of total vegetable production in the country. As per the data published from Department of Agriculture Cooperation and Farmers Welfare, out of total vegetable production of 175008 million tonnes in the year 2016-17, potato accounts for around 27% i.e. 46546 million tonnes (*Horticultural Statistics at a Glance 2017*). As per the FAOSTAT, the total world potato production is around 388 million tonnes in 2017, that is 11 million tonnes higher than

the previous year's record of 377 million tonnes ("FAOSTAT," 2017). Potato is cultivated in more than 160 countries and around 4200 varieties have been reported and the number is increasing with continuous research and advancement (Struik, 2008). China and India

are the biggest producers with almost a third of global potato production.

List of top 10 potato producing countries in 2017 can be studied from Table 1.

Table 1: Top potato producing countries in the world.

Rank	Country	Production in million tonnes (approximately)
1	China	99.20
2	India	48.60
3	Russian Federation	29.60
4	Ukraine	22.21
5	United States	20.01
6	Germany	11.70
7	Bangladesh	10.21
8	Poland	9.17
9	Netherlands	7.40
10	France	7.34

Source: FAOSTAT, 2017

The potato production of India as per FAOSTAT in 2017 is recorded to be 48.605 million tonnes with the cultivated area of 2.179 million hectares. The country ranks second in total potato production contributing 12% of global production only next to China (*Horticultural Statistics at a Glance 2017*). The yield was 223 tonnes/ha. Uttar Pradesh is the largest producer producing 14.755 million tonnes contributing around 30.40% of total country's production ("PotatoPro," 2017.).

Other important potato producing states of India with their production and percentage contribution can be studied from Table 2.

Table 2: Top potato producing states of India.

Rank	State	Area in hectare	Production in million tonnes & percentage contribution to the production
1	Uttar Pradesh	603.76	14.755 (30.40%)
2	West Bengal	386.61	12.653 (26.07%)
3	Bihar	322.5	5.720 (11.79%)
4	Gujarat	81.2	3.836 (7.90%)
5	Madhya Pradesh	108.87	3.144 (6.48%)

Source: (*Horticultural Statistics at a Glance 2017*), Government of India

India exported around 384.24 thousand million tonnes of potatoes with a value of 64,056.48 lakh rupees in the year 2016-17 (*Horticultural Statistics at a Glance 2017*).

Potato nutrition:

Fresh potatoes are high in water and are primarily composed of Carbohydrates (primarily in the form of starch) along with the considerable amount of protein and fiber. Fat content is almost negligible (Weichselbaum, 2010). Due to the high Glycemic Index (GI) i.e. relative rise

in blood glucose level, potatoes are considered unfit for people with diabetes. It is also said that to supply the energy requirement of an average male i.e. 13000KJ, he has to consume about 4 kg of potatoes per day (Burton, 1983). Potatoes are low in protein on amount basis but the quality is very high (Atkinson, et. al, 2008).

Nutrient content of potato per 100g (Camire et. al, 2009) and in % is shown in Chart 1.

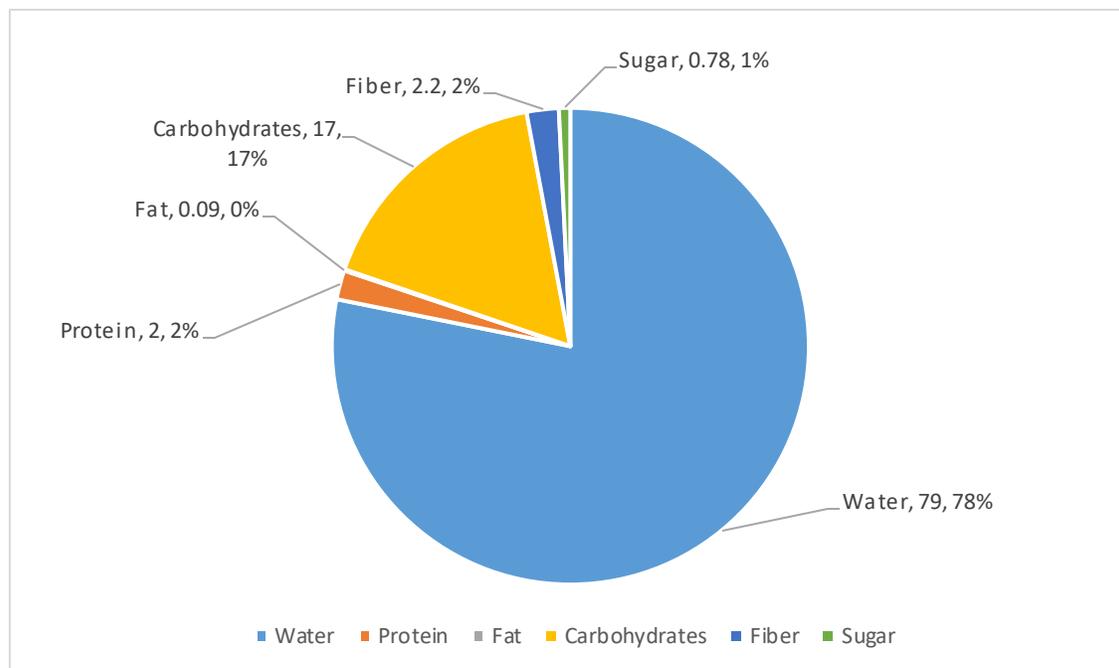


Chart 1: Nutrient content of potato per 100g.

Apart from these major nutrients, potatoes contain a good amount of minerals and vitamins. They are rich in Potassium (421mg/ 100g) and vitamin C (19.7 mg/100g). Similarly the antioxidants like β -carotene, polyphenols, obtained from potatoes (mostly colored potatoes) play an important role in antioxidant defense system helping to lower the incidence of a range of acute and chronic diseases(Zaheer & Akhtar, 2016).

Albeit, these energy-rich materials possess several health-related benefits(Camire et al., 2009), toxicity in potato caused by a class of toxic phytonutrients called glycoalkaloids (which are bitter on high concentration) has also been reported(Uluwaduge, 2018). These glycoalkaloids mainly (up to 95% of total) possess α -solanine and α -chaconine which has been reported to cause poisoning in both human and animals, though the reports are rare(Korpan et al., 2004). The toxicity level depends on the age group and the amount of intake(THOMPSON, 1979). Symptoms vary from mild symptoms like headache, stomach pain, diarrhea, vomiting to fever, low blood pressure,

neurological disorder, and even death.(Mensinga et al., 2005) The level of glycoalkaloids content is found maximum in flowers followed by sprouts, leaves, skin, and minimum in tuber flesh. Also, their level is affected by the physical damage, exposure to light causing greening and age which increases their content and toxicity level(Friedman, McDonald, & Filadelfi-Keszi, 1997). Acrylamide; a known carcinogenic substance occurring due to high-temperature cooking in carbohydrate-rich food has been reported in fried and chips(Pedreschi et. al, 2008) which shocked the whole world when Swedish researchers in April 2002 presented these findings. The frying process which involves removal of water and heat transfer by taking up oil by the piece results in about 35% and 15% of oil by weight in potato chips and French fries(Aguilera & Gloria-Hernandez, 2000). These glycoalkaloids not only possess the harmful effects, some beneficial effects related to these compounds has also been seen and is shown in the diagram(Camire et al., 2009).

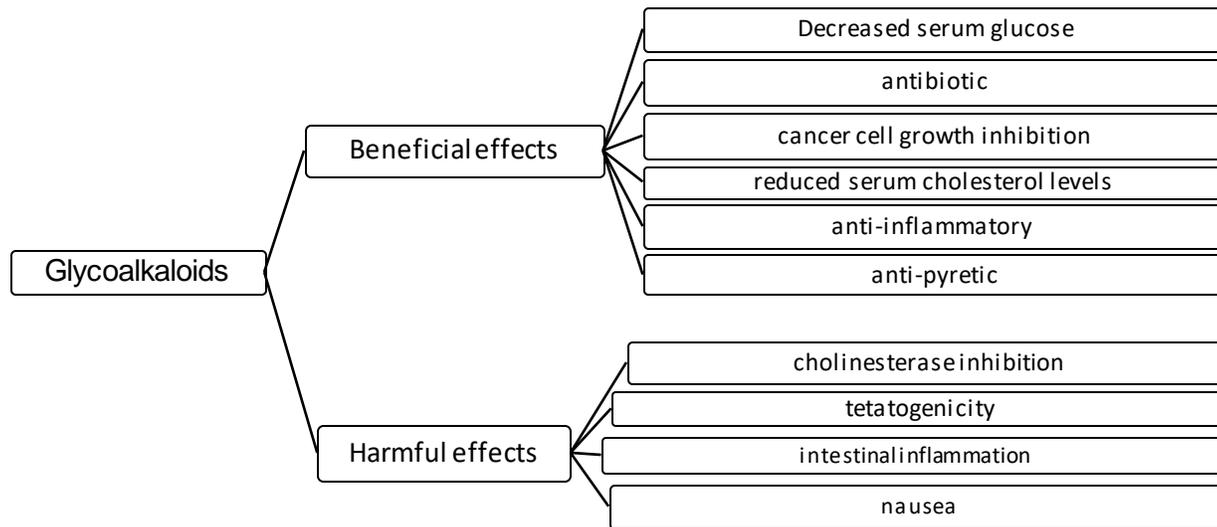


Diagram: Beneficial and harmful effects of Glycoalkaloids in human health.

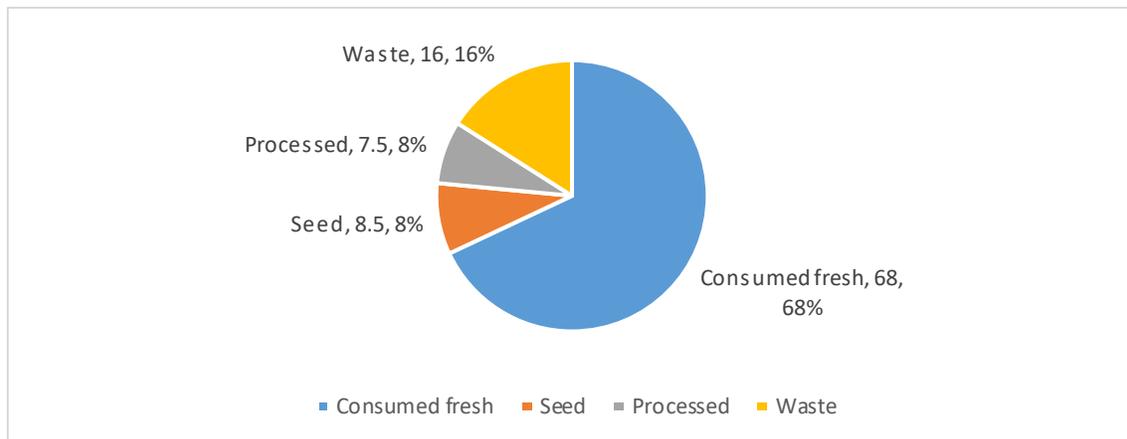
Scope for value addition:

Since the potatoes are mostly water (about 78%) and the solids present are also mostly indigestible (60-80%), processing like boiling, baking, microwaving, frying i.e. processes involving heat that breaks down the starch are performed prior to consumption. Potatoes are eaten like potato chips, French fries, baked, boiled, mashed and using flour to make a cake, pancake, etc.(Zaheer & Akhtar, 2016). Cooked or processed potatoes are more digestible than raw potatoes since raw potatoes contain starch in β -crystalline structure that is resistant to amylase digestion(Englyst et. al, 1992). Due to the loss of water-soluble vitamins and minerals, potatoes are preferred not to be peeled or cut during boiling where maximum loss is recorded as compared to other processing like baking, roasting, and frying(Camire et al., 2009).

With the burgeoning population growth, the role of potato for food security has been given heavy weight as it has the

ability to produce the highest nutrition and dry matter per unit area. Apart from consumption as vegetable potatoes are used for a variety of purposes as chips, fries, frozen, dehydrated and so on. Potato processing industries are highly developed in countries like USA, Canada, and other European countries(Pandey et. al, 2009). In fact, it has been found that in developed nations, as high as 60% of total production is consumed in processed form(Kirkman, 2007) and globally it is likely that the percentage is greater than 50, which are processed into different products and ingredient. Potato contributes around 2.86% of the agricultural GDP of the country (Vision 2050, 2015) with agriculture sector contributing about 15.87% in the nation's GDP(Madhusudhan L, 2015)

The consumption pattern of potatoes produced in the country is shown in the Chart-2.



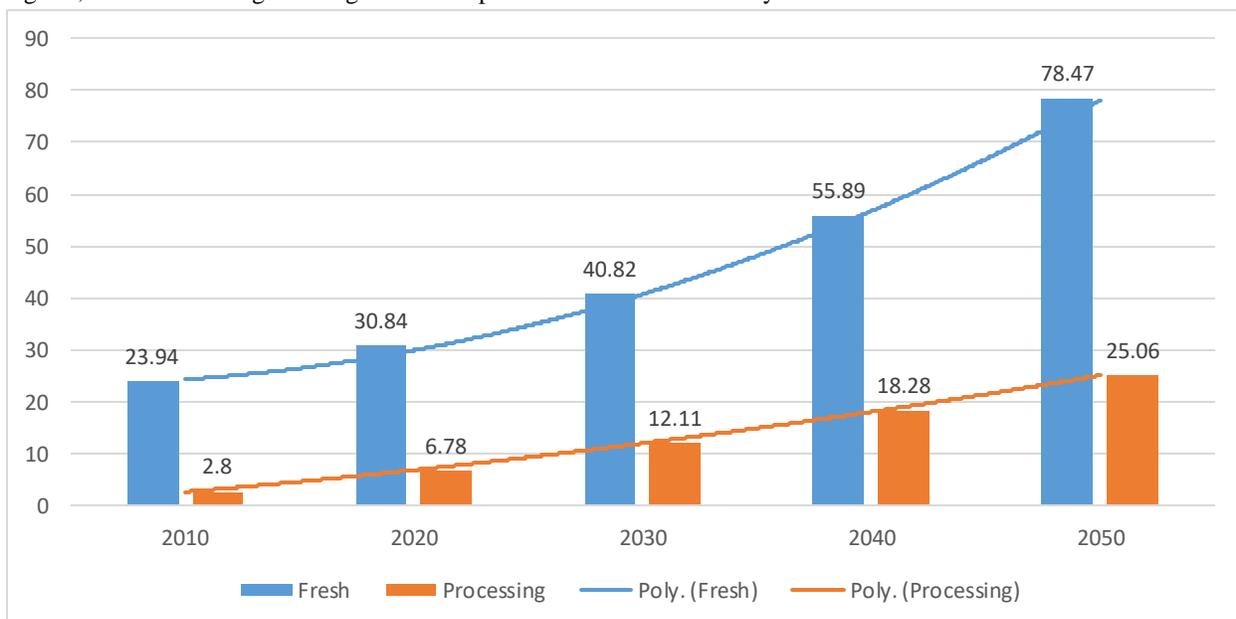
Source: (Vision 2050, 2015)

Chart-2: Consumption pattern of potato produced in the country.

With the increased level of production of potatoes in the country has mostly led to the glutting of the produce in the market giving rise to several issues like storage of surplus produce and their proper utilization. Due to the high water content (up to 80%), this product is perishable and cannot be stored any longer than 3-4 months under normal atmospheric condition. Hence this product must be either stored in cool chambers or their forms must be changed to prolong the shelf life as well as to add the value to the produce. Since the processing sector can save the high rates of cold storage facilities as well as save the produce from market gluts, it has been given significant importance.

Similarly, the demand for the processed potato products are continuously increasing affected by the number of factors like increased purchasing power, change in preferences for fast foods, urbanization, expanding globalization and increased number of working woman preferring ready-cooked foods(Singh et.al, 2016). These value-added processed products are opening up new possibilities to make the agriculture sector highly remunerative and taking the rural agriculture in the national and international markets(Pandey et al 2009).

The demand for fresh and processed potatoes in million tonnes by 2050 is estimated from Chart 3.



Source: (Vision 2050, 2015)

Chart 3: Demand for fresh and processed products over the year.

II. STATUS OF THE PROCESSING MARKET

Although the country stands second in global production the level of processing is mere 7% with per capita consumption of mere 365g which is very poor when compared to USA (37 kg), Canada (35.8 kg), Germany (30.4 kg)(Rana et. al, 2017). Since the majority of potato growing regions fall under tropics and sub-tropics, there are high post-harvest losses up to 12.5% and it has been found that more than one-eighth of the production is retained as seed(Rana, 2011).The per capita processing of potato in India is 365g out of 1.475 kg potatoes per capita. Out of which the potato chips contribute the major portion (around 89.69%)

followed by potato powder/ flakes contributing 9.28% and French fries 1.03%.(Rana, 2011). However, the quantity of the processed products is showing good growth with the level of economic development and easy availability of indigenous potato varieties suitable for processing and wide agro-ecological conditions for growing the raw materials throughout the year.(Pandey et. al., 2010)(Rana & Pandey, 2007).

The total production and total processing of potatoes in different countries and regions for 2013 are shown in Chart 4(R. Rana et al., 2017).

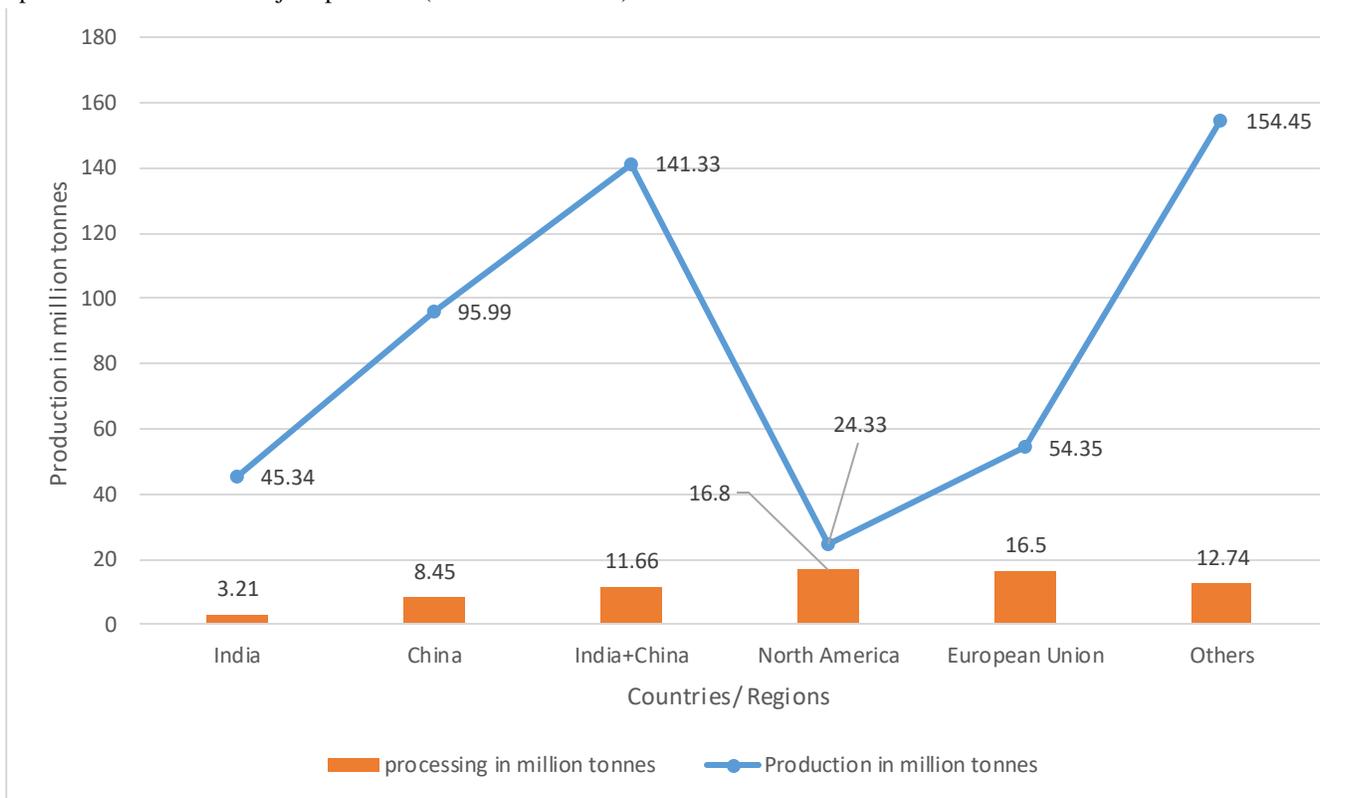
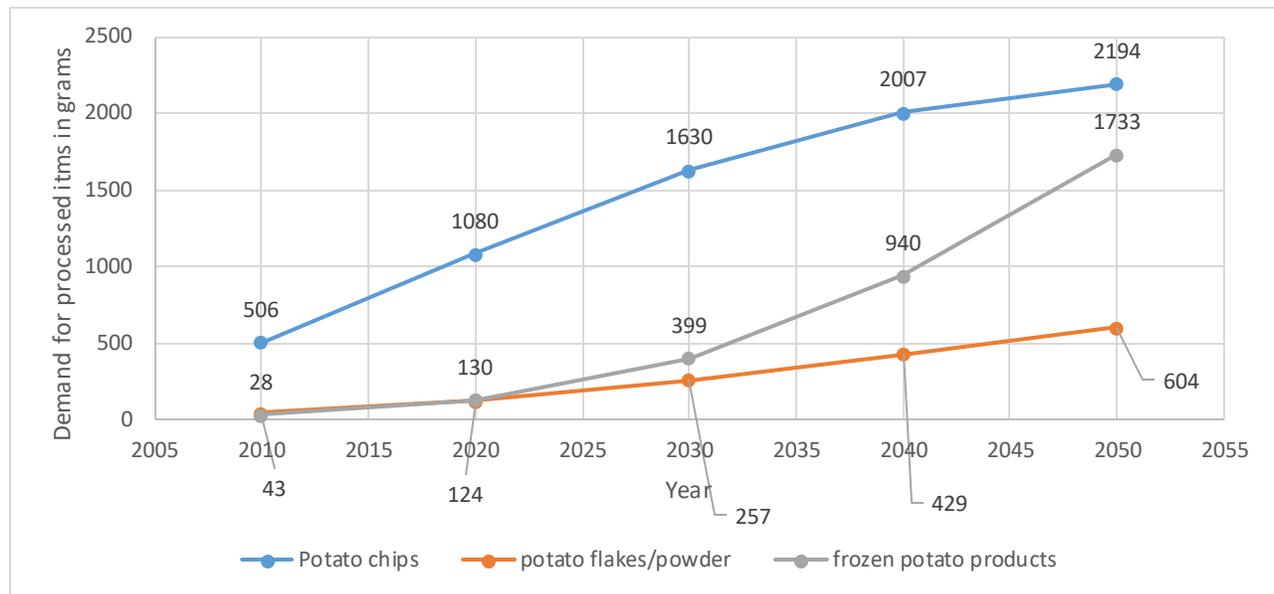


Chart-4: Total production and total processed product in different countries.

The demand trend of the various processed products is also changing. The per capita consumption for potato chips which was 506g in 2010 is expected to reach 2194g by 2050. Similarly, other processed items under various years can be illustrated from the Chart-5.



Source: (Vision 2050, 2015)

Chart- 5: Demand trend for different processed items.

Processing industries in India:

Among the several constraints in the development of processing industries, availability of suitable processing quality potato was the major bottle-neck. Among all the exotic varieties imported by the processing industries, “Atlantic” showed some promise but due to its low yield and susceptibility towards disease like late blight and physiological disorder like ‘hollow heart’ the processors are compelled to use Indian varieties which were grown for table purpose (Marwaha et. al, 2010).

To overcome this major hinderance CPRI (Central Potato Research Institute), Shimla released two processing grade varieties ‘Kufri Chipsona-1’ and ‘Kufri Chipsona-2’ in 1998 (Kumar, 1998) and other improved varieties ‘Kufri Chipdona-3’ and ‘KufriHimsona’ in the later years.

Indian population is skyrocketing and the purchasing ability is enhancing (Thapa et. al, 2019); which has opened a new avenue for the processing industries as with the increased purchasing ability the food preferences of the people are also changing. To live up with the expectation of the consumers, Golden Crisp established in 1997 at Faridabad (Haryana) is the first potato chips industry in India. The other brands like Binnie’s in 1988 at Noida, Uncle Chips at Noida in 1989 and Lay brand chips established by PepsiCo India Holdings Pvt. Ltd. In 1989 at Channo (Punjab) followed after. Apart from them many other processors like Haldiram, ITC, McCain Foods India, G.P. Foods, Vimal Oil

and Food Ltd. has established their units seeing the vast potential and increasing demand for the processed items (Rana et. al, 2009). Among all the processed products that include Potato chips, French fries, Potato flakes/powders and other products like dehydrated chips, alubhujia, samosa, etc., the potato chips continue to be the most popular one. (Pandey et al., 2009).

Potato chips production sector is dominated by Frito-Lay operating approximately 67 plants in 27 countries worldwide processing around 4 million tonnes accounting about half of the world total. Frozen potato products, primarily French fries sector is under the domination of the Canadian family-owned company, McCain Foods processing one-third of the world total. It has about 55 plants in 13 countries (Kirkman, 2007).

Selection of suitable potato varieties is the most important criteria in processing industries. Various morphological and biochemical characteristics are judged for the selection of suitable varieties. Though morphological attributes like shape, size, physical and biological damage are not very important they affect the appearance and consumer acceptability. The most important factors like dry matter, reducing sugar, free amino acids, phenol content comes under bio-chemical attributes which determine the quality and recovery of the processed materials (Gupta et. al, 2014). The quality requirements of the potatoes for the different processing purposes is given in Table-3.

Table-3: Attributes of potatoes for processing purpose.

Qualities	Dehydrated	French fries	Chips	Canned
Tuber Shape	Round to oval	Oblong	Round to oval	Round to oval
Tuber size(mm)	>30	>75	45-80	25-35
Eyes	Shallow	Shallow	Shallow	Shallow
Specific gravity	1.080	1.080	>1.080	<1.070
Dry matter(%)	>20	>20	>20	<18
Reducing sugar(%)	0.25	0.15	<0.1	0.5
After cooking discoloration	Slight	Slight	-	Nil
Texture	Firm to mealy	Fairly firm	Firm to mealy	Waxy

Source: (Marwaha et. al, 2010)

A lot of national and multinational companies are working in the processing sector of the country. A list of potato processing sector in India during 2007 can be studied from the Table-4.

Table-4: Potato processing sector operating in India.

Manufacturer	Location	Product	Capacity (MT/year)
Ace Foods	Mangalore	Chips	2400
A-One Wafers	Mumbai	Wafers	1000
Arumugam Industries	Coimbatore	Chips	4000
Balaji Wafers	Rajkot	Chips	30000
Bikano Namkeen	Delhi	Potato products	1000
Budhari Brothers	Pune	Chips	4000
Merino Industries Ltd	Hapur	Flakes	30000
Golden Fries	Coimbatore	French fries	15000
Faber Leather	Kolkata	Flakes	30000
GP Foods	Kolkata	Chips	30000
Frito Lay	Channo, Pune, Noida & Kolkata	Chips	90000
Haldiram	Delhi, Kolkata, Nagpur & Bikaner	Chips	40000
ITC	Haridwar	Chips	30000
Janata Wafers	Mumbai	Wafers	1800
Kakaji Namkeen	Delhi	Potato products	1000
Kishlay Foods	Guwahati	Chips	2400
Little Bee Products	Ludhiana	Chips	3000
McCains Foods	Gujarat	French fries & Flakes	30000
Mota Chips	Mumbai	Wafers	2400
MTR Foods	Bangalore	Chips	1000
Potato King	Kolkata	Flakes	36000
Satnam Agri. Prod Ltd	Jalandhar	French fries & flakes	25000
Shivdeep Foods	Bikaner	Chips	10000
Twinkle chips	Faridabad	Chips	2400
Vista Foods	Mumbai	French fries	4000
Welcome Wafers	Mumbai	Wafers	1800
Welga Foods	Badayun	French fries	7500
Wimpy's	Delhi	French fries	7500

Source: (R. Marwaha et al., 2010)

III. CHALLENGES AND REMEDIES TO MEET CHALLENGES

The nation has to look at the challenges that the processing industries are facing to improve the processing industries. Most of the industries are operating under-capacity and the demand is continuously increasing. In such a scenario one must find the constraints associated and look for the possible solutions to overcome the challenge:

1. The major hindrance in the processing industries is the availability of quality grade processing raw materials. The focus should be made to make provision of a year-round supply of processing friendly potatoes by identifying the hotspots for production of such potatoes and extension of research activities in identifying more suitable varieties.
2. Development of low-cost improved storage chambers for long term storage of raw materials to continue production throughout the year even in its off-season.
3. For the success of any industry, the consumers are the major factors. Due to the high cost of the processed potato products, the consumers are limited as the majority of Indian population belonging to the low-income level. So, diversification in products is essential to produce budget-friendly products like dehydrated chips to connect more consumers and these products can be produced in glass hood level.
4. Focus on development of noble varieties with desirable characteristics like early maturing, temperature insensitive, resistance to cold sweetening, etc.
5. People often link processed potato products with high calorific diet associated with obesity and other health-related problems. The emphasis in the production of fortified low-fat products is the demand of the generation as more consumers have become conscious and aware of what they eat and what health benefits do they possess. Hence, there is an immediate need to identify varieties with low oil consumption properties and rich in antioxidants and other health benefits nutrients.

IV. POPULAR POTATO PRODUCTS

1. Potato chips.
2. French fries.
3. Shreds/ Lachcha

4. Potato flakes, flour, and starch
5. Canned potatoes
6. Dehydrated potato products.

Potato Chips:

Potato chips are thin, fried, baked popular ready to eat snacks used both in domestic as well as in fast food center and restaurants (Wadagavi, Kallihal, Dadanwale, & Choukimath, 2017). Potato chips should be round to oval and its quality is determined by its golden color with a preferred diameter of 40-60 mm (Kaur, Singh, & Ezekiel, 2008a). 100g potato chips provide about 547 calories of energy with a fat content of 37.47g, total carbohydrate 49.74g, protein 6.56g along with Sodium (525mg) and potassium (1642mg). As per ("Potato Chips - India | Statista Market Forecast," 2019), the revenue of potato chips in India is US\$ 370m in 2019 i.e. US\$ 0.3 per person which is expected to grow annually by 9.7%. USA with a revenue of US\$16,791m generates the most revenue. Per capita consumption is around 0.05 kg. The dry matter content should be greater than 20% (Kaur et al., 2008). Some popular varieties suitable for chips preparation are Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3 (Subodh Kumar Pandey et al., 2006), Kufri Chipsona-4, Kufri Himsona, Kufri Jyoti, Kufri Lauvkar and Kufri Chandramukhi. Potato chips preparation includes the following steps:

- Fresh potatoes free from any deformities are selected and peeled. These potatoes are washed and all the green and damaged parts are removed.
- Thus peeled potatoes are sliced into thin slices of approximately 1.5 to 2.0 mm.
- Sliced potatoes are rinsed in water to remove surface starch.
- Thus starch removed sliced potatoes are blanched in hot water at 60-80°C for 2-3 minutes.
- Now the slices are surface dried.
- Thus dried slices are fried at 180°C till the chips turn golden.
- Obtained chips are uniformly salted or spiced and packed in bags in the presence of nitrogen (Singh et al., 2016).



Fig: Potato Chips

French fries:

French fries are turning into the fastest growing snack food and is growing in India at an annual rate of more than 30%. Top french fries processors and suppliers like McDonald's and KFC pointed out this snack food to be in their top three billing items. 100g French fries supply 274 calories of energy. In general 100g fries consist of 14.06g of fats, 35.66g of total carbohydrates and 3.48g of proteins along with a substantial amount of Sodium (300mg) and potassium (527mg). The quality of French fries is determined by its golden color and texture. It should be crisp outside while soft inside (KF et. al, 2017). The Indian fries market is estimated over 3500 tonnes per year with domestic production of 500 million tonnes and remaining mostly contributed by imported French fries. Generally large and oblong potatoes are selected with dry matter more than 20% (Youssef, 2015). Some popular varieties for French fries production are Kufri Frysona (Sohan Vir Singh et al., 2010), Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3 and Kufri Chipsona-4 (Singh et al., 2009).

French fries preparation includes the following steps:

- Fresh healthy potatoes are selected and washed to remove dirt and dust and green and damaged parts are removed.
- Thus cleaned potatoes are peeled and cut into sticks of dimension 10x10 mm (width x height) with the help of a French fry cutter.
- These sticks are rinsed in water to remove the surface starch.
- Thus cleaned sticks are blanched in hot water at 60-80°C for about 5 minutes.
- These blanched sticks are surface dried to remove excess surface moisture.
- Dried sticks are fried at 180-190°C for about 2 minutes.
- Excess surface oil is removed using blotting paper.

- After oil removal, these fried sticks are let to cool down to room temperature and frozen at -20°C where they are stored till final frying.
- The fries are fried at 180-190°C at the time of serving and salt and spices are added as per the taste (Singh et al., 2016).



*Fig:
French fries*

Shreds/Lachcha:

Shreds are prepared from fresh potatoes of any shape and size containing 20% or more dry matter and low reducing sugars less than 150mg/100g by fresh weight along with the waste potato flesh obtained from other processing activities. Shreds may be prepared from the dehydrated product. The preparation of shreds/lachcha includes following steps:

- Fresh healthy potatoes are taken, washed and peeled. Damaged and green parts are removed.
- Thus peeled tubers are passed through the shredder to make thin and short shreds.
- These shreds are washed with water to remove the surface starch.
- Washed shreds are blanched in hot water at 60-80°C for about 1-2 minutes to improve color development and to deactivate the enzymes.
- The blanched shreds are surface dried to remove excess moisture using dryer.
- Thus surface dried shreds are fried at 180-190°C till the bubbling ceases.
- The excess oil on fried shreds is removed using blotting paper.
- The final product is packed in plastic bags in the presence of nitrogen (Singh et al., 2016).



Fig: Potato Shreds



Fig: potato flakes

Potato Flakes:

Potato flakes are prepared by drying of potato slurry used for stuffing purpose. 100g of dry potato flakes provides about 60 calories energy with 14g carbohydrates, 1g protein, and almost negligible fats. 10mg of Sodium can also be obtained. They can be used in extruded as well as fabricated chips products. Flakes preparation includes the following steps:

- Fresh healthy potato tubers are selected and washed and peeled.
- Damaged and green parts are removed.
- Peeled potatoes are sliced into small slices of 1-2 mm and washed in water to remove liberated starch.
- Thus starch removed slices are cooked in two stages i.e. first at 70°C for 20 minutes and second at 100°C for 30 minutes after cooling for 15 minutes at 12°C in between.
- Cooked slices are mashed and passed through perforated mesh which then is dried on roller drier which is removed as a sheet and broken into flakes.
- The materials are packed in plastic bags at about 6-7% in the presence of nitrogen (Singh et al., 2016).

Potato flour:

Potato flour used as a thickener-flavoring agent which imparts a distinctive pleasing flavor is used in combination of cereal and pulses flour to make a number of products like biscuits, cakes, parantha, bread (Ezekiel & Singh, 2011), etc. 100g potato flour provides about 357 calories of energy. The fat content is very low around 0.34g with the carbohydrate content of 83.08g and 6.9g of protein. Sodium (55mg) and potassium (1001 mg) are also present. The recovery rate of flour is 20% i.e. 100kg potatoes will give around 20 kg flour. It is used to thicken soups, gravies, sauces and baby foods. Potato flour preparation includes the following steps:

- 1 Kg of peeled potatoes is cooked in 2L of water in a pressure cooker.
- Potassium Metabisulphite (5g) is added to reduce browning and boiled (Bharati, Mirajkar, Muniswamappa, Narayanaswamy, & Shobha, 2013).
- Boiled potatoes are mashed and spread on a tray in a thin layer.
- The tray was kept in a hot air oven at 60-80°C for drying.
- After complete drying, grind the mash in an electric mixer grinder to get the powder.
- Sieve the flour and store in an airtight container (Singh et al., 2016).



Fig: Potato Flour

Potato Starch:

Having high swelling power and high viscosity it is superior to other starch sources. Potato starch is characterized by their larger granule size along with low glass transition temperature, paste clarity along with neutral taste(Tigabu& Abebe Desta, 2018). It is used for the preparation of several products like soups, puddings, cakes, biscuits, and cookies(Muhamedbegović et al., 2012). 100g potato starch supplies around 300 calories of energy. Fat content is almost negligible. It is mostly carbohydrate with 80g per 100g of starch. It also has wide industrial application in paper, textile, pharmaceutical industries, adhesives, dextrin, and as a fermentation raw materials, binder for tablets and binder(Kraak, 1992). All types of defected sub-standard, misshapen potatoes can be used for starch recovery. One quintal potato will approximately give around 10 kg of starch. Potato starch manufacture process involvesthe following steps:

- Fresh potato tubers are selected and peeled.
- These peeled potatoes are cut into small pieces and in the rate of 1L water per kg of potato is ground in the mixture to get slurry.
- Addition of 2.5g potassium metabisulphite is recommended.
- Now the slurry is allowed to sieve through muslin cloth with the help of water. Starch get accumulated on the bottom of the tub.
- The water collected above the starch is discarded and starch is rinsed with fresh water until the water becomes clean.
- Now thus collected starch is dried in a hot air oven at 60°C or in sunlight.

- Thus obtained crusty starch is ground to get the powder and sieved and packed in an airtight container(Singh et al., 2016).



Fig: Potato starch

Canned Potatoes:

Mostly preferred for immature and small potatoes. In the case of the larger tuber, they can be cut into small pieces.

Canning of potatoes include following steps:

- Fresh potato tubers are selected, washed and peeled.
- These peeled potatoes are blanched in hot water for 4-5 minutes.
- These blanched potatoes are filled in the can at the rate of 500g per A21/2 size can along with 2% brine leaving about 0.8 cm.
- Now, these cans are exhausted by heating till the temperature reaches 80°C which results in complete removal of air.
- Now finally the cans are sealed and sterilized at 10 psi for 45 minutes and cooled(Singh et al., 2016).



Fig: Canned Potatoes

Dehydrated potato products:

Lowering the moisture content by drying lessen the chances of microbial growth and prolong the shelf life. They are cheaper, easier to prepare, do not require sophisticated

machinery. Dehydrated products preparation includes the following steps:

- Fresh healthy potato tubers are washed and peeled.
- A thin slice of 1.5 to 2mm is made and rinsed in water to remove surface starch.
- Thus obtained slices are blanched in hot water at 60-80°C for 1-2 minutes and drained.
- Thus strained slices are spread for drying and packed.
- When required these slices are fried at 180-190°C for consumption(Singh et al., 2016).

V. CONCLUSION

From the above review study, we came to know that there is a huge scope of processing in potato crop. Though some studies have shown some health-related problems associated with the processed products these can be overcome by following the food safety standards. Processed value-added products have the huge market demand with enhanced market value as compared to fresh potatoes used for table purpose which can improve the income of the farmer and uplift the living standard and can definitely be the important milestone in the endeavor of doubling the farmer's income. The Indian processed product market is nominal compared to developed countries like the US. But the trend is continuously shifting forward triggered by the increased income and globalization. Though the consumption of these products is increasing, there are still some bottlenecks in this sector. One of the major issues is the availability of quality and suitable raw materials. This situation can be improved by increased investment in the food processing industry. There is huge potential for the development of the processing industry at the farm level as these do not require expertise and sophisticated machinery. A huge share of the processed item is imported from the international market. If these items can be produced at the village level then import can be reduced substantially. Apart from these, there is an immediate need for the development of those varieties that are processing friendly suitable in Indian climatic condition. There is still a misconception about the health-related issues like obesity, diabetes which is hampering the processing sector and peoples' choice for these products, which requires improved awareness about lies related to potato nutrition. Still, there is much to do in quality up gradation and product diversification to bridge the newer requirements of the people throughout the globe. Thus, value addition in potatoes is definitely going to

occupy a larger share in the Indian GDP in the days to come and there is a huge potential considering the present international trade scenario.

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