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Significance, status and scope of apricot in India: A review

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Abstract
Apricot (*Prunus armeniaca* L.) is a deciduous stone fruit grown in the temperate climate. India is not a leading producer country, but produces an appreciable quantity of apricot. The country fosters 84 genotypes including 15 commercially important genotypes. However, a large part of the fruit is wasted because of various reasons *viz*. unorganized market, lack of post-harvest technologies and unpredictable demand-supply. The present review comprises characteristics of the fruit, kernel and extracted oil with their aspects for value addition, packaging, storage, marketing aspects and future prospects. It also covers major growing areas of the country, botanical description, ecology, maturity, ripeness, physiology and promising cultivars of the region. Physical, chemical and functional characteristics of the fruit are reviewed. Value addition deals mainly with the products *viz*. dehydrated apricot, chutney, instant chutney powder and frozen fruit besides canned fruit, nectar, pulp juice, jam, infant drinks etc. It has widened to different methods and analysis of drying along with the need of engineering intervention in post harvest.

Keywords: Apricot, stone fruit, characteristics, value addition, hill area

Introduction

Apricot (*Prunus armeniaca* L.), a fruit of Rosaceae family is a stone fruit of mid hill and dry temperate areas i.e. north-western Himalayas of India (Raj *et al*., 2012) [38]. As depicted in the contents of Wikipedia, its annual production in India is 15,435MT during the year 2017. Although, north-eastern China is origin place of the cultivated apricot, a wild variety ‘Zardalu’, seems to be indigenous to India. The nutritious as well as health promoting fruit is being cultivated in Ladakh, North-East, hilly areas of Uttar Pradesh and Himachal Pradesh of India. But, there is a problem of short shelf life of the fruit, which is major obstacle to catch the market demand.

In this context, an appreciable amount of horticultural produce is wasted in the country. The reason behind is improper harvesting and unavailability of efficient post harvest technologies. Apricot is likely to have larger domestic market and wide consumer acceptability in the country. But, the crop has very low shelf life. It needs to be preserved through either of the processing methods while retaining the quality and acceptability with higher market price. It is required to develop such technologies essential for improving the shelf life, value addition, ensuring its availability to large number of consumers for longer duration and harnessing its export potential. Hence, exhaustive study regarding significance, status and scope of apricot is need of the hour.

Major growing area: In India, major part of the growing area is located in Ladakh. It covers about 96.70 thousand square kilometres, which is 75% of the cold arid region in the country. After livestock, apricot is considered as the most influencing and economically viable agro produce of Ladakh. It (32º5’ to 36º north and 75º15’ to 80º15’ east longitude) comprised of Leh and Kargil districts of India.

Classification and varieties: Nugget (USA) was observed as self-fruitful variety, bearing attractive colour with sweetness of fruit (Ghosh, 1999) [14]. The growing region in the country lies from mid hills and widened up to high hills with varying climate and suitability of cultivars. Halman and Rakhaikarpo are indigenous to Ladakh region of India.

The Halman variety of fruits is suitable for drying, while table purpose fruit is sweet Rakhaikarpo. Exotic accessions of Kaisha, Nari, New Castle and Shakarpara are promising in dry cold areas. The region was also recommended with cultivars of Tokopa, Narmu, Australian, Margulam, Rogan, Charmagaz and Khante Turkey (Annon., 2019) [1]. Cultivars suited for Himachal Pradesh are Nugget, Kaisha, Saffeida, Castle and Charmagz. Royal, New Castle, Shakaspara Kaisha, Shakarpara, Early Shipley, Nari Charmagaz are also recommended for the state (Annon., 2019) [1]. The cultivars grown in Uttar Pradesh are Turkey, St. Ambrose, Moopark and Kaisha. Moreover, the state is recommended with varieties of Early Shipley, Bebeco, Charmagaz, Ambroise, Chaubattia Kesri, Chaubattia Madhu and Chaubattia Alankar (Annon., 2019) [1]. Annon. (2019) [1] also revealed early maturing cultivars of baiti and Beladi with late maturing cultivars of Farmingdale and Alfred as newly promising varieties in the mid hills.

Botanical Description: Apricot plants are found with a height up to 9m. It contains white flowers of 5-petals with leaves of oval shape growing altogether. The fruit changes from yellow to orange and finally deep purple at ripening stage in late summer (Raj *et al*., 2012) [38].

Ecology: Apricot needs deciduous climate with low temperature to be grown (Hegedus, *et al.*, 2011) [19]. The tree was found tolerant to dry region and grown in rain fed areas (Pellegrini, *et al*., 2003) [37]. It requires well drained alkaline and saline soil for the best cultivation. It is generally free from chemical fertilizers. Only the well rotten farm yard manure is applied to the trees. Spray of 2.5-5.0% urea and 0.1% boric acid is practiced after petal fall and before leaf-fall for improving the flowering and fruiting of tree. It is mostly propagated through seeds and rarely by vegetative method such as grafting and budding. The multiplication through cuttings is also rarely done. Apricot fruits generally start maturing from last week of may and continue up to august end depending upon altitude and location.

Maturity and ripeness: The maturity stage of fruit is found with yellow skin changed from greenness. However, skin colour varies with cultivar as well as shipping distance. Total soluble solid and duration of full bloom to harvesting stage are also considered as effective choice for maturity indices. Fully ripen fruits are subjected to drying, canning or freezing. High bruising susceptibility of the fruit after ripening stage restricts its picking at firm stage only (Crisosto and Kader, 1999) [9]. Annon. (2019) [2] revealed soft and velvety flesh with rusty-blush colour yielding on touch. Mental wall toss was also suggested as ripeness gauge. The fruit is ripened if it splits open splattering on the surface like jam on pitching hard against the wall, otherwise the fruit bouncing off like golf ball is under ripe.

Physiology: Diseases and damages enhance ethylene production, reduce its shelf life and injure it (Gorny *et al*., 2000 and 2002). Black mold rot is appeared by *Aspergillus niger* mold.

Harvesting and yield: These are harvested manually by shaking the tree branches without any mechanical assistance. Fruits should be harvested in morning hours and direct exposure of fruits to sun should be avoided during grading and packaging (Kureel, *et al*., 2007) [27]. Annon. (2019) [2] revealed fruit productivity of 15-22 tones/ ha or 50-80 kg/ tree. Fruiting of the trees starts after 5 and continues up to 30-35 years of age, which attains peak of fruit bearing at 7-10 years.

Characteristics of apricot fruit

Physical: Sofi *et al.* (2001) [42] reported 3.43cm of fruit length with weight of 19.07g. The same were observed as 3.13-4.07 cm and 7.06-36.24 gram respectively, while analyzing for 25 apricot genotypes (Zaffar *et al.*, 2004) [50].

Bio-chemical: Moisture content was determined as 84.5-88 percent for different varieties of the fruit (Moreiras *et al*., 2001; Sharma *et al.*, 1992) [32, 41]. Percentage of nutritional content was estimated in the fruit as:

Carbohydrate	Protein	Fat	fibre	Ash	Authors
	1	0.3	1.11		Parmar and Kaushal (1982) [36]
9.5	0.8		2.1		Moreiras *et al.* (2001) [32]
	0.67	0.1		0.70	Rathore (2001) [39]

Mineral composition was also determined in terms of mg/ 100g by many authors as:

Calcium	Phosphorous	Iron	Potassium	Authors
20	25	2.20		Parmar and Kaushal (1982) [36]
13.8	20	0.3	226	Biro and Lindner (1999) [6]
20	25	0.30		Rathore (2001) [39]
20	25	0.54	89	Dwivedi and Dwivedi (2007) [11]

However, USDA (2004) [47] reported respective values of potassium, phosphorous, calcium, magnesium, sodium, iron, zinc and copper as 259, 23, 13, 10, 1, 0.39, 0.2 and 0.078 mg/ 100g. Moreover, the fruit was reported with 4.4, 1.9 and 0.4 g/ 100g of sucrose, glucose and fructose respectively (Belitz and Grosch, 1997) [5]. Ascorbic acid content of the fruit was revealed as 7.30mg/ 100g (Sharma *et al*., 1992) [41] and 16.0mg/ 100g (Rathore, 2001) [39]. Total soluble solid was varying up to 15.0 ^{0}B (Singh *et al.*, 1992). In addition, 3.26% reducing sugar and 12.06% total sugar were estimated in the fruit (Singh *et al.*, 1992). Parmar and Kaushal (1982) [36] determined 2.25% of pectin in apricot fruits of Himachal Pradesh. β- carotene was 153 IU/ 100g for wild apricot (Rathore, 2001) [39], whereas Dwivedi and Dwivedi (2007) [11] found the same as 2162 IU/ 100g. The fruit contains β-carotene, vitamins (C and K), thiamine, niacin, phenols, organic acids, esters, volatile compounds and terpenoids. Ripen apricot fruits were high in acid and pectin, but sour fruits were high in acid with low level of pectin as per the classification of NIIR board (2002).

Functional: Botterweck *et al.* (2000) [7] found many of the synthetic sources carcinogenic and causing the liver damage. Hence, demand of apricot increases as the natural source of antioxidant. Yigit *et al*. (2009) [48] also revealed such natural sources helpful against heart attack and cancer. The fruit contains esters, volatile compounds, dietary protein, oil and fibres (Haciseferooullari *et al.*, 2007) [18]. Hence, it is supposed to be useful for skin (Nagarajan and Parmar, 1977) [34] as well as parasitic diseases (Gupta and Bahar, 1985 and Lily and Metzger, 1980) [17, 29]. Application of apricot is likely to be helpful for maintaining the eye health together with lowered risk of cataract formation. It helps in managing the epithelial tissues of bones, teeth, organs and endocrine glands.

High fibre content of the fruit is also meant for reducing the risk of strokes. Raj *et al.* (2012) [38] overviewed about the apricot in terms of an edible plant with medicinal value. The fruit was revealed to be with polysaccharides, polyphenol, fatty acid, cyanogenic glycosides, carotenoids, volatile components and sterol derivatives. The antimicrobial, antimutagenic, antioxidant, cardio protective, antinociceptive, and inflammatory characteristics were also reported by many researchers. Small amount of hydrogen cyanide in the fruit-kernels could be helpful in treating constipation, asthma and cough.

On the other hand, functionality of the fruit was reviewed. It was reported containing vitamins especially A, C, K and B complex and organic acids *viz*. malic acid and citric acid in appreciable quantity. The presence of flavonoids and phenolic also makes the fruit functional. The fruit was found as energy-food and folk medicine for treatment of cough, cold, fever and constipation. Having bioactive ingredients along with pharmacological importance, the fruit was supposed to be effective against chronic gastritis, coronary heart diseases, atherosclerosis, oxidative intestinal damage, tumor formation and hepatic steatosis.

Characteristics of apricot kernel

A huge amount of apricot seeds are obtained from apricot processing, which yields kernels of commercial importance. Underutilized apricot kernels were found equally important. Gupta *et al*. (2012) [16] reported 8.0-15.1 gram fruit weight, 1.78-1.92 gram stone weight, 12.7-22.2% stone recovery and 30.7-33.7%, kernel recovery were revealed with 45.6-46.3% of crude oil yield of kernel. In continuation, Kate *et al*. (2014) [24] found wild pits of apricot yielding 22-38% kernels with 53.4% oil of commercial importance. Targais *et al*. (2011) [45] studied apricot-kernel oil grown in the Ladakh region of cold deserts. The oil from sweet kernels was found edible, while bitter kernels were of cosmetic, medicinal and religious values. The oil was known as massage oil or body oil and helpful in joints ache and backache. The oil yield, crude fibre, crude protein, peroxide and acidity values were 42.2-57.2%, 4.06-7.63%, 15.1-24.2%, 0.834-8.294 meq/ kg and 0.279-0.700% (Ozcan *et al*., 2010) [35]. The oil primarily consisted of 53.06-70.90% oleic and 21.43-35.67% linoleic acids. Gupta *et al*. (2012) [16] also had oleic, linoleic, linolenic, palmitic and palmitoleic acids of 62.07-70.6, 20.5-27.76, 0.4-1.42, 5.0-7.79 and 0.48-0.70 percent respectively in the oil. High content of oleic and linoleic acids suggested its utility as edible oil. The respective values of acid, peroxide and saponification were reported as 2.27-2.78 gram KOH, 5.12-5.27 mili equivalent and 189.8-191.3 gram KOH for each kg of oil. Besides, 72-107 mg/ 100g vitamin E was meant for its suitability in preparing moisturizing creams, massaging oil and cosmetics. Thus, the oil was advocated to be used for edible purpose and industrial applications as well.

Some of the researchers studied the functional characteristics, which needs further to be investigated. The amygdalin contents for apricot seeds (bitter or sweet) of Turkey were studied through HPLC for two years (Yildirim and Askin, 2010) [49]. It was higher for bitter seeds compared to the sweeter one. Chaouali *et al.* (2013) [8] found the cyanogenic glycosides synthesized in apricot kernels of Tunisian flora. Its hydrolysis was supposed to yield hydrogen cyanide.

Value addition and its products

Primary processing of the fruit is comprised of cleaning, sorting and grading. Being delicate, it is cleaned gently followed by sorting of the fresh and bruised fruits separately. Sorted fruits are further graded based on their varieties, maturity stage and ultimate uses of the product.

Dehydrated apricot: It has been found that the equally acceptable dried apricot can be preserved even for 24 months when kept at low temperature. It is one of the simplest methods of post harvest processing of apricot fruits. Besides, the dried product takes significantly less space for its storage, packaging as well as transportation before its consumption or further processing. Thus, shelf life extension will eventually lead to higher income of the apricot farmers. Drying is a function of parameters *viz*. nature of the produce, product quality, heat stability, drying time as well as climatic parameters *viz*. solar intensity, sunshine hour, air humidity, wind velocity etc. Such parameters are guiding factors, while selecting or designing a dryer. Currently, sun or solar drying of different kinds, oven drying and osmotic drying is already being practiced. Such methods are insufficient to solve the problems of apricot farmers regarding the preservation of apricot through drying. In cold regions, it takes 2-4 days for fruit drying under sun. Thus, unavailability or unawareness of proper drying technology makes the farmers helpless in fetching the remunerative price for their crop. Hence, it is high time to develop proper drying technology of apricot fruits suitable for cold arid regions. The technology would be helpful in preserving the apricot fruit for extended period and ensuring the remunerative price to the farmers.

Gradual development: Direct sun drying of crops is being practiced since the time immemorial and even without taking any technical support (Szulmayer, 1971) [44]. Some factors *viz*. large space requirement, process control, increased labourer cost, weather uncertainties, insect infestation, mixing of dust and foreign matters restrict the open drying at large scale. This is the reason; the apricot farmers are changing their practices in the recent days. Many of them had been adapting economical, pollution free, controllable, and renewable energy source as solar dryer. Solar drying has been found as a method for reducing the crop losses with improvement in quality of the product after drying (Munhlbauer; 1986). Moreover, requirement of crop specific design was also suggested for attaining the satisfactory performance of drying system (Steinfed and Segal; 1986).

Oven drying is another option for apricot drying. However, the method requires high energy and hence costlier. Moreover, introduction of osmotic dehydration was needed to be studied for its suitability. Many of the dryers were subjected for performance evaluation and selection of model best suitable for drying of apricot in particular location. Hussain *et al.* (2012) [20] briefed the attempts of gradual improvements of drying techniques with dryers used and utility of the dried apricot in the Ladakh region. Different forms of solar dryers *viz*. tunnel dryer, tent dryer, polyhouse dryer, cabinet dryer, sunbest dryer, PEN dryer and metallic dryer were being practiced. Osmotic dehydration could also improve the quality with consumer acceptability. Organic standards were suggested to maintain for improved quality, acceptability and shelf life of the dried product. Khalil *et al.* (2012) [25] also evaluated the performance of a dryer equipped with solar air heater and drying chamber for apricot drying. The performance was improved from 20% at 0.01kg/ s (natural air flow) to 42.6% at 0.21kg/ s of air flow. Drying from 85 to 8% took around 13 hour at 50ºC temperature and 15% of relative humidity.

Experimental modelling: Solar dryer equipped with a conical concentrator, drying cabinet, blower and solar heater was subjected to apricot drying experiment using indirect forced convection (Togrul and Pehlivan; 2002) [46]. Forced air was supplied through blower to the solar air heater passing over apricots. Logarithmic model satisfactorily described various drying variables *viz*. air temperature, air velocity and relative humidity on constants and coefficients of the models. Mirzaee *et al.* (2009) [31] applied apricot drying experiment with 40-80 ºC temperature and 1.0-2.0 m/ s air velocity to the modified form of the Fick's second law. The model resulted in to activation energy of 29.35 to 33.78 kJ/ mol with moisture diffusivity of $1.7X10^{-10}$ to $11.5X10^{-10}$ respectively. Johnson *et al.* (2015) [23] used table-top dryer fitted with solar system and traditional tray dryer for conducting the experiment on apricot drying. The experiment was based on the variation in temperature and air velocity of 40-60 ºC and (0.11-0.17 m/s respectively. Application of Page model yielded activation energy, diffusion coefficient and drying constant values were recorded as 46.61kJ/ mol, $9.89X10^{-11}$ to $2.91X10^{-10}$ m^2/s and 0.26 to 0.5 h^{-1} respectively. Subsequently, Naeimi *et al.* (2016) [33] concluded significant ($p< 0.01$) variation of drying time with 5-15 mm fruit thickness, 30-50 ºC drying temperature and pre-treatments of sodium metabisulphite and sulphur dioxide. Page model was suggested to be used as per the values of correlation coefficient with chi-square as well as root mean square error.

Pre-treatment application: Moreover, pre-treatment was recommended to avoid its darkened surfaces, while drying. Such pre-treatments might be sulfuring, sulphite dip, ascorbic acid, ascorbic acid mixture i.e. ascorbic acid with sugar, fruit juice dip and honey dip etc. Sulfuring and sulphiting could be some of the best pre-treatments for long-term storage of the dried fruits. However, sulphites are avoided because of asthmatic reactions among few people. Hence, it is recommended to select a particular pre-treatment prior to apricot drying. Manafi *et al*. (2010) [30] prepared the dehydration curves of Peleg's model at varying concentrations of salt-sucrose solution, while drying the apricot slices after pre-treatments. The increase in solution-volume was leading towards increased mass transfer. However, solution to sample ratio of 5:1 produced the best quality product. Moreover, duo of the acceptable taste and high mass transfer were optimum at 5% concentration and 40 ºC temperature.

Quality evaluation: Subsequent upon the preparation of value added products, it is needed to go for quality evaluation related to its nutritional and functional characteristics with consumer acceptability. Inceday *et al.* (2016) [21] conducted experiment on apricot drying through various drying methods and determined antioxidant activity, β-carotene, minerals and colour of the dried apricot. The dried fruit was found with increased colour values of L*, b*, Δ*E*, hue and chroma, but decreased value of a*. The value of β-carotene was increased by 1.4-3.9 times for dried fruit, while comparing it with fresh fruit. Microwave-convective drying of 160 watt at 50ºC could retain antioxidant and β-carotene with lesser drying period. Khan *et al.* (2016) [26] studied physicochemical composition and organoleptic characteristics and of the dried apricot. The fruit moisture was reduced from 83.3% of fresh to 15.7 and 14.61% for open sun and moveable solar dryers respectively. Although, apricot dried in open sun was also acceptable in colour and taste, the process had slightly negative effect. The respective values of carbohydrate, protein, crude fat, crude fibre and ash percentage were increased from 14.03, 0.9, 0.03, 1.02, 0.72 to 75.91, 1.0, 1.99, 2.98 and 3.51% for open sun drying. Their respective values were 75.13, 0.97, 1.82, 2.95 and 3.43 for moveable solar dryer.

Chutney and instant chutney powder: Lal *et al*. (1989) [28] found chutney with good acceptability even after one year of storage at ambient conditions, which was prepared from wild or cultivated apricot pulp. Instant chutney powder was also prepared from wild apricot and recommended for 1:3 dilutions, while making a fine paste. The cost of instant chutney powder of wild apricot was estimated to be INR45/ kg (Sharma *et al*., 2002) [40].

Frozen apricot: It needs unit operations of harvesting, receiving, selection, washing, cleaning, crushing or slicing followed by freezing, packaging and storage. Apricot jam is prepared using pulp-sugar mixture in the ratio of 1:1 with 0.75-1.0% citric acid and 0.5-1.0% pectin by weight of the blend. The same may be poured by desirable essence as per the choice. It contains 66.2% soluble solids, 62% soluble carbohydrate, 33.1% red sugar, 28.2% saccharose, 0.5% pectin, 0.71% acids with 86.34 sugar-acid ratio.

Other products: Canned apricot, nectar, pulp juice, jam, infant drinks etc. can also be prepared from apricot as per the standard methods of preparation.

Varying recipes: Annon. (2019) [3] reported some of the recipes using apricot fruit as an ingredient. Boiling desiccated apricot with sugar for 20minutes yields stewed fruit resembling sweet, sticky and gooey peach cobbler. It is used in the sweets including Hyderabadi desert named as 'Qubani ka meetha'. Dried apricots may be mixed in muesli, couscous and biryani. Syrupy mix of the molten fruit and known as apricot glaze is used for coating grilled veggies. Semolina pudding may also be prepared with apricot base. The suggested method is continuous stirring of semolina in the boiling soymilk with sugar in a saucepan until it gets thickened. Then, it is kept aside for 10-15 minutes followed by blending apricot along with other fruits. It follows transferring the same in to mixing bowl, blending until pureed and refrigerating for 2-3 hours in serving bowls.

Apricot kernels: The seeds are either being thrown or having difficulty in removing the shell to get kernels manually. Seed shelling is needed to be made easy through mechanical intervention for reducing the women drudgery involved. It has been found that the kernels are being processed traditionally for fulfilling their local needs, which can be promoted through introduction of mechanical aid. Hence, development of small scale seed-sheller and value addition to kernel is the best option for apricot farmers to reach broader market.

The design and development of seed-sheller depends on the parameters *viz.* dimensions (length, width and thickness), shape (sphericity), volume and rupture strength etc. of seeds and kernels. Currently, it is being performed manually, which involves women drudgery. The mechanical sheller or seed cracking machine of very large scale was found economical by AICRP on PHT through custom hiring basis (Dixit *et al*., 2010) [10]. However, transportation cost and losses incurred due to jobless human power available at home were missing in the study. Thus, unavailability of small scale seed-sheller or seed cracking machine makes the farmers helpless in increasing their income significantly. Being commodity, the economy of the growing region largely depends upon, demands for solution of such problems. Hence, it is required to design and develop a small scale seed cracking machine and value addition to kernels of apricot.

When it was understood to introduce the mechanical aid for shelling, Dixit *et al.* (2010) [10] performed the economic analysis of extraction technology for apricot kernels. The technology of AICRP on PHT consisted of mechanical decortications and kernel separation along with extraction as well as filtration of oil. The efficiency of economics in terms of benefit-cost ratio, internal rate of return and net present value with net profit and saving were reported over conventional system with respective values of 21.83, 44%, 486, INR 1.34 lakh and INR 55,446. The mechanical decorticator and separator were advocated to be used for reducing women drudgery. But, the custom hiring based system was avoiding the human power available at home and transportation cost was missing. Thus, farmers were supposed to achieve potential benefit with introduction of small scale seed sheller or seed cracking machine at home scale.

Designing the seed cracking machine needs to determine the properties *viz.* dimensions, geometric mean diameter, sphericity, volume and rupture strength of apricot seeds and kernels. Gezer *et al*. (2011) [13] determined the physical properties of apricot kernels of Soganci, Kabaasi, Hasanbey, Hacihahloglu and Cataloglu varieties grown in Turkey. The thickness, width, length and geometric mean diameter were 5.56-6.37, 8.98-10.69, 13.96-17.09 and 9.75-10.21 mm respectively. Their respective ranges for sphericity, mass, bulk density, kernel density and porosity were revealed as 0.55-0.69, 0.45-0.58 gram, 555.45-574.62 kg/ m^3, 930.89-1117.02 kg/ m^3 and 39.98-49.95%. The projected area, volume and terminal velocity were reported to be 113-160 mm^2, 450-580 mm^3, 5.82-6.31 m/ s respectively. Their rupture strength (N) along length, width and thickness were 40.17-49.55, 43.17-61.05 and 87.22-155.13 respectively. Moreover, respective values for static friction coefficients against wood, sheet iron and galvanized sheet iron were 0.461-0.516, 0.429-0.478 and 0.275-0.321. Moreover, percentage of dry matter, crude oil, crude protein, crude fibre and ash were reported to be 96.75-97.82, 28.26-42.48, 15.7-18.3, 15.3-17.1 and 2.91-3.83. It was found to have high content of sodium, potassium, calcium and phosphorous. In addition, the mechanical characteristics for almond seeds (white and red) of Nigeria determined using Testometric (M500-100AT) machine (Sunmonu *et al*., 2015) [43]. The compressive strength, fracture force and deformation at yield were 408.70N/ mm^2, 2679.40N and 7.03mm respectively for red varieties. Their respective values were 396.20N/ mm^2, 2843.90N and 7.27mm for white varieties.

Grading, packaging and storage

The fruit is perishable in nature; thereby need proper care while harvesting, grading, packaging and transportation. Size is the basis of apricot grading before packaging in cartons of corrugated fiber board (CFB) or wooden boxes. Newspaper sheets are used for lining the boxes from inside with some margin for overhanging flaps. Pine needles are padded in the bottom of boxes for avoiding fruit bruising. Paper is used for covering the top layer of fruits, while bringing over hanged flaps followed by nailing the top instead of individual wrapping. CFB cartons of small sizes are light weight with ease of handling and packaging. It saves from bruising and hence suitable for fetching better price. However, it costs higher as compared to wooden boxes and needs to be kept away from rains.

Apricot storage at large scale is seldom practiced. But, it could be stored for 1 to 4 weeks at 0ºC and 90-95% relative humidity depending upon their cultivars (Crisosto and Kader, 1999) [9]. Institute of international refrigeration (1986) [22] stored it safely for 4, 18 and even more than 24 months at -12 ºC, -18 ºC and -24 ºC respectively. Temperature of 0-1 ºC was recommended with 90% relative humidity, 2-5% O_2 and 0-2% CO_2 for modified atmosphere packaging of the ripened fruit (Gorris, 2000) [15]. Senesi and Pastine (1996) found citric acid as effective preservative of cut fruits through lowering the pH.

Marketing aspects and future prospects

The clingstone property makes early ripened fruit varieties suitable for direct consumption. Fruits ripening at later stage are used for direct consumption as well as processing (Balla and Koncz, 1996; Fekete *et al.*, 1997) [4, 12]. However, Szalay (1998) reported delayed Bergeron as the best suited variety for processing. Apricot is supposed to fetch higher price with its wide market potential after processing. Dry apricot marketed at small scale, needs further multiplication with variation in the processed products. Apricot has great potential of marketing in wider area, which is supposed to be achieved through intervention of suitable post harvest technologies. Apricot farmers may fetch higher price through variation in the processed products with increased shelf-life. The income of apricot farmers can further be increased through utilizing the family labourers for different unit operations.

Conclusions

Apricot is deciduous stone fruit limited to certain cultivable area of the country with short shelf-life. However, it has huge potential to cover widened market with extended period of consumption. Introduction of suitable post harvest technology may be helpful in achieving the target with varying processed products. Despite various studies adhered to drying of the fruit, it needs to be examined and processed for variation in the products. Engineering interventions are still missing for small scale seed shelling.

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