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New Approaches for Almonds (*Prunus amygdalus*. Batsch) Production in Mediterranean Climates: A Review

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Abstract

The Almond (*Prunus dulcis*, syn. *Prunus amygdalus* Batsch. *Amygdalus communis* L., *Amygdalus dulcis* Mill.) is a species of Prunus belonging to the subfamily Prunoideae of the family Rosaceae. The plant is classified with the peach in the subgenus Amygdalus within Prunus, distinguished from the other subgenera by the corrugated seed shell. It is native to southwest Asia, from northwestern Saudi Arabia, north through western Jordan, Israel, Lebanon, western Syria, to southern Turkey. Domesticated almonds appear in the Early Bronze Age (3000–2000 BC) of the Near East. A well-known archaeological example of almond is the fruits found in Tutankhamen's tomb in Egypt (c. 1325 BC), probably imported from the Levant. Almond is called Lawz in Arabic, and Baadaam in Persian, Urdu and Hind. The fruit of the almond is a drupe, consisting of an outer hull and a hard shell with the seed, which is not a true nut. Shelling almonds refers to removing the shell to reveal the seed. Almonds are sold shelled or unshelled. Blanched almonds are shelled almonds that have been treated with hot water to soften the seed coat, which is then removed to reveal the white embryo. Once almonds are cleaned and processed, they can be stored over time. Almonds are used in many food cuisines, often featuring prominently in desserts, such as marzipan. The almond tree prospers in a moderate Mediterranean climate with cool winter weather. California produces over half of the world's almond supply. due to high acreage and water demand for almond cultivation, and need for pesticides, California almond production may be unsustainable, especially during the persistent drought and heat from climate change in the 21st century. Droughts in California have caused some producers to leave the industry, leading to lower supply and increased prices.

Keywords: *Almonds; Cultivation; Variety; Irrigation; Drip systems; Processing*

Introduction

The almond (*Prunus amygdalus*, syn. *Prunus dulcis*) is a species of tree native to Iran and surrounding countries, [4] including the Levant. [5] The almond is also the name of the edible and widely cultivated seed of this tree. Within the genus Prunus, it is classified with the peach in the subgenus Amygdalus, distinguished from the other subgenera by corrugations on the shell (endocarp) surrounding the seed. [6] The fruit of the almond is a drupe, consisting of an outer hull and a hard shell with the seed, which is not a true nut. Shelling almonds refers to removing the shell to reveal the seed. Almonds are sold shelled or unshelled. Blanched almonds are shelled almonds that have been treated with hot water to soften the

seed coat, which is then removed to reveal the white embryo. Once almonds are cleaned and processed, they can be stored over time. Almonds are used in many food cuisines, often featuring prominently in desserts, such as marzipan. The almond tree prospers in a moderate Mediterranean climate with cool winter weather. California produces over half of the world's almond supply. Due to high acreage and water demand for almond cultivation, and need for pesticides, California almond production may be unsustainable, especially during the persistent drought and heat from climate change in the 21st century. [7] Droughts in California have caused some producers to leave the industry, leading to lower supply and increased prices. [7] Almonds are important but underutilized nuts with inherent medicinal and therapeutic potentials for promoting human health reported that Almonds (Prunus dulcis) and Black walnuts (Tetracarpidium conorphorum) help to lower cholesterol levels in the blood, the risk of diseases of heart, control of body weight and control of diabetes. These nuts (Walnut and Almond) are also believed to naturally comprise and polyunsaturated and monounsaturated fatty acids, dietary fiber, and protein, as well as various necessary nutrients including several trace elements and vitamins which contribute significantly to healthy living.

Almonds are prunes, which are small to medium-sized trees of fruit that have their place in the family of rose, which is Rosaceae. They were usually positioned in a Prunoideae (or Amygdaloideae), that is a sub-family, but sometimes, they are positioned in their individual Prunaceae (or Amygdalaceae) family [1]. In recent times, it has become seems that almonds evolved from the Spiraeoideae that is a sub-family [2, 3]. The group Prunus consists of several economically significant fruit trees classes such as apricot, cherry, plum, peach, and almond [4, 5]. In South central Asia, the peach and almonds almost developed from the identical inherited species [6, 7]. 26 classes of Prunus form a distinct taxonomic group on the earth. 21 almond classes and 6 natural hybrids present in Iran [8, 9].

Almonds were cultivated at least by 3000 BC [8, 10]. The almond was spread beside the seashore of southern Europe by Greeks, Egyptians, and Romans, and the Mediterranean in northern Africa [11]. Thus the almond and its associated kinds are native to the Mediterranean environment area of the Middle East indicating Pakistan eastward to Turkey and Syria [12, 13]. In the 1700s, Spanish Padres established the Task at Santa Barbara and carried almonds to California [14, 15]. In the late 1800s, the industry started in California due to the growth of great cultivars on almonds, and importers were forced to defend the industry. From then till about 1960, the industry technologically advanced at a moderate speed [14]. Furthermore, approximately 8% of the total world's almonds are cultivated in California.

Under farming, many fruits trees classes have converted from sexual reproduction into vegetative propagation [1]. Outdated systems of production have continued, where cultivar propagation is established on a diverse reproductive system [16]. For millennia, Prunus dulcis has been cultivated by seeds. Prunus dulcis grafting continued with little significance until recently [15]. Both clonal and sexual reproductions are used for Prunus dulcis propagation [16, 17, 18].

Botanical description

The Prunus dulcis is botanically categorized as a drupe with skin like pubescent exocarp, hell is like a fleshy mesocarp and shell is like a hard endocarp [19]. The embryo is enclosed by a pellicle in the seed, composed of a nucleus, endosperm remnants, and seed coat. Prunus dulcis is distinguished from other Prunus classes by its leathery and dry mesocarp, at maturity which is dehisced [20, 21, 22].

Plant

Small to the medium that is average-sized tree exist with open canopy with linear or ovate with notched margins leaves sized between 3 to 5 inches, about 3-4 times longer than wide having finely notch margins and sharp tips [21, 23].

Flowers

Almond tree flowers are sweet-scented with white or light pink and almost identical to peachtree flowers. Almond flowers have a perigynous ovary and many elongate stamens with 5 petals and sepals [22, 23]. Flowers are borne laterally on short lateral branches and spurs, or occasionally on elongated shoots in lateral position [24, 25].

Pollination

Almonds involve cross-pollination because they are self-incompatible [26]. Prunus dulcis is a crop that is a large consumer of fertilizer and water, and it is extremely pollinator-dependent, its production may be dependent on variations in these resources [27]. All pollinators like honey bees are entirely crucial for pollination, particularly since wet and cool weather can arise at the comparatively early blooming period [28, 29]. Moreover in California, almost 8% of the

total world's almond fruits are cultivated, where the temperature change is predicted to decrease water accessibility [30].

Fruit

Almond is a nut fruit. The whole nut fruit includes the hull is a drupe, though the hull dries and splits to reveal the pit of the fruit. Its fruiting starts in 3 to 4 years old trees, and 6-10 years old tree leads with maximal production [26, 31]. On average, an almond tree can produce for more than 50 years. For best fruit cropping high ratio of flowers should be maintained. Almond fruit trees produce flowers in February. Fruits development is considered by an increased cotyledon size and diminishing endosperm and nucleus [23, 32]. The growth of the different fruit tissues in the 4 genotypes presented sequential deviations as has formerly reported in other Prunus dulcis cultivars [33]. Therefore, ripening and growth of the different fruit tissues continued in a somewhat shifted mode from one genotype to another. Till April, the tenderly derived fruit tissues as endocarp, mesocarp, exocarp, and tegument are surrounded and protected by cotyledon. The endocarp is soft and green in color that is easy to open [34]. The endosperm and growing embryo with its typical white cotyledons are noticeable in all genotypes and nucleus size has decreased in May [32]. The endocarp has become appear a woody texture and hard to open and is turnoff into brown color. To end, the maturing season ends and the white cotyledons fill the full space inside the tegument. Mesocarp with the exocarp is starting to dry ultimately exposing the endocarp [34].

Description

The almond is a deciduous tree, growing 4–10 m (13–33 ft) in height, with a trunk of up to 30 cm (12 in) in diameter. The young twigs are green at first, becoming purplish where exposed to sunlight, then grey in their second year. The leaves are 8–13 cm (3–5 in) long, with a serrated margin and a 2.5 cm (1 in) petiole. The flowers are white to pale pink, 3–5 cm (1–2 in) diameter with five petals, produced singly or in pairs and appearing before the leaves in early spring. The almond fruit is 3.5–6 cm (1+3/8–2+3/8 in) long. In botanical terms, it is not a nut but a drupe. The outer covering or exocarp, fleshy in other members of Prunus such as the plum and cherry, is instead a thick, leathery, grey-green coat (with a downy exterior), called the hull. Inside the hull is a reticulated, hard, woody shell (like the outside of a peach pit) called the endocarp. Inside the shell is the edible seed, commonly called a nut. Generally, one seed is present, but occasionally two occur. After the fruit matures, the hull splits and separates from the shell, and an abscission layer forms between the stem and the fruit so that the fruit can fall from the tree.

Difference between Sweet Almonds & Bitter Almonds

- Let us tell you what makes sweet almonds and bitter almonds different from each other.
- The major difference lies in the cyanide content. Bitter almond has 40 times hydrocyanic acid as compared to sweet almonds which are really high.
- Talking about the appearance, both the almond variants look quite similar and it can get difficult to distinguish between them. But bitter almonds are smaller in size. And the taste, you know! While sweet almonds have a great shelf life, bitter almonds can't be stored for long as these have multiple unsaturated fats.
- These need to be kept in airtight containers, away from moisture or heat or direct sunlight. You can eat a raw sweet almond but you aren't supposed to eat a raw bitter almond.
- Bitter almond should be eaten in cooked form only. Eating them in the raw form is nothing but dangerous for your health.

Bitter Almond Uses

In ancient times, bitter almonds were used to treat numerous health issues such as inflammation, pain, spasms, breathing problems, etc. These days, due to high toxicity, they aren't safe to consume raw. Bitter almonds make for the best almond oil due to their strong flavor and aroma as compared to sweet counterparts. Its oil is extensively used in cooking. The bitter variety is useful in making cosmetic products as it contains a high concentration of active botanicals. The almond extract in creams, soaps, etc. is taken from bitter almonds. Bitter almonds contain a slight amount of prussic or hydrocyanic acid in its raw form. Hydrocyanic acid is the solution of hydrogen cyanide and water. Eating raw bitter almonds can strongly affect your nervous system causing breathing issues. One should consume bitter almonds carefully following the apt dosage. Eating more than 10 bitter almonds in a day can lead to death! Therefore, it is better to consult a doctor or nutritionist before consuming bitter almonds.

Area and Production

Worldwide 3,214,522 tones of almond is produced per year. United States of America is the largest almond producer in the world with 2,002,742 tones production volume per year. Spain comes second with 202,339 tones yearly production. Indian almond consumption in MY 2017/18 has been forecasted at 97,000 MT, a 10 per cent increase over the previous year. Also, the early festive season

is expected to lead to higher almond stocks in the Year 2017-18, which are forecasted at 39,400 MT. The 2022 California Almond Objective Measurement Report published Friday by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) estimates that the crop harvested in 2022 will come in at 2.6 billion meat pounds, 11 percent below last year's 2.9 billion pounds. The forecast for the average nut set per tree is 4,082, 12 percent down from 2021. The Nonpareil average nut set of 3,966 is also 12 percent lower than last year. The average kernel weight for all varieties sampled was 1.47 grams, up less than 1 percent from the 2021 average weight. The Nonpareil average kernel weight was 1.55 grams, up slightly from last year.

Figure 1: *Bitter almonds contain prussic/hydrocyanic acid for bitterness.*

Climatic conditions

Almond grows best in Mediterranean climates with warm, dry summers and mild, wet winters. The optimal temperature for their growth is between 15 and 30°C (59 and 86°F) and the tree buds have a chilling requirement of 200 to 700 hours below 7.2°C (45.0°F) to break dormancy. Almond plant can be grown at 400-1000 m altitude successfully. Almonds begin bearing an economic crop in the third year after planting. Trees reach full bearing five to six years after planting. The fruit matures in the autumn, 7–8 months after flowering. Particularly the areas having temperature range of 0-42°C are favorable for its production. Heavy rainfall during flowering season can cause less fruit bearing. While the areas having 1-20 inches annual rainfall can cause different diseases during rainy seasons (moon soon). That's why it is recommended that it should be cultivated in cold and dry areas with less rainfall and having artificial irrigation facilities.

Soil

Sandy loam soil having good drainage is best for its cultivation. Selection of soil for its cultivation should be on scientific basis and also on agriculture expert suggestion. Because heavy loamy soil, clayey soil, sandy soil and salt affected soils are suitable for its cultivation. For Postwar region recommended varieties by Agriculture Research Institutes are Jardonola, Nonpareil, Ne Plus Ultra and Vesta.

Propagation

Propagation through seed doesn't gives true to type offspring. So its propagation is done through non sexual propagation method. The suitable method for non-sexual propagation is through budding or grafting. Almonds are usually grown by grafting. Because almonds are most closely related to peaches, they are usually budded to them but can also be budded to plum or apricot root-stock as well. That said, since these fruiting trees can also be propagated via hardwood cuttings, it is natural to assume that rooting almond cuttings is possible. Cut a 10- to 12-inch (25-30 cm.) cutting from the almond. Be sure the cutting has 2-3 nice looking buds. Remove any leaves from the cutting. Dip the cut ends of the almond cuttings into rooting hormone. Plant the cutting in a soil-less media which will allow it to be loose, well-draining and well aerated. Place the cutting with the cut end in the pre-moistened media down an inch.

Irrigation

It requires 300-400 mm rainfall annually. Due to long and deep root system it requires less water as compare to other deciduous fruit plants. In normal condition it is necessary to irrigate it once in fifteen days. But during summer irrigation after each week insures good quality fruit and good production. It is recommended that by leaving each feet distance around the stem whole area under canopy should be irrigated. It should be tried that water should not directly touches the stem because it causes different diseases in stem. These diseases can cause the loss production or it may lead to plant death.

Figure 2: *Almond Plantations.*

Figure 3: *Fruits of Almond.*

Suitable Varieties

The following verities are best for its cultivation.

- Dry Temperature Region Varieties- Ni Plus Ultra, Texas and Thin shald
- High and Middle Mountainous Region Varieties- Nikitskai, Non Peril, ISL, Merced, and White Brandis
- Others: Vesta, Jardonola, Nonpareil, Ne Plus Ultra, Mission

These varieties having soft seed coat and these are originated from California America. Almonds are highly nutritious and contain healthy fats, fiber, protein, magnesium and vitamin E. It is not a nut, but a seed of a fruit from the tree- Prunus Dulcis, also called Almond tree. Almonds contain lots of. The health benefits of almonds include lower blood sugar levels, reduced blood pressure, Lowers inflammation and lower cholesterol levels. They're high on protein so they keep you full for longer and they're rich in manganese which helps strengthen bones and and also help muscle and nerve function.

Different types of Almonds available in India commonly

There are three prominent types of almonds available in India- Mamra, Gurbandi and California.

Mamra– accounting for just 4% in the world, it has Carbohydrate content, more oil & therefore contains more calories than the other two. It has lesser protein content as compared to California almond. Mamra are cultivated organically without using chemicals, hence it is the first choice for people. It shows great results in growing kids.

California– These almonds are sweeter in taste because of chemical processing. It's ideal for cooking and garnishing. They are the mostly consumed almonds, having almost 85% stake in Almond market. They are larger in size and are available in neatly packed conditions.

Gurbandi (Choti giri) – These almonds are also rich in nutrients like omega 3, vitamin E and phytochemicals, gives abundant energy and are rich in antioxidant.

The Best Almond Varieties in India

California Paper Shell

Figure 4: *California paper shell.*

This mid to late season variety features a papery shell of a light brown hue. Kernels are excellent flavored but are susceptible to bird damage.

Shalimar

This mid-season variety features large-sized nuts with pointed ends. It has a light brown shell and carries a distinctive crunchy flavor.

Nonpareil

The elongated nuts comprise a pale brown colored thin shell. This early maturing variety produces thick nuts with medium-sized kernels.

Merced

Figure 5: *Figure 5: Merced.*

This mid to late-season variety produces flat and light brown nuts. The light-colored kernel is encased within a papery shell.

Pranyaj

Its medium-sized almonds are in flat to bulging shape. Its shells are thin and have a darker tone comparatively.

Mukhdoom

The plumpy kernels are covered with a light-colored and semi-soft shell. The variety is mid to late season bearing.

IXL

Figure 6: *IXL.*

The brownish nuts of IXL consist of a softshell of an intermediate color. The kernels are plumpy and medium in size.

Drake

These small to medium-sized nuts appear in light cream to light brown shades. The roundish nuts are narrow at one end.

Ne Plus Ultra

Also known as 'Neplus', it features a flat and long kernel encased within an elongated shell. The almonds have slight wrinkles but are well-sealed.

Waris

Figure 7: *Waris.*

The almond registered the highest breadth size of 20.42 mm. The medium size almond is bulged at one side and pointed at the apex.

Peerless

This early flowering variety bears medium to large-sized nuts. It's well-sealed and the hard shell sets this variety apart from others.

Primorskij

Recorded with the heaviest kernel and nut weight, Primorskij is popular for the highest shelling percentage. These almonds with papery shells perform best in the Kashmiri climate.

Monterey

Figure 8: *Monterey.*

The almonds of Monterey mature lately and produces large and elongated nuts. The kernels are encased within a soft and well-sealed shell.

Sonora

Medium to large-sized almonds of Sonora variety produces elongated and light-colored kernels. The shell is paper-thin.

Fritz

This is one of the heavy yielding and early maturing variety that produces small to medium-sized kernels.

Ruby

Figure 9: *Ruby.*

This almond variety matures late and is popular for its semi-hard shell. Its kernel comes in medium to small-size.

Fertilizer Requirement

Nitrogenous fertilizers are more beneficial for almond than other deciduous fruit plants. That's why organic and inorganic fertilizer use throughout the year at-least at once is very essential. But before applying any fertilizer keep in mind the fertility status of soil and age of plant. Organic fertilizer or farm yard manure should be applied from mid-November to mid-December. And nitrogen half dose with phosphorus and potassium full dose should be applied from flower formation to fifteen days. The remaining nitrogen dose should be applied after fifteen days of fruit formation. It is recommended that fertilizer should be applied under the whole canopy of plant with following simultaneous irrigation.

Root-stock Preparation: Prepare the root stock nursery of apricot, peach or bitter almond. Use one year old branch of almond (Scion) for grafting. The grafting may be done into two seasons 1st in February- March and 2nd in August. After 1-1.5 year of grafting plant is ready for transplanting. Just like other deciduous plants its transplanting should be done in December-January. If plants start flowering in nursery then the transplanting should be stopped. Commercial production will be started after 4-5 years of plant transplanting.

Pit preparation for plant Transplanting

The pits should be ready, 2 months before transplanting the plants. For pit preparation dugout the pit having 3×3 feet dimension. The soil of upper 1 feet layer that is dugout should be mixed with the same proportion of farm yard manure and sand or clay. The sand or clay that should be used depends upon the soil type in which we are transplanting the plants. The mixture of these three components is then sieved and filled into the pits. After it fill the pits with water. The distance between pits should be 20 feet and same between the rows. In very hot areas the distance should be reduced to 15 feet.

Pruning of plants

Pruned off the 0.5 m of upper plant part simultaneously after transplanting. After it 3-4 branches should be remained on plants for its further flourishing. One year old branches should be pruned off after each year. If plant bears more fruits then some of the new branches should be pruned off for better quality fruit.

Inter cropping with other crops

Commercial production will be started after 4-5 years of plant transplanting. If we grow any leguminous crop during this duration it will not affect the growth of the plants by making more profit. But after passing these 4-5 years of non-productive duration, inter-cropping should be avoided. If inter-cropping is done then we have to put all inputs of fertilizer to crop to avoid nutrient deficiency in the soil.

Harvest, postharvest handling techniques

In agronomical processes, irrigation is the most significant aspect affecting almond seed weight, quality, and yield, however, there is no significant impact was observed on the lipid concentration and composition of fatty acid [35]. Practically crop of almonds does not disturb the lipid composition but induces discrepancy to the physical characters of almond grain due to the greater seed moisture concentration. A late harvest of drupes fruits prompts a higher concentration of dry material in the grain. Genetic features, weather and soil conditions, fertilizers usage, and the condition of the plant's maturity can affect at harvest level, and also the concentration of minerals in a plant [36].

Maturity

At maturity, the hull of the almond splits and physically nuts separate from the tree at this spot. Harvesting of the almond tree started when hulls of almond nut fruit in the inside of the canopy are open [37]. During maturation, the drying of the seed coat proceeds, and the seed coat turns brown. If harvesting is delayed it increases the threat of navel orange worm invasion [38].

Almond trees are harvested by mechanical or automatic tree shakers. While shaking the young trees may be damaged, therefore in the first few years, the young trees are harvested by hand knocking. Almond nuts are spread on the ground for drying for 1-2 weeks [39].

Immediately after crop harvesting the fruits can be dried and hulled instantly or stocked for fumigation against Navel Orange worm [37]. Fruit nuts are dried under hot air till the moisture content reaches 5 to 7 percent [40]. Then the nuts are dehulled and shelled. If final processing is pending the nuts in the shell can be stored in a container for many weeks or months [41]. Nuts are then shelled and sorted for size and appearance [42]. In the last the nuts are bleached for color development, then salted, roasted, and/or flavored before wrapping. Furthermore, former studies described that

storing at low oxygen and low-temperature atmosphere caused less off-flavors development [43].

Storage

Either in-shell or shelled if dry, almonds may be stored for many months, or frozen for very long periods in years [41]. Commercially, for long-term storage, the nuts are fumigated for navel orange worm and kept at a temperature below 40°F [39, 43].

Genetic engineering for the improvement

The objective of the study was to investigate the genetic diversity of almonds. Genetic engineering contains direct handling of an organism's genome through biotechnology to adapt the genetic makeup of cells, containing the transmission of genes within and across different kind's limits to yield advanced crops [44]. The process can be used to remove, (knock out) or target a specific part of the genome. Genetic engineering techniques have been applied in various fields including medicine, research, industrial biotechnology, and agriculture [45].

There are four main targets in making genetically improved crops. The first aim is to provide defense against environmental pressures, such as pathogens or cold or resistance to herbicides. The second aim is to alter the quality of the crop by raising the nutritious value and providing additional industrially valued qualities and quantities. Thirdly, to construct materials that it does not normally make or to provide the novel model. Forth is to honestly improve yield by accelerating growth, or making a tolerant organism, for example improving salt, cold, or drought tolerance in plants [46, 47]. The basic chromosome number of wild-type almonds is eight and it's DNA substances are small. Almond fruit occupies a very anomalous place between other fruit trees. Almond is considered the main crop and is cultured in diverse climatic areas after tolerance to drought, salinity, and cold [47].

Isozymes detection

Isozymes are various forms of enzymes that catalyzed the conjoint substrate but are mixed based on their physical appearances for example shape, electrical charge, molecular mass, and protein structures [57]. Isozymes can be separated and analyzed due to the difference in their electrophoretic mobility [54].

In-plant genetic and breeding isoenzymes have been used due to their individuality like simple inheritance, lack of gene interactions, co-dominant expression, and polymorphism present in various plant species and lack of environmental effect [59].

Isozymes can be identified in different tissues by different processes. Iso enzyme's variability is the key source of genetic markers which can be used for recognition of hybrids and cultivars, initial selection, recognition of genetic diversity, quantification of genetic associations among populations [55].

In Prunus almond fruit following Isozymes are present these include glutamate dehydrogenase, alcohol dehydrogenase, malate dehydrogenase, formate dehydrogenase, and shikimate dehydrogenase [60, 61]. Isozymes can be separated by using the polyacrylamide gel electrophoresis method and these isoenzymes can be used to recognize genetic variability in Prunus almonds [56].

Therapeutic applications

Almond numerous active components as dietary fiber [62], proteins like albumin, globulins & amandine, amino acids, certain important essential minerals as magnesium and calcium, vitamins especially B vitamin, and monounsaturated fats [63, 64]. Furthermore, almonds contain phenolic and phytates that constrain the amylase enzyme activity and are supposed to perform synergistically to reduce starch digestibility [65]. The reduced rate of digestion of carbohydrates may describe reported growths in blunted blood glucose response and satiety with consumption of almonds nuts, which describes them as a low glycemic food [66]. Almond flour mixed with honey or sometimes with sugar is often used as a gluten-free food substitute for wheat flour in baking and cooking [67].

These components showed the therapeutic activities. Almond oils also comprise of fatty acids like stearic acid, palmitic acid, palmitoleic acid, oleic acid, eicosanoid acid, linoleic acid, arachidic acid, behenic acid, alpha-linolenic acid, and erucic acids due to these fatty acids almond oil has outstanding emollient properties [68]. The oil can be used for massage therapy to relieve sprains [13].

Insects-Pests and disease

In India usually San jose scale, aphid, flat head borer and mites are common insects that attack almond plants. For the control of these insect any insecticide can be used. Root rot, gummosis, die back and short-hole are common disease in almonds. Except root rot all other diseases can be controlled by applying Bordeaux mixture and pre-marks spray during January and February months.

It can be controlled by applying the above discussed pesticides, but the main target is to find the hole made by insect into tree and inject the insecticide into it by an injection. And the poisonous tablets

having fumes making properties should be placed into these holes by covering it with wax.

Description

Diseases of Almonds

Almond brownline and decline Peach yellow leafroll mycoplasma

Symptoms

Stunted tree growth; drooping/wilting of leaves; brown necrotic areas under bark

Cause

Phytoplasma

Comments

Most common on young trees; grow trees from pathogen free stock

Management

Stunted trees should be removed and replaced; plant only certified pathogen free trees

Almond kernel shrivel Peach yellow leafroll phytoplasma

Symptoms

Late blooming; new growth stunted; paler, smaller leaves; kernels of nuts shriveled at harvest

Cause

Phytoplasma

Comments

Most common where peach rootstock has been used for grafting; remove infected trees

Management

Remove diseased trees; plant only certified trees

Category: Bacterial

Almond leaf scorch; golden death Xylella fastidiosa

Symptoms

Chlorotic leaf margins; necrosis of leaf margins beginning toward tip of leaf and spreading to base; patches of necrotic tissue with chlorotic margin

Cause

Bacterium

Comments

More of tree will be affected each year; bacterium can infect rye, blackberry and nettle and if these plants are nearby they may act as reservoir; transmitted by leafhoppers and spittle bugs

Management

If discovered early (while disease affects only one branch) disease can be removed by pruning primary scaffold 5 to 10 ft below symptoms; older infections may require the tree to be removed and replaced

Crown gall Agrobacterium tumefaciens

Symptoms

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die

Cause

Bacterium

Comments

The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall

Management

Only plant disease-free nursery stock; plant trees in well-draining soils; avoid wounding the plants as much as possible; fresh wounds can be treated with a biocontrol agent (Agrobacterium tumefaciens K84), if available, to prevent the bacterium colonizing

Category: Fungal

Alternaria leaf spot Alternaria alternata

Symptoms

Light brown lesions on leaves which expand to form circular lesions on leaf blade or semi-circular lesions on margin; leaves may develop light yellow necrosis which dries and turns tan in center of leaves; infected leaves dropping from tree; fruit does not drop from tree

Cause

Fungus

Comments
Disease emergence favors warm weather

Management
Late spring treatment with appropriate fungicide if Alternaria symptoms are present

Anthracnose Colletotrichum acutatum

Symptoms
Blighting of blossom; dieback of limbs; death of foliage with leaves remaining attached; nuts with orange lesions

Cause
Fungus

Comments
All cultivars susceptible; occurs more often in warm, wet conditions

Management
Fungicide treatment and cultural practices required to control disease. Orchards with a history of anthracnose infections should be sprayed at 5-10% bloom and applications should be repeated every 10 to 14 days; dead infected branches should be pruned; low angle nozzles should be used in orchards with spray irrigation to prevent wetting of leaves

Brown Rot Blossom Blight Monolinia laxa

Symptoms
Blighted blossoms; stigma and anther of flowers turning brown and necrotic; blossom collapsing and turning brown; light brown powdery fungal masses may be visible on infected flowers; gummy exudate at base of flowers; cankers forming on twigs associated with blossoms

Cause
Fungus

Comments
Disease emergence favors frequent rainfall during bloom

Management
Fungicide application at 5-10% bloom and full bloom to protect flowers; one application at full bloom usually sufficient if there is no rainfall; two or three applications should be made if bloom is accompanied by rainfall

Hull rot: Rhizopus stolonifera Monolinia spp

Figure 10: *Monilia on a tender fruit Almond.*

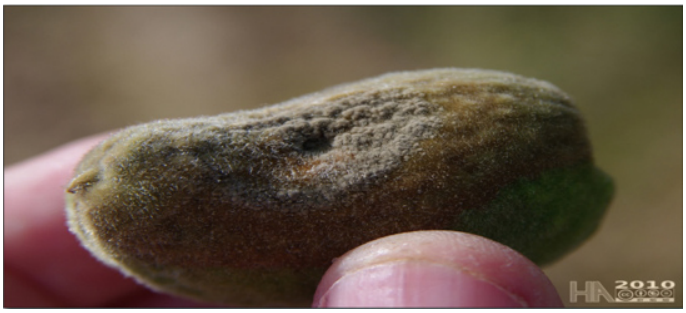

Figure 11: *Monilia on a tender fruit Almond.*

Symptoms
Tan lesions on hulls which enlarge and cause fruit to shrivel; dark gray spore masses visible between hull and shell; leaves in proximity to infected fruit may wither and curl; leaf death occurs on side of shoot closest to infected fruit

Cause
Fungus

Comments
Hulls of fruit are susceptible to hull rot until they are dry

Management
Management of irrigation should be practiced. Reduce irrigation at hull split; demethylation inhibitor and quinone outside inhibitor fungicide may be applied in combination with irrigation management

Shot hole: Wilsonomyces carpophilus

Symptoms
Circular purplish spots on foliage which enlarge and turn chlorotic then tan; drying of lesions causes missle of lesion to drop out of leaf causing small holes to develop

Cause
Fungus

Comments
Spores transmitted in water; disease more common in wet conditions

Management
If fungal fruiting structures are present in Fall (visible under a hand lens as small black spots in the center of lesions) then a fall treatment with fungicide is required; fungicide should be applied before wet periods to protect tree

Verticillium wilt (Blackheart) Verticillium dahliae

Symptoms
Leaves on one side of tree turning yellow; wilting early in season

Cause
Fungus

Comments
Fungus overwinters on soil, recurring each year; problematic if orchard is interplanted with other susceptible plants e.g. cotton, tomato, melon

Management
Orchards should not be intercropped with susceptible plants e.g. cotton, tomatoes or melons; solarization or fumigation of soil prior to planting may be used to kill fungi in soil

Insect & Pests

Category: Insects

Pavement ant (Southern fire ant) Tetramorium caespitum
Solenopsis xyloni, S. molesta

Figure 12: *Pavement ant.*

Figure 13: *Southern fire ant.*

Symptoms
Hollowed out nuts on ground

Cause
Insects

Comments
Prevalent in orchards using drip or spray irrigation

Management
Monitor orchard for ants in April and May; apply ant baits before harvest to manage high ant populations; remove nuts from orchard floor as soon as possible

Harvesting & Yield
When it starts opening of outer cover (fruit coat) of fruit, it means crop is ready to harvest. After harvesting the fruits from plant the outer cover should be removed and fruit should be dried in the shade.

Figure 14: *Almond Fruits and Seeds.*

The average healthy and mature almonds tree can produce 50-65 pounds (23-30 kg) of nuts in Pakistan. A good yield of a mature commercial orchard run by professional almond growers is about 4500 pounds (2040 kg) of shelled nuts per hectare.

Almond Processing: Pre-Cleaning, Hulling & Processing

In the last post, we were able to see the three step almond harvesting process. This week, we continue on the journey of the almond to the huller/sheller and almond processor. There are multiple steps that almonds take postharvest, and hopefully this will help you appreciate your next batch of almonds a little bit more! All of the footage shown below was taken at RPAC Almonds and Parreira Almond Processing Company in Los Banos, California.

How Are Almonds Sold?

Almonds are sold in three different forms:

- Whole Natural – Plain kernel
- In-Shell – The outer hull has been removed, but the kernel is left inside the shell
- Processed – Where any further processing has been performed to the kernel, such as blanching, roasting, slicing or dicing

Almond Pre-Cleaning

Once the almonds arrive at the facility, they are unloaded from the trailer, with an initial sorting to remove soil and grass from the field.

Figure 15: *Pre cleaning Almond.*

The almonds then pass through a pre-cleaning phase. The almond pre-cleaner consists of three steps that the almonds pass through before entering the huller.

1. De-sticker – The de-sticker separates out the large sticks, so that the sticks stay on top of the chain of the machinery and the almonds fall through to the next machine. There are sand screens that shake out the fine soil and the nuts and bigger soil clumps pass down to the de-stoner.
2. De-stoner – The de-stoner works off of positive air and vibration to separate the soil clods from the almonds, and then the almonds pass to the de-twigger.
3. De-twigger – The de-twigger then gets the small twigs out of the mixture. The large stickers were separated out during the first step.

Figure 16: *Almond Pre-Cleaning systems.*

Almond Hulling & Shelling

The hulling and shelling plant is where they take the product from the field, clean it, hull it, shell it, and remove most of the foreign material. There is also an aspiration system that is running throughout this facility to control any potential issues with dust. The piping runs along the ceiling to suck up as much dust as possible, and then releases the dust to a truck outside of the facility, where it is recycled and used in landfills (offsetting the need for excavation).

Figure 17: *Almond Hulling & Shelling.*

There are a lot of steps that go into removing the hull and shell from the almonds. In total, there are 8 different steps. However, once the hulls and shells have been removed, the kernels will skip the additional steps and pass through to the end step.

At the start of the process (stage 1), there are 3 separate machines that all attempt to crack the hulls and separate them out from the kernels. The almonds are spread out equally among the three machines, which have counter-rotating belts to remove the hulls.

Figure 18.1: *Almond Hulling & Shelling.*

During stage 2, it is the same idea, where the nuts are spread out equally among the machines, but the machines in this stage work to target smaller and smaller nuts as they progress through the machines. When the hulls are removed, the nuts are transported on bucket elevators to the end of the packing line and bypass the additional separation steps.

Figure 18.2: *Almond Hulling & Shelling.*

At the very end of the process, the kernels are taken to the meat deck to further separate out the kernels from everything else, using screens and positive air flow. The hulls and shells are separated and then the kernels are sent to the bucket elevators to be bulk packed into bins.

Almond Sampling or (USDA Grading Process)

As the almonds are being packed into the bins, a random sample is taken of each lot for USDA grading purposes. This step is completed in order to determine the quality of nuts received by the different growers (for their compensation), as well as to be reviewed by the USDA inspector each week during their visit. All grading is done in the quality control lab, where highly trained staff and an electronic machine sort out a 500g sample. The samples are checked for size and for any foreign material or defects, such as insect damage. Innovation, such as the electronic scanning equipment, enables the grading time to move much quicker.

This quality control room is also used for samples that are taken at the end of the processing/handling step. Those samples are for internal use, so they know exactly what is in each bin and where they do the final grading to determine which batch meets each customer's specifications.

Almond In-Shell Packing

The in-shell packing line was not running the day of my visit, but you can still get an idea of the process from the pictures below. About 15% of RPAC's product goes to this line, and this is where the end result is a kernel that is still in-shell, although the outer hull has been removed.

The in-shell packing process is as follows

Sorting – The in-shell almonds go up an elevator into a screening deck to get rid of any twigs or foreign material and through an aspirating system to pull out any loose shells or hulls.

Figure 19: *Shorting of Almond.*

Optical Sorting – The almonds pass through an optical sorting machine to sort out most types of foreign material or nuts that still have the hull attached

Figure 20: *Shorting of Almond.*

Metal Detector – The almonds then pass through a metal detector and are packed

Figure 21: *Metal Ditector.*

Packing – The final product is packed into bulk bins or 50 pound bags (where the bags are pulled tight and sewed up on the line) that are palletized and shrink wrapped for shipment

Figure 22: *Packaging of Almonds.*

Almond Processing

Both RPAC and Perreira Almond Processing Company are located on one site. Parreira Almond Processing Company operates the hulling/shelling operation and RPAC runs the processing and marketing operation. During the processing step, the bins of almonds that have already gone through the huller and sheller enter the processor in bulk bins and pass through the following steps:

- **Bin Dump** – The almonds are filtered to remove any additional field debris.
- **Optical Sorting** – They go through three different optical sorters. The first two optical sorters are the same and remove any kernels that fail to meet customer specifications, while the third works a bit differently: the almonds that get blown backwards are the rejects and the ones that move forward gravitationally are of good quality and proceed.

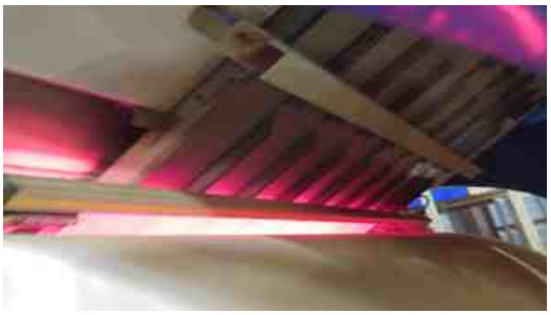

Figure 23: *Almonds processing.*

Sorting by Size – The kernels are then sorted based on the size of nuts. As you can see in the pictures below, there are 8 different sizes in which the nuts are sorted.

Figure 24: *Almonds shorting processing.*

Packing – They are then bulk packed into bin-sized bags, sampled and sealed. All product is then stored inside at room temperature until they are sent out for shipment.

Quality Control – The sampling before the final seal on the bulk bins is an internal quality control step that is used to grade and market the product. A sampling probe is used to gather a sampling size from each bin, which is taken into the quality control lab to be graded based on the quality of the almonds. This grading is then attached to the bin, along with all of the other tracking information, and is used to market the product to each customer's unique specifications. This process demonstrates the bulk packing steps. However, the almonds can also be packed into smaller sizes.

What About the Pasteurization Step?

All almond kernels sold in the United States are required to be pasteurized before they can enter the market. This is not required if the almonds go on to further processing (e.g., roasting, blanching, slicing, etc.), or if they are sold in-shell. The pasteurization step does not occur at this processor because only about 5% of the product they produce will be sold as whole kernels into the United States market. The rest of their product is either exported, further processed or goes onto another facility that completes the pasteurization step.

Sustainability of Almonds

Sustainability plays a large role in the growing, harvesting and processing of almonds as well. All of the excess soil, sticks, rock, any other field debris, and hulls are recycled and repurposed. For example, at this operation, the excess soil is used to fill in abandoned canals, at the landfill so they do not have to excavate good soil, and to build up livestock/dairy pins, while the sticks are ground up and used for livestock bedding, and the hulls are used to replace low grade alfalfa hay and corn silage (saving approximately 900,000 acre feet of water that would be used to grow the hay and corn separately).

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