

SPANISH OLIVE OIL PRODUCTION

Spain, occupying 85% of the Iberian Peninsula, is one of the largest countries in Europe with 194,885 square miles of territory; one third is agricultural. The Mediterranean Sea is on the south, the Atlantic Ocean on the north and west and the Pyrenees Mountains to the east. Between many of the mountain peaks, narrow valleys exist, but one of the most important topographical features is the great central plateau with an average elevation of 2,000 ft. above sea level.

The climate is marked by extremes in temperature and low rainfall. Most of Spain receives less than 24 inches of rainfall on the average. At Madrid in the center of the country, winter cold is sufficient to freeze surrounding streams, while summer temperatures in Seville can rise as high as 120°F in the summer. The Mediterranean and Atlantic coasts however, offer great moderation in temperatures, which is important for production of olives, citrus, and various tree fruits and nuts.

The country is divided into 50 provinces within 17 autonomous regions. The 40 million Spanish people are essentially a mixture of the indigenous peoples of the Iberian Peninsula with successive peoples who conquered and occupied the peninsula for extended periods. Most of the people speak Castillian Spanish. In addition, Catalan is spoken in the northeast, Galician in the northwest, and Basque in the north.

Spain has traditionally been agricultural, but since the mid 1950's industrial growth has been rapid. In 1986, Spain became a full member of the European Community (now the EU), which has elevated the economy. Agriculture is still a mainstay of the economy, employing about 10% of the labor force. The leading agricultural products in order of value are: grapes, olives, potatoes, barley, wheat, almonds, tomatoes, citrus, sugar beets, and onions. Livestock is also important. Much of the agriculture is dry farming with only small portions of the most productive land along rivers being irrigated.

Olive Oil Production in Spain

Spain has 4.7 million acres of olive trees under cultivation, which ranks it as the top producer and exporter of olive oil in the world (~30%). By comparison, Italy, the second ranked producer, has 2.0 million acres. Although Spanish olive acreage has been steadily declining since the 1960's, new plantings in recent years have altered the trend, particularly in the Andalusia region, which produces approximately 75% of Spain's olive oil. Due to the gradual replacement of older low-producing orchards with higher density and more productive orchards, average production per acre has been rising.

Oil production has also risen during the same period to just over 655,000 metric tons in 1996/97. Production is highly influenced by seasonal rainfall (most of the orchards are not irrigated), and alternate bearing (low yields followed by higher yields due to the influence of crop on the next year's production). World production is approximately 2,000,000 tons per year, valued at \$1.7 billion (US).

National average consumption of olive oil is 411,000 tons, based on the years 1990-93, and has been moderately increasing in Spain (per capita = 24.2 pounds – 3.0 gallons). As a comparison, Italy consumes more oil than it produces (production = 450,000 tons and consumption = 600,000 tons, per capita = 23.1 pounds – 2.9 gallons). Spain exports much of its excess production in bulk to other European Community (EC) countries where it is consumed or repackaged and exported.

Consumption in Canada, Australia, Japan, Saudi Arabia, France, Portugal, UK, Germany, and the US continues to rise at a steady rate. Traditionally, consumption in most of those countries has been very low. US consumption of imported olive oil was 115,000 tons in 1992-93 and increased to 130,000 tons in 1995-96. Per capita consumption is 0.001 pounds, i. e., approximately 0.002 cup. In other words, Spaniards consume 24,000 times more olive oil than Americans do.

Spain, along with the European Union, has a national marketing campaign to boost the generic consumption of olive oil through promotion of the healthful aspects of a Mediterranean diet. Brand advertising is based on personal taste, confidence in companies, and price aggressiveness. Price is the predominate factor in Spain, though quality is important.

Catalan Olive Oil Production Region (Northeast)

Oil olives are produced on 118,000 Hectares (297,578 acres) in the rolling hills of Catalunya. The primary variety is Arbequina but several other minor varieties such as Farga, Morrut, Sevilleana, and Empeltre are also grown. These hills are quite dry, receiving only 10 - 20 inches of rainfall each year. The best orchards are located on deep soils and can produce about two tons of olives per acre per year dry farmed and 4 tons per year when irrigated (170 gallons of oil/acre). Using 1996 bulk prices of 610 pesetas (\$4.81) per kilo/liter of oil; the growers' potential return is \$3,270 per acre, gross.

The entire Catalan region has about 150 private oil mills operated cooperatively in each village. Each mill has 50 to 200 producer members and handles 500 - 5,000 tons of olives per year. Almost all farmers live in small villages of 250 people to towns such as Llerida with 30,000 inhabitants. Most of the farms are 12 - 15 acres in size. The entire region produces 15 - 20,000 tons of oil per year (4-5 million gallons), representing approximately 6% of Spain's total production. About 40% of the production of the region is extra virgin olive oil and comes primarily from the Arbequina variety. The region also produces almonds, peaches, carob, citrus, filberts and vegetables.

Current Status of Mills in Catalunya

- Most are using three-phase system decanters.
- Many are upgrading to two-phase decanters.
- Only two are still using traditional presses and mats.
- None are using stones to mill the olives (all use hammermills).
- Average size is 1,500 tons processed per year.
- Many have a capacity that is too small for economic efficiency.
- Some are in conjunction with wineries and oils are picking up fermentation odors.
- Some, whose cleanliness is not maintained well enough, have inferior quality oil.
- A few are using excess heat in the extraction process.
- Most sell 50% locally and have 50% for export.

Agromillora Nursery (Tarragona)

We visited the greenhouses of the Agromillora nursery where they produce 2 million olive trees each year and sell them internationally. While there, we met Jordi Mateo, chief propagator, and Jorge Pinochet, horticulturist, who described their operation. The greenhouses were spotless and new with a system of movable benches for efficiency and mass production.

- 2.1 million plants produced per year, 80% Arbequina, 20% Piqual, Manzanilla, Empeltre, etc.
- Sales are to Spain (50%), Argentina (40%), France (5%), and others (Chile–Brazil-Portugal).
- Quality control is maintained with the ELISA virus screening system.
- Molecular markers (RAPD's) are used for variety identification.
- Has an international license for specific clones of Arbequina–18 and FS-17 from Italy.
- Experiments with high-density plantings are conducted in Spain, France, & Argentina.

Their final product is an 18-inch tall liner in a 4-inch pot (300 cm³) which takes about a year to produce. It sells for approximately \$ 1.50 per plant, depending on the quantity purchased. Production starts from cuttings that are dipped in rooting hormone and placed in heated mist beds containing perlite. Once rooted, they are transferred to 4" plastic pots containing peat, moved to the greenhouse bench, and watered with a nutrient solution. The growth is augmented with lights (longer day length) and heat.

Arbequina is their primary variety because it is the best local variety for olive oil production. Its characteristics include precocity, self-fruitfulness, cold hardiness, and small tree size with lower vigor for high density planting, and excellent quality oil. Vigorous liner plants should achieve growth up to 6 ft. in the first year.

Trees are available for sale and shipment to the US by contacting Jordi Mateu, El Rabato s/n, 08739 – T.M. Subirats, Barcelona (Spain). Email: agromil@ediho.es

Mas Bové Research Institute

Just outside Tarragona, near Reus, we met with Dr. Joan Tous at the Mas Bové Institute of Ag Research and Technology (IRTA) experimental station. We visited his experimental orchards with collections of several hundred varieties of olives from throughout the Mediterranean region. Most of the plantings were between three and nine years old and just beginning to provide data.

One of the main goals of the Research Institute Extension Program is to encourage the growers to gradually replace old orchards with irrigated, higher density plantings of new varieties. They are also trying to upgrade the skills of the oil mill operators in order to improve overall quality.

They have trials that are comparing:

- 15 Arbequina clones for production, maturity, and quality information.
- Effect of soil depth on production.
- 40 new varieties in 5 locations.
- Maturity indices for Arbequina.
- Sensory Evaluation Panel ratings for quality.
- Oil diagnosis methods for fatty acid content and acidity measurement.
- Training systems (central leader, vase, epsilon).
- Ultra high density plantings of 800 to 1,000 trees per acre.

The experiments measure:

- Tree vigor - height, width and cross sectional trunk area (cm²).
- Phenology - flowering and maturation.
- Production - yields per Hectare.
- Fruit characteristics - weight, shape, caliper, oil content, and pulp-to-pit ratio.
- Oil quality - acidity, fatty acid content, sensory rating.

In addition, they have laboratory facilities to process small quantities of experimental olives and a taste panel established that utilizes International Olive Oil Council (IOOC) guidelines.

In 1994, the Mas Bové research institute recruited one hundred ten people to serve on an officially trained tasting panel. Forty-five were disqualified for not being able to detect the standard olive oil defects. Many others had schedule conflicts and could not fulfill the requirement for 120 hours of training over an 8 month period. Today, twenty-eight remain as official taste panel members.

Taste panel trainings are done in cooperation with the International Olive Oil Council so that the oil ratings are reproducible and based on standard minimum performance criteria. Panel members learn how to identify defects and rank oils. Many of the rankings are subjective by degree of intensity and the intensity needs to be comparable to a standard.

Very Old and Very New Orchards

Just outside Reus, we had an opportunity to see a 120-hectare (297-acre) orchard called La Boella. It has 50 hectares of super intensive planted trees at 12 ft. x 4 ft. spacing (907 trees per acre). The oldest trees produced 3.6 tons per acre in the fourth year; in the third year, they produced 5-6 kilos per tree (2,400 trees/H) and a yield of 0.67 tons per acre.

Primarily, the trees are trained into a central leader form and maintained at a height of seven feet with mechanical topping. The fruit is harvested with an over-the-row grape harvester (BRAUD brand) which removes almost 100% of the fruit. The machine costs \$150,000 in the US and is commonly used in wine grape harvest. It can harvest 60-80 tons per day. Their calculations determined that labor cost savings were \$0.22 per kilo or \$242.00 per ton based on their pay rates of \$6 to \$10 per hour. The fruit has minimal bruising and is very clean. It is rushed to the processor as quickly as possible and oil quality is excellent.

In the southern portion of the region, with Victor Cabus, the local farm advisor, we visited some orchards that had trees over 1,000 years old. It was a very unique feeling to stand next to a tree that had been growing and producing for ten centuries! We saw several varieties, such as Farga, Sevillanca, Empeltre, Plans, Valentin, Verdriel, Argudel, Palomar, and Morrut.

These orchards had tree spacings of 50 x 50 ft., were dry-farmed, and quite low yielding. They are an historical throw back, but represent how olives were farmed for many years. Returns are low but the trees are maintained at a very low cost. The fruit is harvested with a hand pushed spiked roller that pokes each fruit and scrapes it off into a tray. Each week the orchard has its olives picked up in this fashion. The fruit is of low quality and the oil is refined after milling.

Cooperative Montbrió del Camp

We also had the opportunity to visit one of the Siurana Union Cooperatives that was producing olive oil from the Arbequina variety. Their milling system includes an unloading station, washer, hammermill grinder, mixer, Sinolea separator, two horizontal decanters, and two large vertical centrifuges. All of the separation equipment was the Rapanelli brand. The facility also produced wine and had a local store for sales of various cooperative products like nuts, oil, wine, vegetable seeds, and fruit. The oil was determined to be of excellent quality during an informal tasting of several oils.

Vea Processing Facility in Lerida

Driving north from the Mediterranean coast toward Lerida we passed through the dry farmed and mostly steep hillside orchards in this region which were planted at the traditional spacing of approximately 20 ft. x 20 ft. or wider. Some orchards are mixed with almond, carob, or filbert trees. The olive variety grown is almost exclusively the self fertile Arbequina. The trees are trained in the open vase form, pruned by hand, and harvested manually. Workers pluck the fruit onto tarps with rakes and combs. Hand-harvesting costs, as indicated by the producers, are around \$250 per ton. Some orchards on level ground on the valley floors are harvested with mechanical shakers, which saves 2/3 of the harvesting costs.

The Vea Family processing facility in Sarroca, just outside Lerida, is a very well known olive oil producer and exporter of oil to the US. They have the Lerida and Estornell brands in the marketplace. In 1992, they developed a special label and gift box commemorating the 500th anniversary of the discovery of the New World by Columbus. The oil was produced from special trees that were planted over 500 years ago. The Vea operation has been a family-owned and operated business for many generations and the present father, Avelino, is now training his son, Gerard, to eventually take over the business.

Their facility consists of a milling and bottling plant, utilizing a hammermill grinder, mixer, Sinolea selective separator, three horizontal decanters, and two centrifuges. The day we were there they were trying to extract the maximum quantity of oil from their olives by maintaining temperatures of 111.2°F for the paste in the maxilator (mixer), 116.6°F in the sinolea machine, and 129°F for the centrifuge water.

The Vea operation produces and blends several different quality levels of oils from olives in the area. Their primary variety is Arbequina, but they also purchase Farga, Morrut, Verdial, Empeltre, and Sevillena. They are very proud of the quality oils they produce, which have a local market value of \$ 4.18 per kilo, compared to the oils from the larger, high volume producers of Andalucia, which is \$ 2.20 per kilo, wholesale. [1 kilo = ~ 1 liter]

Madrid, Spain - International Olive Oil Council (IOOC)

Our tour group met with staff of the International Olive Oil Council (IOOC), Aurelio Segovia and Bernadette Pajuelo. We also met with Juan Ramon Izquierdo, Ministry of Agriculture, who is involved in the training of a taste panel in California. The IOOC is essentially the watchdog for enforcing the United Nations International Olive Oil and Table Fruit Agreement between member countries. Their main focus is regulating the legal aspects of the olive oil industry and preventing unfair competition.

The IOOC:

- Maintains expertise in oil testing.
- Promotes and defends the image of olive oil.
- Supports research for improvement of olive oil.
- Regulates label wording according to the international law.
- Produces *Olivae* magazine for industry education.

The council is in the process of proposing changes in olive oil labeling based on the location where the olives are produced rather than where the oil is bottled. They have proposed the use of terminology such as, "Made", "Bottled", and "Produced" to aid the customer in this distinction. They have also suggested that the US adopt the IOOC standards nationally as Canada has. Canada has also established enforcement procedures within their country. Another option suggested was the development of a "DO" or Denomination of Origin identification program for California.

The staff has agreed to help coordinate the development of a California Olive Oil Taste Panel that would be established and recognized by the Council. The IOOC staff was also a great resource for establishing the protocol for training and will be supplying the California Olive Oil Council with standard oil defects for testing and training.

Andalucia Olive Oil Production Region (Southwest)

The Andalucia region of Spain accounts for 60% of the nation's area under cultivation and 75% of Spain's olive oil. The region has almost 3 million acres of olives, with new plantings still going in. Ten of the largest oil mills are located in the region and together, they account for 2/3 of the country's olive oil production. The gently rolling hills of the area are almost completely covered with olive trees.

Many of the orchards have multiple trunks, which came from an old practice of planting several trees in one large hole at the time the orchard was established. If one or two died during the arid summers, there would always be one or two that survived. When all three or four grew, they were trained at an angle, leaving the appearance of an open vase-type tree. New orchards are usually planted to a single trunk and at slightly closer spacings. In this way, full yields appear sooner and a single trunk can be shaken for mechanical harvest.

Almost all of the orchards are cultivated to preserve soil moisture and treated with herbicides prior to harvest for ease of fruit collection on tarps under the trees. Erosion is a problem in rainy years since the open soil is left unprotected much of the year. Drought in 1994 -95 severely limited production and prices climbed accordingly. Heavy rains the last two years have dramatically increased production and lowered overall oil prices.

The primary variety grown in the area is Piqual, a variety with large fruit and high oil content. It is easily removed for mechanical harvest by shakers. Other varieties grown for blending are Lechin de Sevilla, Picudo, and Hojiblanca. Some growers are also planting Arbequina (12,000 acres) and other non-traditional varieties to provide enhanced blending opportunities.

World Olive Germplasm Repository - University of Cordoba

The University of Cordoba has 15 researchers working on various aspects of olive oil development. The germplasm group is measuring:

- Production (Yields)
- Oil Content (%)
- Type of Oil (Fatty Acids)
- Tree Precocity
- Tree Stature
- Resistance to Pests
- Fruit Size
- Soil – Mineral Tolerances

Since most of the world's known olive varieties are located in this one orchard, it was very interesting for us (Californians) to see what some of the fruit from our unidentified trees back home might be. We walked through the trees and saw, as well as photographed, many of the primary olive oil varieties of the world, including Cornicabra, Empeltre, Picudo, Koroneiki, Gordal de Sevilla, Manzanillo, Sevillano, Ascolano, Arbequina, Piqual, Frantoio, Leccino, Maurino, Pendolino, Aglandau, and Picholine. We also saw a few novelty varieties with interesting shapes and flavors (Zarza – Tomatillo - Zaito - Dolce di Andria).

The researchers at the Germplasm Repository have catalogued the varieties by leaf shape, pollen shape, fruit characteristics, and pit shape. They then used DNA markers to correlate the various physical differences between varieties. The pit (endocarp) is the part of the plant that is least affected by environmental conditions and one of the easiest to correlate with positive DNA identification.

Pits for variety identification can be sent to Dr. Diego Barranco Navero, University of Cordoba, Dept. of Agronomy, Avda. Menendez Pidal s/n, PO Box 3.048, 14080 – Cordoba – Spain. The pits should be cleaned of all olive flesh with a non abrasive scratch pad, placed in a plastic bag, and clearly labeled as to origin and sender.

Olive Breeding Program (New Varieties) – University of Cordoba

Several variety comparison trials across Europe and Spain were started only a few years ago to determine the varieties best suited to a particular area. Not enough data has yet been developed from these trials to have an impact on varietal renewal. Another factor about olives is that the only real source of genetic variation is through genetic mutations, the frequency of which is extremely low. Mutations are also very difficult to detect. Few breeding programs existed previously because the juvenile phase of non-fruiting for olive seedlings is 15 years or more.

Recently, it was discovered that applying fertigation and systematically shortening lateral shoots of a single leader to a height of 4 ft. Above that point, the tree is allowed to branch and vegetate freely, inducing flowering within 3 to 5 years.

A breeding program with Arbequina, Piqual, and Frantoio as initial parents was started in 1991 – 1993. These crosses provided seeds that were planted in 1993 through 1994. As these new varieties begin to bloom and fruit, they will be evaluated for all of the parameters important for economic oil production and quality. The goal is to find the perfect variety that is high yielding, easy to harvest, tolerant of many pests and soils, and produces a large quantity of very high quality oil. Some of the new seedling varieties have 30% oil content. Projections are for further widespread testing of promising varieties and their release in eight years.

Olive Culture & Processing Research Station – Jaen

The research station in Jaen was established in 1902 and dedicated to olive oil improvement. There are currently 14 major research projects, funded primarily by the national government. Some of the principle projects are:

- Genetic improvement to develop new varieties
- Oil extraction technology
- Smart Mill – Developing real time response to technical parameters
- Use of by-products
- Education – Technology transfer

At the station, we met with Dr. Marino Uceda Ojeda, one of the principle researchers in the world, and Dr. Manuel Hermoso Fernandez, both of whom are developing information about quality parameters in olive oil processing. Dr. Uceda gave a scientific background to explain many of the processes in olive oil extraction. He presented hard data to eliminate many of the myths surrounding oil processing and to solidify the reasoning and techniques for producing the greatest quantity and quality of olive oil possible from the fruit. The following is an outline of his information.

I. Quality Parameters

- A. Nutrition; health benefits of the “Mediterranean Diet”
- B. Consumer Satisfaction; preferences for regional tastes
- C. Particular Use; salad – frying - blending

II. Olive Oil Composition

- A. 98% lipids and 2% Unsaponifiable volatiles, polyphenols, pigments, aromas, & flavors
- B. Lipids consist of glycerides and fatty acids such as Palmitic, Linoleic, and Oleic. Linoleic acid increases with olive maturity, Palmitic decreases with maturity.
- C. Oil viscosity is low (thick) with low linoleic acid content.
- D. Water soluble (unsaponifiable) flavor components of oil
 1. Terpenes - 300 to 700 mg/kilo
 2. Chlorophyll - 0-10 PPM = color & antioxidant
 3. Tocopherols - vitamin E & antioxidant
 4. Esters - flavor
 5. Phenols & Polyphenols - 50 to 500 mg/kilo = flavor & antioxidant

Laboratory Measurements of Olive Oil Components and an example of the characteristics of Arbequina oil which can be used to identify this variety.

- Acidity - 0.25%
- Peroxide - 6.22 to 5.0
- K 270 - 0.1 (Absorption of various UV light wavelengths)
- Color - 2/3 to 2/5
- C 16:0 - 13.2
- C 18:1 - 72.4
- C 18:2 - 9.3 to 8.3
- Stability (120° C) - 7.75
- Polyphenols - 161 to 262 PPM

III. Factors that Influence Oil Quality

A. Variety - 45%

Comparative Polyphenol Content By Variety

<u>High</u>	<u>Medium</u>	<u>Low</u>
Picholine	Leccino	Arbequina
Koroneiki	Frantoio	Blanqueta
Empeltre		
Piqual		
Manzanillo		

B. Maturity - 25%

C. Growth conditions - 15% (water stress, disease, etc.)

D. Processing - 15%

E. Climate has very little influence on olive oil fatty acid composition (palmitic, linoleic, oleic, etc.). Polyphenol content can be 3-5 times different however in one area compared to another. This can have a dramatic effect on flavor

F. In fertilizer studies in Spain and other Mediterranean countries, there is no influence from soil nutrient content on oil quality or composition.

G. Pruning has no influence on oil composition or quality parameters.

H. In general, the polyphenol content of irrigated olives is slightly lower. Irrigation also has an influence on the polyphenol content of olives when considering extreme conditions such as olives stressed by drought and losing moisture. Olives naturally lose moisture in the maturation process.

I. The rise in oil content late in the growing season is actually a loss of moisture. The olive tree manufactures and stores oil in the fruit throughout the season but the rate of oil storage flattens out before maturity providing no real gain in oil due to late harvest.

- J. Polyphenol content decreases rapidly during the maturation process. Changes from green to purple to black skin then to black flesh are all progressive stages in polyphenol loss.

IV. Olive Harvest

- A. While olives are on the tree the acidity level is $< 0.5\%$. Changes occur after harvest.
- B. Harvest methods all vary on how much damage they do to the fruit. Hand harvest is the best, but very expensive. Mechanical harvest can be almost as good if done properly with the right equipment. The key is not to break the fruit skin in any way.
- C. Harvest date is a maze of choices between type of oil desired, long-term stability of the oil, color, and linoleic acid content. For example, with Arbequina, a one month delay in harvest can cause a four month loss in oil stability due to the drop in polyphenol content.
- D. Olives should be stored in shallow bins for transport (to prevent smashing bottom fruit) and the bins must have ventilation holes (to reduce fermentation).
- E. Ideally, olives should be processed within a few hours of harvest.

VI. Handling Fruit before Milling

- A. Fruit is classified and separated by quality. Fruit with defects is processed separately because a very small portion of bad fruit can ruin the whole batch. One liter of defective oil can ruin 1,000 liters of good oil.
- B. Olives that do not need washing are processed 'as is' because extra moisture can cause problems. Only olives that have been harvested from the soil or require removal of copper, sprays, etc. are washed.
 - 1. Washed fruit has more moisture; water is really on the exterior of fruit.
 - 2. Extractability is lower (6-7%) on washed olives if crushed in a hammer mill because an emulsion forms between the oil and water.
 - 3. Polyphenol content is lower in washed olives; there can be as high as a 49% loss in oil stability by washing olives.
 - 4. Wash water is usually dirty and has a good chance of passing flavors into the oil.
 - 5. Sensory rating for a defect is usually affected negatively with washed olives compared to non-washed olives. Oil from washed olives has:
 - a. Lower bitterness rating
 - b. Lower "Piquant" rating
 - c. Less fruity flavor
 - 6. It is important that no fruit remains stuck in the bins, hoppers, etc., at the processing plant as it can ferment, and ruin the oil.

7. Olives are stored for as short a period as possible and at cool temperatures (40 - 45° F). Temperatures above 50° F can cause problems. Wet fruit is also much more likely to ferment than dry fruit.

VI. Milling

- A. Stone mills, because of their inefficiency, have been replaced by hammer mills in almost all of Spain. The stones are also more difficult to clean, and the slow milling time can increase oxygen exposure and paste fermentation.
- B. The hammer mill is easier to clean and much faster, allowing for the deployment of a continuous flow system. Oil produced from a hammermill is generally greener since the skins are broken up more. Its disadvantages include the creation of an emulsion between the oil and water, heat that is generated in the process, and metal flavors that can be introduced into the oil. The emulsification problem is overcome by malaxation for a slightly longer period and the metal flavor problem has been generally overcome with new metal alloys that are much stronger. New stainless steel mills reduce oxidation and do not impart a metallic flavor into the oil.
- C. The size of the hammer mill mesh is changed as the season progresses and the fruit becomes riper and softer. A smaller mesh screen is needed to produce a finer paste from firm olives. This breaks the cells containing the oil better. As the fruit ripens the cells break much more easily, a larger mesh screen can be used, and a more coarse paste can be worked.

VII. Mixing of the Olive Paste (Malaxation)

- A. The paste is slowly mixed, bringing small droplets of oil in contact with each other to form larger droplets. This improves the extractability of the oil. Optimally, the malaxator is designed to assure thorough mixing, leaving no portion unmixed.
- B. Malaxation usually requires 45 min. to 1.5 hours. More than 1.5 hours has shown no benefit in extractability of the oil. The more contact between the oil and the water portion of the olive, the more the final polyphenol content of the oil is reduced.
- C. Temperature of the paste during malaxation is very important. It should be warm (80° to 86° F, which is still cold to the touch) to improve the viscosity of the oil and improve extractability.
- D. Temperatures above 86° F can cause problems such as loss of fruit flavors, increases in bitterness, and increases in astringency.
- E. Sometimes it is difficult to get good oil extraction from certain pastes and it is usually because the olives have too much moisture. The solution is to let the olives sit for a few days in a well ventilated area, raise the temperature of the paste, or add talc to absorb the excess moisture. A paste moisture content of < 45% is easily worked but a moisture content of > 50% is more difficult to extract oil.

VIII. Sinolea Separation

- A. The Sinolea machine is a selective filtration process that extracts oil from the paste with stainless steel blades. It produces excellent oil that should be kept separate from oil extracted in other processes to take advantage of its unique quality and value.
- B. No contact with pads, no pressure, and no pressing gives an advantage to quality.
- C. The equipment is complicated and requires frequent cleaning, maintenance of the stainless steel blade mechanisms, and a constant heat source to keep the paste at an even temperature. Extraction is stopped when vegetable water appears in the oil.

IX Traditional Press

- A. The traditional press uses filtration mats and pressure to separate the liquid and solid portions of the olive paste. This method requires little energy but a great deal of hand labor. Nearly all Spanish producers changed from presses to the 3-phase system of decantation in the mid 1980's.
- B. Paste that is too fine can squirt all over the walls. The solution is to make a more coarse paste, keep the center tube clear, press at a lower pressure, and allow more time for the liquid to filter through the mats.
- C. Cleanliness of the mats is extremely important. Each time the mats are used small particles of paste plug the filtration channels and can cause a loss of oil. The number one problem with the use of traditional presses is in getting fermentation defects into the oil from the mats. Mats can start to ferment if not used continuously or if not cleaned regularly. The solution is to wash the mats every day, or to use the presses continuously until harvest is finished.
- D. Experiments in Spain indicated that oil from presses had an overall higher free acidity and a lower rating in sensory analysis. Pressed oils tend to have greater flavor and higher polyphenol content. Many defects such as fermentation of mats is higher in press systems compared to continuous flow decanters.

X. Decanters, 3-phase & 2-phase

- A. Decanters are large horizontal centrifuges that separate the oil from the solids and water. It is the same process as in a decantation tank, just much more rapid. The savings in time increases the efficiency of the system, but also decreases the time the oil is in contact with the fermenting vegetation water.
- B. The decanters spin at approximately 3,000 rpm. Centrifugal force moves the heavier solid materials to the outside; a lighter water layer is formed with the lightest layer of oil on the inside. There is no exact line of separation between the three phases of solid, water, and oil so the solid phase usually has some water in it, the water has some oil in it or the oil has some water in it. In the latter case, which extracts the maximum quantity of oil, an additional vertical centrifugation is done to remove all of the vegetation water from the oil.

- C. The 3-Phase system decanter separates the paste into a relatively dry solid, vegetation water, and oil. Water is added to this system to get it to flow through the decanter. A minimum quantity of water is added to separate the solid material better and to retain water-soluble polyphenols as much as possible.
- D. The system should be run at approximately 65 to 70% of maximum capacity to get good separation of phases.
- E. Samples are taken every hour and analyzed daily to determine the status of the separation. Preferably, the solid shows an oil content of no more than 6-7% and 50% moisture while the vegetation water does not contain over 0.3% oil and 8% solids.
- F. The first 2-Phase system decanters were introduced in 1992. They function under the same principle as 3-Phase decanters except that the solid and water of vegetation exit together. No water needs to be added to the 2-Phase system.
- G. Experience with the two systems has shown that the 2-Phase system has some advantages, i.e., better retention of polyphenols because no water is added and less loss of oil if the system is operated properly. One problem with the 2-Phase system is a greater potential to lose oil when the olives are low in moisture because there is a thinner interface between the two phases during centrifugation. Another difficulty can occur because there is less visual evidence of what is happening with waste characteristics because the solid and vegetation water phases being mixed.
- H. When very clean oil (containing no water) is obtained from a 2-Phase system, it means that there is a loss of oil to the waste solids because of the limited separation area within the decanter. The solution is to extract oil with some water in it and immediately run it through a vertical centrifuge or two to clean the oil further.
- I. Water can be added to the paste just prior to entering the 2-Phase decanter if the moisture content of the olives falls below 42%.
- J. Talc (a water absorbing neutral compound) is sometimes added to the paste early in the season if the olives have an excessive moisture content.

XI. Differences between Oil Extraction Methods

	<u>Press</u>	<u>3-Phase</u>	<u>2-Phase</u>
Solid waste K/ton olives	330	500	800
Waste moisture %	25	48	55
Waste water K/ton olives	600	1,200	250
Veg. water moisture %	94	90	99
BOD PPM of water	100,000	80,000	10,000
Acidity %	0.89	0.65	-
Peroxide	6.5	7.9	-
Polyphenol PPM	203	164	200
Fermentation	0.75	0.00	0.00
K – 232	1.86	2.06	-
Bitterness	1.4	0.5	-

The 2-phase system produces the greatest weight of solid waste because it has the highest moisture content. It also produces the least amount of wastewater with the lowest Biological Oxygen Demand (BOD). The polyphenol content is lowest in the 3-phase system because of the addition of water.

XII. Vertical Centrifuge

- A. Vertical centrifuges spin at two times the velocity of a decanter and provide four times the separation force for the solid, water, and oil phases. They provide either clean oil (oil without vegetation water) or clean water (no oil), but not both.
- B. Ideally, the centrifuges are opened every hour to clean and remove solids that accumulate.
- C. Fresh warm water is added to “clean” the oil, creating a greater interface area between the phases. Many processors use two centrifuges, one for the “wet” oil from the decanter and a second one to separate the oil from the wastewater of the first centrifuge. Added water is only 2-4°F warmer than the water/oil mixture to be separated.

XIII. Sensory Evaluation of Oils

- A. Human sensory evaluation is much more accurate (100 times) for olive oil than laboratory equipment. Aroma and taste are very complex and can not be determined in the laboratory. The tongue can also detect texture differences difficult to measure analytically.
- B. The “typical” varietal character associated with Piqual is a combination of variety and processing. It is not always present and is not necessarily a characteristic of the fruit if processed under excellent conditions and immediately after harvest.
- C. Single varietal oils are not as good as blended oils since not all varieties by themselves possess a balance of fragrance, soft mouth appeal, and excellent flavor. The blend offers the opportunity to mask astringency, add longevity to a low polyphenol oil, and create depth.

XIV. Top Ten Factors in Producing Quality Olive Oil

1. ***The Olive Should Be Treated as a Fruit*** – The delicate nature of a ripe fruit needs to be protected from pressure, temperature, and abrasion. Breakdown of the fruit begins the fermentation and oxidation process creating defective oils. Affirmation of this premise is essential in producing quality oil.
2. ***Control Diseases and Pests*** - Any pest that directly attacks the fruit must be controlled to prevent fruit decay.

3. ***Harvest and Transport Fruit With Care & Separate Ground Fruit*** – Do not compromise the integrity of the fruit. Limit the depth of containers to reduce pressure on the fruit. Ground fruit is second class fruit and should be kept separate from tree fruit.
4. ***Classify, Separate, & Process Different Classes of Fruit Separately*** - It is well known that different fruit qualities will produce different qualities of oil. Olive fruit should be separated at the processing facility by ground and tree fruit as well as variety, fruit condition, ripeness, or other sanitary condition. Give priority to the best fruit.
5. ***Do Not Store the Fruit*** – Prolonged storage or slow working of the fruit is contrary to the production of quality oil. Oxidation and fermentation occurs in the stored fruit, which can lead to defects and off flavors in the oil.
6. ***Process the Olives Quickly and at a Moderate Temperature*** – Quality oil comes from fruit that was worked at temperatures below 86°F. This is important for protection of the aromas and reduction of oxidation. Poor quality fruit worked at higher temperatures can actually reduce certain undesirable characteristics.
7. ***Sell Several Grades of Oil*** – There should be a whole line of oils offered for the consumer at different prices all classified by quality parameters reflecting the source of olives and oils produced.
8. ***Store the Oil with Care*** – Good storage is extremely important and will permit the proper aging and conservation of desirable flavor components. It is fundamental to store oil in clean stainless steel at temperatures below 65°F.
9. ***Keep Everything Clean*** – The failure to maintain cleanliness is a major factor in reducing oil quality since olive oil can so easily become contaminated. Odors from the fermentation of waste products can get into oils in the processing plant. Clean machinery, floors, and walls will prevent rancid odors that can also contaminate the oil. Cleanliness is especially important in the olive washing machines where the wash-water needs to be kept clean at all times.
10. ***Be an Olive Oil Expert*** – Know just what it takes to produce, harvest, store, and process olives of high quality. Become familiar with the sensory evaluation of olive oil and be able to recognize the major defects that can appear in olive oil. Know your customers, educate them about the different classes of olive oil, and help them enjoy this noble food.

Nuñez de Prado (Baena)

The Nuñez de Prado brand is recognized in the United States as superior quality Spanish oil. Their label states that they are producing oil from organically grown olives, using traditional pressing methods, and harvesting and handling the fruit by hand to achieve an elevated quality.

Their facility in the small town of Baena is a very beautiful setting. The operation is in its seventh generation and is currently managed by four brothers. The farm consists of 1,903 acres located in the hills of the region.

The four brothers are master marketers who have established a show facility filled with antique olive oil production artifacts, a viewing area overlooking the press house, and an interesting display of bonsai olive trees. Portions of the building are a museum to the past with the old clay jars used for oil storage and a small bottling line for public demonstration of how the oil is bottled, labeled, and packed.

While we watched, men in white laboratory jackets busily packaged the oil in handsome square bottles topped with red waxed corks. They even operate the old press house for demonstration of the Spanish styled three stone crushing wheels and a unique gravity separation system that was the precursor to the Sinolea selective filtration system called the Acapulco system.

They took us into the fields to illustrate how the olives were harvested in the past by hand even though it was obvious that they use mechanical tree shakers and other modern conventional farming methods in the bulk of their operations. Their trees are planted on a diamond pattern 23 x 23 x 23 ft. and trained to the open vase system. Their yields average around 2.7 tons per acre with great fluctuations depending on the rainfall. The main varieties are Piqual, Picudo, and Hojiblanca, which makes up their blend.

The four siblings presented us with an oil produced last year as their traditional blend and a new oil recently produced this season. Last year's oil was a balanced blend with the characteristic Piqual flavor while the new oil was more typical of a fresh, green, piquant, light oil.

Further Reading about Spanish Olive Oil Production

- Tous J. M. & Aroca A. R. Variedades del Olivo, IRTA

This book describes the olive industry in detail and varieties produced in the Cataluña Region. For sale through the Institute of Ag Research & Technology (IRTA) (Spanish only)

- Barranco D. et al. El Cultivo del Olivo

The worlds' greatest olive oil researchers have cooperated to write the second edition of the European "bible" of olive oil production, just published in November 1997. It contains chapters on all aspects of olive culture and processing. (Spanish only)

- World Olive Encyclopaedia by the International Olive Oil Council

This comprehensive encyclopaedia, released in English in 1996, contains chapters on the history and evolution of the olive, the biology and physiology of the olive, genetics, production techniques, pest control, oil processing, table olive processing, economics, marketing, legislation, and the international agreement on table olives and olive oil.

Available from: Corti Brothers, 5810 Fulsome Blvd., Sacramento, CA 95819

- Olivae Magazine; Special Issue on Spain, December 1995. International Olive Oil Council.

*Available in English. Subscribe to: The Intl. Olive Oil Council
Principe de Vergara, 154
28002 Madrid, Spain*

Relating the Tour of Spain to Olive Oil Production in California

By Bill Jaeger - December, 1997

Impressions of a Napa Valley Vintner who experienced the development of the fine wine industry in the 1960s, '70s, and '80s, and sees great similarities in the development of boutique extra virgin olive oils in the 1990s. Myths we live by, as in the wine world, here are some myths which must be overcome.

Myths

- Myth #1: There is *only* one perfect olive variety that must be used to make the *best* oil.
- Myth #2: The *best* oil always comes from a single olive variety, rather than a blend.
- Myth #3: The old fashioned stone mill & press system is the *only* way to make the *best* oils.
- Myth #4: Great olive oils are those that are "hand-made".
- Myth #5: Labor availability for olive harvesting is not a problem.
- Myth #6: There is no limit to what people will pay for the *best* olive oils.
- Myth #7: Produce the *best* extra virgin olive oil and people will beat a path to your door.
- Myth #8: Consumers will overlook minor product flaws.
- Myth #9: Olive oil will keep indefinitely in your cupboard.
- Myth #10: Traditional spacing of trees in olive orchards makes for better oils.

Discussion

The Product

The *best* extra virgin olive oil is the one concocted by its producer as his or her notion of the *ultimate* condiment oil. It will be a blend of oils from those olive varieties that produce the various components, viscosity, flavor, and nuances that make an oil most attractive. The varieties to be selected are not confined to those now known to exist, as Luther Burbank's legacy survives, and new hybrids are reaching the market even now. The cross-breeders are not looking for the perfect variety; rather they are looking for varieties, each of which can add an important component to the *ultimate* oil. The components of each producer's *ultimate* oil should probably be kept a trade secret.

If the olive oil producer is also a grower, it will not be just the "mouth feel" or flavor that determines the varieties used; yields, in tons of olives per acre, and gallons of oil per ton, and the influence of added irrigation water, in addition to the ease of harvesting, the hardiness of the trees (frost and disease), etc. will determine what varieties are used.

Processing

The hammermill does produce oil of *the highest quality* from whatever olives are processed and, according to tests, the University of Cordoba people say the 2-phase Perialisi decanter is the best equipment to use for oil extraction. (To assure the best quality, olives must be processed within two hours of picking.)

Standards

Worldwide olive oil standards are already established by the IOOC. There is no point and unbelievable difficulty in trying to change those standards. Local standards could be made higher, but why? Imported olive oils, the competition for local oils, will never have to meet higher standards than those imposed by IOOC, but *all* oils should have to meet IOOC standards.

Harvest Labor

Because the farm labor available at harvest time is headed for serious shortages in all areas of the world that produce olives, mechanical harvesting of fruit will be essential. Future olive orchards will have to be planted to accommodate the techniques of these yet-to-be-invented harvesting machines.

Just-in-Time Bottling

The matching of bottling with sales and delivery to customers in the super-efficient computer world of today means that top grade olive oil should be kept in bulk tanks under ideal storage conditions, (it is more stable in bulk than in bottles) until a batch is being ordered. The processor should bottle it for "just-in-time" delivery, in climate controlled delivery vehicles that avoid leaving it on a dock in Minnesota in January.

Processors will need to provide on-site bulk storage for their oil producing customers. Producers, serious about providing commercial supplies of their oil on a year round basis to retailers, restaurants and other customers who don't have the discipline to set aside annual allotments for monthly requirements, will find that they can better hold onto good accounts by spreading the bottling and deliveries over the year

New Olive Orchards

Densely planted olive orchards, looking more like hedge-rows, with as many as 800 – 900 trees per acre are the latest thing in trying to make olives capable of mechanical harvesting and trying to get an economic crop as early as the second year following the planting. Dwarf varieties and rootstocks are being bred with the hope they can prevent the olive wood from becoming too much for the harvester. Removing every other tree after 6 – 10 years may be another alternative, especially if you can sell those trees to landscapers.

Spain as a Valuable Information Source

With extensive research taking place in Spain, the world's largest olive producer, and especially at the University of Cordoba, Spain is an excellent candidate for obtaining information, plant materials, harvest equipment, and processing equipment.

California as an Olive Producer

In the USA, Arizona and Texas are the only states other than California that can even produce olives. With the olive industry already so well developed in the Mediterranean countries of Europe, Africa, and the Near-East and already supplying the whole world, what would cause Californians to want to start a competing industry? California does have the land, at reasonable prices, and the climate; it has no worse a labor supply problem, and it can easily develop the know-how and its own varieties.

Nevertheless, it's still a start-up industry, where today's international olive oil prices, *below* the break-even point for most local producers, are highly subsidized by the European Union, and there is next to no chance that we could ever develop an export market for the product. The *only* reason Californians should consider starting extra virgin olive oil production is that the USA market is so underdeveloped and there is a great potential here with this "heart-smart" product. Furthermore, Americans are more apt to buy locally produced olive oil in preference to imports *if the price is reasonably competitive.*

North Bay vs. Central Valley

North Bay flat land is very expensive, and flat land makes for easier mechanical harvesting. Although the *new* olive oil industry in California got its start in the North Bay, not many large scale olive oil producers will locate there because of high costs and how remote new olive oil presses would be from large scale olive orchards that will be planted in the flat Central Valley when olive oil turns profitable.

The culture, the experienced people, the agricultural economy, and the miles-on-miles of cheap flat land are all in place and available now in the Central Valley. Unlike the *fine* wine business, where the coastal valleys crops *gain an advantage* from their cooler nights over the warmer Central Valley, it is likely that the warmer Central Valley will have an agricultural advantage over the cooler coastal valleys when it comes to olives. Without this agricultural advantage, the Sonoma – Napa head start in premium olive oil production is not apt to result in wide scale economic success, but will be watched by those Central Valley growers waiting for the right moment to enter the field. That right moment for them will be when circumstances bring an end to the European olive oil subsidies.

Marketing

Nothing sells itself. Possibly, the most difficult thing to predict is the future of retailing in America. How people will decide what olive oil to buy and where they will buy it, is anyone's guess. No one has the answers. Of course, many people will continue to buy, just as they have, but the Internet may lead to better profitable sales than being in the catalog of the best food stores. For those in the olive oil production business, it is never too early to start developing marketing strategies. Eventually marketing and selling will consume the lion's share of the time involved in the business.

TOURING SPAIN'S OLIVE COUNTRY

By Jeff Allen

Here it is, almost the 21st century, and the most trend-setting state in the union is finally catching on to the value of the ancient olive tree. As part of a group from this state, I got a first-hand look at how Spain makes the most of its olive industry.

My interest in participating in the Spanish olive tour was spurred by my own olive-pressing experience. I entered the 1997-harvest season with four pickers (myself included) and a grand idea of filling two large bins with olives for pressing. I hoped to produce about 200 bottles of my own oil to last all year and to give as gifts to lots of friends, clients, and family members. By nightfall, after nine exhausting hours of picking, we had only one-half of one of the two bins filled, resulting in 39 bottles of oil on the wall...I knew I had a lot to learn.

So the following week I joined the California Olive Oil Council's tour through Spain, excellently guided by Paul Vossen and Darrell Corti. We had a wonderful, diverse group and a lot of fun and laughs. I would call it a seven-day crash course on every aspect of the industry, including: science and research; propagation; growing; pruning; irrigation; fertilization; picking; hauling; storage; pressing; processing; marketing; pricing; and even politics. There was lots of information to digest and bring home; of course, this digestion had to be accomplished while attempting to digest the largest, richest meals I have ever consistently consumed in a one-week period. Our Spanish hosts were incredible!

So what did I learn? Here are some highlights:

Science: At the laboratories, we saw the in-depth research done on new and different olive varieties and various experiments with cross-pollination. We also visited a demonstration farm that featured 300 varieties from different countries.

Propagation: We toured vast, brand new greenhouses where we often saw one type of olive propagated in quantities of 500,000 to a million a year. These cuttings are then sent around the world, with the stock in the greenhouses being rotated two to three times a year.

One thing that impressed me was that the olive cuttings are moved from liner size directly to seven or fifteen gallon containers. Being in the nursery business, I am used to moving the plants up in scale. But I should have known the vigorous olives could move up much more quickly!

Pruning: We saw as many styles as ranches, from hacking off the edges of the trees to cutting the trees back completely. There are extensive test gardens being created where the olives are being grown in hedges. In this way, all of the pruning and harvesting can be done mechanically.

Pesticide Use: Another noticeable element of olive growing in Spain is the extensive use of chemical warfare, more than we'll ever see here in California. The biggest problems seem to be flying pests (olive fly) and verticillium wilt.

Irrigation: Again, many and varied approaches: some ranchers only water the trees the first season, others used continuous watering systems.

Harvesting: The range included by hand, hand rakes, pneumatic combs, shaking, and rollers and sheets under the trees to catch the fallen olives. As I mentioned above, there is some experimentation with all mechanical harvesting as well.

Hauling: Our group saw trucks containing sandbag-size sacks filled with olives and other trucks simply filled with loose olives (watch out for those potholes!). The trucks were headed for the processing plant, where cooperative farmers make use of the facilities.

Pressing and Processing: Each plant we visited had their own style, and of course, their style was the best style! We saw the plants use mats, three granite cone-shaped wheels or two granite wheels for crushing to fully automated hammermills and humming decanters.

I was amazed to hear how much of the Spanish olive harvest is sold to Italy for processing and repackaging. Much of the Italian olive oil available in the US actually contains olives from Spain.

Storage: Driving through the countryside was reminiscent of our wine country, with large stainless steel containers on the ranches, but filled with oil, not wine.

Marketing: This area was very similar to what we see in California's wine country. There is a wide difference in styles, all appealing to the individual's palate and personal choice. My observation was that people tended to buy by region.

Pricing: There are regulations as to grading of olive oils that seem to dictate much of the pricing.

Last, but not least, politics: We offered to join the International Olive Oil Council as the State of California and were met with the kind of hemming and hawing you see present in most political discussions. Politics are alive and well in the Spanish olive oil industry, just as they are here in the US.

My two most lasting impressions: One was of skipping one of those wonderful meals (in a castle!) and hiking up a rocky, quarry-like hillside to the fog-shrouded top, coming over the crest and looking down upon acres and acres of olive trees, growing down in the lush valleys and back up the craggy hillsides. The trees just go on and on for miles!

The other was of the absolutely first-class treatment we were given by one particular olive company. We were greeted with a sumptuous meal (of course) in beautiful surroundings, treated to a premium olive oil tasting, then taken by Range Rover out to the grounds where pristine fields of olives were being harvested by neat companies of pickers. Clearly marketing is not a new concept in Spain!

Since returning from this tour, I feel very enthusiastic about the future of the olive industry in California, and can't wait to be a part of it. Sonoma County in particular seems a perfect setting, because consumers in this area are already oriented to buying from a regional market and has shown strong support for local farmers. The knowledge I gained on this tour has been invaluable. I look forward to the next Paul Vossen excursion.

Jeff Allen is the owner of Allen Landscaping, where he incorporates the use of olive trees into his landscape designs. He is also the owner of Muchas Grasses Nursery, a wholesale nursery specializing in ornamental grasses and Phormiums, and soon, olive trees.