

Current Opportunities in the California Olive Oil Industry (2007)

Paul Vossen

Farm Advisor UC Cooperative Extension – Sonoma County
133 Aviation Blvd. # 109
Santa Rosa, CA 95403

INTRODUCTION

The California olive oil industry has recently developed a much better position to compete in the domestic olive oil market based on a new economic profile. Olive oil production today is rapidly moving towards the super-high-density (SHD) growing system in the orchards and the automated continuous flow processing system in the mills. The SHD system is based on over-the-row mechanical harvest, which significantly lowers production costs compared to trunk shaker or hand harvest methods commonly used in older production systems. SHD olive orchards also incorporate precocious cultivars in combination with close spacing to bring the trees into bearing early, which provides a quicker return on investment. The new continuous flow milling system uses automated stainless steel machines that process olives into oil of superior quality and require very little labor. The super-high-density system is not a panacea, however, as it is more expensive to establish, requires more intensive management, is limited to only a few precocious oil cultivars, must have relatively flat ground for large machinery access, and its long term viability is still unknown. The initial cost of an automated mill is also very high.

The market for olive oil in the United States has doubled in the last ten years and the US is currently ranked fourth in world consumption. Consumers are buying more olive oil primary because of an association with a healthy diet and its status as a specialty product, but almost all if it is imported. In 2006, California had 10,200 acres of olives grown for oil, which were processed in 27 mills. This oil supplied less than one percent of US consumptive demand indicating that over 300,000 acres could be planted to supply current needs. California olive oils have won many awards, are known to be equal to or better in quality than most imported products, and consumers are readily buying the domestically grown product. Other competitive advantages are California's excellent climate, soils, irrigation water, labor force, mechanization, and other technological advances in orchard management and processing systems. The University of California has played a key role in supporting this new industry with research and educational programs on cultural practices, pest control, cost analysis, evaluation of different types of processing systems, and sensory evaluation of olive oil. This new olive oil industry is growing and appears to have a lot of positive potential.



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CALIFORNIA OLIVE OIL - IN PERSPECTIVE

Almost all of the olive oil in the world is produced on about 24 million acres in the countries surrounding the Mediterranean Sea. The big three: Spain, Italy, and Greece produce about 75% of the world's olive oil. The other European, North African, and Middle Eastern countries produce about 20%, and the new world countries of Argentina, Australia, Chile, South Africa, New Zealand, and the USA produce the remaining 5% (IOOC, 2003). In the USA, California is the only state with significant production. In 2006, California produced an estimated 400,000 gallons of olive oil, which is only 0.06% of the world's olive oil and less than 1% of the USA's domestic consumption of about 60 million gallons. North Americans consume about ¾ of a liter per person per year while the per capita consumption for the Greeks, Spanish, and Italians, is 26.1, 15.0, and 13.5 liters respectively. Worldwide olive oil only represents about 3% of the world's consumption of fats and oils, but in the USA it is about 8% and has doubled over the last few years (Market Research.com, 2002; Vossen and Devarenne, 2005).

Most of the 10,200 estimated acres of oil olive orchards in California have been planted in the last ten years; about 40% in just the last two years. Most of the older orchards that went in at the start of the gourmet olive oil resurgence in the late 1980's and early 1990's were planted in coastal counties. They are almost all small-scale plantings (2-10 acres), spaced at a high density of about 200-300 trees per acre, and are growing primarily Italian cultivars such as 'Frantoio', 'Leccino', 'Maurino', and 'Pendolino'. Most of the newest plantings are located in the Central Valley, are much larger in scale (50 to 200 acres – one is 800 acres), and they have been planted at a super-high-density of 670-900 trees per acre with the varieties 'Arbequina', 'Arbosana', and 'Koroneiki'. The nurseries supplying the trees for these new plantings are scrambling to meet the demand for trees as it is anticipated that several thousand acres will be planted with the demand continuing into the foreseeable future. When the currently planted acreage in California comes into bearing over the next 3-5 years, the state will be producing about 1 million gallons of olive oil per year (Vossen and Devarenne, 2005; Vossen, 2006a).

Estimated average production in the Central Valley for the SHD system is about five tons per acre producing 850 liters (225 gallons) of oil. The coastal areas produce about half that per acre, but producers there have typically sold their oils at higher prices. Some European growing regions have defined quality based on the flavor of oils produced in their specific appellations, but oil quality is subjective and can not yet be identified by growing region in California (Romero et al., 2005; Uceda and Aguilera, 2005). California's olive oils, as defined by flavor and style, have been closely associated with variety, harvest maturity, and processing technique. Many examples of California olive oils produced in the coastal counties, the Sierra foothills, and in Central Valley orchards that have won awards internationally. Numerous brands from small-scale coastal and foothill growers have won awards in blind competitions in Europe, yet recently, the largest producer of a SHD system olive oil blend from the Central Valley in California won an award for "Best of Show" oil at the Los Angeles Fair "Olive Oils of the World" competition, which was judged by international tasters (Apollo, 2006; Davero, 1998; LA County Fair, 2006; The Olive Press, 2002).

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PROFITABILITY

There needs to be a distinction made between the production costs for high density coastal oil olive plantings and the SHD plantings in the Central Valley. According to UC cost studies, coastal areas can produce about 2.5 tons of olives per acre, which translates into 852 one-half liter bottles at 45 gallons of oil per ton. The per-acre production costs there are \$9,500, which makes the per-bottle cost \$11.15. If bottling and marketing were not included, the oil would have to sell in bulk for \$53.33 per gallon (\$14.09/l) in order to meet costs. These orchards have more overhead due to higher land costs and management costs that are spread over only a few acres. Small scale growers and millers in these areas have become artisan producers of unique oil styles that can not be made with fruit from the SHD system cultivars. The higher prices required to meet costs and lower volumes for the small scale growers have limited them primarily to specialty and direct marketing strategies.

In the Central Valley, production per acre is higher and costs can be spread out over larger acreages. Land, water, and labor costs are also lower. With the SHD system, the fruit can be harvested with an over-the-row machine at 10% the cost of hand harvest. Combine that with large automated processing machinery that spreads the milling costs over a much larger volume of oil, the cost for a ½ liter bottle is \$4.93. This is based on a production cost of \$8,400 per acre, but twice the yield (5 tons), and the same 45 gallons oil yield per ton, producing 1,704 one-half liter bottles per acre. For producers not interested in marketing their own bottles of oil, the super-high-density system also can work economically if the fruit is sold above \$460.00 per ton or if the oil is sold in bulk for over \$15.00 per gallon (\$3.96/l) (Vossen et al., 2001; Vossen et al., 2004).

The current bulk price for olive oil in California is \$23.00 per gallon potentially making the SHD system profitable compared to most imported oils sold in supermarkets. Without the potential of the super-high-density production system, the California industry would likely stay small and very specialized. One of the primary objectives of California producers is to convince Americans to buy new brands of California olive oil instead of the long established supermarket brands such as Bertoli, Carapelli, Colavita, DaVinci, Felippo Bario, Star, Sasso, and others that commonly sell for \$6-13 per half liter bottle. Currently, the California Olive Ranch (COR) brand oils are successfully selling in some supermarkets at \$10-12.00 per ½ liter bottle. (Vossen, 2006c - unpublished).



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**SAMPLE COSTS TO PRODUCE BULK OLIVE OIL -
SUPER-HIGH-DENSITY ORCHARD - SACRAMENTO VALLEY - 2007**

• Culture & Pest Control (pre & post harvest) (\$180/ton)	~ \$ 900/acre
• Harvest & Fruit Transport (\$80/ton)	~ \$ 400/acre
• Overhead (office, taxes, insurance, & repairs) (\$60/ton)	~ \$ 300/acre
• Capital Recovery (buildings, equipment, irrigation system, depreciation, establishment loan interest) (\$160/ton)	~ \$ 800/acre
• Capitol Recovery (land) (\$72/ton)	~ \$ 360/acre
TOTAL APPROXIMATE COSTS	~ \$2,760/acre
	~ \$ 552/ton
	~ \$ 13/gallon

These costs are based on several assumptions: 110 acres in production; land cost \$5,000/acre; 670 trees/acre; fruit yield of 5.0 tons/acre; oil extraction of 42 gallons/ton producing 210 gallons/acre. Accumulated establishment costs are \$8,334/acre at the end of the fourth year, after subtracting income from production the 3rd and 4th years. Costs include: land preparation, trees, planting, irrigation, fertilization, weed & disease control, harvest, insurance, taxes, repairs, and capital recovery (depreciation and interest) on buildings, equipment, irrigation system, and land.

The costs do not include fruit processing into oil, bulk oil storage, bottles, bottling, labeling, boxes, oil storage, transport, or marketing, which alone (without the oil) have been roughly estimated to be \$30 per gallon. Paying a distributor and slotting fees for retail sales could add another \$30 per gallon. That translates to a cost of \$9.65 for a ½ liter bottle of oil. Add on some profit (40%) and the retail price becomes \$13.51. Note: This is an excellent quality product with sensory characteristics of very fruity, fresh, crisp, olive oil – unlike most of the old, fermented, rancid, or flat imported olive oils being sold in most US markets. The full document can be downloaded at: <http://coststudies.ucdavis.edu>. (Vossen et al., 2007)

KEYS TO SUPER-HIGH-DENSITY ORCHARD SUCCESS

The super-high-density system has many obvious advantages such as less labor input needed for harvest and pruning which is either entirely or partially offset by machines. The trees come into bearing starting the second year with significant and harvestable fruit the third year reaching full production by the fourth or fifth years, compared to wider spaced orchards that require at least twice as many years to reach their full per-acre productive capacity (Vossen, 2002).

The super-high-density system is more intensively managed than other oil olive systems; it requires a great deal of orchard management skill and more initial investment capital. The following are keys to making it work:

- ***The site:*** should be on well-drained soil that is not excessively steep in order to accommodate the mechanical harvester. Excessively fertile “bottom” ground that is very deep will likely not limit the vigor of the olives, which could lead to poor fruiting and excessive shading in high rainfall areas. An adequate amount of high quality irrigation water is required to meet the growth demands of young trees and fruit production demands in order

to achieve high annual yields and good shoot growth that minimizes alternate bearing. A range from 12 to 36 inches of water per acre are required depending on climatic demand and it should meet the minimum requirements of < 2 ppm boron, < 3.5 ppm bicarbonate, < 480 ppm total salt, < 9 SAR, and < 345 ppm chloride. The soil should meet the minimum requirements of having a pH in the range of 5-8.5, SAR < 15, chloride < 15 meq/l, boron < 2 ppm, a ratio of magnesium to calcium of < 1:1, and a potassium level > 125 ppm. Elevations above 2,000 ft. elevation are not recommended due to the increased risk of cold injury to trees or fruit before harvest. Orchard temperatures should not get < 25°F for young trees, < 15°F for mature trees, and < 29°F for fruit before harvest usually in mid October to mid December. Olive trees also do not do well in climates with hot dry winds or rain during bloom in late April and early May (Vossen, 2007).

- **Varieties:** The only three varieties that we know work well in this SHD system are ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’. They are precocious and tend to bloom and fruit on whatever shoot growth occurred the previous year. Other varieties will be much more difficult or impossible to maintain within the confines of the over-the-row harvester (< 10 ft.) (Pastor, 2005). ‘Arbequina’ is an early ripening cultivar that is cold hardy and produces a mildly pungent and almost never bitter oil with intense fruitiness. ‘Arbosana’ is a lower vigor cold hardy cultivar that is harvested about two weeks later than ‘Arbequina’ and produces a much more pungent and bitter style oil. ‘Koroneiki’ is a cold sensitive, late maturing variety that has about the same vigor as ‘Arbequina’ but is more alternate bearing and produces oils that are quite bitter, very pungent, and that have undertone flavors of banana, tropical fruits, and green herbal tea (Tous et al., 2003).
- **Tree spacing:** is determined by matching the variety with the inherent vigor of the ground along with climatic influences. If the soil is deep and fertile, the trees should be planted at a slightly wider spacing, perhaps 5 ft. x 13 ft. (670 trees/acre), but the best spacing for this system is 4 ft. x 12 ft. (907 trees/acre). The in-row spacing should be such that fruiting branches growing off the central leader just touch, and the between-row spacing should not be greater than 1.3 times the allowable tree height to accommodate the harvester. Rows growing into hedgerows should be oriented North-South and no more than 80% of the orchard floor should be shaded in mid summer (Tous et al. 2003, Vossen, 2006b).
- **Push the young trees:** start them off with plenty of moisture, adequate fertility, and good weed control so they grow rapidly and fill their allotted space within the first 3-4 years. Young actively growing trees will require from 4-10 gallons of water per tree per day in the hot summer months depending on the climate. Nitrogen levels must be adequate as indicated by tissue analysis, and there should be zero weed competition within three feet of the trees (Vossen et al., 2006; Vossen and Connell, 2006).
- **Train the trees:** to an upright mini central leader form by tying the leader as it grows vertically to a support stake and keep the lower 3 feet clean of all lateral branches for good closure of the mechanical harvester catch frame. Very little to no additional pruning is done in the first 3 years (Vossen, 2006b).

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- **Pruning mature trees:** No large lateral branches are ever allowed to grow in this system, all of the fruiting should occur within about 2 ft. of the central leader. Lateral branches longer than that or > 3 years old should be cut back to a short stub near the central leader by hand. Trees are mechanically topped every other year in the summer to maintain a maximum height for the harvester and the skirts are mechanically trimmed to prevent interference with the closure of the harvester catch frame around the base of the trees. Trees are pruned more heavily in years just prior to an anticipated heavy crop (Vossen, 2006b).
- **Fertility level for mature trees:** especially nitrogen is reduced after the 3rd year in order to create less vegetative vigor. More nitrogen is provided in years with a very heavy crop to encourage more vegetative shoot growth and better production the following year. Years with a light crop are given less nitrogen fertilizer (Vossen and Connell, 2006).
- **Controlled deficit irrigation:** management practices are followed after the 4th year to limit vigor, save water, and maximize oil quality. Mature trees produce the maximum amount of oil per acre receiving between 50-70% ET, and the best oil flavor quality is achieved when trees are irrigated between 35-55% ET. Controlling the amount of irrigation water the trees receive is the best way to minimize excessive vigor in light cropping years and improve shoot growth in heavy cropping years (Berenguer et al., 2006; Grattan et al., 2006).
- **Monitor carefully for leaf diseases:** Closely spaced hedgerow orchards need to be watched closely and sprayed preventively for foliar diseases, see their description below.

OLIVE PESTS

There are very few pests that bother olives and since the fruit is crushed, cosmetics are unimportant compared to table fruit. Some pests are economically important and must be controlled, but there is nothing that would significantly limit production.

- **Olive fruit fly:** This is the most important pest of olives in California. The olive fruit fly (*Bactrocera oleae*), invaded California in 1998 and has now spread throughout the whole state. The adult is very similar to other Tephritid fruit flies. It is 4-5 mm long with a reddish brown color and a small black spot at the tip of its wing. It has 3-5 generations per year and can remain active year round in warmer parts of the state. Eggs laid under the fruit skin develop into maggots and destroy the fruit flesh. Some damage is tolerable since the fruit does not rot or produce off flavors in the oil until a very advanced level of damage occurs. Control is achieved using mass trapping, spraying with kaolin clay to create a barrier film on the fruit, or by spraying spinosad in a bait formulation. Combinations of these methods can also be used to improve effectiveness and reduce costs. Recent research in California has shown that untreated trees can have close to 100% damage by mid October while mass trapping can reduce damage down to about 30% damage and the two spray techniques down to less than about 3% damage. All of these methods are organic (Vossen and Kicenic Devarenne, 2006).

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- **Scale insects:** Several species feed on leaves, twigs, and fruit causing minor damage and rarely serious injury, but they can under some conditions. These insects are all small (3-5 mm) shell-like creatures that, once settled, stay in one place to feed and stunt the tree's growth. Black scale (*Saissetia oleae*) is the most prevalent of the scale insects and if present in large numbers can leave a thick layer of sooty mold fungus that feeds on its sweet excreted juices almost smothering the tree. It is usually kept in check by natural enemies and by opening up the tree with pruning, which increases mortality because of higher temperatures. If necessary they can be sprayed with horticultural oils. The other scales are: Oleander (*Aspidiotus nerii*) and Olive Scale (*Parlatoria oleae*) (Krueger and Vossen, 2007).
- **Foliar diseases:** There are two very similar leaf spotting fungal diseases that cause defoliation and weakening of the tree. They are Peacock Spot (*Spilocaea oleaginea*) and Cercospora (*Cercospora cladosporioides*). Fixed copper fungicides are used and should be applied before major fall rains allow the disease to spread from last year's leaf infections to the new shoot growth. In wet coastal climates two sprays may be necessary, but in drier areas only one is needed (Krueger and Vossen 2007).
- **Verticillium wilt:** This fungal disease (*Verticillium dahliae*) is soil borne, can infect almost every cultivar, and can kill the trees. Fields with known disease pressure such as the West Side of the San Joaquin Valley or areas where cotton or Solanaceae plants had been recently grown, should not be planted in olives because of the high risk (Krueger and Vossen 2007).
- **Root rot:** Olive trees are not tolerant of wet soils and can easily be killed if trees are not planted into well drained soils. The primary fungus that ultimately can kill trees and causes root rot is (*Phytophthora sp.*). This disease is prevented by not planting in soils with poor drainage or by improving drainage with underground tile systems and raised planting berms (Krueger and Vossen 2007).

PROCESSING OLIVES INTO OIL

The olive cultivar dictates much of the flavor of an olive oil, but after that fruit maturity is the most important consideration in the ultimate quality and especially the style of olive oil produced. Olive oil can be described as both ripe fruity and green fruity and they are distinctly different. Olives harvested early when they are still green or just turning yellow to red are characterized as having herbaceous flavor characteristics such fresh grass, herbal, artichoke, nettle, mint, tomato leaf, etc. Early harvested fruit is also much more bitter and pungent, because it is higher in polyphenols. Later harvested fruit that is picked when the fruit is more mature and colored to red and black produces oils that are much less bitter and pungent. They also that have some ripe fruit undertone flavors that are often described as floral, buttery, nutty, apple, banana, berry, or tropical (Gutierrez, 1999; Tous et al., 1997). California growers can chose when they harvest their fruit to produce oil flavor profiles (oil styles) that they feel are attractive to their niche of consumers.

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To produce high quality oil the olives must be harvested without breaking the fruit skins and ideally the fruit should be processed within 2 to 4 hours ideally and within a maximum of 12 to 24 hours. Fruit should be separated by quality with each grade processed separately (Hermoso et al., 1998). California currently has 28 olive oil processing facilities and many of them have been upgraded and enlarged in the last few years with very modern, almost completely automated systems that require very little manual labor. Automated mills use sensors, flow meters, temperature controllers, real time product analysis, automatic arms and various other robotics plus sophisticated software to do most of the work from a computer screen. The steps in modern olive oil processing include: fruit cleaning, washing, and crushing; paste malaxation and separation; oil cleaning; and oil storage.



- **Fruit Cleaning and Washing:** Most mills pass the olives over a vibrating screen and blower that removes leaves and other debris. Excessive amounts of leaves or twigs can give the oil a chlorophyll or woody flavor. Olives are washed to remove soil or spray residues that may negatively affect flavor. (Civantos, 1999; Hermoso et al., 1998).
- **Fruit Crushing:** Olives are crushed pit and all to break the cells and release the oil for extraction. The primary machines used to crush olives, are the hammermill and diskmill, which differ in the fineness of paste they create. A finer paste releases more fruit flavor into the oil, but can become homogenized and more difficult to extract the oil. Stone crushers are seldom used in modern olive oil processing because of space required, discontinuous nature of the batch process, and greater exposure of the paste to oxidation (Civantos 1999).
- **Paste Malaxation:** The malaxation machine is essentially a jacketed stainless steel tank that slightly warms and slowly mixes the paste. Malaxation reverses the emulsification that occurred in the crushing process, so that large oil droplets are formed, which helps separate the oil from the paste solids and fruitwater. The mixing process optimizes the amount of oil extracted and allows the oil to fully absorb the flavor of the fruit. The paste is slowly stirred for 30 to 60 minutes at a temperature of about 80° to 86° F (26.6-30°C). Temperatures above 86° F (30°C) can cause problems such as loss of fruit flavors and can increase bitterness and pungency. The newest trend in the management of olive oil paste is to reduce oxygen exposure. This can be done by either flooding the surface of the mixing tanks with nitrogen or vacuum exclusion of oxygen in special malaxation tanks. Limiting oxygen exposure is believed to reduce enzyme activity that can break down polyphenols, which are antioxidants and major flavor components of olive oil (Alba, 2001; Di Giovacchino et al., 2002; Hermoso et al., 1998).

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- **Paste Separation:** Modern oil extraction is almost exclusively done with a stainless steel continuous flow vertical centrifuge, called a decanter. Old traditional presses that squeezed stacked up filter mats full of paste are seldom used because that system requires more labor, the cycle is not continuous, and the filter mats can easily become contaminated introducing fermentation and oxidation defects into the oil. Decanters spin the paste at approximately 3,000 rpm and the centrifugal force moves the heavier solid materials to the outside; a lighter water layer is formed in the middle with the lightest oil layer on the inside. In a three-phase system, water is added to get the paste to flow through the decanter, but this washes away some of the flavor and antioxidants, and results in a lower polyphenol content. Two-phase system decanters separate the oil from the solids and fruit-water that exit together. No water needs to be added, so there is better retention of polyphenols. The 2-phase system also produces almost no wastewater compared to the 3-phase system and its waste water has a much lower biological oxygen demand (BOD), but the solid waste is quite wet and more difficult to manage (Alba, 2001; Civantos, 1999; Hermoso et al., 1998).
- **Oil Cleaning:** A machine called the vertical centrifuge that spins at 6,000 rpm is used to further separate most of the remaining fruit water and fine solids from the oil before it goes into storage (Alba, 2001).
- **Oil Storage:** After processing, oil should be stored in bulk for 1-3 months to further settle out any remaining particulate matter and fruit-water. This eliminates sediment in bottles and oil contact with processing water residues that can lead to off flavors. Premium quality oils should be stored in stainless steel and maintained at a constant temperature of between 45 - 65°F (7.2 – 18.3°C) (Alba, 2001; Hermoso, 1998). Some oils are filtered before bottling.

SENSORY EVALUATION OF OILS

The University of California currently has an olive oil research taste panel that evaluates olive oils according to scientific methodologies set forth in the International Olive Council (IOC) standards. The panel meets twice per month most of the year. One objective in olive oil sensory analysis is to determine if the oils contain defects from improper fruit storage, handling, pest infestation, oil storage, or processing problems. Another objective is to describe the positive characteristics of the oil in relation to its intensity of olive-fruity character. Olive oil should have a fresh fruity olive flavor that is characteristic of the variety or blend of varieties making up the oil. Bitterness and pungency are often present in olive oils, especially when newly made. They are not defects and will mellow as the oils age (Alba et al., 1997; Harwood and Aparicio, 2000; Kiritsakis et al., 1998; Uceda, 2001).



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CONCLUSIONS

Small scale olive oil producers in California have been producing high value specialty olive oils for many years. The current California industry is very small, but the domestic market for olive oil is huge and the demand is increasing. Americans certainly have the potential to consume more olive oil like the Europeans. Now, with the new SHD orchard system and automated processing mills, many California growers and processors have the ability to produce excellent quality olive oils at a reduced cost. Orchards configured for over-the-row olive harvest and the use of state-of-the-art, automatic, continuous flow processing equipment are the keys to industry expansion and success. California olive oil producers are now in a position to be competitive in the domestic market with the big volume producers and importers from Europe.

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