

Production of Quality and Safe Dried Grapes



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1. Introduction

Adaptability of grape cultivation has been extended from temperate regions to tropical sites in some countries including India. Majority of commercial grape cultivation in India is mainly under tropical belt comprising states of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. In fact, about 95 per cent of the total grape is produced in Maharashtra and Karnataka states. Other than these states, few pockets of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Madhya Pradesh and Mizoram are also growing grapes. As per an estimate 2,980 thousand tons of grapes were produced from an area of 138 thousand hectare area during 2017-18. While 71.0 per cent of produce is consumed as fresh, nearly 27.0 per cent is dried for raisin production, 1.5 per cent for winemaking and 0.5 per cent is used for juice. In India, raisins are mainly produced in Sangli, Solapur and Nashik districts of Maharashtra and Vijayapura and Bagalkot districts of Karnataka. Grape production is mainly confined in these areas (about 95% of total production) where higher temperature with low relative humidity prevails after grape harvesting. These conditions help in faster drying of grapes (10-14 days) with good colour development. The grape quality parameters including type of grapes (small berries with 14-16 mm diameter), TSS content > 22 °Brix (more sugar content results in more raisin recovery), skin thickness (faster drying of thin skinned berries with improved eating quality), yield per vine (12-15 kg may be optimum) etc. has importance in deciding raisin quality. Besides grape quality, prevailing high temperature (35 to 40°C) and low humidity (> 20%) conditions during grape drying has its own importance. Availability of these conditions helps in faster drying of grapes and achieving attractive colour of raisins.

Generally, three drying methods are employed to produce raisins; sun drying, shade drying and mechanical drying (grape drying inside dryers). Drying practices vary with geographical locality, consumer acceptability and variety of grapes. The areas where harvesting is followed by severe winter, consumers prefer naturally dried grapes and compromise on colour. Black coloured grape varieties are dried naturally and in some areas drying on vine is also preferred. The quality of the dried grapes implies that several desirable changes (physical, chemical, and biochemical) must have occurred during the drying process. The physical characteristics found out are probably the result of cultivars, cultural and processing differences. Contamination of raisins by different microorganisms can be due to improper handling during harvest of grapes, drying process, transportation, storages and exposure of the product during in the markets.

2. Grape growing for raisin making

In the grape growing regions, raisins are made from different grape varieties and varietal impact is well known. However, other than variety, different factors also play an important role in producing quality raisin. These factors are described below.



2.1. Variety

Variety has its own impact on raisin quality. Each variety produces berries having varietal specific taste, colour, shape and size. Generally, Thompson Seedless and its clonal selections such as Tas-A-Ganesh, Sonaka, Manik Chaman etc., Sharad Seedless and its clonal selections (Krishna Seedless, Sarita Seedless, Nanasaheb Purple, etc.) are being used for raisin preparation. However, the varieties having suitable characters for raisin making like small size berries, good aroma, more sugar accumulation, thin skin etc. are preferred but processors are also using grape varieties having bold berries for raisins making as consumers also prefer big sized raisins. Smaller berries lose water more rapidly than large berries because of the greater relative area of skin surface to flesh. Water loss is not affected by sugar content; however, 20 °Brix berries tends to lose water more rapidly than higher maturity berries. However, raisin recovery is related to higher TSS in berries. Usually, 25% raisin recovery is achieved when berries contained 22-23 °Brix TSS and raisins have 16% moisture content.

2.2. Canopy

Vine canopy plays an important role in deciding raisin quality. The sugar and sugar acidity ratio is directly affected by number of shoots on a vine and leaves per shoot. Balanced pruning is the standard cultural practice used to control grapevine crop level and regulate vine vigour. Thus, the leaves available for the development of a bunch weighing 200 to 250 g may decide the sugar development required for raisin. Balanced pruning related to capacity of buds to generate required number of bunches i.e. 2.0-2.5/sq ft area should be available to each vine. Increased bunch load beyond this may result into reduced sugars (< 20%) in berries which will lead to low raisin recovery. The vineyard with sufficient canopy (10-12 leaves above bunch) supports the bunch for required food material and protect from exposure to direct sun light. Such type of bunches (bunches under canopy) will maintain uniform green colour which reflects in green coloured raisins than bunches exposed to direct sunlight.

2.3. Rootstocks

Moisture stress and soil salinity are common abiotic stresses in the major grape growing regions of India. Rootstocks are playing vital role in overcoming the adverse effects and production of quality grapes for raisin making. Different rootstocks behave differently for fruitfulness during the season. In India, Dogridge rootstock is most commonly used under drought conditions. Under the conditions of excess moisture during fruit bud differentiation Dogridge rootstock imparts more vigour that leads to reduced fruitfulness upto 10-15%. Among the available rootstocks, 110 R is known to control the vigour and increased fruitfulness. Recent experiments indicated that in Thompson Seedless vines grafted on 110 R produced higher raisin recovery.

2.4. Growth regulators

Compactness of grape bunches, size of the berries, total soluble solids, sugar content and thickness of outer waxy cuticle play a significant role in drying and quality of raisin. Although these characteristics are variety specific, they can be manipulated to certain extent by application of growth regulators and manipulation of pre-harvest production practices. The growth regulators application schedule for grape growing to produce raisins is entirely different than production of grapes for fresh consumption. GA₃ treatment on different parameters is widely variety dependent. Berry length in Thompson Seedless and Manik Chaman was increased 11 and 15%, respectively by application of GA₃ at prebloom (10 ppm) at 50% flowering (15 ppm) at 80% flowering (15 ppm) and at fruit set (25 ppm). GA₃ application was resulted in bold size berries with more pulp content due to which an increase in yield/vine by 21% in Thompson Seedless and 38% in Manik Chaman was recorded. An increased pulp content also resulted in increased raisin recovery upto 30% in Thompson Seedless and 23% in Manik Chaman in comparison to without GA₃ application. GA₃ enlarges rachis which reduces compactness and leads to faster grape drying. During drying process air circulation is better in loose bunches compared to compact bunches that results in uniform drying and reduction in rotting of berries located in the inner side of the bunch. Interestingly, GA₃ treated grapes dried 1-2 days later than the untreated grapes. However, it is well known that application of GA₃ increases skin thickness and results in raisins with light browning still overall acceptability of raisins prepared from GA₃ treated grapes was more in case of Manik Chaman while in case of Thompson Seedless, raisins prepared from untreated grapes were preferred.

2.5. Water and nutrient applications

The water requirement of vine depends upon the location, soil type and weather conditions. The vineyards are generally drip irrigated. The water requirement differs based upon the crop growth stage and weather conditions. Even though the raisin grapes are smaller in size compared to table grapes, but nevertheless 10-12 tons per acre productivity of grapes leads to raisin recovery of 2.5-3.0 tons and thus, the irrigation water requirement does not differ between them. In general, the crop water requirement ranges between 350 to 450 mm from foundation pruning till harvest. During the stage covering the period from foundation pruning to shoot growth stage (normally mid-April to May), water requirement is higher. Vines should not be under stress while attaining sufficient canopy and canes of desired thickness (8-10 mm). In the bud differentiation stage, irrigation should be reduced to facilitate better bud differentiation. Reduction in irrigation water by 50% during shoot growth and fruit bud differentiation stage reduces the vine yield by 10%. Further reduction in the irrigation water throughout the cane maturity till the next pruning



reduces the grape yield by 26% in heavy soils. However, in light soils, 50% yield reduction has also been observed in vineyards. During the fruit pruning season, the vines should receive sufficient irrigation to promote strong shoot growth and adequate leaf area at shoot growth stage. Berry growth to veraison period is most critical stage as cell division and elongation occurs in the berry. Providing 50 % of the recommended irrigation level during this period reduces vine yield by 8-9% and further reduction in application of irrigation water till harvest reduces the yield by 15%. The vines should not be over-irrigated from veraison to harvest as this will lead to delay in harvest and possibly reduction in the sugar content leading to poor raisin recovery. The irrigation schedule for Thompson Seedless vines raised on Dogridge rootstock is given in Table 1.

The grapevines are drip irrigated and the same technique can be efficiently used for delivering nutrients based on crop growth stages, at split intervals and on demand. Fertigation allows the application of nutrients precisely and uniformly to the wetted volume where active roots are concentrated. This improves the fertilizer use efficiency as compared to conventional practice of direct application of fertilizer to the soil. The nutrient doses given for fertigation should be modified according to the petiole nutrient status of the vines, as over the year's nutrient build up in the soil increases. Grape petioles are sampled twice under double pruning and single cropping season for regular monitoring for nutrient status of vines; during the bud differentiation stage and full bloom stage. Optimum range for petiole nutrient content is given in Table 2. Nutrients present in the irrigation water and the contribution of organic manures should also be taken into consideration. Grape being mainly grown in tropical conditions in our country, the soils have poor organic carbon content. These conditions directly affect the soil physico-chemical and biological properties. Generally, it is recommended to apply 25 t FYM/ suitable other organic sources every pruning season to improve the soil physico-chemical and biological properties. In general, for mature vineyard the total nutrient requirement on per hectare basis are 266.6, 177.5 and 266.6 kg respectively of N, P_2O_5 and K_2O . The nutrient quantity given are guidelines only for distributing the NPK doses at different growth stages and may change based on the site and climatic conditions. The nutrient application schedule, based upon crop growth stage is given in Table 2.

Note

- One kg P=2.29 kg P_2O_5 and one kg K= 1.21 kg K_2O
- The schedules have been standardized in the Research Farm of National Research Centre for Grapes, Pune using saline irrigation water. Hence depending on water quality, the amount of water needed may change. Irrigation should be applied only after the soil has reached field capacity after rain.

Table 1: Irrigation schedule based upon pan evaporation and fertigation schedule for various growth stages of Thompson Seedless vines raised on Dogridge rootstock (see note below)

Growth Stage	Expected duration (DAP)	Water requirement (L/ha/day per mm of evaporation)	Month of operation	Expected Pan evaporation (mm)	Approximate water (L/ha/day)	Nutrient application (kg/ha)		
						N	P*	K**
Foundation Pruning								
Shoot growth	1-30	4200	Apr.-May	8-12	33,600-50,400	60	-	-
	31-40	4200	Apr.-May	8-12	33,600-50,400	20	71	-
FBD	41-60	1400	May-June	8-10	11,200-14,000	-	142	-
Cane maturity and FBD	61-120	1400	June-Aug.	0-6	0-8,400	-	-	80
121days - fruit pruning	121 -	1400	Aug.-Fruit pruning	0-6	0-8,400	-	-	-
Fruit Pruning								
Shoot growth	1-40	4200	Oct.-Nov.	6-8	25,200-33,600	80	-	-
Bloom to Shatter	41-55	1400	Nov.-Dec.	4-6	5,600-8,400	-	53	-
Berry growth and development	56-70	4200	Dec. - Jan.	3-6	12,600-25,200	-	53	-
	71-105	4200	Dec. - Jan.	3-6	12,600-25,200	80	-	80
Ripening to Harvest	106-harvest	4200	Jan. - Mar.	8-10	33,600-42,000	-	-	80
Rest period	Harvest to Back pruning	-	Mar.-Apr.	8-10	-#	26	36	26

DAP = Days after pruning, FBD = Fruit bud differentiation, * = P₂O₅, ** = K₂O

In heavy soils only, not subjected to moisture stress during harvesting.

#Applicable if rest period is for 15-20 days.



- The above nutrient values are the guidelines for distributing the NPK doses values may change based on the site and climatic conditions.
- Under normal climatic conditions generally, it takes 10-12 days for sprouting.
- The nutrient applications should take into account soil, petiole and water testing report.
- Contribution of nutrients from other sources like composts, FYM, green manuring etc. should also be taken into consideration for adjusting the nutrient dose. All the manures and fertilizers, irrigation water and other inputs should be tested for presence of heavy metals (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl) before use.

Micronutrients

- Amongst the micronutrients, zinc and iron are the most commonly deficient nutrients.
- Due to large variation in the type and content of calcium carbonate in soil, no specific recommendations are available. However, under established deficient conditions, on an average 50 kg per hectare each of zinc sulphate and ferrous sulphate and manganese sulphate should be applied per season.

Table 2: Optimum range of petiole nutrient contents for Thompson Seedless vines grafted on Dogridge rootstock

Nutrient	Bud differentiation stage	Full bloom stage
Macronutrients		
N (%)	1.20 – 1.53	1.44 – 1.80
P (%)	0.387 – 0.472	0.283 – 0.356
K (%)	0.590 – 0.680	1.61 – 2.95
Ca (%)	0.727 – 1.03	0.508 – 0.81
Micronutrients		
Fe (ppm)	54 – 80	32 – 80
Mn (ppm)	42 – 209	76 – 174
Zn (ppm)	30 - 88	51 – 130
Cu (ppm)	5 – 10	5 – 10

- Micronutrients are preferably applied as foliar application and based on petiole analysis. On an average, 3-4 sprays of 0.2 – 0.4 % of sulphate forms of Zn, Mn and Fe in a pruning season meet the crop needs. Do not spray fertilizers containing heavy metals.
- Boron is strictly applied on the basis of petiole analysis report. Apply boron if content is less than 30 ppm.

Even though the above mentioned petiole K content (0.59 – 0.68%) at bud differentiation stage is sufficient in soils high in available K content, nevertheless there are chances of leaf curling, which could affect management of disease and pests due to inadequate spray coverage. It is therefore, advisable to maintain petiole K levels at bud differentiation stage above 1.5%.

2.6. Insect-pests and diseases

The grapevine is affected with major pest and diseases during the period of berry development. During the initial stage of vine growth, the major pest like thrips becomes the problem. The insect sucks the sap from the growing berry at cap fall stage. The antenna pierced by the insect sucks the sap from the berries leaving the small scars on it. As the berries grow in size, the scar develops in larger size. During the period of veraison to harvest, the temperature in the atmosphere starts rising. This situation supports the incidence of mealy bug. In severe case, the pest covers the entire bunch thus spoiling the eating quality of fruit.

During period of berry setting to veraison stage of berry development, the incidence of powdery mildew is seen in the vineyard. The temperature ranging from 28 to 32°C and old canopy supports disease incidence. The symptom of powdery mildew is seen as covering of bunch with powdery coating. These bunches are unfit for consumption and the raisin prepared from such grapes are not be preferred by the consumers. Hence, management of insect pests and diseases helps producing good quality grapes. The various agrochemicals to control the different pests and diseases should be applied considering their MRL values and suggested PHI. Only label claimed agrochemicals should be applied to manage incidences of diseases and insects and pests. These practices will improve hidden parameters of raisins.

2.7. Harvesting of grapes

To produce raisins, sugar content in grape berries with juice acidity, should be between 21 and 27%. Berries attaining more than 22 °Brix TSS are considered ready to harvest. Berries in grape bunch show difference in TSS content. The upper and middle berries have higher TSS content than the berries at lower portion of bunch. For measuring the TSS in grapes, it is advised to collect the



berries from different locations of bunches. About 70-80 berries generally collected from different bunches are treated as one samples. Collected berries are crushed and juice extracted is used for TSS determination by using refractometer. Minimum five samples of berries are required to calculate TSS in grapes from an acre plot. In particular, the influence of fruit soluble solids on raisin quality makes the time of harvest an important consideration. Higher-maturity fruit produces higher yield as well as quality. Thus, raisin quality considerations are also influence by the time of harvest. The decision on harvesting of grapes is most important in the areas where unseasonal rains during grape drying season are experienced. Considering the weather forecast, the harvesting decision can be preponed or postponed. The harvesting of grapes for raisin making should be avoided during expected rain period. It is advised to harvest grapes when prevailing relative humidity reduced up to 50 per cent. In case of rains, harvesting may be delayed till reduced TSS in berries is recovered. The harvesting at higher TSS results in higher raisin recovery. This is a simpler way to obtain good raisins. Damaged berries by attack of pest and diseases should be discarded. Not more than two layers of bunches in a crate should be placed. Filled crates should be placed immediately in shade after harvesting and before transport. Generally, high-quality raisins which are plump, meaty, and fine wrinkled are the result of grapes harvested at high soluble solids content.

3. Grape Drying

3.1 Grape drying shed

In India drying of grapes in sheds is the common practice. These sheds consist of long, iron mesh platforms in 8-12 tiers on which the grape bunches are placed in single layer. Mesh platforms supported by iron poles and wires with a width of 4-5 feet. The distance between two tiers is maintained about 10 to 12 inches. Minimum distance of 2.5 to 3 feet is maintained between upper rack and roof of shed. This helps in ease of spreading of bunches, collections of raisins and other practices. In addition, the space allotted between two tiers helps for easy air flow requires for fast drying of grapes. The sheds have a zinc sheet roofs which protects the bunches from direct sunlight. There are no walls and the wind is allowed to flow freely over bunches. During the selection of site for erecting the drying sheds prevailing temperature, humidity, adjoin water bodies etc. should be considered. Generally areas having temperature of 40-45 °C, lower relative humidity (20-30%) and wind flowing during grape drying period i.e. Mid-February to Mid-April, are found suitable for grape drying. Therefore, the drying sheds should be erected away from water bodies and should generally have hot, dry wind flowing at high velocity. Low temperature slows drying process while at higher temperature, raisin colour gets affected. If RH is higher i.e. more than 50%, the colour of raisins becomes dark while berry rotting

starts when the more than 70% prevails for longer duration. Grapes should not be exposed to direct sunlight during the process of drying. To avoid the exposure of grapes to sunlight during drying process, placing of curtains on the sun facing side is the common feature of raisin sheds.

3.2 Dipping of bunches

Before dipping the bunches in dipping oil solution, the bunches should be inspected for damaged berries and such berries are removed from the bunches. To remove dust particles from berry skin, bunches are dipped for a period of 30-60 seconds in clean water. Water should be changed after every 4 – 5 dippings as lot of dust particles from skin of berries goes to water and make it muddy. Washed and clean bunches should be used for further process of pretreatment with solution of ethyl oleate and potassium carbonate. Dipping of grapes in solution (ethyl oleate and potassium carbonate) is main practice which induces faster water loss from grape berries. The different brands of dipping oils are available in the market. Generally a combination of ethyl oleate (1.5%) and potassium carbonate (2.5%) is used for the purpose. Dip the grape bunches in the solution for 2 to 6 minutes. The pretreated bunches are then spread in single layer in side grape drying shed.

For effective drying and maintaining the quality parameters in raisin, the pH of the solution should be between 11.0 - 11.5. During the process of grape bunch dipping, strength of solution gets diluted. Generally, 10 liter of dipping solution is found enough to dip 80 to 100 kg grape bunches.

3.3 Activities during grape drying

- Single layer of pretreated grape bunches is spread on the mesh. The position of bunches is changed (up and down) by hands every day to give better exposure of dried air/ temperature to all berries equally.
- To obtain good colour and avoid browning of raisins, application of ascorbic acid is recommended. A spray of 300 ppm ascorbic acid on third day of drying leads to better quality raisins.
- Generally, golden raisins are produced by sulfur fumigation process and shade drying so they become golden amber in color. In some seasons, under persistent wet and humid conditions generally after summer rains, mould begins to spread through the fruit on the racks. In this situation sulphur burning is practiced to produce sulphur dioxide. A quantity of 2-3 g sulphur burning is found sufficient for a shed having 4 t grapes in drying process. However, exact quantity of sulphur may vary and depends upon the size of shed, rack numbers and total grapes inside a shed. During sulphur burning, the racks are enclosed by curtains for 2 to 3 hours. The



sulphur application gives very good colour to raisins and controls the microbial growth. The MRL values for sulphur dioxide content in raisins are already fixed by EU and OIV as 2000 ppm for bleached raisins due to its allergic nature.

- When the moisture content of 14 to 16 % reaches are raisins, collected for further processing. By chewing the raisin, the exact time of raisin collection can be decided. But it is a skill, so quantification of moisture content in raisins can be done by drying the raisins in oven. Dry the raisin samples in oven at 50-60 °C and record the weight of samples every day. When the weight become constant, calculate the moisture percentage by dividing the loss of weight during drying in oven by initial sample weight and multiply this value by 100.

4. Processing of Dried Grapes

The processed raisins are prepared from clean, sound, dried grapes and are properly stemmed and cap stemmed except for cluster or uncap stemmed then the raisins are sorted and cleaned. For the raisin processing following activities should be performed to be able to store them for longer time without deterioration in quality and safe supply to consumer.

4.1 Cleaning, Grading and washing

During the process of cleaning, collected raisins are separated from stems. For this purpose locally available machines can be adopted to remove the big stems and these machines can also grade the raisins based on their size. After primary cleaning, cap stem removing is done by hand and the process of grading is done at this time only. Generally raisins are graded on the basis of size and colour. If any unwanted material is noticed in raisin lot, it is picked out. To remove dust particles from surface and unwanted oil residue, the raisins are passed through clean water. After washing raisins are dried by blowing of hot air to remove moisture from surface.

4.2 Storage of raisins

Raisins are hygroscopic in nature. Contact to moisture may result in mold, rot and fermentation and if a fermentation process is initiated, it may eventually affect the entire lot. 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. Higher temperature generally causes the risk of discoloration and hardening and the product should thus be stored away from heat sources. Temperatures < 10°C, mite growth is usually inhibited. Storage of raisins at ambient conditions also deteriorates the quality in terms of colour, mouth feel,

aroma etc. For quality and longer shelf life, storage at low temperature is always advised. Store the raisins at 10 °C and 50-60% RH. Raisins are packed in 400 gauge LDPE film bags and stored in corrugated boxes of 5 to 15 kg capacity to withstand the mechanical, climatic, biotic and chemical stresses to which raisins may be exposed during transport, storage and cargo handling and to preserve the original raisin color and to prevent the attack of pests.

4.3 Packing and labeling

The raisins should be packed as per demand of market. The material used for packing should be from food grade and as per norms specified by FSSAI. To improve quality of raisins during market chain, vacuum packing may be suitable option. The FSSAI has already declared the norms for labeling of food materials.

5. Drying of coloured grapes

Red or black coloured grapes are very rich source of phenolics, tannins and antioxidant activities. Health beneficial properties are available in seeds and skin of grapes. The benefits of these grapes are well known and uses in Ayurvedic medicines are well documented. Dried coloured grapes are also called as Monukka also. As very old coloured seeded grape variety Black Monukka may be only used for making dried grapes in older period so the dried grapes obtained from other coloured seeded grape varieties are also called as Monukka only. Due to medicinal importance of coloured dried grapes, demand is higher for making Ayurvedic medicines. The coloured seeded varieties have higher antioxidant properties than seedless coloured varieties. These grape varieties are already well adopted by grape growers. The activities defined for grape growing, raisin making and raisin processing are almost same. Some modifications are needed, as there is no issue of good colour development. Only modified activities are explained bellow in detail.

5.1 Treatment of bunches

The coloured bunches are treated as described in raisin making process. As green or yellow colour is not target here so need to give any application of ascorbic acid or sulphur fumigation is not required. However, in case of unseasonal rains during process of drying, sulphur fumigation can be given to control the microbial incidence only.

5.2 Grading

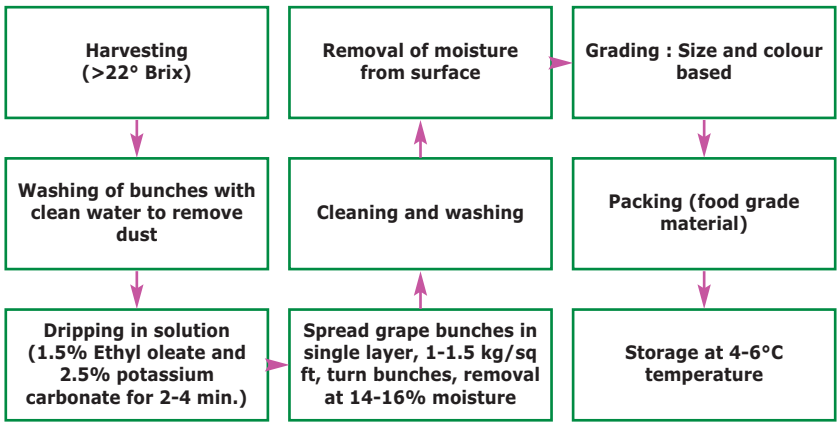
Raisins are graded on the basis of seeded or seedless and size. Other defects are permitted as per norms.



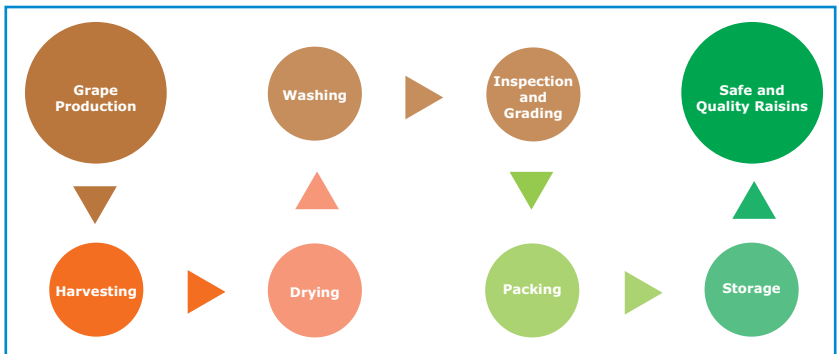
Manual Grading



LASER based grading



Grape drying process



Checkpoints for quality raisins



Bunches are ready for harvest



Inside view of drying shed



Raisin ready for collection



Variability in dried grapes



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