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Developments in mechanization of root and tuber crop peeling machine

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■ **Abstract :** The root and tuber crops are of immense importance with respect to their varying utility and nutritional aspects. This review is aimed at discussing the developments in mechanization of peeling systems for the root and tuber crops in food processing related industries and at house hold. The root and tuber crops are produced in significant amount in India and world. Production of ginger, potato and sweet potato in India for the year 2017-2018 was 1075 MT, 49344 MT and 1465 MT, respectively. These crops are consumed in all over world for their peculiar characteristics. These root and tuber crops are rich sources of phytochemicals and bioactive compounds which are reported to have many health benefits. Many of these root and tuber crops are covered by a protective covering or peel which in general is inedible and is of less significance in view point nutrition. Hence, before further processing or consumption usually this peel is removed. The peel is removed by many methods like manual, mechanical, thermal and chemical. Being high level of heterogeneity in the structure of root and tuber crops like ginger, potato and sweet potato peeling processes face a numerous problems. There had been considerable developments in mechanization of peeling systems, however each of these with certain shortcomings. Mechanical peeling is more efficient (75-80%) with minimum loses, easy to operate and other advantages. This review will help in finding the pros and cons of various in mechanized peeling systems and future scope for improvement in these systems.

■ **Key words :** Peeling, Processing, Ginger, Potato, Sweet potato

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The world well knows about India has most of area under the agricultural. But India the insufficient or lack of processing on vegetables and fruitsthey are under goes to spoils or wasted. In India different type of cope are cultivated and harvested. Root and tuber crop are one of them. In India this root and tubervegetable crop are cultivates potato (49344 MT), sweet potato (1465 MT), onion (21402 MT), radish (3174 MT),carrot (1446 MT) and other as well as in spice tuber and roots crop like ginger (1075 MT), garlic (1702 MT), turmeric (1061 MT) and other (Agricoop, 2017-2018).

In this tuber and root crop there is potato, sweet potato, ginger and other, we used peeling processes before use. Among food products around the world, potato is the fourth well-known crop after wheat, rice and corn (Ghazavi, 2010). Potato is a versatile, carbohydrate rich food highly popular worldwide and prepared and served in a variety of ways.Freshly harvested, it contains about80 per cent water and 20 per cent drymatter. About 60 to 80 per cent of the drymatter is starch. On a dry

weight basis,the protein content of potato is similarto that of cereals and is very high incomparison with other roots and tubers.In addition, the potato is low in fat (FAO, 2008).

Potato :

Potatoes are rich in several micronutrients, especially vitamin C – eaten with its skin; a single mediumsized potato of 150 g provides nearly half the daily adult requirement (100 mg). The potato is a moderate source of iron, and its high vitamin C content promotes iron absorption. It is a good source of vitamins B1, B3 and B6 and minerals such as potassium, phosphorus and magnesium, and contains folate, pantothenic acid and riboflavin. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing, and dietary fibre, which benefits health (FAO, 2008).

Sweet potato :

Sweet potatoesbelong to the morning glory family, while potatoes are members of the solanacaeae family (Chakraborty *et al.,* 2017). It is large, starchy, sweet-tasting, tuberous rootvegetable. It is native to tropical areas including Central and South America (Lynn and Eric, 2014). It is nutritious root crop that contains significant amounts of fibre, beta carotene and vitamin C, particularly in varieties with highly colored roots. Protein contents of sweet potato leaves and root range from 4.0% to 27.0% and 1.0% to 9.0%, respectively (Chakraborty *et al.,* 2017). The sweet potato could be considered as an excellent novel source of natural health-promoting compounds, such as β-carotene and anthocyanins, for the functional food market (Chakraborty *et al.,* 2017).

Ginger :

Ginger (*Zingiber officinal*) is a tropical monocotyledon and herbaceous perennial specie belonging to the order *Scitamineae* and family *Zingiberaceae*. It is oldest rhizome widely domesticated as a spice.India is a leading producer of ginger in the world and during 2012-13 the country produced 7.45 lakh tonnes of the spice from an area of 157839 hectares. Ginger is cultivated in most of the states in India. However, states namely Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65 per cent to the country's total production (ICAR Kerala, 2015). It's essential oils, mainly oleoresin and gingerol, used in the pharmaceutical, bakery and soft drink beverage industries as well as culinary and cosmetics preparation (Onu *et al.,* 2015).

Peeling :

Peeling is one of the integral parts of a food processing, and the majority of agricultural crops need to be peeled in order to remove the inedible portion at the initial stage of food processing (Dvid O'Beirne *et al.,* 2014; Tapia *et al.,* 2015). Peeling is an important step for processing of many agricultural commodities. High peeling efficiency and low product loss are the important characteristics of ideal peeling system. Further, the peeling process should utilize the as less chemicals and energy as possible, should avoid the formation of heat ring and minimize the pollution load (Tapia *et al.,* 2015). There are various methods of peeling with their own benefits and limitations depending on various factors (Emadi *et al.,* 2007). Manual abrasive peeling could resultin close to the ideal peeling (Somsen *et al.,* 2004; Arazuri *et al.,* 2010). Mechanical method has theadvantage of retaining edible portions of the producefresh and damage-free. However, this method is notflexible and generating high losses (Emadi *et al.,* 2007, 2008). Chemical peeling applies a hot solutionof caustic soda in which the product is immersed fora certain period of time. Despite a concern in therise for chemical cost and the associated disposalproblems, it is commonly used for peeling of somevegetables such as tomatoes (Das and Barringer, 2006). Several authors have investigated the chemicalpeeling for various fruits and vegetables (Floros and Chinnan, 1990; Garrote *et al.,* 1993; 1994; Barreiro *et al.,* 1995, 2007). Moreover, steam peeling is one ofthe most popular methods due to its high automation,precise control of time, temperature and pressure bymodern process control devices. Thus, it minimizespeeling losses and reduces environmental pollutionas compared to chemical peeling (Garrote *et al.,* 1997, 2000). Recently, enzymatic peeling which isbased on the treatment of fruits with corresponding glycohydrolase enzymes has been suggested (Pretel *et al.,* 1997). This method involves no harshtreatment, hence, the amount of broken segmentsand juice losses are much less than the conventionalmethod and the peeled fruit has a better texture and appearance. Enzymatic peeling

has been studiedwith focus on citrus fruits (Ben-Shalom *et al*., 1986; McArdle and Culver, 1994; Rouhana and Mannheim, 1994; Soffer and Mannheim, 1994; Pretel *et al*., 1997; Prakash *et al.*, 2001; Pretel *et al*., 2005). The others have investigated the potential of enzymaticpeeling in some stone fruits (Toker and Bayindirli, 2003; Kaur *et al.*, 2009) and vegetables (Suutarinen *et al*., 2003). Currently peeling is carried out by various methods which can be categorized under following heads.

– Manual peeling (knife or blade).
– Chemical peeling (caustic soda or Lye).
– Thermal peeling (flame or dry heat peeling, steam or wet heat peeling).
– Mechanical peeling (abrasive devices, devices with drums, knifes or blades etc).

Manual peeling :

Manual peeling oldest method and it is performed using stationary or rotatory hand peelers or knives against the surface of fruits and vegetables. Fresh-cut fruit and vegetables with good microbiological quality can be obtained by this method. The one paper reported that knife peeling caused less wounding in comparison to abrasion peeling in carrots (Klaiber *et al.,* 2005). This can result lower microbial contamination after processing. On the other hand, O'Beirne *et al.* (2014) did not find differences between coarse abrasion and hand peeled carrot surfaces considering *E. coli* O157:H7 cells attached to the surface after peeling. However, despite of good results obtained by manual peeling, this method is limited to small scale processing and is laborious and requires more time.

Chemical peeling :

Chemical process of peeling generally used in factories and industries. It involved use of caustic soda. Once the caustic solution of NaOH (Lye) comes in contact with the surface of the fruit, it dissolves the epicuticular waxes, penetrates the epidermis, and diffuses through the skin into the fruit. It provides chemical reaction which smoothen the skin of fruit and vegetable such as citrus fruits. Outer surfaces of vegetable or fruits are gets loosed when they are immersed in alkaline solution for short period of time under high temperature. The loosen the outer surface which are unwashed away by high striking water. However, the physical properties were important for the result. Color is the most significant physical property as the temperature of the lye solution increases. The color darkens as the temperature increases and even it gets a brownish color as the temperature reaches to 80-90° C (Talodhikar *et al.*, 2017). The disadvantage of this method includes: i. It acquires cost of alkaline solution or medium. ii. It affects the vegetable and fruits due to chemical action. iii. The difficulty in the removal of chemical traces as it may be poisonous.

Thermal peeling :

Thermal peeling is done by dry heat (hot gases or fire) as wall as wet heat (steam, refrigerant).This methods apply particularly those fruits and vegetable are tough and thick skin (Talodhikar *et al.,* 2017). Temperature, pressure and electronic devices are used to minimize the peeling losses and increase peeling efficiency. Steam peeling is one of the most popular among modern methods of peeling (Tapia *et al.,* 2015). Generally thermal cooling is done for short period of time but relatively at high temperature (Talodhikar *et al.,* 2017). First, the building up of internal pressure because of high temperature causes mechanical failure of the cell, And Second, the effect of heat on the tissue which results in loss of rigidity due to biochemical changes (Talodhikar *et al.,* 2017). This dry method causes cauterizing of surface and small pieces of charred skin which when removed give's poor appearance. While wet method uses superheated steam which causes the skin puff and cracks (Talodhikar *et al*., 2017).

Mechanical peeling :

Mechanical peeling includes different types of process that interact with directlyskin and then removes the skin (Tapia *et al.,* 2015). Common commercial mechanical peelers consists of abrasivedevices, drums, rollers, knives and milling cutters (Shirmohammadi *et al.*, 2012). Mechanical peelers are environmental friendly and nontoxic and they provide high quality fresh final products.

Except some fruits such as mango, that manualpeeling is common, for other kind of fruits and vegetablesdifferent types of peeling are in use, for example, mechanicalpeeling of tough skinned fruits, chemical peeling of citrus andthermal peeling of potato. Among different types of peeling,"mechanical methods are preferable because mechanicalpeeling keeps edible

portions of produce fresh and damage free (Emadi *et al.*, 2007) freshness and less damage are both ideal goals ofpeeling processes. In addition, mechanical methods areenvironment friendly and they do not create negative effectson the environment and tissue, considering harmful effects onenvironment and the fruits and vegetable tissues that chemicalmethods cause. Besides other disadvantages that thermalpeeling methods create such as cooked ring, poor appearanceof tissue and charred skin remained after applying. The main factors affecting the peeling process are mechanical and physical properties of fruit and vegetable tissues, such as skin thickness, firmness, toughness, and variety, rupture force, cutting force, maximum shearing force, shear strength, tensile strength and rupture stress. The general downside of these methods relates to the associated material loss; however, it is still preferred among the current methods (Shirmohammadi *et al.*, 2012).

Among the current peeling methods, mechanical peeling can attract the customer satisfaction because of its benefits such as reduced product loses, damages and other. The mechanical peeling becomes so popular because they produced fresh peeled product. Mechanical peeling is more efficient 75-80% (JAFC, 1997) but recorded peeling efficiency is in the range of 70% (Singh, 1995) with minimum loses, easy to operate and other advantages.

Singh and Shukla (1995) designed a power operated batch type mechanicalpeeler for potato peeling. The machine consists a peeling drum with protrusions onthe inside surface and the drum rotates and then detaches peel from potatoes byabrasion.The capacity of themachine is 100 kg/h with a peeling efficiency and peel losses of 78 % and 6 %, respectively.

Suter (2002) designed roller type potato peeler which uses set of abrasive roller. The motion of roller is controlled by means of sensor. The focus was only on electronic and drive control system. The drawback of such type of peeler neither achieved high efficiency nor reduces peel losses

Emadi *et al.* (2007) developed a new abrasive peeling methods for the pumpkin. The design of the twoinnovative peeling devices, called abrasive pads and abrasive disks, are aimed atevenly peeling of the pumpkin uneven surfaces.

Adetoro (2012) developed a yam peeling machine consisting of a drum eccentrically mounted on a shaft rotating at various speeds ranging between 20 rpm and 50 rpm. The efficiency of the machine ranges 80% and 95% depending on the speed of rotation of the drum and the size and shape of the yam tuber.

Jayashree and Visvanathan (2014) developed a concentric drum brush typeginger peeler with a capacity to peel 7 kg per batch. The peeler consists of two concentricdrums. The innerwooden drum of size 430 × 364 mm was provided with nylon bristles (25mm long and 0.7 mm thick) for theentire length and the outer drum ofsize 470 mm × 550 mm was madeof mild steel diamond cut mesh. The optimum operating conditionsfor peeling ginger were obtained atdrum load of 7 kg, for inner drumspeed of 45 rpm, outer drum speedof 20 rpm and for the peeling durationof 15 min. The peeling efficiency was 61 % and the correspondingmaterial loss was 5.33 %.

Balami *et al.* (2014) designed a cocoyam peeling machine consisting of a rotating drum which is eccentrically placed on a shaft. The cocoyam peeling machine is powered by New Leeson 2 hp 1 ph 115/230 Volts electric motor through a V-belt. The cocoyam was fed gently through a feed tray onto the perforated revolving peeling drum which is enclosed within the peeling chamber. The peeling efficiencies of the machine were 50%, 64% and 68% at 400, 700 and 933 rpm, respectively.

Conclusion :

Peeling of root and tuber crop produce is one of the important unit operation in order to get the rid of inedible portion. There are various methods of peeling each with certain advantages and limitations. The manual and other methods of peeling, except mechanical peeling method, are cumbersome. Various models have been developed for mechanical peeling of root and tuber crop produce, however, these models lack the flexibility and efficiency owing to difference in physical and geometric characteristics of various root and tuber crop commodities. Though considerable developments have been taken place in mechanization of peeling systems for root and tuber crops, further studies on development of efficient and flexible mechanical peeling system are required. The development of effective peeling for root and tuber crops could be useful for the industry.

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