Raisin quality: the deciding factors

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Introduction

Drying is one of the old and the cost effective method for fruit preservation. Even though, new preservation methods and ability to supply market with fresh fruits during the whole year are developed, drying stayed one of the most used technological operations worldwide. The drying process keeps diversity of the product on the market and responds to consumers demands. The grape drying is performed in several ways: a) "drying-on-vine" method, where grapes are dried on vine directly, b) drying in open sun (traditional method), where grape bunches are spread over either the ground or on a platform in thin layer directly exposed to the sun (this method can be done also in shade), c) drying under controlled conditions in drying chambers and d) drying in shed where pre-treated grape bunches are spread on meshes inside drying shed and protected from direct sun light. When grape bunches are dipped into an alkaline solution containing, for instance, ethyl oleate, this component penetrates into the waxy layer on fruit surface and causes the formation of small pores facilitating rapid moisture loss. This process shortens the required duration for drying of grapes to desired level of moisture. The yield and quality of final dried product depends on the TSS (Brix) of the fresh grape berry taken for drying purpose.

The grape properties directly affect raisin quality. These properties are influenced by several factors, and some of them cannot be manipulated by grape growers (variety, the age of vine, soil and climate conditions), while some others, such as soil management, irrigation management, nitrogen and potassium nutrition, canopy management, insect-pests and disease management etc., which can be improved by the grower. All these parameters together contribute for good quality grape production. Besides these parameters of fresh grapes at harvest, post-harvest factors such as proper handling of harvested bunches, adoption of suitable method for grape drying, environmental conditions etc. also affects raisin quality. In order to obtain good quality raisins, both physical parameters (berry size, berry colour, the nature of waxy cuticles) and chemical (moisture content, sugar content and acidity) fruit composition at harvest

influences quality of fried grapes. . Among technological parameters of quality (size of the berries, uniformity, conditions of the berry surface, moisture content, and chemical composition) for creating healthy safe product, microbiological quality (absence of the decay, moulds, yeasts and foreign matter, insect infestation) is of essential importance.

Quality parameters

A. **Raisin size**: The size of a single raisin is directly related to size of fresh grape berry. The bolder or smaller berry size is directly contributed by regional factors and vineyard soil type and grape variety itself. But the most important factor which determines the size of a single raisin is the crop load on a vine. More crop load results in smaller berry which in-turn produces smaller raisins.

B. **Raisins colour**: The colour of raisins should be uniform and light coloured. If the grapes are dried in the sun, the raisins become dark coloured. To obtain the best raisins w, the grapes should be completely ripe, should avoid bruising during transportation, prevent the exposure of grapes bunches to direct sunlight during process of drying, select the drying area away from water bodies and wind velocity.

C. **Cleanliness**: One of the other factors in the quality of raisins is its skin cleanliness. If it rains during the process of drying and the semidried grape is wet or if the single grape berry gets split or squeezed during loading in crates and transporting it to drying shed from vineyards, the juice oozing out from a single berry may get adhered to other berries and the chances of dust sticking also makes fresh grapes unfit for drying. Such grapes are not suitable for making raisins as it results in bad coloured raisins and often fetches poor price in market. So maintaining cleanliness of grapes is also one of the important factors during grape drying process. .

D. **Softness or hardness of the raisins**: A desirable raisin should be soft in texture. The skin of raisins which belongs to unripe grapes will be full of flexures and hard and feels like a piece of leather to the teeth while chewing. Although softness or hardness of the raisins is partly related to grapes variety, preparation method and its moisture amount meddle with raisins softness to a great deal as well.

E. **Moisture content of the raisins**: If the raisin after being dried and washed has more than 18% of moisture, it will be contaminated with moulds, and if the moisture content is less

than 11%, it will have an undesirable flavour and have hard mouth feel. The most appropriate moisture content for raisins should be between 14 to 16%.

F. **Raisins flavour**: This characteristic is more related to the method of drying and raisins variety from the point of its being seeded or seedless and the source of heat used for drying. Apart from these factors, other factors which are different in different kinds of raisins meddle with its quality. These factors include .

Important factors:

I. Size affecting factors: Variety, rootstocks, nutritional and water management, insect-pests and diseases.

II. Colour affecting factors: Variety, growing site, canopy structure, bunch exposure etc.

III. Weight affecting factors: several factors affect weight of berries including variety, rootstocks, water and nutritional, insects-pest and diseases

IV. Taste: Compositional factors of berries like sugar content, acidity and sugar acidity ratio

Vineayrd factors which influence quality of fresh grapes and thereby raisin quality:

Variety: Variety has its own impact on raisin quality. Each variety produces berries having varietal specific aroma, colour, shape and size. The pulpiness or juiciness is also trait of a particular variety. The varieties having suitable characters for raisin making like more pulpiness, good aroma, more sugar accumulation in berries, thin skinned berries etc. should be planted in suitable areas. The smaller berries lost water more rapidly than larger berries because of the greater relative area of skin to flesh. Water loss was not greatly affected by sugar content; however, 20 °Brix berries tended to loose water more rapidly than higher maturity berries. But more raisin recovery is related to higher TSS in berries. There are significant differences among varieties for drying rates.

Canopy: Vine canopy plays important role in deciding raisin quality. The sugar and sugar acidity ratio is directly affected by number of leaves per bunch. Balanced pruning is the standard cultural practice used to control grapevine crop level and regulate vine vigour. Increased bunch load results in reduced sugars in berries which lead to low raisin recovery.

Water: Total water use for each vineyard varies from location to location and depends on soil type and structure, the amount of rainfall and residual soil moisture, rooting depth of the

vines, water availability and floor management practices. Vineyard irrigations end at least two to three weeks prior to harvest to minimize vegetative growth, enhance crop maturity and quality, and ensure that soil is dry enough for laying down raisins. Water stress reduces berry size. The water stress not only reduce yield, but small berries could also have a negative effect on raisin quality. Sugar accumulation, which is crucial for quality-raisin production, can be delayed by severe water stress, resulting in leaf senescence, but may be increased when mild water stress reduces vegetative growth. A luxurious water supply before or during harvest may reduce sugar content and, consequently, induce poor raisin quality due to lower drying ratios.

Insect-pests and diseases: Management of insect pests and diseases play role in producing good quality grapes. The various agrochemicals to control the various pests and diseases should be applied considering their MRL values and suggested PHI. These practices will improve hidden parameters of raisins.

Berry quality: Raisin quality is greatly decided by quality parameters of berries. Berry size, skin thickness and pulpiness have own importance in raisin quality. The berries having big size results in bold raisins, pulp always give plumpness to raisins and acceptability is affected. Thin skin is desirable factor. GA application to bunches results in thick skinned berries. Thin skin can be managed in vineyards by avoiding GA application during berry development stage unlike in production of grapes for table purpose.

Harvesting: Fruit harvesting date is one of the factors, which is highly effective on quantitative and qualitative traits of raisin through alteration in fruit characteristics and even plant yield. To produce raisins, sugar content of the single grapes considering the ratio of grapes juice concentration to its acidity, should be between 21 and 33%, so one should proceed to pick the crop at the end of the season. The grapes that are collected before complete ripeness, has a relatively high amount of acidity and so will cause an undesirable product of raisins. In particular, the influence of fruit soluble solids on raisin quality makes the time of harvest an important cultural consideration. Higher-maturity fruit produces higher-quality raisins as well as higher raisin yields. Thus, raisin quality considerations should also influence the time of harvest. Generally, high-quality (high-maturity) raisins are plump, meaty, and fine wrinkled, the result of having harvested grapes at high soluble solids content.

Dried Grapes: Methodologies, Quality and Uses

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Introduction

Grape is an important fruit crop of India. Commercial grape cultivation in India is mainly restricted for table purpose and has reasonably high level of productivity in the world. An area of 115230 ha was covered under grape cultivation with production of 2689910 MT was recorded during 2012-13. Grape is mainly cultivated in Maharashtra followed by Karnataka, Tamil Nadu, Mizoram and Andhra Pradesh. Some northern states viz.; Punjab, Himachal Pradesh and Jammu and Kashmir are also producing grapes. While 74.5 per cent of grape produced is available for table purpose, nearly 23.5 per cent is dried for raisin production, 1.5 per cent for winemaking and 0.5 per cent is used for juice. The drying of grape bunches under sheds is common practice followed in major raisin making areas of India. Major raisin making regions are Sangli, Solapur and Nashik districts of Maharashtra; and Bijapur and Bagalkot districts of Karnataka. As per an estimate a total of 150 thousand tonnes of raisins was produced during 2012.

Methods of grape drying

The drying process keeps diversity of the product on the market and responds to consumers demands. The grape drying is performed in several ways: a) "drying-on-vine" method, where grapes are dried on vine directly, b) drying in open sun (traditional method), where grape bunches are spread over either the ground or on a platform in thin layer directly exposed to the sun (this method can be done also in shade), c) drying under controlled conditions in drying chambers, d) In freeze drying, Grapes are processed in such manner where moisture is removed from the product using a very low temperature and a vacuum and e) drying in shed where pre-treated grape bunches are spread on meshes inside drying shed and protected from direct sun light. When grape bunches are dipped into an alkaline solution containing, for instance, ethyl oleate and potassium carbonate, these components penetrate into the waxy layer on fruit surface and causes the formation of small pores facilitating rapid moisture loss. This process shortens the required duration for drying of grapes to desired level of moisture. The drying of grapes in side shed is regular feature in the country. Sulphur fumigation is a practice followed to maintain good colour of dried grapes.

Spraying of oil in the racks: Fresh grapes are spread on the rack and sprayed with standard strength of solution of ethyl oleate and potassium carbonate. For this purpose, a specially designed multiple-nozzle forked sprayer is required. The amount of solution required for spray is 450 litres per 8 T of grapes. The fruit may be left for several days before spraying but in the meantime will dry very slowly. Unsprayed fruit is also liable to some sunburn damage in very hot weather. When rack spraying, it is particularly important that the fruit is spread evenly and all leaves are removed, so that total wetting of the berry surfaces is possible. The first spray consists of 2/3 strength standard emulsion, followed four days later by a 1/3 standard strength spray, both applied with a multi-nozzle forked sprayer. This practice is commonly used in Australia.

Quality of dried grapes

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Safe raisins

Quality of dried grapes involves safety also. Whole chain (from production of grapes to processing) is responsible for supply of safe raisins to consumer. Presence of physical, chemical and microbiological contaminants make raisins unsafe for human consumption. Presence of any material which harms consumers' health disqualifies the raisins as quality product. Make sure that the residue of agrochemicals or heavy metals not cross the specified MRLs values in any case. Ochratoxin A has very low limit i.e. 20 ppb for grapes and processed products. Presence of microbes also create problem. To suppress the growth of microbes use of SO2 is common practice. But, SO2 content in raisins never cross the specified MRL values. The label must clearly show that the raisins are sulfur treated.

Checkpoints for quality: Various activities involved in grape production, processing and supply chain consumers are equally important for quality raisins. Fig. 1 showing various check points which can be utilized to maintain the quality of dried grapes.

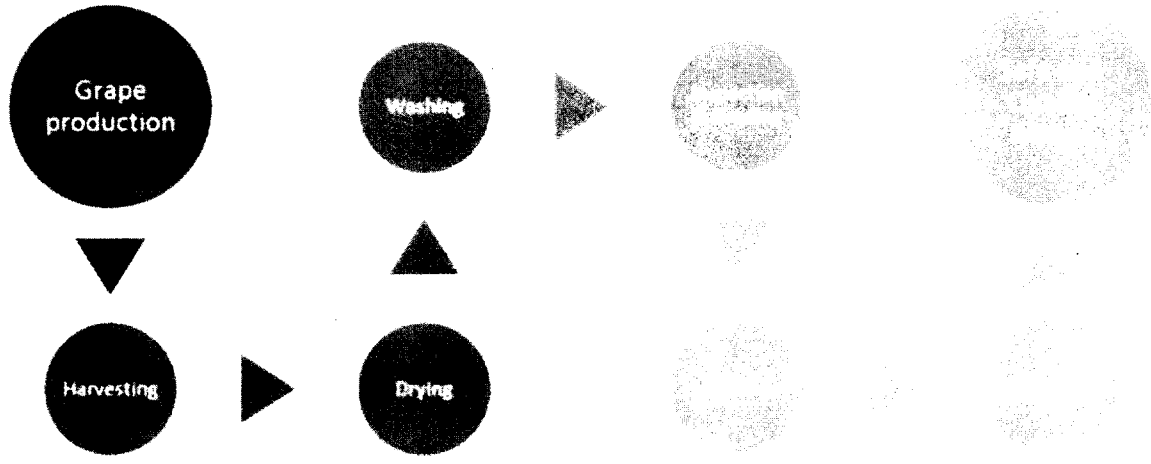

Fig.1. Checkpoints for quality raisins

Dried grapes: the opportunities

Raisin Juice: Raisin juice is pure extract of dry raisins in a form of dark brown syrup, produced by boiling without the addition of sugar or other food additives. The raisin juice has high content of elements (K, Na, P, Mg, Ca) and vitamins (C, B3, and A). Because raisin

juice's carbohydrates are in the form of glucose and fructose, it easily passes into the blood without digestion. This is of nutritional importance, especially for babies, children, coeliac disease patients, sportsmen, and in situations demanding immediate energy.

Raisin Concentrate: Raisin Concentrate (RC) also is the most important products obtained in the raisin processing industries. These RC products are now used to make the syrups, drinks and confectionery productions and introduced as natural substitute for sugar in food applications.

Raisin wine: Raisin wine, also called straw wine, is a sweet wine made from grapes that have been laid or hung to dry, usually in the sun. The type of raisin, drying method and winemaking method can vary between wineries and regions. This beverage was traditionally made in parts of France and Northern Italy, but winemakers around the world had begun making this wine by the late 20th century. Typical raisin wine recipes feature little more than raisins, water, citrus juice or acid and sugar.

Raisin paste: Mild heating helps in keeping the paste soft while it is stored. The dried and ground raisins are then wrapped in polythene cases to be further cooked. Preservatives are not required since raisin juice has low pH and high sugar content that makes it self-preservative. Since raisin paste is extrudable, it is put on cookies to add an element of fun and flavor.

Bakery products: There are many different types of recipes for making baked products like raisin buns, oatmeal raisin cookies White raisin bread, cinnamon raisin bread, carrot raisin bread, raisin rolls etc.

Alcohol/Biofuel: Inferior quality raisins can be used for production of ethanol. Chopped and water soaked raisins are fermented and pure ethanol can be prepared. The alcohol produced from these inferior type raisins can be utilized as biofuel.

Salad: The raisins are widely used in making different recipes of salads.

Raisin Production in India

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The world production of grapes is presently 65,486,235 MTs, out of which India accounts for 1.2 million Mt of grapes making a share of 1.83 percent of the world production and 3 percent of the total fruit production in the country. Area under this fruit has been increased by 50% and its production by 71% in the country in the last decade (1994-2004) due to the economic importance of this fruit. India has achieved the highest productivity of 20 t/ha in the production of table grapes. Presently in India about 78 percent of grape is used for table purpose, nearly 17-20 percent is dried for raisin production, while 1.5 percent is used for juice and only 0.5 percent is used in manufacturing wine. The processing of this fruit in our country is very less as compared to the traditional grape growing countries in the world where more than 80 percent of the produce is processed in the form of wine, raisin and juice. The processed products viz. wine; raisins and grape juice are the most popular products from the grape all over the world. Raisin is prepared from the sound dried grapes of the varieties conforming to the characteristics of *Vitis vinifera* L. The grapes are processed in an appropriate manner into a form of marketable raisin with or without coating with suitable optional ingredients.

Status of raisin at world level

The raisin trade in international market is increasing day by day. USA is the largest raisin producer in the world. USA and Turkey together produce almost 80% of the total raisins of the world. USA, Turkey and South Africa are the largest raisin producers at the global level besides Greece, Australia, Iran, Afghanistan, China, Russia and others. India has achieved the production level in the range of 55,000 to 65,000 t of raisins, which is next to Turkey at world level. Efforts on improvement in quality of the Indian raisins have been initiated to promote the export of this product in world market. As the overall investment in raisin grape production is considerably less as compared to table grape production for export, hence the raisin exporters are expected to accrue better price realization out of this product in terms of superior cost: benefit ratio. India's export of raisins is 314 Mt with the value of 0.473 million US dollars.

Characters of good raisin

The raisins of good quality should have following characteristic features:

- Good and uniform appearance of produce in terms of its color (perfectly green or grey-green), size (round) and smooth texture
- A higher pulp content and a pleasing taste without any sugar coat outside
- Intact skin and its outer layers, free from injuries, dust and foreign matter.

Important grape varieties for raisin making

Major production of raisin (90 per cent) in the world is from Thompson Seedless. The Thompson Seedless is a white, thin skinned grape, which produces the best raisins available today. Its small berries are oval and elongated. It does not contain seeds and has high sugar content. Besides the other varieties viz. Muscat of Alexandria, Waltham Cross and other white and colored seeded varieties are also used for raisin production. In India, Thompson Seedless and its mutants i.e. Sonaka, Tas-A-Ganesh. Manik Chaman are

mainly used for raisin production. NRC for Grapes, Pune, screened a sizeable germplasm for production of quality raisin production and identified some varieties viz. A 17-3, E 12/3, Mint Seedless, Superior Seedless, KR White, Manik Chaman, A18-3 (Coloured seedless) and Cardinal (for manukka) for this purpose.

Technology for Quality raisin production – an Indian perspective

Grape berry has juice / pulp containing sugar, acids, flavonoids, vitamin and minerals and outer protective skin has different layers. Drying process has to be selective to remove the water from berry without affecting outer skin structure and arrangement of wax plates. The quality of waxy layers in terms of wax plates is about 0.1 mg/cm^2. This layer only protects the berries from getting dried in fresh form. During storage of berries at ambient and low temperature, the water moves out from the stalk and rachis and not from the skin coated with white waxy layer and this result in drying of pedicels in first instant and then berry drop.

Waxy layer on the green berry skin is the main target of various pretreatment of grape berries for quickening the drying process. Many treatments have been worked out in different countries after various research trials and an appropriate and economic treatment have been listed below for drying of grapes in India.

A water solution containing 2.5% potassium carbonate and 1.5% ethyl oleate for dipping of berries has been suggested. A dipping time of 3 minutes duration has been recommended to increase water removal @ of 1.4 mg/cm^2 in comparison to 0.4 mg/cm^2 in control. However, the cumulative quantity of waxes has been reduced only by 13 per cent in treated berries and therefore the drying effects is due to loosening of waxy plates on the outer skin and not removing the wax on the skin. This has been further proved based on the microscopic studies on skin structure with such treatments and without treatment in Australia.

When drying occurs fast, the sugar concentration increases in berry in short possible time and therefore the enzymatic reactions of peroxidase and polyphenolase also gets reduced and thereby leading less browning of the product. This process also helps in suppressing the microbial and fungal growth during drying process. A temperature of 25°C and above in dipping emulsion has been recommended for good results. A berry picks up approximately 35µ mol solution and looses 70 percent during draining and utilizes only about 10-12 µ mol. A pH of such solution has been suggested always in the range of 9.5 to 11.00. A pH more than 11.00 breaks the skin and less than 9.5 favours microbial growth and fermentation. This treatment is more effective when berries attain the maturity of 20° brix and above and in other cases there is less pick up of dipping solution and therefore no effect.

In case of higher levels of dipping oil (pickup by skin 7200 ppm); there will be sucking of moisture in berries from outside this results in unpleasant taste in the product.

Water removal from berries takes place in three stages in treated berries. In first stage, the moisture removal is highest reducing initial weight to 40 to 50 per cent. When there is drying of 50 per cent, surface free area of berry is reduced by 28 per cent and as a result the water removal process is slowed down subsequently.

In second and third stage, the water is removed from pulp to skin and then removed by evaporation. This process continues till berry is dried to the extent of 13 per cent moisture. Drying sheds based on covered iron rack system are fabricated where the number of shelves is kept from six to eleven with interspaces varying from 22.9 cm to 45

cm. The rows of racks are generally spaced apart from a distance of 60 to 150 cm. The length of the rack could be from 600 to 1800 cm having South-North orientation and flow of dry air from West to East. This is a modified drying system of Australia, The shelves of iron rack are netted with nylon mesh and density of fresh grapes on this mat for drying is maintained from 1.7 to 2.2 g/cm^2 depending upon the height of shelf from 22.9 cm to 45 cm. This Australian method of dipping and rack system for drying has reduced the drying period to 10-12 days when compared to 20-22 days in conventional method. On the contrary, in USA, the grapes are dried without any treatment by spreading on graft paper placed between grapevine rows in vineyard. While in South Africa this is done on concrete slab. In both the cases the drying is in open sunshine and not in shed as followed in Australia. In Afghanistan, the drying is done in closed rooms by hanging the grape bunches on the ropes and it takes about 40 to 45 days for drying. There, the grapes are grown without following training and pruning and yield is only 1.5 to 2 tons/acre with T.S.S ranging from 28 to 32^{0}B.

The position of bunches can be changed time to time in order to expose the all berries of the bunch in order to reduce the moisture content up to desire level. If rain occurs during the process of drying, the berries absorb moisture very rapidly. If moisture increased in environment it invites the attack of moulds. To decrease the humidity in side the drying sheds, exhaust fans remain at on position. This practice is also helpful in maintain the desirable vapour pressure in side the shed. The temperature of drying shed can be increased by use of hot air blowing fans.

Separation of dried grapes from its stalks and rachis in bunches is done now using machines designed and fabricated for this purpose locally. However this was being done manually in the past, while the operation of sorting and grading of dried berries continued with the manual force for want of appropriate machine for this purpose.

Packing and storage

Raisins are strongly hygroscopic. Contact to moisture may result in mold, rot and fermentation and if a fermentation process is initiated, it may eventually affect the entire lot. Under appropriate temperature and humidity conditions, there is a risk of infestation by maggots, mites, cockroaches, moths, beetles, rats, mice and ants. Mite infestation may be determined by examination with a magnifying glass: mites may be distinguished from crystallized glucose because they are whitish, slow moving dots. At temperatures > 25°C and on exposure to mechanical pressure, there is a risk of candying, agglomeration, syrup formation and fermentation. Heat generally causes the risk of discoloration and hardening and the product should thus be stored away from heat sources. At temperatures < 10°C, mite growth is usually inhibited.

In view of the above, the final packing of produce is done in 400 gauge LDPE film bags and stored in corrugated boxes of 5 to 15 kg capacity at low temperature (4°C) to withstand the mechanical, climatic, biotic and chemical stresses to which raisins may be exposed during transport, storage and cargo handling and preserve the original raisin color and prevent the attack of pests.

Recent advances in technology for raisin production

The traditional method of producing raisins requires a substantial amount of seasonal labor. Over the years, several methods have been developed which would mechanize at least a portion of the raisin production process. In traditionally raisin producing countries, the raisin industry is moving forward with a transition from a conventionally labour-intensive operation to highly mechanized production system. A

major reason for this is ever-increasing labour cost and non-availability of labours to perform different steps of grape drying from fresh produce to the final product. A direct implication of such a transition is reflected in adoption of drying-on-vine as the technology of choice, which involves severing the fruiting canes when sufficiently mature, then allowing them to hang on the vines until they dry into raisins and finally harvesting with mechanical harvester. A major researchable issue is to develop suitable trellis system that can consistently produce at least 4 to 5 tons of high quality raisins per acre and can be harvested with a grape harvester. The desired trellis system should separate the vine canopy into distinct fruiting and renewal zones, which facilitates harvest cane severing and promotes a good environment for the growth of renewal canes. The fruiting zone, which later becomes the drying zone, is oriented in a fashion towards sun to enhance the drying rate, thereby making it possible to dry Thompson Seedless grapes on the vine without oils or other aids in most seasons.

Drying on vines has at least three potential economic advantages when compared to traditional production systems. First, mechanical pruning and harvesting will substantially reduce the costs and uncertainties associated with hand pruning and harvesting. Harvesting of as high as 160 acres land area can be harvested with only 6 to 8 employees in contrast to the requirement of at least 20 to 40 workers in case of conventional practices. A second potential advantage is that the grapes dry on the vine rather than on the ground. This makes the raisins much less susceptible to rain damage, which is always a concern for raisin growers. Grapes drying on the vine can apparently withstand substantial rainfall without damage. Further, the quality of the raisins produced by this technique is usually high, as the produce never touches the ground. This reduces problems of contamination with physical components like dirt, sand and mold. However, one potential drawback of this system is that it normally takes 6 to 7 weeks after the canes are severed for the grapes to dry completely. This means that the drying grapes are exposed to inclement weather for a longer period of time, although they are likely to withstand rain better than grapes drying on the ground.

Prospects of raisin industry in India and quality compliance

In India, raisin is mostly produced in Sangli, Solapur and Nasik districts of Maharashtra and Bijapur district in Karnataka. The technique of raisin production in India is mostly based on the dipping of the berries in Australian dip emulsion, which contains 2.5% potassium carbonate and 1.5% ethyl oleate and subsequent drying in shade in open tier system. The place, Junoni, in Sangola taluk of Solapur district in Maharashtra has been selected for the establishment and promotion of grape drying units on large scale based on its appropriate geological and weather data and proved the place most suitable in terms of latitude, longitude, rainfall, temperature, humidity, air velocity, etc. for drying the grape in natural way. 'Junoni' - a barren land is presently leading the raisin activities in the country and has now turned into industrial urban town.

The conventional technique of cleaning of Indian raisins after drying the grapes is not efficient to comply with the Codex standard and therefore, improvement has to be made in respect of cleaning of raisins preferably by adopting mechanical means. In fact, some mechanization has to be introduced in each unit operation during the journey from harvesting of fresh grapes to raisin making to avoid any non-compliance to the Codex standards. Moisture levels in Indian raisins are generally low and thereby their texture and mouth feel is hard and therefore, this needs to be increased to 15 - 16.5% to have a better mouth feel and soft texture. To have Indian raisin as a product of international quality

standard, the cleaning has to be done by mechanical means and the drying has to be completed at moisture level of 15 - 16.5%.

The packaging and labeling has also to be improved so that our product complies with the international quality standards in this regard. Different packing materials of food grade quality should be tested for their suitability with regards to easy availability, convenience, environmental profile and overall economics. There is urgent need to develop technology for storage of the raisins under ambient condition to save the huge expenditure incurred towards electricity in cold storage. Further this storage technology should protect the raisins from browning or discoloration while on storage.

Thus there is a big potential of raisin industry in India in terms of the marketing of this product in domestic and international market for import substitution and better utilization. Besides, there is possibility of diversification of raisin industry by promoting the production of flavoured and coloured raisins and promoting raisins as neutraceuticals in public health care.

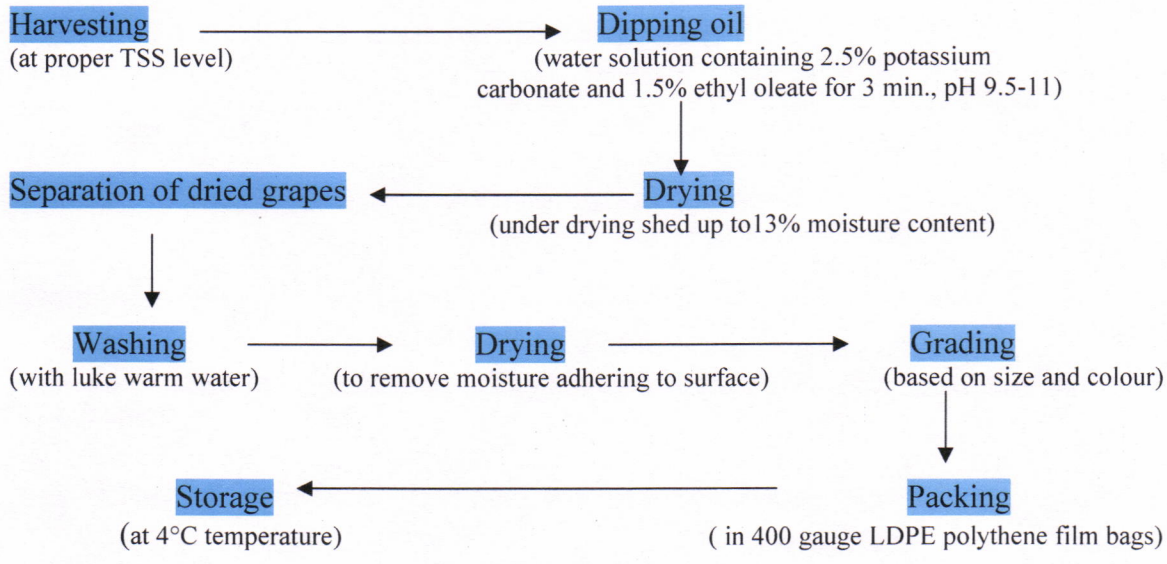

Fig.1: Flow chart of raisin making

Status and Prospects of Raisin Industry in India

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1. Introduction

Grape is an important commercial fruit crop of India, which contributes to the maximum share of the export of fresh fruits and vegetables from India to Europe and other parts of the world. The world production of grapes is presently 65,486,235 MTs, out of which India accounts for 1.2 million Mt of grapes making a share of 1.83 percent of the world production and 3 percent of the total fruit production in the country. Area under this fruit has been increased by 50% and its production by 71% in the country in the last decade (1994-2004) due to the economic importance of this fruit. Its economic significance is due to good back up of grape industry in terms of backward and forward linkage that offers employment to large number of skilled and unskilled people on the farm, trade and service. India has achieved the highest productivity of 20 t/ha in the production of table grapes. Presently in India about 78 percent of grape is used for table purpose, nearly 17-20 percent is dried for raisin production, while 1.5 percent is used for juice and only 0.5 percent is used in manufacturing wine. Though this fruit is processed to the largest extent relative to other fruits in the country, the processing of this fruit in our country is very less as compared to the traditional grape growing countries in the world where more than 80 percent of the produce is processed in the form of wine, raisin and juice. Except raisins, the various other processed products that could be prepared from grape or may have grape as a component are wine, juice, squash, syrup, jam, jelly, vinegar, pickles, chocolates, tartaric acid, oil, cattle feed, tannin, etc. However, the processed products viz. wine, raisins and grape juice are the most popular products from the grape all over the world.

As the quality standards stipulated by the regulatory bodies are becoming more and more stringent, the fresh grape industry in the country is facing problems in marketing of the produce in both domestic and international market. In India, major grape growing states belong to the peninsular region, where the cultivation of this crop faces frequent infestation of a variety of pests and diseases. To mange such pest attacks, use of a large number of pesticides is almost obligatory. This produces apprehension of pesticide residues in table grapes and to prevent any consumer health risk, the worldwide safety standards in terms of MRL regulations, etc. are becoming extremely stringent. In such situation the maximum benefits from grape cultivation can only be derived by establishing the processing industries for production of value added products like good quality raisin, wine and juice which has market potential for domestic as well as international market.

2. Raisin a brief account

The word 'raisin' originates from the Latin word 'racemes', which means 'a cluster of grapes or berries'. Historically the production of raisin from grapes by sun-drying can be traced back to 1490 B.C. in Greece. By the 14th century, raisins became an important part of European cuisine, which could be enjoyed as such as well as a component of different recipes. The physicians consider raisin as an instant source of energy with nutrition in concentrated form. Besides the usual contents of sugar, essential amino acids and fatty acids, raisins have high contents of phytochemicals like oleanolic acid, oleanolic aldehyde, betulin, betulinic acid, 5-(hydroxymethyl)-2-furfural, etc., all well-known antioxidants. The dentists consider raisins as cavity-fighter as oleanolic acid present in raisins produced from Thompson Seedless grapes inhibit the growth of at least two species of oral bacteria viz. *Streptococcus mutans*, which causes cavities, and *Porphyromonas gingivalis*, which causes periodontal disease.

Raisin is prepared from the sound dried

Table 1. Suitability of grape varieties for raisin making by Australian soda oil dip method

Sl. No.	Name of cultivar / variety / clone	TSS of fresh grapes (°Brix)	Raisin recovery (%)	Average weight of raisin (g)	Organoleptic score out of total 30 points
A	**White seedless**				
1.	Perlette	18.00	16.92	0.382	18.5
2.	A 39-3	16.86	20.15	0.350	16.5
3.	A 17-3	21.90	23.10	0.903	26.5#
4.	Centennial Seedless	22.20	27.50	0.863	22.5#
5.	E 12/7	20.00	25.00	0.395	23.5#
6.	A 39-2 (Mint Seedless)	19.46	26.82	0.870	25.0#
7.	Arkavati	18.56	23.86	0.335	19.0
8.	Arka Shweta	18.33	21.42	0.507	16.0
9.	Superior Seedless	20.00	26.50	0.979	22.0#
10.	Pusa Urvashi	19.00	22.30	0.407	16.5
11.	KRWhite	23.40	27.80	0.330	22.5#
12.	Early Perlette	22.50	24.50	0.472	18.0
13.	Loose Perlette	21.00	23.50	0.486	18.5
14.	E 12/3	22.50	28.50	0.417	22.5#
15.	Merbein Seedless	22.00	27.00	0.390	17.5
B	**Thompson Seedless & Its Clones**				
16.	Thompson Seedless	24.33	24.85	0.413	19.5
17.	Sultanine - II	20.74	30.30	0.378	19.0
18.	Sultana Seedless	24.46	28.53	0.411	19.5
19.	Tas-A-Ganesh	23.86	27.60	0.386	16.3
20.	Manik Chaman	21.94	26.53	0.447	23.5#
21.	Thompson Seedless (Italy)	21.33	24.18	0.419	20.0
22.	H-5 Clone	23.20	28.60	0.399	16.5
23.	Pusa Seedless	22.50	26.00	0.435	19.5
C	**Coloured seedless**				
24.	Flame Seedless*	22.26	24.28	0.527	16.0
25.	Kishmish Rozavis*	25.90	28.51	0.385	16.5
26.	Crimson Seedless*	21.50	24.50	0.701	16.5
27.	A 18-3*	21.80	24.50	0.699	23.5#
28.	E 32/8*	22.50	26.70	0.445	19.0
29.	Marroo Seedless	20.50	23.50	0.388	15.5
30.	Sharad Seedless*	22.40	27.50	0.339	19.0
31.	Black Monukka	23.00	26.70	0.418	21.5#
	Mean	21.55	25.55	0.493	19.6
	CD at 5%	2.60	3.78	0.069	3.1

* **Black / coloured raisins,** # : Quality accepted for commercialization

The studies also indicated that we could further diversify the raisins based on colour and flavour characteristics; while manukkas (seeded dry grapes) from cvs. Cardinal and Spin Sahebi were also acceptable.

grapes of the varieties conforming to the characteristics of *Vitis vinifera* L. processed in an appropriate manner into a form of marketable raisin with or without coating with suitable optional ingredients. Thompson Seedless is the most widely used grape variety to make raisins.

3. Raisin - global scenario

Economic analysis indicates a continuous increase in production and development of raisin trade in international market. USA is the largest raisin producer in the world. USA and Turkey together produce almost 80% of the total raisins of the world. USA, Turkey and South Africa are the largest raisin producers at the global level besides Greece, Australia, Iran, Afghanistan, China, Russia and others. India has achieved the production level in the range of 55,000 to 65,000 tonnes of raisins, which is next to Turkey at world level although there is no price stability for raisin production in last two years due to saturation of production. Efforts on improvement in quality of the Indian raisins have been initiated to promote the export of this product in world market. As the overall investment in raisin grape production is considerably less as compared to table grape production for export, hence the raisin exporters are expected to accrue better price realization out of this product in terms of superior benefit : cost ratio.

Total export of raisins in the world is 672,418 Mt valued at 663.924 Million dollar. Worldwide, the major exporting countries are Turkey, Chile, Greece, USA, South Africa, Belgium and Argentina. Turkey is the largest exporter of raisins exporting about 196,008 Mt valued at 183.942 Million dollar. Other major exporters of raisins are Iran, USA, Chile, South Africa, Greece, Netherlands, Belgium, Argentina and Uzbekistan. India's export of raisins is 314 Mt valued at 0.473 Million dollar.

UK is the largest importer of raisins importing about 105,005 Mt valued at 126.186 Million dollar. Other major importers of raisins are Germany, Russian Federation, Netherlands, Canada, Japan, UAE, France, Italy, Australia, Ukraine, Belgium, Brazil, Poland, China and USA. Import of raisins in India 9876 Mt valued at 12.192 Million dollar.

4. Characters of good raisin

The raisins of good quality should have following characteristic features:

- Good and uniform appearance of produce in terms of its color (perfectly green or grey-green), size (round) and smooth texture
- A higher pulp content and a pleasing taste without any sugar coat outside
- Intact skin and its outer layers, free from injuries, dust and foreign matter.

By and large, raisin imported from Afghanistan in the country meets these parameters and therefore, there is always demand for such produce even at higher price.

5. Grape varieties for raisin making

Major production of raisin (90 per cent) in the world is from Thompson seedless. Besides the other varieties viz. Muscat of Alexandria, Waltham Cross and other white and colored seeded varieties are also used for raisin production. In India, Thompson Seedless and its mutants viz. Sonaka, Tas-A-Ganesh. Manik Chaman are mainly used for raisin production although Arkavati variety developed at IIHR, Bangalore found to be the best due to its desirable attributes for raisin making. NRC for Grapes, Pune have also come out with other varieties viz. A 17-3, E 12/3, Mint Seedless, Superior Seedless, KR White, Manik Chaman, A18-3 (Coloured seedless) and Cardinal (for manukka) for the production of raisin but industry are yet to accept on commercial footing. Data on these varieties after due evaluation at NRC for Grapes, Pune is presented in Table 1.

6. Technology for Quality raisin production an Indian perspective

Grape berry has juice / pulp containing sugar, acids, flavonoids, vitamin and minerals and outer protective skin has different layers. Drying process has to be selective to remove the water from berry without affecting outer skin structure and arrangement of wax plates. The quality of waxy layers in terms of wax plates is about 0.1 mg/cm^2. This layer only protects the berries from getting dried in fresh form. During storage of berries at ambient and low temperature, the water moves out from the stalk and rachis and not from the skin coated with white waxy layer and this result in drying of pedicels in first instant and then berry drop.

Waxy layer on the green berry skin is the main target of various pretreatment of grape berries for quickening the drying process. Many treatments have been worked out in different countries after various research trials and an appropriate and economic treatment have been listed below for drying of grapes in India.

A water solution containing 2.5 kg of potassium carbonate and 1.5 L of ethyl oleate in every 100 L for dipping berries has been suggested. A dipping time of 3 minutes duration has been recommended to increase water removal @ of 1.4 mg/cm^2 in comparison to 0.4 mg/cm^2 in control. However, the cumulative quantity of waxes has been reduced only by 13 per cent in treated berries and therefore the drying effects is due to loosening of waxy plates on the outer skin and not removing the wax on the skin. This has been further proved based on the microscopic studies on skin structure with such treatments and without treatment in Australia.

When drying occurs fast, the sugar concentration increases in berry in short possible time and therefore the enzymatic reactions of peroxidase and polyphenolase also gets reduced and thereby leading less browning of the product. This process also helps in suppressing the microbial and fungal growth during drying process. A temperature of 25°C and above in dipping emulsion has been recommended for good results. A berry

Grapes for Raisin Making

Shades for Drying Grapes

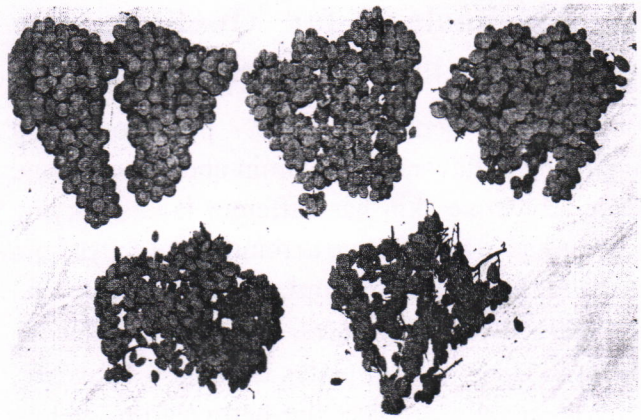
Raisin Grapes on the Racks

picks up approximately 35 μ mol solution and looses 70 percent during draining and utilizes only about 10-12 μ mol. A pH of such solution has been suggested always in the range of 9.5 to 11.00. A pH more than 11.00 breaks the skin and less than 9.5 favours microbial growth and fermentation. This treatment is more effective when berries attain the maturity of 20° brix and above and in other cases there is less pick up of dipping solution and therefore no effect.

In case of higher levels of dipping oil (pickup by skin 7200 ppm); there will be sucking of moisture in berries from outside this results in unpleasant taste in the product.

Water removal from berries takes place in three stages in treated berries. In first stage, the moisture removal is highest reducing initial weight to 40 to 50 per cent. When there is drying of 50 per cent, surface free area of berry is reduced by 28 per cent and as a result the water removal process is slowed down subsequently.

In second and third stage, the water is removed from pulp to skin and then removed by evaporation. This process continues till berry is dried to the extent of 13 per cent moisture. Drying sheds based on covered iron rack system are fabricated where the number of shelves is kept from six to eleven with interspaces varying from 22.9 cm to 45 cm. The rows of racks are generally spaced apart from a distance of 60 to 150 cm. The length of the rack could be from 600 to 1800 cm having South-North orientation and flow of dry air from West to East. This is a modified drying system of Australia, The shelves of iron rack are netted with nylon mesh and density of fresh grapes on this mat for drying is maintained from 1.7 to 2.2 g/cm^2 depending upon the height of shelf from 22.9 cm to 45 cm. This Australian method of dipping and rack system for drying has reduced the drying period to 10-12 days when compared to 20-22 days in conventional method. On the contrary, in USA, the grapes are dried without any treatment by spreading on graft paper placed between grapevine rows in vineyard. While in South Africa this is done on concrete slab. In both the cases the drying is in open sunshine and not in shed as followed in Australia. In Afghanistan, the drying is done in closed rooms by hanging the grape bunches on the ropes and it takes



Raisin Bunches at different stage of drying

Cleaning and size grading of raisin

Manual color grading of raisins

about 40 to 45 days for drying. There, the grapes are grown without following training and pruning and yield is only 1.5 to 2 tons/acre with T.S.S ranging from 28 to 32°B.

Separation of dried grapes from its stalks and rachis in bunches is done now using machines designed and fabricated for this purpose locally. However this was being done manually in the past, while the operation of sorting and grading of dried berries continued with the manual force for want of appropriate machine for this purpose.

7. Cultural practices used for good raisin production

Excellent canopy and health of the leaves contributes a lot for the good and quality production of grape and so also its resultant dried product. After October pruning, about 3200 degree dry heat units have been recommended for the achieving of 10 to 12 tonnes of grape per acre with 23° brix in grape, For 1kg berry production, an area more than 10 cm^2 has been recommended. An area of 13 to 19 cm^2 is followed in USA and South Africa, respectively. Treatments of GA application and girdling are hardly followed for grape production meant for raisin in these countries. Adequate canopy to cover and protect bunches from sunlight is another factor to sustain green color in grapes for raisin production. Higher doses of nitrogen reduce the pulp, firmness in berries and therefore monitoring of nitrogen in annual cycle once in soil and twice in grape leaf petiole is must for quality raisin production. Further, application of phosphoric acid, calcium chloride and magnesium sulphate in the form of spray on set berries is an important operation in view of obtaining good color and texture in the berry skin.

Appropriate quantity of water and its stage of application once fruits are set on the vine is also an important operation. In view of this, water level of 10-35° cm bar up to veraison and 10 to 45-50° cm bar quantity after veraison is desirable for quality raisin production. If the water is given in more quantity before harvest, the raisins become sticky during storage.

Table 2.Quality analysis for physical parameters in Indian raisins

Physical parameter	Codex standard	Limits found in samples tested	Indian sample size (%) complying to Codex standards	Sample from USA No.1	Sample from USA No.2
Piece of stem / kg	2	0 - 9	29.4	Nil	Nil
Cap stem / 500 g	50/500	0 - 84	44.70	7	Nil
Immature (%)	6	0.24 - 3.10	100	3.1	1.5
Damaged (%)	5	0.24 - 9.84	94.11	3.8	1.8
Sugared (%)	15	0 - 15.54	94.11	3.4	Nil
Moisture (%)	18	11.65 - 15.23	100	12.5	16.3

Table 3.Quality analysis for chemical parameters in Indian raisins

Chemical parameter	Codex standard	Limits found in samples tested	Indian sample size (%) complying to Codex standards	Standard sample from USA No.1	Standard sample from USA No.2
Arsenic	Nil	Nil	100	Nil	Nil
Lead	Nil	Nil	100	Nil	Nil
Mineral oil	5 g/kg	Nil	100	3.1	1.5
SO_2 (mg/kg)	1500	51.2 - 128	100	Nil	Nil
Sorbital	5 kg/mg	Nil	100	Nil	Nil
Pesticide residues	Nil	Nil	100	Nil	Nil
Colour contamination	Nil	Nil	100	Nil	Nil

There was no microbial count in all the samples.

Finally a stage of harvesting berry for raisin production determines the raisin yield and quality. Average maturity of berry in the whole vineyard at harvesting time has to be more than 22°Brix for good color and good yield.

8. Packing and storage

Raisins are strongly hygroscopic. Contact to moisture may result in mold, rot and fermentation and if a fermentation process is initiated, it may eventually affect the entire lot. Under appropriate temperature and humidity conditions, there is a risk of infestation by maggots, mites, cockroaches, moths, beetles, rats, mice and ants. Mite infestation may be determined by examination with a magnifying glass: mites may be distinguished from crystallized glucose because they are whitish, slow moving dots. At temperatures > 25°C and on exposure to mechanical pressure, there is a risk of candying, agglomeration, syrup formation and fermentation. Heat generally causes the risk of discoloration and hardening and the product should thus be stored away from heat sources. At temperatures < 10°C, mite growth is usually inhibited.

In view of the above, the final packing of produce is done in 400 gauge LDPE film bags and stored in corrugated boxes of 5 to 15 kg capacity at low temperature (4°C) to withstand the mechanical, climatic, biotic and chemical stresses to which raisins may be exposed during transport, storage and cargo handling and preserve the original raisin color and prevent the attack of pests.

9. Recent advances in technology for raisin production

The traditional method of producing raisins requires a substantial amount of seasonal labor. Over the years, several methods have been developed which would mechanize at least a portion of the raisin production process. In traditionally raisin producing countries, the raisin industry is moving forward with a transition from a conventionally labour-intensive operation to highly mechanized production system. A major reason for this is ever-increasing labour cost and non-availability of labours to perform different steps of grape drying from fresh produce to the final product. A direct implication of such a transition is reflected in adoption of drying-on-vine as the technology of choice, which involves severing the fruiting canes when sufficiently mature, then allowing them to hang on the vines until they dry into raisins and finally harvesting with mechanical harvester. A major researchable issue is to develop suitable trellis system that can consistently produce at least 4 to 5 tons of high quality raisins per acre and can be harvested with a grape harvester. The desired trellis system should separate the vine canopy into distinct fruiting and renewal zones, which facilitates harvest cane severing and promotes a good environment for the growth of renewal canes. The fruiting zone, which later becomes the drying zone, is oriented in a fashion towards sun to enhance the drying rate, thereby making it possible to dry Thompson Seedless grapes on the vine without oils or other aids in most seasons.

Drying on vines has at least three potential economic advantages when compared to traditional production systems. First, mechanical pruning and harvesting will substantially reduce the costs and uncertainties associated with hand pruning and harvesting. Harvesting of as high as 160 acres land area can be harvested with only 6 to 8 employees in contrast to the requirement of at least 20 to 40 workers in case of conventional practices. A second potential advantage is that the grapes dry on the vine rather than on the ground. This makes the raisins much less susceptible to rain damage, which is always a concern for raisin growers. Grapes drying on the vine can apparently withstand substantial rainfall without damage. Further, the quality of the raisins produced by this technique is usually high as the produce never touches the ground. This reduces problems of contamination with physical components like dirt, sand and mold. However, one potential drawback of this system is that it normally takes 6 to 7 weeks after the canes are severed for the grapes to dry completely. This means that the drying grapes are exposed to inclement weather for a longer period of time, although they are likely to withstand rain better than grapes drying on the ground.

10. Prospects of raisin industry in India and quality compliance

In India, raisin is mostly produced in Sangli, Solapur and Nasik districts of Maharashtra and Bijapur district in Karnataka. Out of the total production of 1.2 million tons of table grapes, around 17-20% of the fresh produce is dried to raisins. In spite of such a huge production, India has not yet attempted to export raisins.

The major raisin varieties include Thompson Seedless and its clones like Manik Chaman. Besides, E 12/7, E 12/3, Mint Seedless and KR White are also proved to be promising varieties. The technique of raisin production in India is mostly based on the dipping of the berries in Australian dip emulsion, which contains 2.4% potassium carbonate and 1.5% ethyl oleate and subsequent drying in shade in open tier system. The place, Junoni, in Sangola taluk of Solapur district in Maharashtra has been selected for the establishment and promotion of grape drying units on large scale based on its appropriate geological and weather data and proved the place most suitable in terms of latitude, longitude, rainfall, temperature, humidity, air velocity, etc. for drying the grape in natural way. 'Junoni' - a barren land is presently leading the raisin activities in the country and has now turned into industrial urban town.

The explorative research conducted by the NRC Grapes establishes the fact that the Indian raisins comply to all the physico-chemical, microbiological and organoleptic parameters specified by the Codex Alimentarius Commission except for a few physical parameters like number of cap stems and stem pieces in unit quantity as described in Tables 2 and 3. The conventional technique of cleaning of Indian raisins after drying the grapes is not efficient to comply with the Codex standard and therefore, improvement has to be made in respect of cleaning of raisins preferably by adopting mechanical means. In fact, some mechanization has to be introduced in each unit operation during the journey from harvesting of fresh grapes to raisin making to avoid any non-compliance to the Codex standards. We need to develop and standardize a training system to promote desired vine growth, mechanized harvesting of the grape bunches and drying the grapes on the vines. The cultural practices in terms of fertigation, irrigation, thinning, stage of harvesting, etc. need to be standardized for producing quality raisins, which can meet the demands within the country as well as the international market. Further, moisture levels in Indian raisins are generally low and thereby their texture and mouth feel is hard and therefore, this needs to be increased to 15 - 16.5% to have a better mouth feel and soft texture. To have Indian raisin as a product of international quality standard, the cleaning has to be done by mechanical means and the drying has to be completed at moisture level of 15 - 16.5%.

The packaging and labeling has also to be improved so that our product complies with the international quality standards in this regard. Different packing materials of food grade quality should be tested for their suitability with regards to easy availability, convenience, environmental profile and overall economics. We need to develop technology for storage of the raisins under ambient condition to save the huge expenditure incurred towards electricity in cold storage. Further this storage technology should protect the raisins from browning or discoloration while on storage.

Thus there is a big potential of raisin industry in India in terms of the marketing of this product in domestic and international market for import substitution and better utilization. Besides, there is possibility of diversification of raisin industry by promoting the production of flavoured and coloured raisins and promoting raisins as neutraceuticals in public health care.

11. Conclusion

In India, the raisin industry has tremendous prospects of increasing national wealth and thereby achieving social and economic benefits. An improvement in the technology of cleaning may improve the acceptance of our raisins at international market. Besides, we also need to improve in the spheres of the technology to maintain proper moisture levels, packaging and labeling for export. Establishing the raisin industries with international standards can thus derive the potential benefits of grape cultivation. Such a product diversification and value addition will improve the profitability and sustainability of grape industry. This will further minimize the post harvest losses and help to obtain more income and provide additional employment through value addition