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Establish Protocols and Guidelines for Table Olive Processing in Australia

A report for the Rural Industries Research and Development Corporation

by Stanley George Kailis and David Harris

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Foreword

The Australian table olive industry/trade currently has no nationally accepted guidelines for ensuring the quality and safety of processed table olives. The aim of the project was to scope the Australian table olive industry, compile quality and safety data by laboratory investigation and from the literature, and prepare a manual for olive growers and processors. This report covers these objectives from both national and international viewpoints and the manual is presented as a second publication from this project.

Table olives are either produced domestically or imported from overseas. The Australian and international food industries have recognised the importance of quality assurance and in particular the implementation of quality systems such as ISO 9000 series and SQF 2000 and HACCP (Hazard Analysis Critical Control Point) in processing foods. As olives are a fermented food product, it is essential that stakeholders, such as growers and processors, be provided with the necessary quality and safety information.

The current report covers the following areas.

• Historical and international table olive perspectives
• Australian table olive perspectives
• Production of raw olives
• Establishment of table olive enterprises
• Quality and safety aspects of table olives

Australia has the ideal conditions for growing and processing table olives. The industry is in its infancy and most producers are at the boutique/small-scale level. In a climate where the majority of table olives eaten by Australians are imported, real opportunities exist for a domestic table olive industry. Attention to quality and safety will ensure that Australian table olive producers are in a position to tackle and make inroads into the international export market.

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Simon Hearn
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Olive Industry

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Executive Summary

With the escalating activities of the Australian Olive Industry there is demand for detailed information on processing table olives particularly with reference to safety. Such information is included in this report and makes reference to specifications, processing procedures and the importance of good manufacturing procedures and good hygienic procedures in the processing of table olives.

Elements of the project are summarised as follows:
• Literature search
• Data collection
• Situation analysis of Australian table olive industry stakeholders
• Establishment of chemical, physical, microbiological and testing methodologies
• Analytical testing of olives
• Information on olive processing
• The Australian Table Olive Production Manual©
• Implementation of table olive processing education at Tertiary. Technical and further education institutions.

As a result of the above, preparing a meaningful report for the Australian olive industry, the investigators have focussed the report along the following lines which includes research and literature data and material at points relevant to the discussion of specific topics. Areas of research are indicated in the body of the text.

Chapter 1. *Historical and international table olive perspectives*
Chapter 2. *Australian table olive perspectives*
Chapter 3. *Production of raw olives*
Chapter 4. *Establishment of table olive enterprises*
Chapter 5. *Quality and safety aspects of table olives*
Chapter 6. *Methods for testing and assessing table olives*

The Australian Table Olive Production Manual is a complementary publication to this report and provides the practical application of the material in this report and presented in a manner that can be used by table olive growers and processors as well as those in education institutions.

Chapter 1. This chapter reviews briefly the early history of the olive with reference to table olives and current aspects of the international table olive trade. Here Australian olive growers/processors need to understand how the Australian table olive industry will articulate within the international market place particularly with respect to exportation of table olive products. Australia is a significant importer of table olives particularly from Spain and Greece so opportunities exist for expanding the Australian table olive industry.

Chapter 2. This chapter reviews current perspectives on table olives in Australia. Clearly Australians on a per capita basis eat small quantities of olives - approximately 0.9kg/person/year. Olive consumption is increasing, but more public education is required to promote consumption. Australian table olive production is increasing, but annual production levels are low compared to imported table olive products. Many table olive varieties are available from Australian olive nurseries, many of which were introduced in the 19th and 20th centuries. Principle varieties are Manzanilla, Kalamata, Sevillana and Jumbo Kalamata. New varieties are being introduced. The nature of table olive products available for sale in Australia are whole, stuffed and marinated olives with herbs and spices sold loose or in consumer packs. Supermarkets, continental delicatessens and specialty food shops are the main outlets. Very few Australian processed table olives are on the shelves of all these outlets. National supermarkets sell a substantial range of loose and packaged table olive products. Australian table olive producers except for one processor in South Australia are at the boutique or small-scale level.

Chapter 3. Table olive quality begins at the planning stage. Growers need to select varieties that meet consumers needs. Consumers like both black and green table olives that medium to large in size with good texture and flavour. Raw olives need to be produced under conditions which maximise these attributes. Authentic planting stock should be used to establish the olive orchard at spacing distances suitable for manual harvesting. Olive trees should be trained so that harvesting does not damage the fruit. Productive trees should receive sufficient irrigation and nutrition to ensure healthy trees and olives. Where chemicals are used in the management of the olive orchard only approved products should be used and withholding periods observed. Olives should be harvested at the maturation stage required for the method/style. Harvested olives should be stored and transported away from heat and sunlight in a clean, hygienic manner. Physical and chemical data on a number of different olive varieties indicate that depression pressure values fall as the olive fruit matures. Only small differences were observed between the varieties tested. Proximate analysis data, on moisture, fat, protein and carbohydrate is also presented as is information on the quality of oil. Like olive oil table olives are a source of unsaturated fatty acids. The levels of soluble sugars in olive flesh, important for fermentation during table olive processing are also presented.

Chapter 4. Here the requirements of establishing a table processing operation are discussed. The initial planning of the operation, the types of products to be made and the facilities required need to be considered in the context of health and safety. Processing equipment needs to be made of food grade materials, easily cleaned and safe to operate. Processing begins by accepting quality olives and passing them through preprocessing stages such as storage, washing, sorting and grading. Then the olives are processed by soaking in water or brine, treated with or without lye. Most table olive processing includes fermentation in brine that requires careful control to prevent spoilage and reduce the risk of physical, chemical or microbiological, contamination. After processing the olives are stored or packed in brines with controlled salt and pH levels. Olives are also processed by drying with salt or heat. Here the olives are not packed in brine. Once processed olives can undergo secondary processing where they are destoned, stuffed with fillings or packed in marinades of herbs and spices. Processed olives can also be included in antipasti or crushed to make olive pastes or tapenades.

Chapter 5. Extensive chemical, physical, microbiological and organoleptic data is presented on processed table olives. Physical data refers to the firmness of olives. Chemical data provides base line micro and macro nutrient levels for olives as a foodstuff. Proximate analysis of processed olives provides the necessary data that is required for labeling for nutritional and statutory purposes. Microbiological testing indicated that all olives tested in the study were free of harmful food poisoning organisms. Also limits for both fermentative and harmful organisms for table olive safety are presented. Systematic organoleptic evaluation of olives indicated that olive wrinkling and softening were major problems. The management of olive spoilage is also addressed.

Chapter 6. Information on the testing procedures used in the experimental aspects of the project is reported here. This includes physical, chemical, microbiological and organoleptic evaluations of brines and/or olive flesh. Tests include fats, mineral and sugars in olive flesh as well as salt levels in brines.

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1. Historical and International Table Olive Perspectives

1.1 Introduction

Today the Australian olive industry, which involves both growing olives and processing them into foodstuffs, is vibrant and dynamic. Two sectors are evolving - table olive production and olive oil production. Drawing upon the rich history of the olive spanning thousands of years and current international research, those in the industry have the common objective to produce high quality olive products using the latest technologies. The development of the Australian table olive industry must be considered in a national and international context to reach its economic potential. The success of the Australian table olive industry will depend on capturing a significant proportion of the domestic market, mostly served by imported products, and the development of international markets.

Table olives are prepared from the fresh fruit of the European olive *Olea europaea*. Fresh olives, picked when green-ripe, turning colour or black-ripe depending on the processing style to be used, are inedible due to the presence of the extremely bitter glucoside, oleuropein. Processing fresh olives to reduce bitterness and make them edible can be done by either soaking them in water, brine or dilute alkali, or drying, by salting or heating. A characteristic of processed table olives, favoured by consumers, is their residual bitter taste.

Currently most Australian table olive enterprises are at the boutique to small-scale levels. A small number of these are processing or planning to process 100 Tonnes/year or more with one major processor having a capacity of 750Tonnes. Capturing a significant segment of the national supermarket table olive sales has to date proved difficult. So, many Australian table olive products are sold as specialty lines through food shops, wineries, gourmet centres and delicatessens. Often Australian produced table olives are purchased within the producing region eg McClaren Vale (South Australia), Hunter Valley (NSW), Margaret River (Western Australia), Rutherglen (Victoria), Kingaroy (Queensland) and Launceston (Tasmania). Table olives from a small number of processors from South Australia and New South Wales have penetrated state and national markets.

Table olives are popular with Australians, however, most table olives that Australians eat are imported from Spain and Greece. These include; Spanish style green; black Californian/Spanish style; Greek style green and black olives; and Kalamata style black olives. Table olive consumption by Australians is approximately 0.9kg per person per year and increasing. Those Australians with Mediterranean or Middle Eastern links are eating substantially more. Table olives either whole, cracked, stuffed, marinated or incorporated into pastes, are eaten with bread and cheese, with salads and cold collations and cooked foods.

1.2 Historical Aspects of the Table Olives

The domesticated olive tree is of very ancient origin probably arising at the dawn of agriculture. It is thought to have originated in the Middle East spreading south and west to the rest of the Mediterranean basin through movement and trading activities of Phoenicians and ancient Greeks. Historically and to the present time olives have been culturally and economically significant for the Mediterranean and Middle Eastern regions. Although the olive is not indigenous outside these regions, it has been introduced in countries with a suitable growing environment eg Mediterranean-like climate. The olive was taken to countries such as south and north America by Spanish missionaries and later by immigrants from the Mediterranean region. Olive trees are now also growing in Australia, South Africa, New Zealand, China, India and Japan. In parts of Asia and northeastern Australia the boundaries for commercial olive growing are being tested.

The domestic olive is known as *Olea europaea* subsp. *Europaea*. It is made up of a group of varieties and semi-wild forms that have evolved by hybridisation and selection from several wild olive species. The European olive has been cultivated around the eastern Mediterranean and Middle East since ancient times. Compared to many other species such as grape and citrus, very little selective breeding has been done on olives. Over 2000 named varieties are recorded but these are generally clones selected from spontaneous, uncontrolled crosses or are at most, a few generations removed from 'wild' forms. Scientific breeding programs are underway in several centres including Australia. Such research could deliver varieties with improved fruit yield and/or fruit quality disease resistance.

For thousands of years olives have been an important foodstuff, possibly essential, for inhabitants living around the Mediterranean basin and in the Middle East. Processing methods, ie debittering the olive, used by these groups probably evolved by trial and error. When the first olive was eaten or processed is unclear. Very ripe fruit, of some olive varieties, although still bitter, were probably eaten directly off the tree. The process of debittering olives could have developed by drying the fruit in the sun or by soaking in water. Soaking in water as an operation to make food more palatable was well understood by hunter and gatherer communities. As most olives in the old-world grew close to the sea, especially the Mediterranean, the possible use of sea-water as a soaking medium is understandable. Through trial and error and with the development of agrarian communities, table olive processing became well established at the domestic level using traditional recipes that were handed from one family to another and down the generations with or without modifications. Quality was unpredictable because of little understanding of the fermentation process, lack of hygienic practice and absence of control measures resulting in poor quality products of low economic value. In the last 100 years table olive processing has moved from the village to well managed large-scale production centres particularly in southern Europe, northern Africa, Middle Eastern Countries and the United States of America (USA).

1.3 Historical Aspects of Australian Table Olives

Australia is now emerging as a significant table olive producing country. The Australian olive industry has its roots in the early days of colonisation where settlers planted the first olive trees some 200 years ago. Australian olive growing had its beginnings in New South Wales where George Suttor, a market gardener, brought in and planted the first olive tree in 1800. The first commercial olive growing endeavour is credited to another pioneer John MacArthur. Over time, further plantings were made in other parts of Australia. Early olive plantings were made in Western Australia, probably from Spain in 1831 and South Australia in 1836. Five varieties were imported from Marseilles by the South Australian Company in 1844 and later, planting material was brought in from Portugal, Spain, Provence and northern Italy. These were promoted for oil production rather than for table olives and whole fruit was often relegated to animal feed. Most of the groves were not maintained because colonists and early settlers, predominantly from greater Britain and Ireland, were not accustomed to eating olives or olive oil. In fact the latter was seen as a medicine. Several groves were actively worked providing limited quantities of table olives for eating, and olive oil for medicinal purpose. More recent groves were planted at Robinvale, Horsham, Dimboola and Hopetoun in Victoria as well as at Bordertown and Palmer in South Australia. One of the oldest consistently worked olive groves in Australia, was planted by the monks at the Benedictine Mission at New Norcia, Western Australia in 1856.

An olive grove dedicated to table olives, *Kasbah Olives* was established by Francois Solente near Loxton (South Australia). Green olives predominantly of the Verdale variety were produced for the fresh fruit market and commercial processing. Loxton became a centre for table processing and today has the largest processing plant in Australia. Unfortunately the Solente grove was recently removed because of lack of commercial interest in the Verdale variety. The demise of this variety is evident as another significantly sized grove in South Australia is now being top grafted to produce Kalamata variety olives.

Renewed interest in olives and olive oil in Australia occurred after World War II, late 1940s to 1960s, with the influx of southern European migrants and more recently from The Middle East. These new settlers, who consumed table olives as a regular foodstuff, had little impact on the local industry, as they preferred to produce their own table olives, using traditional methods. Such immigrants however have had profound effects on much of the Australian lifestyle including eating habits. Traditional foods in Australia, emphasising meats and dairy products, have now in part been replaced by Mediterranean and Middle Eastern Foods. Over the past 10 years as Australians have recognised the Mediterranean Cuisine, the consumption of table olives and olive oil has increased markedly.

1.4 Australian Table Olive Activities

Australian table olive activities involve both locally produced as well as importations. Most imported olives are; of the Spanish green and black (Californian/Spanish) styles where lye has been used during processing; Greek Style green and black olives; and Kalamata style black olives. Specialty olives include Green olives in marinade (Australia), Picholine (France), Bella de Cerignola (Italy), Ligurian (Italy) and Arbequina (Spain).

In general Australian boutique and small-scale producers of table olives favour natural processing. Here olive varieties such as Manzanilla, Sevillana, Jumbo Kalamata and Verdale are processed as green olives in brine, whereas naturally black ripe olives of the Kalamata variety are processed in brine or by the traditional water soaking method. Larger scale table olive processors produce similar products except that some treat green olives with lye, which result in Sevillian type olives. Although lye treatments speed up processing there are significant drawbacks such as environmental issues and a highly competitive international market.

Australian table olive products are mostly marketed by processors to the food services industry in bulk, or through specialty food outlets. The olive industry, like the wine industry, has adopted tourism as a major strategy in marketing table olive products with other foods in regional Australia. Uptake of Australian table olives by national supermarkets has been slow due to high prices, low levels of availability, and a lack of products such as pitted and stuffed olives and existing buying habits. It is expected that existing imports will persist because of traditional trading patterns of importers, wholesalers, retailers and consumers. Competition from other Southern Hemisphere producers is another threat.

Currently most olives come from South Australia and Victoria. This will change when recently planted orchards in Western Australia, New South Wales and Queensland reach commercial production levels. A number of olive enterprises are making substantial investment in table olive production facilities.

1.5 International Perspectives

Although there are innumerable types of table olives available to consumer, cultural practices strongly influence the popularity of particular preparations. Amongst Spanish consumers green Sevillian style olives are popular, whereas in Greece consumers prefer naturally black ripe olives in brine or salt dried olives. With Italian consumers, sun dried and heat dried olives are popular, as are those produced by traditional methods eg Ligurian, Castelvetrano and Ferrandina olives. Californian style black olives, produced by chemically treating of green-ripe olives with lye are the principle table olive produced in the USA. Generally around the eastern Mediterranean and the Middle East table olives are processed by fermentation in brine. There is renewed interest in this processing method as it is considered more natural than current industrial methods, which use lye.

1.6 International Table Olive Trade

World fresh olive production is between 13-18 Million Tonnes/year depending on the season. About 10% of these olives are processed into table olives. It is likely that as the Australian olive industry matures, at least a similar proportion of the annual Australian olive crop will be processed into table olives. If Australia follows similar trends in California and South Africa the proportion of fresh olives processed as table olives could increase markedly.

Table 1.1. Countries with significant interests in international table olive trade

Major Producing Countries	Major Importing Countries	Major Consuming Countries	Major Exporting Countries	Major Consumers per Person
EC •Spain •Italy •Greece	USA	EC • Spain • Italy • France	EC •Spain •Greece	Cyprus
	EC • France • Germany			Syria
				Jordan
			Morocco	Spain
Syria	Brazil		Turkey	Israel
USA	Canada	USA	Argentina	Palestine
Morocco	Russia	Turkey		Lebanon
Turkey	Romania	Syria		Greece
Egypt		Egypt		Italy
Algeria	Australia	Brazil		
Argentina		Algeria		
		Jordan		

Table Olive Production: World production of table olives has increased nearly 50% based on the 1990/1 season. Most production occurs in countries around the Mediterranean basin or in the Middle East (Table 1.1). The 89th session of the IOOC confirmed the expansion of the world table olive sector. World table olive production for the 2002/03 season reached a record level of 1,748,000Tonnes, a greater than 18% increase compared to the 2001/02 season and more than 30% compared to the average of the four production years 1998/99 to 2001/02. For the same period the European community (EC), Turkey and Syria produced over 65% of the worlds' table olives with the USA, Morocco, Egypt, Algeria and Argentina significant producers. Production for the 2003/04 season is estimated to fall to 1,457,500Tonnes.

Table 1.2. World and Australian table olive statistics in Tonnes x 1000

Season	Production	Consumption	Exports	Imports
World				
1990/91- 1993/94	953	971	208	
1998/99 - 2001/02	1342	1278	365	350
2002/03	1748	1657	506	426.5
2003/04 Forecasted	1457	1582	481	441.5
Australia				
2002/03	4	17	Negligible	13
2003/04 Forecasted	4.5	17.5	Negligible	13

Table Olive Consumption: The IOOC notes that world consumption of table olives has been growing steadily in recent years. World table olive consumption in 2002/03 season increased 30% compared to the reference years 1998/99 to 2001/02 to 1,657,000Tonnes of which nearly half was consumed by the European Community (33%) and USA (>12%). This is in contrast to olive oil where these two groups account for nearly 80% of world consumption. On average the European Community, USA, Turkey and Syria are the top consumers of table olives. On a per capita basis those persons living close to the

Middle East consume the most olives. There is a delicate balance between table olive production and consumption. Any shortfall in world table olive consumption and production is generally met from olives carried over from the previous season.

Table Olive Exportation: Over 30% of the world table olive production, estimated at 481,000Tonnes for the 2003/04 season, is exported mainly by the European Community, Morocco, Turkey and Argentina accounting for around 90%.

Table Olive Importation: Major table olive importing countries accounting for 65% of the world average are USA, the European Community, Brazil and Canada. Australia accounts for 3% of world table olive imports. As most olives imported into Australia are from Spain, Greece and Italy, such imports account for 5 to 6% of the European Community table olive exports. Increases in Australian table olive production, consumption and export will therefore impact more on the export sector of the world table olive trade than world production.

2. Australian Table Olive Perspectives

2.1 Introduction

Australia is now emerging as a significant table olive producing country. Australia has the physical resources, horticultural infrastructure and food processing expertise to support a modern table olive industry. To date, only relatively small amounts of Australian table olive products have been available and these for predominantly domestic markets. Sustained growth of the table olive industry will depend on advances in efficient production and market development. Regions in Australia where olive varieties suitable for table olive processing and regions with existing or emerging table olive processing activities are indicated in Fig 2.1.

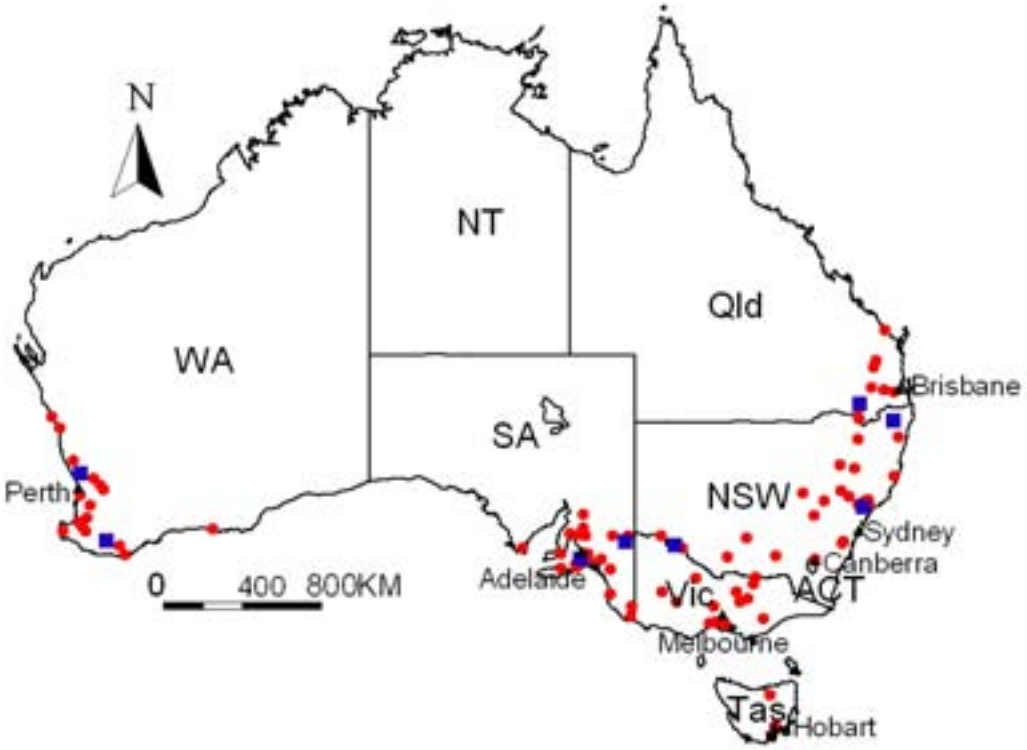


Fig 2.1. Potential table olive producing sites based on existing or proposed processing activities and suitable varieties

Major barriers to Australian table olive production are high harvesting costs, the lack of production expertise and perhaps, the lack of production facilities. There have been numerous attempts to establish a table olive industry in Australia. Most have failed due to the inability to compete commercially with the imported product or the lack of acceptance of the Australian product. As important, is the isolation in which early promoters operated. This has now been addressed by the establishment of industry bodies working towards common goals.

Australian Table Olive Trade: The Australian table olive trade involves all olive products - olives and pastes and includes those made in Australia and those imported from overseas. This trade can be considered under three headings.

- Olives grown, processed and packed in Australia

- Olives imported into Australia, either packed in the country of origin or repacked in Australia before sale

- Olives mainly imported, which undergo secondary processing such as stuffing or marinading before sale

2.2 Industry Consultations

***Experimental*:** The objective of the industry consultations was to conceptualise the needs of table olive growers and processors

***Methodology*:** Over 450 olive growers, table olive processors and potential processors were consulted at meetings, workshops and site visits as to their impressions and requirements relative to table olive processing.

***Meetings*:** (111 persons) - Perth, Canberra, Brisbane, Maitland, Bendigo, Adelaide

***Workshops*:** (310 participants) - Perth, Adelaide, Brisbane, Wangaratta (Vic), Rutherglen (Vic) Mornington Peninsula (Vic), Hunter Valley (NSW), Moss Vale (NSW) (Cessnock), Murgon (Qld)

Site Visits: Western Australia – Perth, Frankland, Gingin, York, Talbot Brook, Geraldton, Margaret River; South Australia – Adelaide, Mount Compass, McClaren Vale, Loxton, Virginia, Balaclava; New South Wales/Canberra – Hunter Valley, Mudgee, Inverell, Canberra, Queenbeyan, Wagga Wagga, Victoria – Rutherglen, Wangaratta, Mornington Peninsula) and Queensland – Gatton, Kingaroy

Participants were asked about their interests in olives. Most were interested in olives as consumers. Around 80% indicated their interest as olive processors both for table olives and olive oil. A number indicated that they had originally planned to focus on olive oil production. However, now that the industry had progressed, it appeared that with competition and possibly lower returns, they were now seriously interested in table olive processing and saw the table olive project as essential to the olive industry.

The groups broadly accepted that suggested varieties should be the focus of the Australian table olive industry and that there was sufficient diversity to produce all olive styles of interest for the Australian and international market. Relevant information on these cultivars is presented later in this report. A number of growers who had planted oil cultivars eg Frantoio, Leccino were also interested in the possibility of processing these varieties as table olives.

Another point of interest was varietal performance under different growing conditions. Again although this was not part of the current investigation it is interesting to note that unless the growing conditions are optimised for quality fruit production, then processing is compromised. Those interviewed were also concerned that to date only hand harvesting, an expensive and time-consuming operation, is still the principal method of picking the crop.

Growers and processors were especially interested in the following olive products.

- Naturally black olives in brine
- Untreated green olives in brine
- Untreated turning green olives in brine
- Kalamata Style olives
- Dried Olives - salted, heat dried
- Specialty products - tapenade, marinated olives with herbs and spices

Industry stakeholders showed little interest in producing olives treated with lye- caustic soda (sodium hydroxide), such as Spanish-style green olives. However in the long term this method of processing will need to be considered by large-scale processors especially if they wish to target international markets. There was absolutely no interest by the focus groups in processing the Californian Style Ripe Black Olives, a product that is treated chemically with alkali then artificially coloured by an oxidation process. Growers and processors were particularly interested in the economics of table olive production and in particular the environmental impact of processing and hence their interest in processing methods that produce large volumes of waste-waters.

2.3 Australian Table Olive Activities

Table olive activities undertaken by Australian table olive growers/processors can be conceptualised as follows.

• Growers sell unprocessed olives to the fresh food market or to third party processors

• Growers vertically integrate their olive activities eg orchard to plate, selling their products to restaurants, pizza bars and small scale food outlets

• Growers process their olives and then sell them to third party processors for secondary processing and packaging

• Independent processors buy olives from growers for processing.

2.4 Current Aspects of Table Olive Production

Discussions with Australian olive growers/table olive processors indicate a strong interest in using natural processing methods such as brine fermentation and salt/heat drying methods rather than processing with lye. This follows similar interest worldwide. Here Manzanilla, Sevillana or Verdale olive varieties can be processed as green olives in brine, whereas naturally black ripe olives of Kalamata variety are processed in brine or by the traditional water soaking method.

Larger scale table olive processors produce similar products except that some treat green olives with lye, which result in Sevillana type olives. This view may change as availability of raw olives increases, especially for green olive processing. Lye treatments speed up processing but use larger amounts of water and energy than traditional methods involving brine fermentation.

Specialty olives include Jumbo Kalamata, a large olive processed at the green to turning colour maturation stage and Ligurian style olives using Taggiasca or Frantoio varieties. Australian growers/processors and third party processors are also undertaking secondary value-adding operations, producing specialty products such as olives in marinades, tapenades, olive pastes and antipasti.

Table olive processing activities undertaken by Australian growers/processors can be divided into four categories **:**

• Growing/producing fresh olives

• Primary processing - debittering the olives

• Secondary processing - producing specialty products from processed olives

• Marketing - packaging olive products for wholesale and retail sale.

Growing/producing olives involves all operations from producing the fruit to delivering the olives to the processing facility.

Primary processing involves any operation (soaking, fermentation, lye treatment or heating) where the olives are debittered and preserved for bulk storage.

Secondary processing involves increasing the financial and organoleptic value of the olives by adding herbs and spices, vegetables, marinades, destoning with or without stuffing with materials such as anchovy, peppers, cheeses, nuts, garlic or onion. Marketing involves packaging olive products for wholesale and sale to end users such as pizza bar, café and restaurant operators, food processors and consumers.

2.5 Australian Table Olive Production

Australian table olive production for the 2002/03 season was estimated to be 4,000 Tonnes. It is expected that Australian table olive production will increase over the next 10 years. By 2013 Australia has the potential to produce 18,000 to 45,000 Tonnes of table olives/year which far exceeds the current level of consumption. For the 2003/04 period, production of Australian table olives is expected to be 4,500Tonnes, an increase of 12.5% over the previous season.

With the resurgence of the Australian olive industry in the 1990s, there is great interest by growers and processors to produce truly Australian table olive products. Table olive processing in Australia is generally small scale, with only one large plant, sited in Loxton, South Australia capable of processing up to 500 Tonnes/year.

New processors are still at the pilot stage with some planning to produce 100 Tonnes/year. Their current production is less than 10 Tonnes/year. There are many small-scale boutique table olive operations that are processing less than 1Tonne of olives per year.

Commercially available Australian table olive products include green and black olives - whole, varietal, sliced, stuffed, pitted, and marinated as well as olive pastes and tapenades. Varieties commonly processed into Australian table olives include Kalamata, Volos, Gordal Sevillana, Manzanilla, Barouni and Verdale. Pitted and sliced olives are used in cooked foods and pizzas. Olives marinated with combinations of olive oil, lemon, vinegar, garlic chilli and other herbs and spices are popular. Olives stuffed with fetta cheese, caper, anchovy, sun-dried tomato, pesto, garlic, almond and pimento extend the olive into the gourmet market. Table olives are sold in many forms including whole, stuffed, marinated and sliced.

The indicative scale of Australian table olive production as new plantings come in line is given in Table 2.1. Information is given on possible size of the operation and for boutique to small-scale growers/processors the number of olive trees required.

Table 2.1. Indicative scale of future Australian table olive enterprises*

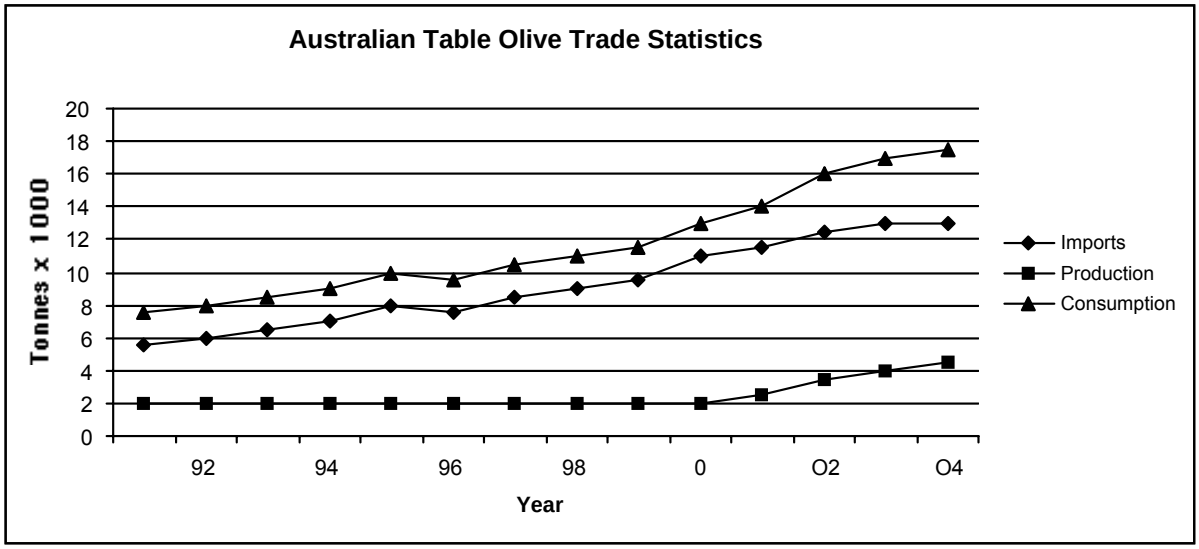
Size of Operation	Capacity in Tonnes/Season	Olive Trees Required*	Orchard Area
Boutique	Less than 5	Less than 200	1Ha or less
Small-Scale	5 to less than 100	200 to less than 4000	1- 16 Ha
Medium-Scale	100 to less than 500	4000 to less than 20,000	16 - 80 Ha
Large-Scale	Greater than 500	Greater than 20,000	Greater than 80 Ha

*** based on an average seasonal crop of 25kg/tree**

2.6 Australian Table Olive Imports

Australia is a net importer of table olives mainly from Spain, Greece and to a lesser extent Italy with only small quantities coming from domestic processors. Table olive importations into Australia, mainly from the EC, are of the order of 12,000 Tonnes/year and valued at Aus$40 million, representing an approximate doubling of imports since 1992/93. This marked increase in importations is a significant indicator as to the popularity of olives in Australia and is a clear signal to Australian growers and processors as to demand. Imported table olives are black and green, which are sold in bulk by wholesalers to the food services industry or repackaged by third parties into consumer size quantities to be sold at retail customers. Most imported olives are; of the Spanish style green and black styles where lye has been used during processing; Greek style black and green olives; and Kalamata style black olives. These are included in all types of products - whole olives with or without marinades or stuffings, olive pastes, tapas and hors d' oeuvres.

Fig. 2.2. Australian table olive trade data over the last thirteen table olive crop years (the data for the last two crop years are provisional and estimated, respectively).



Current table olive imports are around 12000Tonnes/year, whereas Australian domestic production has increased markedly from 2000 Tonnes/year in 1999/00. It is now estimated 4000 Tonnes/year. As few olives are exported from Australia, olive consumption by Australians is currently of the order of 16000 Tonnes/year. Most of the olives are imported in bulk quantities and repacked into consumer size containers either in their original form or marinated with herbs, spices and other aromatics. Imported olives include black and green olives – whole pitted or stuffed and those provisionally processed. The latter require further adjustments before being ready for consumption.

Table olives are mainly sold in supermarket outlets, food stores, delicatessens and gourmet centres. Kalamata style olives are very popular with Australian consumers as are stuffed and marinated olives.

Tapenades and olive pastes are also popular, but to a lesser extent. Table olive consumption by Australians is around 0.9kg/person/year. That is less than one olive/day! Table olives are eaten with bread, cheese and wine, included in salads and incorporated into cooked foods.

2.7 Table Olive Economics

Financial information relates to both growing olives and olive processing. Australian olive orchards range from boutique to large-scale intensive plantings. Boutique and small-scale operations are often associated with vineyards and wineries and have between a few hundred to around 5000 olive trees. Medium scale orchards range from 16 to 80Ha, whereas large-scale olive operations have more than 20,000 trees. To date most table olive production in Australia ranges from boutique to medium scale

2.8 Australian Table Olive Exports

Exportation of Australian table olives is relatively low, with a current value of around $900,000/year. Those exported are either locally produced or imported and then exported from Australia, mainly to Asian and Pacific countries.

2.9 Australian Table Olive Consumption

Australians consume around 0.9Kg of olives/person/year, making them one of the largest consumers per capita outside those living in and around the Mediterranean. On a per capita basis, Australians consume more table olives than Americans or Canadians. As Australia exports few table olives, Australian consumption amounts to the quantity of table olives imported plus the amounts produced locally. Consumption of Australian produced table olives remained steady at 2000 Tonnes/year from 1990/1 to 1999/2000, however since then consumption of Australian produced table olives has increased two-fold to 4000 Tonnes for 2002/03 season.

This increase in consumption probably reflects the escalation of the Australian table olive industry. Consumption of imported table olives has also increased steadily for the same period, but is expected to level at 12,000 Tonnes over the 2002/03 and 2003/04 seasons.

Based on the amount of olives imported, Australians appear to consume mainly marinated and/or stuffed Spanish style green olives and black olives in brine. Consumption of Australian processed table olives is considerably lower than those imported but the amount is increasing. Australian imports have doubled over the last 10 years reaching nearly 12,000 Tonnes/year. Estimates of Australian table olive production are around 4000 Tonnes/year. Current data suggests that by 2006 the wholesale and retail values of table olives in Australia, from all sources, domestic and imported, could exceed $40 million and $80 million respectively.

Where Australian consumers have a choice they prefer to eat olives processed in brine, green and black. Australian processors are currently interested in producing crisp green olives and Greek-style green olives. Commonly eaten olives by Australians are from Spain - Manzanilla, Sevillana, Hojiblanca and Greece - Kalamata and Conservolea (Volos). Even some of the oil olives such as Leccino, Arbequina and Taggiasca processed as table olives are popular with consumers, however, only a small number of varieties are of international importance. Such olives are eaten as snacks, hor'doerves, mixed into salads, used in pizzas or bruschetta, and in cooked dishes.

2.10 Potential for Table Olive Production in Australia

Some believe these statistics overstate the situation because of the small quantities of raw olives available for processing, whereas others estimate plantings to exceed ten million olive trees.

The quantity of fresh olives available for table olive production, from the expected plantings, based on 25kg/tree/year in the "off years" and 50 kg/tree in the "on years", could be within the range of 18,000 to 45,000 Tonnes within 10 years. This volume of olives is greater than the current Australian consumption of table olive products. The most optimistic scenario would provide up to 10 times the current Australian production of table olives. Even producing 18,000 Tonnes of table olives per year will require substantial investment, infrastructure and technical expertise. Furthermore the long term management of the "off" and "on" producing years, pests and diseases and water resources is still unclear. Production levels of 45,000 Tonnes/year, after taking into account local consumption, would give balances equivalent to major table olive exporting countries such as Turkey, Syria and Greece.

Major initiatives will need to be implemented by the Australian table olive industry to significantly penetrate the international export market for table olives. The possible impact of the Australian olive industry on the international table olive trade, in the event of catastrophes in traditional olive producing countries eg fire, green-house effect, war and terrorism, has yet to be considered.

2.11 Size of Australian Table Olive Processing Operations

During the initial consultations with stakeholders, the size and scope of their table olive enterprises were ascertained (see Table 2.2.). Subsequent interaction with additional stakeholders followed a similar pattern. A complicating factor is that one can be in the table olive business without planting a single olive tree, so the table olive industry exceeds the contribution of only growers. As many players will influence and impact on the viability and credibility of the Australian table olive industry it is critical that a quality chain is developed ensuring quality and safety is not lost between the olive orchard to the consumer. Here all persons dealing with table olives need to be familiar with the FSANZ Food Standards and their implications.

Discussions with over 100 olive growers and stakeholders from around Australia in 2001 resulted in the view that production capacity could be divided into at least four categories ranging from boutique to large scale. Sixty-one persons who had already planted table olives and were considering their options of whether to sell fresh fruit to others or process the olives themselves. Their olive groves ranged from 20 to 2500 trees with the exception of one processor that was linked to a mega-grove of 350,000 trees. Most of the growers, around 80% could be considered as small-scale operators (Table2.2.). Four could be categorised as medium scale and 9 boutique scale. As a point of explanation the towns indicated in the table refer to where meetings were held. The Canberra meeting was attended by persons from ACT, NSW and Victoria. A similar pattern with respect to the scale of operation exists in Western Australia.

Assuming an annual useable crop of 50kg.tree within 8-10 years after planting the resulting Tonnes/year can be calculated. Of course if there is a shortfall, additional olives can be purchased.

2.12 Olive Growing in Australia

Since 1995 there has been intense interest in the commercial potential of an Australian olive industry. Olive orchards have been established at numerous centres in southern and eastern Australia. Initial interest was for olive oil production but interest in an Australian table olive industry is increasing at all levels from boutique to larger scale enterprises. Table 3 gives details of areas/regions in Australia with interest in table olives or have varieties growing suitable for table olive production.

Table 2.2. Size of Australian table olive operations.

Scale of Operation	Tonnes	Adelaide	Bendigo	Brisbane	Canberra	Hunter Valley	Total
Boutique (1-100 trees)	Up to 5	1		2	6		9
Small Scale (101-2000 trees)	5 to 100	9	3	17	12	13	54
Medium Scale (2001-10000	100 to 500	1		1	2		4
Large Scale (greater than 10000 trees)	> 500	1					1
Totals		12	3	20	20	13	68

The Australian olive industry is fragmented with most growers having between 500 to 5000 trees. Such olive groves are often found within popular wine growing regions around Australia. Major olive orchards (50,000 trees or more), accounting for around 70% of all planted olive trees, have been established in New South Wales, Victoria, South Australia, Queensland and Western Australia. Although accurate statistics on plantings or productive olive trees in Australia are unavailable, one estimate is around 8.5 million trees.

Based on an average seasonal production of 25kg of olives/tree, the potential table olive crop is around 20,000Tonnes/year representing around 1% of the world production of table olives. To date Australians eat only relatively small amounts of table olive products with most of these imported from Spain and Greece.

Consumption of Australian processed olives, which is low, will increase as the industry matures. Some processors are targeting international markets. Sustained growth of the Australian table olive industry will depend on advances in efficient production and market development.

Although table olive processing and olive oil processing are two quite different operations, at the orchard level this delineation is not as clear. For the olive grower two issues are important to table olive production - variety and fruit quality.

In our investigations there were few orchards specifically set up for table olive production. What is clear is that olive growers at the boutique/small scale end of the industry were showing increased interest in table olives to extend their options and they were particularly interested in dual purpose olive varieties eg Manzanilla, Mission.

There were several olive orchards in South Australia and Western Australia that have targeted the table olive industry where substantial numbers of Kalamata variety olives were planted. Those with existing olive orchards were keen to learn if the varieties that they had planted were suitable for table olive processing.

In summary the following varieties suitable for table olive processing, are commonly found at various sites in Australia (red markers) are as follows. Frantoio (Correggiolla, Paragon), Jumbo Kalamata, Leccino, Manzanilla, Nevadillo Blanca, Mission, Sevillana, UC13A6, Barnea, and Barouni. Varieties with limited distribution suitable for table olive products were Boothby's Luca, Lecqure, Picual, Hardy's Mammoth, Azapa, Boutillan, Giant Kalamata.

Established/emerging table olive processing areas regions are indicated in Fig 2.1. Two of the larger scale enterprises are sited in South Australia and New South Wales

Table 2.3. Areas/regions in Australia with interest in table olives or have varieties growing suitable for table olive production

Australian States	Some Areas/Region/Sites with Olive Varieties Suitable for Table Olive Production	Commonly Planted Varieties Suitable for Table Olives
Australian Capital Territory	Canberra	Kalamata
New South Wales	Orange, Cowra, Forbes, Wagga Wagga, Hunter Valley: Cessnock, Branxton, Broke, Maitland, Vacy Casino, Moss Vale, Mittagong, Bowral, Goulbourn, Inverell, Tamworth, Mudgee, Riverina	Correggiolla, Frantoio, Jumbo Kalamata, Kalamata, Leccino, Manzanilla, Nevadilo Blanca Mission, Paragon, SA Verdale, Sevillana, UC13A6
South Australia	Fleurieu/Kangaroo Island,Strathalbyn, Meadows, Myponga, McLarenVale, Willunga, Normanville, Yankalilla, Cape Jervis, Eyre Peninsula, Port Lincoln, Yorke Peninsula, Kadina, Kulpara Northern Region Balaklava, Jamestown, Clare, Riverton, Southern Flinders Adelaide Plains Virginia. Adelaide Hills, Balhannah, Stirling, Crafers	Barnea, Barouni, Jumbo Kalamata, Kalamata, Manzanilla, SA Verdale, UC13A6
Tasmania	Devonport, Hobart, Launceston	Barnea, Frantoio, Kalamata, Paragon, SAVerdale
Victoria	Mornington Peninsula, Tinzanna, Macedon, Geelong, Bellarine Peninsula, Alexandria, Euroa, Mansfield, Wangaratta,Rutherglen, Robinvale Goulbourn-Strathboogie, Ararat, Heywood, Beaufort, Kaniva, Stawel, Elmhurst, Great Western, Armstrong, Pomonal, Sunbury, Boort	Barnea, Correggiolla, Frantoio, Kalamata, Manzanilla, Nevadillo Blanca, Paragon, Sevillana, Volos
Western Australia	Bridgetown, Northampton, Geraldton, Dongara, Gingin, Dandaragan, Bindoon, Margaret River, Frankland River, New Norcia Mogumber, Denmark, Esperance, Swan and Avon Valleys, McAlinden, Donnybrook, Baldivis	Correggiolla, Frantoio, Kalamata, Leccino, Manzanilla,, Sevillana, UC 13A6, WA Mission
Queensland	Gin Gin, Grantham, Murgon, Kingaroy, Inglewood, Ipswich	Manzanilla, Nabtamri, Paragon, Nevadillo Blanca, Kalamata, UC13A6

2.13 Conceptual Diagram of the Table Olive Industry

The Australian olive industry is presented as a conceptual model in Fig.2.3. Here the grower can undertake primary and secondary processing, package the products and then sell them at various levels of customer – wholesaler, food services industry sector, retail sector or direct to consumers. This sequence is likely with small-scale producers. Alternatively the grower can pass on the olives to third parties to complete processing and marketing. Some growers may sell fresh olives directly to processors or send them to the fresh market sector for sale to small-scale processors or home processors.

2.14 Australian Olive Nursery Survey

Experimental: The objective was to document the varieties supplied by Australian olive nurseries for table olive production. Hence nurseries specialising in olive trees were approached to ascertain the availability of table olive planting stock

Olive nurseries were surveyed as part of the project with the objective of determining the availability of planting stock of olive varieties in Australia that would be suitable for table olive processing. This information allowed the investigators to focus on specific varieties for particular styles and processes. This information was published in The Australian Olive Grower in 2001 and additional information presented at the Australian Olive Association Annual Conference 2001.

Table 2.4. Table Olive Varieties available for growing in Australia

Variety	Country of Origin	Use	Fruit Weight	Processing Type
Ascolano Tenera	Italy	Table	Very High	Green
Azapa	Chile	Table	Variable High to Very High	Green, Black
Barnea	Israel	Dual	Medium	Green, Black
Barouni	Tunisia	Table	Very High	Green, Black
Californian Mission	Mexico/Spain	Dual	Medium	Green
Cucco	Italy	Dual	High	Green, Black
Hardys Mammoth	Uncertain	Dual	High	Green
Hojiblanca	Spain	Dual	High	Green, Californian Style
Kalamata	Greece	Dual	High	Black
Kalamata Jumbo		Table	Very High	Green
Leccino	Italy	Oil	Very High	Black
Manzanilla (o)	Spain	Dual/Table	High	Green, Black
Nabtamri	North Africa	Table	Very High	Black
Olive Prugno (Prugne) Oliva di Cerignola	Italy	Table	Very High	Green
Picholine	France	Dual	Medium	Green
Gordal Sevillana	Spain	Table	Very High	Green
UC13A6	Africa/USA	Table	Very High	Green, Black
Verdale	France	Dual	Medium	Green, Black
Volos (Conservolea)	Greece	Dual	High	Green, Black

Olive sizes - medium = 2 to 4 grams, high = 4 to 6 grams and very high = greater than 6 grams
Green = olives picked at yellow green stage
Black = olives picked at *naturally black ripe* stage
Californian Style = olives picked at the turning colour stage

2.15 Varietal Information in Australia

Information on varietal suitability of olives under different growing conditions is limited. Researchers and industry stakeholders are actively seeking information on varieties old and new to the industry. Much of the data collecting has been directed to olive oil production and there is a drastic need to systematically collect information on table olive varieties. The following varieties information has been developed as a guide for growers and processors, until local information becomes available. Information is presented in alphabetical order for ease of reference and not importance. The importance of varietal authenticity is highlighted by the fact that up until recently, original sources of olive trees were either unknown, had been incorrectly named, grown from undocumented wild selections or obtained from historical groves such as Blackwood, Yanco, Wagga Wagga and New Norcia.

It is encouraging that new–to-industry cultivar selections such as Barnea being planted in Australia are authentic. Recent reports emanating from the research underway at Roseworthy, South Australia indicate that olive trees sourced from reputable nurseries have matched with international standards and include the following varieties suitable for table olive production.

Arbequina, Barnea, Frantoio, Hojiblanca, Kalamata, Manzanilla, Picual and Sevillana.

There is less certainty with other varieties such as *Verdale* and *Californian Mission.* An interesting aspect of this study was that the researchers identified 14 “different” olive varieties, including *WA Mission, Paragon, Corregiolla* and *Mediterranean,* as the one variety, Frantoio.

Additional varieties to be considered by Australian Growers and Processors

Nocellara di Belice – This is an Italian olive variety processed as a green olive. It can be grown under irrigation or under dryland conditions where the rainfall is around 600mm/year. The fruit is of similar shape to Manzanilla, weighs around 6-8g and has a flesh:stone ratio of around 6-8:1. Giarrafa variety is planted for cross-pollination.

Chalkidiki – This olive variety originates in the Chalkidiki Peninsula in Northern Greece. It is also known as Donkey olive – *Gaidourolia* and has similar morphological features to *Ascolana tenera.* Although some difficulties have been experienced in processing this variety because of low levels of fermentable substrates and pale colour, it has some advantages such as a high oil content (20%) and the large fruit size (6-10g or more).

Arberquina – This small fruited (pea like) variety, generally used for olive oil production, is popular in Spain when processed in brine. These olives are eaten as snacks much the way Australians eat salted peanuts. After the flesh is consumed the round stone is kept in the mouth releasing salt and a nutty flavour.

In contrast, important local olive varieties grown at other international centres are provided in Table 2.5, however at the international trade level, the important table olive varieties are Kalamata, Conservolea, Manzanilla, Sevillana and Hojiblanca and to a lesser extent Olive de Cerignola and Ascolana Tenera.

The investigators have some concerns regarding varietal authenticity for some of the named varieties. Several examples can be sited here.

- Confusion between Manzanilla and Californian Mission
- Varieties of dubious origin- Jumbo Kalamata, Hardy's mammoth
- Potential for substitution of Kalamata olives with Barnea variety olives
- Different olive varieties showing similarities at the DNA level, but clearly showing different morphological characteristics

It is the responsibility of nurseries to provide the planting stock of authentic variety, the grower to deliver olives of authentic varieties for processing and processors to process and package olives of authentic variety. Although DNA databases are being developed using RAPD, AFLP and microsatellite technologies using fresh olive leaves to authenticate varieties, there appears to be a shortage of information on DNA typing using fresh or processed olives. Currently morphological evaluation is the only practical technique for varietal differentiation.

A systematic approach is required. There is a need to develop a centre that is able to deliver to nurseries authentic certified propagating material from which mother trees true to variety can be developed at the nursery level. It is then up to individual nurseries to have quality management procedures ensuring growers receive the correct planting material.

2.16 Table Olive Availability

Australian table olive products are mostly sold by processors to the food services industry in bulk, or through specialty food outlets. The olive industry, like the wine industry, has adopted tourism as a major strategy in marketing table olive products with other foods in regional Australia. Uptake of Australian table olives by national supermarkets has been slow due to long-standing buying practices, high prices, low levels of availability and a lack of products such as pitted and stuffed olives. It is expected that existing imports will persist because of traditional trading patterns of importers, wholesalers, retailers and consumers. Competition from other Southern Hemisphere producers, southern America and Africa, are a further threat.

Fig 2.3. Table Olive Industry – Conceptual Model

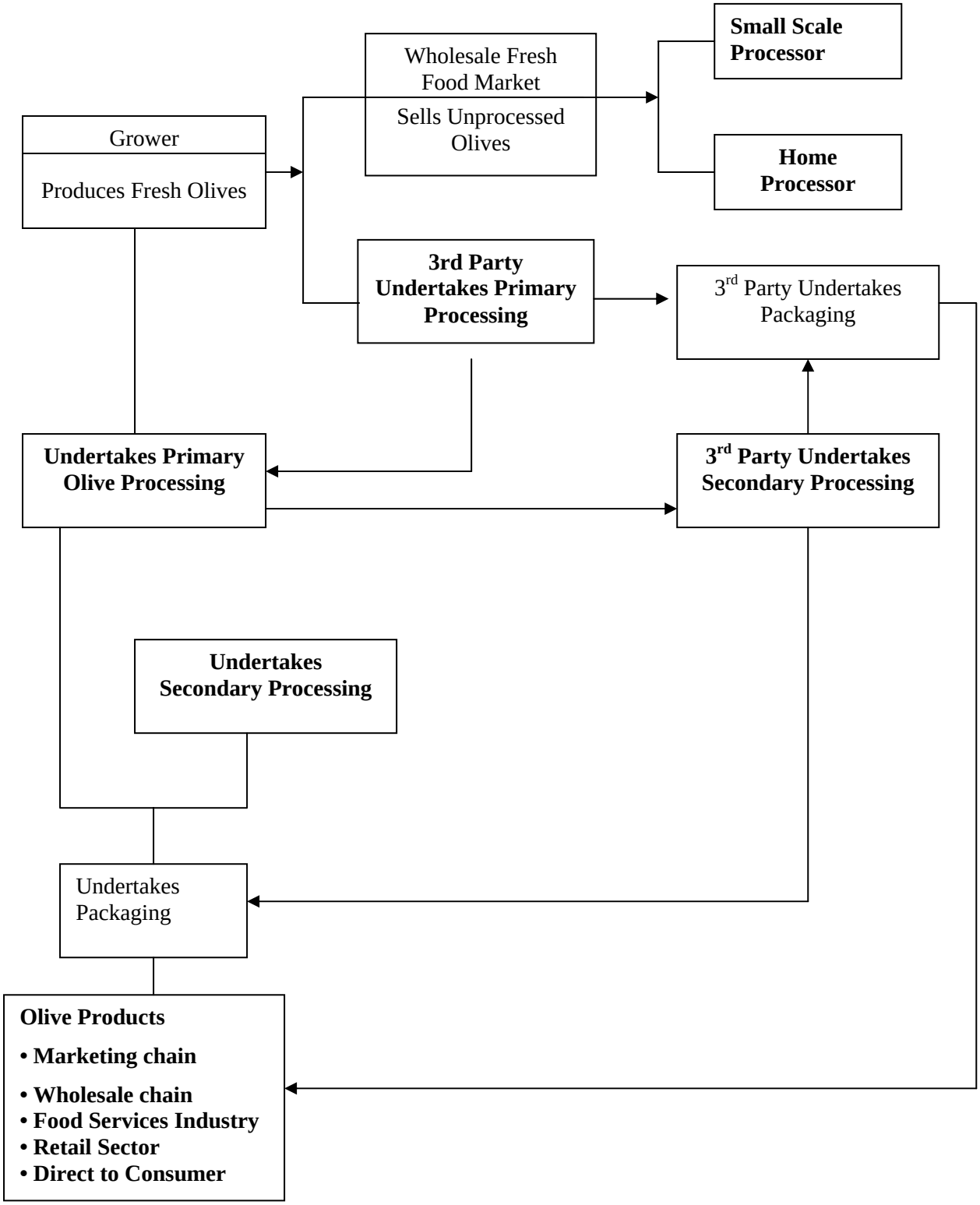


Table 2.5. Principal table olive varieties grown in countries other than Australia

Variety	Countries	Use	Fruit Weight	Processing Type
Azeradj	Algeria	Dual	High	Green, Black
Sigoise	Algeria	Table	Medium	Green, Black
Arauco	Argentina	Dual	Very High	Green, Black
Oblica	Formerly Yugoslavia	Dual	High	Green, Black
Zutica	Formerly Yugoslavia	Dual	Medium	Green, Black
Picholine Languedoc	France	Dual	Medium	Green
Tanche	France	Dual	Medium	Black
Kalamata	Greece	Dual	High	Black
Conservolea	Greece	Dual	High	Green, Black
Ascolana tenera	Italy	Table	Very High	Green
Carolea	Italy	Dual	High	Green, Black
Itrana	Italy	Dual	High	Black
Nocellara del Belice	Italy	Table	High	Green
Soury	Lebanon	Dual	Medium	Green, Black
Picholine Marroqui	Morroco	Dual	Medium	Green, Black
Carrasquenha	Portugal	Dual	High	Green
Galega Vulgar	Portugal	Dual	Medium	Black
Redondal	Portugal	Dual	Medium-High	Green
Manzanilla Cacerena	Spain	Dual	High	Green, Black
Hojiblanca	Spain	Dual	High	Green, Californian Style
Manzanilla de Sevilla	Spain, USA, Israel	Table	High	Green
Al-Doebli	Syria	Dual	High	Green, Black
Meski	Tunisia	Table	Medium-High	Green
Domat	Turkey	Table	Very High	Green
Gemlik	Turkey	Dual	Medium	Black
Memecik	Turkey	Table	High	Green, Black
Californian Mission	USA	Dual	Medium	Green, Black

Olive sizes - medium = 2 to 4 grams, high = 4 to 6 grams and very high = greater than 6 grams
Green = olives picked at *yellow green* stage
Black = olives picked at *naturally black ripe* stage
Californian Style = olives picked at the turning colour stage

2.17 Olive Styles and Products

Table olives are prepared from the sound fruits of suitable varieties of the cultivated olive tree (*Olea europaea sativa* Hoffg, Link). When treated or processed the olives are ready for consumption. Olives used for processing are harvested at the appropriate level of maturation and processed so that microbiologically safe and edible products are produced. For international trade in olives, individual countries are required to indicate the varieties considered suitable for processing.

There is a myriad of olive products available worldwide, with each olive growing country producing local and regional styles.

- Castelvetrana style
- Green ripe Californian style
- Greek donkey olives
- Kalamata style
- Ligurian style
- Date olives - Thrumbes
- *Maiatica di Ferrandina Style*
- Sicilian-style green olives
- Picholine style
- Olives de Nimes

Some internationally recognised styles, traded internationally, have also emerged.

• Untreated black olives in brine (Here no lye is used during processing)
• Spanish style green olives
• Treated black olives in brine

Most producing countries use only a few varieties as raw material and these are processed by a handful of methods. The commonest internationally traded varieties are Manzanilla, Kalamata and Conservolea.

For the prospective table olive processor trying to unravel this situation is complex. Generally the olives undergo a primary process which debitters the olive, and this is followed by a secondary process which involves adding other components to the olives or brines such as olive oil, vinegar, herbs, spices and aromatics. Destoning the olives with or without stuffing such as pimento, anchovy or almonds is another secondary process.

***Experimental*:** The objective here was to obtain a snapshot as to the type of olive products available in Australia. so that growers/processors have an understanding of the types of products being made available to consumers. Visits were undertaken to representative wholesale and retail table olive operations. The reasons for undertaking this review was to give Australian olive/growers processors an understanding of the products being offered to food retailers, food processors and food services industry.

2.18 Overall Table Olive Activities

Table olives are available from a number of diverse outlets and these are listed in Table 6. In season, fresh unprocessed olives are available from growers, continental delicatessens, wholesale fruit and vegetable markets and popular food markets such as Adelaide, Fremantle and Victoria markets. Bulk quantities are available from food wholesalers and grower/processors. Loose processed olives are mainly available from continental delicatessens, gourmet shops, and popular food markets. Packaged olives are widely available in small and large supermarkets, continental delicatessens, gourmet shops, cellar doors and regional food shops. The latter provide a variety of locally produced products including olives and olive pastes.

Table 2.6. Enterprises supplying processed and unprocessed olives

Enterprise Category*	Processed Olives			Unprocessed Olives
	Loose	Packaged	Bulk Commercial Quantities	
Continental Delicatessen (4)	yes	yes	yes	yes
Local Supermarket (3)	no	yes	no	no
Major Supermarkets (3)	yes	yes	no	no
Specialty/Gourmet/Cellar Door (9)	yes	yes	no	no
Food Wholesaler (3)	no	yes	yes	no
Grower/Processor Boutique (16)	no	yes	yes	yes
Grower/Processor Small Scale (6)	no	yes	yes	yes
Grower/Processor Medium Scale (2)	no	yes	yes	no
Wholesale Fruit and Vegetable Markets (1)	no	no	no	yes
Popular food markets (3)	yes	yes	no	yes

*** indicates number of consultations**

2.19 Wholesale Olives

Table olive products were generally imported (Spain and Greece) with some products eg Kalamata variety olives produced or transformed into specialty styles eg marinated in Australia **(Table 7**). Container sizes varied from a few kilograms in cans and jars to plastic barrels with up to 200kg of olives. Available olives were either lye treated eg black and green Spanish style or naturally processed in brine eg Kalamata style, Greek style black and green. Most items had only undergone primary processing. Olives sold in large barrels are purchased by third parties for preparing specialty products to be sold loose or packed into consumer size containers with or without further embellishment eg stuffings and marinades. These latter products are not included I the table below.

Table 2.7. Products available from wholesale table olive operations

Olive Style	Container Type	Quantity	Origin
Black Spanish Manzanilla, Hojiblanca	Can Jar Plastic Barrel	3.5kg 1.5kg 200kg	Spain
Green Spanish Manzanilla, Sevillana Chalkidiki	Jar Plastic Barrel Plastic Barrel	1 to 2kg 12.5kg 200kg	Spain, Greece
Green Spanish cracked	Plastic Barrel	12kg	Greece
Green Spanish pitted	Jar Plastic Barrel	2kg 200kg	Spain, Greece
Green Spanish stuffed with pimento	Jar Can Plastic Barrel	1 to 2kg 3kg 200kg	Spain
Green Spanish sliced	Jar Can	1 to 2kg 3kg	Spain
Kalamata style	Plastic Barrel Plastic Barrel	5-9kg 200kg	Greece, Australia
Kalamata style - marinated	Plastic Barrel	5Kg	Greece, Australia
Kalamata Style - extra jumbo	Plastic Barrel	12kg	Greece, Australia
Kalamata style - continental mixture	Plastic Barrel	5Kg	Greece, Australia
Kalamata style - home style split	Plastic Barrel	5Kg	Greece, Australia
Greek Style black Conservolea	Plastic Barrel	200kg	Greece
Greek Style Jumbo Kalamata	Plastic Barrel	200kg	Australia

2.20 Loose Table Olive Sales

With this part of the investigation, detailed information was recorded as to the types of table olives available in supermarkets, continental delicatessens and specialty food shops.

Table olives are available loose from larger national supermarkets, continental delicatessens, specialty and gourmet food outlets (Table 2.8). Here a large number of different products are available, however these are based around the types and variety of olives that are available at the wholesale level. Generally there is no indication as to the source or origin of the olives ie Australian or imported. They are mostly placed in very visible containers, with the name and style of the product, protected from handling by consumers. There is less control in continental delicatessens where customers can sample before they buy. Black Spanish style olives are the cheapest selling for as little as $6/kg where as embellished olives eg stuffed olives packed in olive oil with herbs, spices and sun-dried tomatoes can retail at around $40/kg. Customers purchase the required quantity of the olives, which are placed in an unlabelled plastic container and sealed. It is assumed that these olives will be consumed quickly as storage conditions are not provided.

Even with this limited survey, collectively 33 different products were available with the majority in marinades. A point of interest is that National supermarkets had the greatest range compared to continental delicatessens whereas smaller local supermarkets of which four were surveyed only one had loose olives available for sale.

Table 2.8. Enterprises selling loose olives to retail customers

Olive Style/Product	Continental Delicatessens					Supermarkets National		Local
Black - Kalamata	yes	yes	yes	yes		yes	yes	
Black - Kalamata - marinade - chili and oregano			yes					
Black - Kalamata - marinade - chili and garlic				yes		yes		
Black - Kalamata - marinade - lemon and garlic							yes	
Black - Kalamata - marinade - with herbs							yes	
Black - Kalamata - pitted	yes		yes	yes		yes	yes	
Black Date (shriveled)	yes		yes					
Black Greek Style		yes	yes					
Black Spanish Style			yes	yes				
Black Spanish Style - pitted			yes				yes	yes
Black Spanish Style - sliced							yes	
Green - Greek Style Donkey - marinade - herbs and spices			yes					
Green Spanish Style	yes	yes	yes	yes				
Green Spanish Style - marinade - chili and garlic				yes		yes	yes	
Green Spanish Style (Donkey)- marinade - herbs and spices-							yes	
Green Spanish Style - marinade - lemon and vinegar							yes	
Green Spanish Style - marinade - lemon and garlic				yes		yes	yes	yes
Green Spanish Style - marinade -Thai style herbs						yes	yes	
Green Spanish Style - pitted								yes
Green Spanish Style - pitted - anchovy in oil	yes					yes	yes	
Green Spanish Style - pitted - fetta cheese in oil	yes			yes		yes	yes	yes
Green Spanish Style - pitted - marinade - chili and garlic				yes		yes	yes	
Green Spanish Style - pitted - pimento	yes			yes		yes	yes	
Green Spanish Style - pitted - pimento - marinade -herbs and spices			yes	yes				
Green Spanish Style - pitted - sundried tomato in oil				yes		yes	yes	
Green Spanish Style - sliced							yes	
Green Spanish Style cracked - marinade - chili	yes							
Mixed - Connoisseur - marinade - herbs and spices-	yes					yes	yes	yes
Mixed - Continental - marinade - herbs and spices				yes		yes		
Mixed - Green and Black Spanish Style - sliced	yes							
Mixed - pitted - marinade - chili and herbs							yes	
Mixed - pitted - marinade - herbs and spices							yes	
Mixed - Provencale - marinade - herbs and spices						yes		
Number of different olives styles available	10	4	10	13		14	20	5

2.21 Packaged Table Olive Products

With this part of the investigation, detailed information was recorded as to the types of table olives available in supermarkets, continental delicatessens and specialty food shops. There is no shortage of packaged table olive products available to Australians with some 57 different products listed in Table 2.9. Here table olive products ranged from whole, pitted and sliced olives with or without embellishments, antipasti with olives and olive pastes. Most products were imported with many packed in Australia. Few products were of truly Australian origin indicating the lack of penetration in the retail field. Olives were packed mostly in glass bottles and some, generally imports, were in cans. A small number were packed in cryopacks. The number of individual items sold by each enterprise is indicated in the table and includes different products and different sized packs. Again the basic olive types were used with different embellishments such as garlic, chili, Mediterranean herbs, lemon and vinegar.

Australian products are available in regional areas where they are sold at specialty food shops, wine cellars and in a few sites specialty olive shops. The product range is similar to that listed in Table 2.9.

Table 2.9. Enterprises selling packaged olives to retail customers
(* indicates Australian products.)

Olive Style/Product	Continental Delicatessens					Supermarkets National		Supermarkets Local			
Antipasti - Green Spanish Style olives and fetta cheese	1							1			1
Antipasti - Mediterranean Gourmet		3	2				4*	1	1		
Antipasti - Mediterranean Mix	2							1			
Antipasti - Tapas		2									
Antipasti - Char grilled, Mediterranean		1									
Black - Kalamata	4	2	2		3*	2	6*	2	1		1
Black - Kalamata - halves (bacchetta)											
Black - Kalamata - marinade - Chili			1								
Black - Kalamata - marinade - garlic and vinegar											
Black - Kalamata - marinade - herbs and spices		2	1				1	1	1		1
Black - Kalamata - pitted	3		1			2	3	1			1
Black - Kalamata sliced	1		2				1				
Black - Kalamata - marinade - balsamic vinegar						1					
Black - Kalamata sliced - marinade - balsamic vinegar							1				
Black heat dried olives	1	1	1								
Black Greek-style		2	1		1*						
Black Greek-style - chili and spices		1									
Black Greek- style - lemon and garlic		1									
Black Spanish Style	4	4	4	3			6	3	3	1	1
Black Spanish Style - pitted	1	2				1	1	2	3	1	
Black Spanish Style - pitted - almonds		2									
Black Spanish Style - pitted - anchovies		2									1
Black Spanish Style - pitted - spices									1		
Black Spanish Style - sliced	2	2				2	3	1	1	1	
Green - natural fermentation in brine - Frizantina Style					1						
Green - natural fermentation in brine - Ligurian Style		1			2						
Green Spanish Style	2	5		1	1*	2	3	2		2	2
Green Spanish Style - pitted - natural pepper							1				
Green Spanish Style (Greek)		1									
Green Spanish Style (Greek) - pitted		1	1								
Green Spanish Style (Greek) - pitted - pimento			1								
Green Spanish Style (Greek) - pitted - pimento	5	2	2			4			2		2
Green Spanish Style - halves (bacchetta)							1				

Table 2.9. Enterprises selling packaged olives to retail customers (Continued)
(* indicates Australian products.)

Olive Style/Product	Continental Delicatessens					Supermarkets National		Supermarkets Local			
Green Spanish Style - marinade - herbs and spices	1	1									
Green Spanish Style - marinade - Mediterranean				1							
Green Spanish Style - pimento - marinade - herbs&spices		1							1		
Green Spanish Style - pitted	3	1						1	2	2	1
Green Spanish Style - pitted - pimento		5					12	2	2	2	
Green Spanish Style - pitted - anchovy			2			1	1				
Green Spanish Style - pitted - blue vein cheese						1	1	1			
Green Spanish Style - pitted - fetta cheese								1			
Green Spanish Style - pitted - Parmesan cheese						1		1			
Green Spanish Style - pitted - pimento - tuna		1									
Green Spanish Style - pitted - smoked salmon		1					1	1			
Green Spanish Style - pitted - tuna		1									
Green Spanish Style - Queen							2*				
Green Spanish Style - Queen - pitted	1										
Green Spanish Style - Queen - pitted - pimento	1										
Green Spanish Style - sliced	1	1	1								
Green Spanish Style crushed - marinade - seasoned	1	1									
Green Spanish Style marinade - Lemon and Garlic		1					2*	1			
Mixed - cocktail - marinade - herbs and spices	1										
Mixed - Mediterranean - marinade - herbs and spices		23									
Mixed - Provencale - marinade - herbs&spices								1			
Olive Paste - black	2		2	1							
Olive Paste - green	3		2	1	1						
Olive Paste - Tapenade	1		2		3*						
Number of Items	41	53	28	7	12	17	40	24	18	9	11

Industry concerns include the types of olives to produce and having details of the production methods. Growing olives under the appropriate conditions and selecting suitable varieties is paramount to achieving quality. The data presented in this section conceptualises the industry and the influence and relevance of national and international markets. Knowing what table olive products are available to consumers will guide Australian processors as to the important table olive presentations.

3. Production of Raw Olives

3.1, Introduction

Good quality olives are required to produce quality olive products. Hence quality starts at the olive orchard. Here the grower needs to understand the olive tree and the quality of the fruits produced. Poor selection of varieties, grown under sub optimal conditions can influence the properties of the raw olives. This matter is highly relevant because from our experience in meeting with olive growers/processors around Australia has revealed that they need technical support both at the orchard as well as the processing level.

3.2 Raw Olives

Olive fruit is categorised as a drupe fruit because it has a woody stone surrounded by flesh that is enclosed and protected by the skin. The stone, also called the endocarp, formed during the development of the fruit, encloses generally one and occasionally two seeds. Like other drupe fruits such as peaches and apricots (depending on the variety), olive fruits can be freestone or clingstone. With clingstone fruit, removing the fruit from the stone requires some effort.

The flesh, also called the mesocarp, of the fresh olive is juicy and depending on the variety and maturation level, ranges from a yellow green to deep purple black in colour. The chemical composition of the flesh is complex containing minerals, vitamins, oil, carbohydrate, protein, fibre and pigments. Unlike other drupe fruits, olive fruits are rich in oil and low in soluble sugars. A characteristic of olive fruit is the high content of phenolic compounds and unique bitter glycoside, oleuropein. During processing, the levels of oleuropein are markedly reduced and hence the fruit is debittered. Soluble sugars in the olive flesh are essential for supporting fermentation during processing. With dried olives, the soluble sugars contribute to the organoleptic qualities of the processed olives. Structurally, the flesh is made up of cells and fibrous materials such as cellulose and lignin. The water-soluble components of the cells are vacuolised whereas the oil is complexed in the cytoplasm.

Olive skin, also called the epidermis or epicarp, provides a protective barrier for the internal components. It is mostly a continuous structure except for numerous small openings, lenticels that allow the olive fruit to transpire. The olive skin also supports an extensive microbial population of bacteria, yeasts and fungi. A number of these organisms proliferate during spontaneous fermentations during processing, and others can cause food poisoning to consumers, and spoilage.

3.3 Basic Requirements of Raw Olives

Olives have a soft fleshy structure and if damaged through bruising while on the tree, during harvesting, or while transporting and storing, will result in lipolytic and other enzymes being released in the flesh. Because of the high water content of the flesh, the enzymes are able to rapidly degrade the oil releasing free fatty acids to levels greater than 3-4%. Similar reactions occur in over-ripe olives. Thus crop management is essential to ensure the quality olives are used for processing.

Only the best quality fruit should be processed as table olives. Quality includes ensuring authentic varieties, using sound fruit of an appropriate size and at the correct maturation stage. Common table olive varieties include, Manzanilla, Kalamata, Chalkidiki, UC13A6, Sevillana, Hojiblanca, and to a lesser extent Verdale, Picholine and Barouni. Some oil olive varieties Arbequina, Taggiasca, Frantoio and Leccino are also used for table olive processing.

Consumers prefer medium to large sized olives, with a non-tough skin and a flesh to stone ratio of 5 to 1 or more. Freestone varieties are best as the flesh separates easily from the stone. Small smooth stones are preferred. Small and large olives are better suited to specialty markets. The basic requirements of raw olives for table olive production follow in Table 3.1.

Table 3.1. Basic requirements for raw table olives

Basic Requirements	Comment
Plan the table olive enterprise	Select growing site - climate, land features, availability of services, labour force
Appropriate Variety	Authentic varieties planted, Variety appropriate to style
Olive trees grown under optimal environmental conditions	Appropriate Climate Well draining soils Slightly acid to neutral pH Maximum radiation
Olives grown under good horticultural practices (GHP)	Nutrient applications Leaf analysis Integrated pest and weeds management with minimal use of chemicals
Effective harvesting	Correct maturation state for style Fruit not damaged during harvesting Fruit protected from sun and heat in the field
Post-harvest handling	Olives sorted according to maturation and size with small and defective olives removed Olives stored under cool hygienic conditions Transport olives under cool hygienic conditions
Efficient delivery of olives to processor	Olives stored under cool hygienic conditions

3.4 Planning the Table Olive Operation

To be strategic, the potential grower must determine the size of the orchard and which varieties are to be planted. Limitations include the varieties available from the nurseries and their authenticity as well as the available financial, physical and human resources at the time. The latter is important because olives for table olive processing are picked by hand. When olive trees become commercially productive, crop yields can reach 15 Tonnes/ha. For a typical olive orchard of 20 ha with 6000 olive trees, the level of production can reach 300Tonnes which is the equivalent of 150,000 two-kilogram packs of olives.

Planning an olive grove requires an understanding of the end products to be produced ie table olives or olive oil. In many situations these two end objectives can coexist. From our discussions with growers during the project, few had planned to produce table olives. Many had established small olive groves, predominantly for olive oil production. A similar pattern occurred with larger scale operations particularly where dual purpose olives eg Manzanilla, Kalamata had been planted. Only a small number of growers had planned to produce only olives suitable for table olive production. Examples of these are groves in South Australia and Western Australia where Kalamata variety olives have been planted.
New entrants to the industry need to consider the following when planning their table olive operation.

- The market segment for their products - fresh fruit sales, processed olives, packaged olives
- The quantity of product to be processed
- Styles to be produced
- The available growing technologies - irrigated, non-irrigated, organic
- The quantity of trees/olives required to meet production
- Extra sources of olives in case of shortfalls
- Market for culled olives during sorting and grading

Climatic Considerations: The ideal climate for olives is one that has a mild wet winter and a long dry summer. Such a climate is found in southern Australia. Natural precipitation varies within this zone ranging from 100mm to over 1000mm. As table olives need irrigating over summer and autumn, additional sources of water are necessary for commercial production. Sufficient chilling must be available at the site for flowering and fruiting, but frost prone sites must be avoided. Long dry summers reduce the risk of fungal diseases as well as ensuring the olives will ripen, particularly when naturally black ripe olives are required. Growing olives where the temperature requirements are met, but summer rainfall is prevalent, will require irrigation over winter. The winter to spring is a critical period for the flowering of the plant.

The olive, *Olea europaea*, produces fruit when average daily temperatures in June/July average around 10°C or less and summers are long and warm enough to ripen the fruit. The trees and fruit can suffer severe damage at temperatures of minus 5 to 10°C making them unsuitable for table olive production. Prolonged frosts have similar effects. Hot dry winds at the pollination stage may reduce fruit set and productivity and may desiccate young trees and break limbs in mature trees.

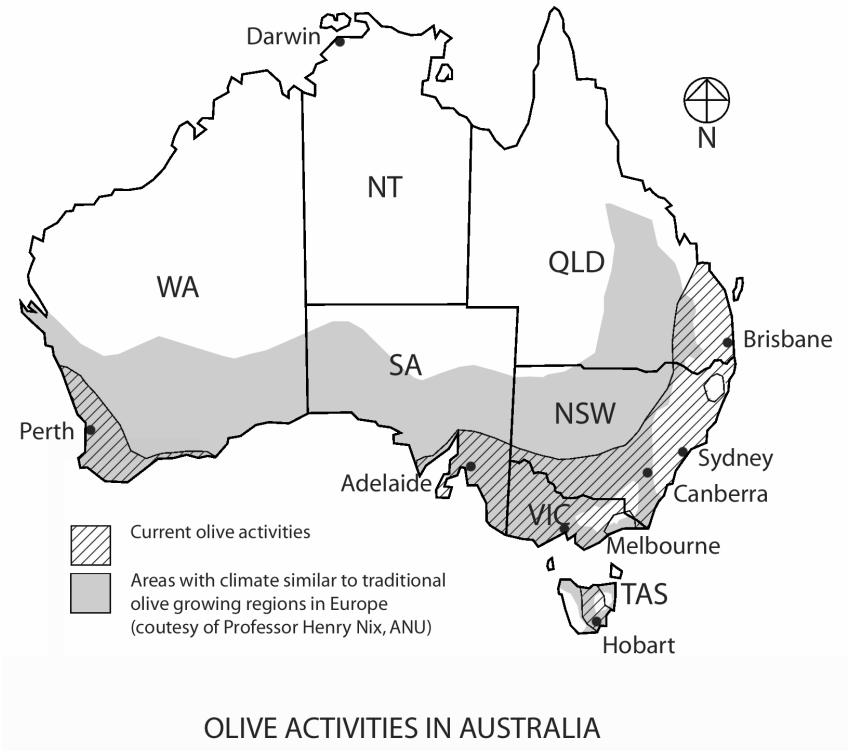


Fig. 3.1. Relationship between areas of current olive activities previously reported by Kailis and Sweeney and predicted growing areas by Professor Henry Nix

Under hot environmental conditions olive trees without irrigation undergo physiological shut down to conserve moisture, production is reduced and if heat conditions are prolonged the trees become stressed as does the fruit, making it less suitable for processing.

Rainfall: Most Australian olive groves are irrigated or can be sustained by rainfall (600 and 800mm/year). Rain at pollination time may reduce fruit set and productivity. Olives can withstand drought, though fruit production is reduced. Hail or frost damaged olives are unsuitable for table olive production. Sites and soil must be well drained, have a favourable pH to ensure efficient nutrient uptake, sufficient nutrients to meet the trees needs, and have sufficient organic matter to support the soil biota. Potassium that accumulates in the olive fruit is lost from the tree and soil when the olives are harvested. With poorly drained sites, elevated rows of trees at a height of 50cm with graded ridges and two metre alleyways can be constructed. Olives are planted in the centre of the ridge.

Dry plant matter placed along the ridge protects against erosion, keeps the soil cool and reduces water losses.

Site Selection: Site selection is important for table olive production. Olives will grow in most soil types. If planted on sites with poor draining soils, production is compromised through lack of vigour due to water logging. Planting sites with slight slopes facilitate both air movement and water drainage. Flat areas with poorly structured soils are susceptible to water logging. Slightly acidic to near neutral friable soils should be selected as the need for soil amendments and hence establishment costs is reduced.

As steeper slopes are prone to erosion, planting should be along contours. Olive trees require direct sunlight for growth, initiation of fruit buds, fruit yield and quality. Radiation levels in Australia are more than sufficient for olive fruit production and problems only occur when trees receive substantial amounts of shade. To maximise radiation, olive trees are best planted on north facing slopes with tree rows in a north - south orientation.

Natural Growing Cycle: Olive bears fruit 2-3 years after planting, depending on stock age. Pollination and fruit set occur in late spring, fruit grow over summer and ripen during autumn/winter. Seven to ten years after planting, trees can produce 25 to 50kg of olives/tree and possibly up to 100kg olives per/tree, depending on alternate bearing patterns.

Poor cropping over 3 successive seasons is an indication that there is a major problem with the grove and if this cannot be corrected, it signifies poor commercial prospects.

3.5 Varietal Considerations

Australian growers/processors need to be strategic in their approach to table olive production and select olive varieties that have favourable growing and processing characteristics. Although most olive varieties can be processed as table olives, it is important that commercially viable varieties, that deliver consistent characteristics from season to season, are chosen. Olive size, shape, flesh to stone ratio, ease of pitting, colour and texture are all very important selection criteria. Numerous olive nurseries around Australia service the olive industry. Subject to agricultural and quarantine requirements olive trees are traded interstate. Most olive trees, suitable for table olive processing, are clonally propagated as self-rooted cuttings. Difficult-to-root table olive varieties such as Kalamata and Sevillana are grafted onto clonal rootstock Frantoio and to a lesser extent on seedlings. Several commercial olive propagators, particularly in South Australia, prefer bud grafting rather than scion grafting procedures. Also refer to Table 3.2.

Grafted olive trees on clonal rootstock are more uniform than those grafted onto seedlings. One olive propagator in South Australia has successfully bud grafted olive "escapes", generally considered to be a pest, as rootstock for Kalamata variety olives, a technique commonly practiced in southern Greece and Italy.

Commonly processed table olive varieties include Kalamata, Verdale, Manzanilla, Sevillana and Hardy's Mammoth. Commonly available olive varieties from nurseries include:

- Large olives - Sevillana, Barouni, Jumbo Kalamata, Hardy's Mammoth, UC13A6
- Medium size olives - Kalamata, Conservolea (Volos), Barnea, Leccino, Manzanilla, Picual, Mission (Californian) and Verdale
- Small olives - Frantoio (Paragon, Correggiolla, Mediterranean, New Norcia or WA Mission) and Arbequina.

There is scope for the development and introduction of new to industry varieties such as Chalkidiki, Nocellara del Belice and Taggiasca. Most Australian olive orchards have 4 to 6 varieties. With single variety orchards, Kalamata or Manzanilla pollinators may improve productivity.

Table 3.2. Factors in selecting cultivars for table olive production

Feature	Description
Olive Size and shape	Medium to large 2-6g. the olive size should be broadly uniform Shape should be uniform ranging from spherical to elliptical dependent on variety.
Flesh to Stone Ratio	Ideally this should be around 5:1 however minimum ratios are 3: for black olives and 4 in green olives. Values are lower for naturally black ripe olives left to dehydrate ie shrivel on the tree.
Flesh detachment from stone	Easier detachment of stone from flesh is advantageous for ease of eating and de-stoning
Texture of Flesh	The olive flesh should be non-granular and non-fibrous. Olives should be free of internal flesh damage such as browning due to infestation or environmental stress.
Olive Firmness	Olives should be harvested so that they are firm enough to resist damage during harvesting and post-harvest handling
Skin and Flesh Colour	Olives should have the characteristics required for the particular method/style of processing. That is green-ripe, turning-colour and naturally black-ripe olives. The olive skin should be thin, fine and delicate
Stone Size, Shape and Surface	The olive should have; a stone that is small, round/elliptical and smooth without sharp protuberances; and flesh that is easily detached from the stone eg freestone and without sharp protuberances.
Overall Appearance	Olives should have a clean appearance with no injury or defects.

There is a great diversity of table olive varieties growing in traditional olive areas. Studies on those cultivated in Portugal, Spain, France, Italy, Greece, Turkey and Tunisia indicate links with ancient types. New varieties can also be developed through breeding and evaluating the fruit from feral olive seedlings. A problem around the world has been varietal authentication. Even varietal differentiation is of current interest because of similarities between Kalamata and Barnea olives processed by the Kalamata style method. Current research is addressing this with the development of libraries linking morphological characteristics such as, shape and size of olive leaves, fruit and stones, with DNA profiles. The large look-alike Jumbo or King Kalamata, because of its popularity with Australian consumers, is worthy of further scientific investigation.

Some of the most sought after varieties for table olive processing are Manzanilla, Sevillana, Barouni and Hojiblanca for green olives, Conservolea, Kalamata and Hojiblanca, for naturally black ripe olives. Other internationally recognised varieties are Chalkidiki (Greece), Nocellara de Belice (Italy) and Picholine (France). Even oil olives such as Frantoio variety can be processed as Ligurian olives and Leccino variety for naturally black olives in brine. The very small fruit of Arbequina variety popular amongst Spanish consumers are seen as an alternative snack to salted peanuts. The use of olives from the Barnea, a cultivar recently introduced for processing by the Kalamata method is gaining interest in Australia.

Table olives which are generally promoted or available for planting by Australian growers are Ascolana tenera, Azapa, Barnea, Barouni, Californian Mission, Cucco, Hardy's Mammoth, Hojiblanca, Kalamata, Kalamata Jumbo, Leccino, Manzanilla, Nabtamri, Olive de Prugno (Prugne), Picholine, Gordal Sevillana, UC13A6, Verdale, and Volos (Conservolea). This list reflects the available germplasm, but does include most internationally important varieties for table olive processing. Verdale has been a favourite of Australian olive growers for years because of its productivity and ease of processing, whereas Kalamata olives are well recognised for their firm flesh, organoleptic characteristics and their easily recognised shape. Large and very large olives are processed by the Spanish Green Style method generally called "Queens' and include Sevillana (Spanish Queen) and UC13A6 (Californian Queen). There is scope for the introduction of new to

industry varieties for Australian olive growers, particularly from Italy, Turkey, North Africa and Middle Eastern countries.

Large olive varieties such as Sevillana, UC13A6 and Uovo de Piccione, with high flesh to stone ratios, are sought after and marketed as "Queen" olives. Popular varieties include Barouni, Jumbo Kalamata, Kalamata, Leccino, Manzanilla, Verdale, and UC13A6 with varieties such as Barnea, Arbequina, and Frantoio providing new opportunities. Olive size, flesh- to -pit ratio and firmness of fresh or processed olives are being evaluated. Olives with a high flesh- to- stone ratio generally have greater acceptance with consumers, whereas over sized olives from the Jumbo Kalamata variety and those obtained by size sorting of other varieties, are suited for the boutique market.

Olives with a high flesh- to- stone ratio absorb more salt than those with low ratios, so that monitoring salt concentration of brines becomes more critical for health safety and to prevent spoilage.

3.6 Establishment of the Table Olive Orchard

Soil requirements: The olive, although considered to be a hardy species, requires a high level of management to yield well. Soils should be assessed for pH, nutrient and organic matter levels and corrections made before planting. The orchard floor, is prepared by deep ripping, especially with duplex and heavy soils.

Planting olives: Planting densities of 250 to 300 trees/ha are currently the most suitable for table olives as they facilitate manual harvesting. Such densities must take into consideration the growth habits of individual varieties and if possible future growing and harvesting technologies. Trees can be planted into 1m x 1m holes on small sites or in rip lines with large sites and supported with stakes so that each tree can utilise 40 square metres of orchard floor and below ie 8m x 5m or 6m x 7m. As long as water is available through natural precipitation and/or irrigation, olives can be planted at any time of the year.

The preferred times however are late autumn and early spring. The planting procedure should ensure that roots are not damaged either mechanically or chemically by concentrated fertilisers which could slow growth.

Nutritional requirements*:* Olive trees will respond to fertilisers, applied by broadcasting or by fertigation, with applications made on the basis of nutrient analyses of soil and/or leaf samples. Taking leaf samples especially around December/January to ensure the correct balance of macro- and micronutrients. During establishment, trees need nitrogen additions but once productive, phosphorus and potassium are also required. Deficiencies of specific elements in the soil eg boron or potassium can lead to deformed fruits and reduced productivity.

Irrigation requirements: Newly planted olive trees require 10L/tree/week.

Training young olive trees: Once planted, the olive trees are trained to a maximum height of two metres as a vase shape with a single trunk to facilitate management and harvesting. During the establishment period, trees must be observed for vigour as well as the presence of any pests or diseases. Once the desired canopy structure is achieved the olive trees should be pruned to maintain canopy shape and to ensure tree health by allowing air circulation and light penetration. Although table olives are mostly picked by hand, planting stock with one main leader will make staking easier and leave the option for machine harvesting in the event the olives are picked for oil production. As a one metre branch free trunk is not required where olives are picked by hand, advantage can be taken of the basitonic nature of the olive tree by allowing the olive trees to grow as a bush.

3.7 Productive Olives Trees Grown Using Good Horticultural Practices

GHP and olives: Fresh olives, for table olive processing should be produced, according to good horticultural practices. Here the olive trees should be grown under conditions ensuring quality fruit with chemical residue levels meeting the appropriate health standards, and harvested at the appropriate maturation states.

Irrigation requirements: Because olive weight is related to water availability, targeted irrigation will ensure table olives of a good size with favourable flesh to stone ratios. Research in California indicated that irrigation levels and fruit size correlated with increased financial returns for table olives. Larger olive groves have substantial irrigation installations. Where water is readily available, 2-5megalitres of water/Ha/year is distributed at the appropriate times, particularly during flowering, fruit setting time and prolonged dry periods. For mature olive trees, 250 trees/Ha, annual yields should range from around 10 to 20 Tonnes/Ha depending on water availability. Mature trees require a seasonal average of 500-800L/tree/week.

Irrigation must be commenced once the olive trees are planted. This ensures that trees come into production earlier. Ridged groves need more frequent irrigation, because of their lower water holding capacity.

Producing Large Olives: The size of olive fruit depends on a number of factors such as:

- Variety
- Growing conditions
- Irrigation levels
- Crop load

This is in contrast to simply sorting out the larger olives from a typical crop. Maximising the first 3 factors, then thinning out the crop will also contribute to the olives ultimate size. Such strategies are used for other fruits such as apples and pears. With the latter fruits modified, espalier techniques for commercial application have been developed. To use this technology for commercial purposes with the olive needs further research. It should however be recognised, that over-large olives may require more time to process. Three ways by which olive crops can be thinned out are:

- Thinning fruit by hand
- Removing productive wood
- Using the chemical agent Naphthalene Acetic Acid

Pruning olive trees for production: As olives destined for table olive production have been traditionally picked by hand, specific training for this purpose has not had the level of research directed to mechanised harvesting of oil olives. Although the olive is a slow growing evergreen, it can grow extensively, making harvesting difficult and dangerous for workers particularly if they need to use ladders or mechanical aids such as cherry pickers. Ideally trees should be trained and managed so that all operations can be undertaken from the orchard floor. Initially pruning is kept to a minimum to encourage early bearing. Branches crossing into the canopy can be bent out rather than removed. Pruning and training should follow the natural growth habit of the olive tree that will result in a bush or an open vase. Trees should be managed to a height that facilitates picking the olives by hand from ground level rather than having to use ladders. The tree should be shaped so as to allow air circulation and light penetration through the canopy without causing radiation damage. Effective airflow through the canopy reduces humidity and the risk of some diseases. A correctly trained tree should show light penetration through the canopy so that maximum sized olives are produced. As olive fruit develops on one-year-old wood, pruning operations should be directed to new growth. That is all dead and non-productive wood should be removed.

Tree Protection: Painting the trunk with latex paint or placing protective paper protects young trees from sunburn or herbicide damage. Competition from weeds is a potential problem for young trees. This is easily managed by either regular mowing, planting legume cover crops for green mulch, spraying with herbicides or to a lesser extent by tilling.

Productivity: Because olive trees are often planted as 1 to 1.5 year old trees, most varieties will commence production within 2 to 3 years after planting. The time from planting to first harvest is dependent on variety and management techniques. Most olive varieties will take at least 4-5 years to bear commercially useful crops but longer if not cared for properly.

Pests and Disease Management: Pests and diseases can affect the growth, vigour and productivity of the olive tree as well as the quality of the fruit. Australia has been considered relatively free of olive pests and diseases, however since the resurgence of the Australian olive industry, several unexpected problems have emerged including, olive-scale, peacock spot and olive-lace bug, curculio-weevil (beetle), bird and animal attacks and soil pathogens such as phytophthora, nematodes and *Verticillium*. In drier areas, such as in Western Australia, Rutherglen bug and grasshoppers have attacked young trees leading to dieback. Some growers have reported olive fruit damage by insects and soft nose caused by the fungus anthracnose. To date, olive fly and olive moth have not been found in Australian olive groves. Some indigenous insects however do attack young trees and olive fruit. Mediterranean fruit fly is a potential problem for the olive. Olive trees are also harmed by some soil-borne pathogens such as phytophthora and nematodes that damage roots resulting in dieback.

Integrated Pest Management: Very few chemicals should be needed for successful olive cultivation. All of these problems can be controlled but they should be positively identified and expert advice on management sought to minimise indiscriminate spraying of broad-spectrum insecticides that will also kill beneficial insects.

Correct pruning to allow adequate airflow through the leaves will help keep many problems under control. Copper sprays applied after harvest and pruning to the tree canopy can be used as a general antifungal treatment.. If the site has been previously used as an orchard the soil should be tested for these organisms and treated under agricultural agency direction.

Integrated pest management strategies (IPM) using cultural techniques and safe chemical sprays such as *Bacillus thuringiensis* should be adopted. A number of additional pesticides and fungicides have been approved for use with olive trees. mineral oil for scale insect pests, Natrasoap for lace bug; copper hydroxide or copper oxychloride for various leaf spots and fruit rots in olives; granular metalaxyl for phytopthora root and crown rot in potted nursery trees; glufosinate-ammonium and fluazipop-p-butyl for weed control; chloropyriphos for ants (around the tree butt), African black beetle (as a drench around the tree base) and light brown apple moth (foliar spray on non bearing trees); methidathion for scale insects; dimethoate for lace bug, green vegetable bug and Rutherglen bug; fenthion for lace bug, green vegetable bug, Queensland fruit fly and Mediterranean fruit fly; and Alpha-cypermethrin as a but drench for curculio beetle and cutworms (See Table 3.3).

Most important is that chemicals are used correctly taking into account orchard workers' health and withholding periods are observed.

3.8 Harvesting for Table Olives

The two most important factors in harvesting for table olive production is:

- Picking the olives at the correct maturation stage for the processing method or style
- Ensuring that only quality fruit is picked for processing.

Table 3.3. Withholding periods for some chemical agents used in olive growing.

Chemical Application	Use	Withholding Period
Insecticides		
Natrasoap	Lace Bug	None
Fenthion	Lace bug,, green vegetable bug, Rutherglen bug, Queensland and Mediterranean fruit flies	Do not harvest olives for 14 days after last application
Dimethoate	Lace bug,, green vegetable bug, Rutherglen bug, Queensland and Mediterranean fruit flies	Do not harvest olives for 7 days after last application
Chlorpyrifos	Ants, African black beetle, light brown apple moth	Not required when used as directed
Methidathion	Scale insects - black scale, olive scale, Californian red scale	Do not harvest olives for 90 days after last application
Mineral Spray Oil	Scale insects - black scale olive scale Californian red scale	Do not harvest olives for 1 day after last application For green olives do not apply 6 weeks before harvest to prevent spotting
Buprofezin	Scale insects	Do not harvest for 28 days after last application
Fungicides		
Copper Hydroxide	Fungal leaf spots including peacock spot and some fruit rots	Do not harvest olives for 1 day after last application
Copper (cupric) oxychloride	Fungal leaf spots including peacock spot and some fruit rots	Do not harvest olives for 1 day after last application
Herbicides		
Glufosinate-ammonium	Numerous weeds and grasses	Do not harvest olives for 21 days after application Do not graze or cut treated areas for stockfood for 8 weeks after application
Fluazifop-P	Numerous weeds and grasses	Not required if used in accordance with directions. Grazing animals - hold for 7 days after grazing on treated areas before slaughter

Olives should be harvested by hand in preference to mechanical harvesting to reduce the risk of damaged fruit that when processed produces an inferior product. Trees may need to be worked over at least three times to obtain fruit at the correct maturation stages. Picking the whole crop at once may save pickers' time, but needs manual sorting later.

Olives Harvesting with hand or mechanised rakes, tree shakers or overhead harvesters increases the risk of bruising leading to gas pocket spoilage and soft olives when processed. More serious damage occurs with black olives.

Mechanical harvesting with shaking or vibration devices has limited application for olives destined to be processed as table olives. As yet machine harvesting has not been a real option, because of bruising and marking of the fruit. Olives are damaged when they come in contact with branches during shaking or vibrating and when they fall to the ground. Damaged fruit when processed reveals surface scars as brown spots and the fruit is more likely to form blisters or gas pockets. There is possibly some scope to harvest naturally black ripe olives that are going to be salt dried or heat dried. Ethylene releasing compounds, which weaken the olive fruit attachment, have also been used to facilitate mechanical harvesting so that less force is required, but their application is limited because with indiscriminate use, substantial leaf loss, detrimental to future productivity, occurs.

Green-ripe and turning colour olives show appreciable injury when mechanically harvested. This becomes more obvious during processing. Immersing machine harvested green-ripe olives into weak lye solutions within 20mins at harvest limits bruising. Although these olives are generally as good as those harvested by hand this procedure is not widely practiced. Green-ripe olives produced under irrigation sodium hydroxide solutions of 0.2–0.3% w/v in potable water are used with higher concentrations for unirrigated olives, 0.6-0.8% w/v. The olives are transported from the field to the processing facility to continue processing. Immersion time in this transporting solution should be short and limited to 1-1.5hours. Some cultivars may require longer periods to remove browning damage, and if this is the case lower concentrations of sodium hydroxide are used to avoid skin sloughing. Nevertheless, green-ripe olives treated in this way can be used for producing Spanish style olives but are unsuitable for producing table olives by natural fermentation methods.

With heavier olive crops expected in the future, as olive trees in Australia mature, serious consideration must be given to methods that can resist damage by mechanical harvesting. Costs for hand harvesting olives are currently $1.5-$2/kg depending on the variety, tree shape and height, weather, availability of labour and distance from major community facilities. In contrast machine harvested olives estimated at 30cents/kg would therefore radically reduce table olive production costs.

3.9 Maturation States for Table Olive Production

Three principal maturation states of raw olives relevant to processing table olives are:

- Green-ripe
- Turning colour
- Naturally black -ripe olives

The exact time of harvesting will depend on the variety, region, crop load and growing conditions. Generally green-ripe olives can be picked in late summer-early autumn and naturally black ripe olives from late autumn to late winter. Turning colour olives are picked between these periods. Olive ripening depends on the variety and crop load. Olives on heavily laden trees are smaller and take significantly longer to reach the naturally black ripe stage than those with a lesser load. Features of olives at different ripening stages are given in Table 3.4.

Table 3.4. Features of olives at different ripening stages.

Maturation Stage	Description
Green-Ripe	Olives at this stage are normal sized green to yellow in colour with firm flesh resistant to pressure within the fingers without marks other than the natural pigmentation.
Turning Colour/Semi-ripe	Olives at this stage are still firm and have started to accumulate purple pigments in the skin and appear multicoloured, rose, brown or purple in colour. The flesh lacks pigment or is partially pigmented close to the skin.
Naturally Black Ripe	Olives at this stage are close to full ripeness with near total pigmentation of the flesh. Oil content has also reached maximum levels

Changes in firmness and texture occur as the olive fruit proceeds from green-ripe to the black-ripe stage. Olives at different maturation stages can have a difference of 30 to 40% in fruit firmness. Mature fruit have higher quantities of soluble compounds therefore lose weight during processing as well as having an increased risk of gas pocket formation.

3.10. Olive Ripening

There are three stages of maturation of the olive relevant to table olive processing and these are reviewed below.

Green-Ripe Olives: Olives at the green-ripe stage are most suitable for processing as green table olives by any method or style. When olives change from a leafy green to a yellow green to straw colour ie green-ripe they have generally reached their maximum size and are ready for picking. When squeezed between the fingers the olives should release a creamy white juice that has an oily feel and the characteristic fruity aroma of olive flesh. Using olives at the unripe leafy green stage for processing poses technical problems such as lower fermentation rates because of poor skin permeability and a lower flesh to stone ratio. When processed the olives have a "rubbery" texture and poor organoleptic characteristics.

Olives-Turning Colour: Olives that have started to change to a light rose to red-brown colour are termed - *turning colour*. At this maturation stage the flesh is still creamy white in colour but is softer than that of olives at green-ripe stage. Turning-colour olives can be processed in brine, but if processed in caustic soda then they are subjected to oxidation. Only green or lightly pigmented olives of the Californian Black type (also called Spanish style black olives) are used to avoid a soft product. Note that trade products called Black Ripe Olives are not produced from naturally black ripe olives.

Naturally Black Ripe Olives: Good quality naturally black olives, with adequate flesh pigmentation should be hand-harvested, before the first frosts, to ensure the best final product. Overripe black olives with pigment to the stone process to a softer product. Harvesting with hand rakes or long poles results in damaged fruit which process to a mushy product with poor organoleptic qualities. Damage may be more difficult to see with black olives than green olives. Olives that are allowed to fully ripen on the tree are called *naturally black ripe* olives. Fruit from most olive varieties ripen to a deep red to black colour. Here the skin changes colour due to the accumulation of red/purple anthocyanin pigments. The olive is termed *naturally black ripe* when the pigments diffuse and accumulate in the flesh right down to the stone. Olives with black skins and white flesh do not meet the requirements of naturally black ripe olives and so will not give the desired product. For example raw Kalamata olives with only black pigmented skin process to a light brown colour. The best stage to harvest for naturally black olives in brine, so that a firm product results, is when the pigment is half to three-quarters through the flesh. When over-ripe naturally black olives are processed, they lose much of their texture resulting in soft products, and have an increased likelihood of off-flavours. Over-ripe black olives are preferred for some types of dried olives.

Harvesting Techniques for Table Olive Processing: Hand picked olives should be collected into padded baskets to prevent damage, then placed in 20-25kg slotted crates. To improve efficiency olives are picked using a milking action. Inexperienced pickers should be given in-site training before picking is commenced especially regarding the prevention of damage to the olives and the trees. While in the orchard, picked olives should be stored in a cool place especially out of the sun until transported to the packing shed or processing facility. As olive varieties process at different rates they should be kept in separate crates.

3.11 Post-harvest Handling of Raw Olives

Deterioration of olives must be prevented at all post-harvest, handling, storage and transport stages. Green-ripe, turning colour and naturally black ripe olives are all subject to damage if handled badly or stored harshly. Green discolouration is obvious if the olives are injured. Although damage is less obvious with black olives, they still need careful handling because injury may lead to the development of soft olives during processing or gas pocket formation with fissures during processing.

Transporting Raw Olives: Olives should be transported carefully to the processing facility and processing commenced as soon as possible. To prevent post harvest deterioration olives must be packed and transported (if over long distances preferably at night) in shallow ventilated crates that allow air circulation, but never in closed crates or sacks. The transporting vehicle must be in a clean and hygienic condition, and not be carrying at the same time other chemicals, petrol in cans or animals. Olives packed in large containers, 250 to 500kg crates, are more likely to deteriorate during storage and transport than if packed in the smaller sized crates indicated above.

Storage of Raw Olives: All olives should be processed as quickly as possible after picking, that is 1-2 days, to avoid deterioration. Depending on the maturation stage, olives stored for longer periods under ambient conditions can, within 7 days, develop fusty and musty defects through heating and sweating. Fresh olives stored at ambient temperatures will deteriorate quickly through the action of enzymes within the olive flesh and by the action of bacteria, yeasts and moulds on the fruit and from the external environment. Processing such olives yields soft products with poor organoleptic qualities.

Black ripe olives deteriorate more quickly than green-ripe olives. Storing unprocessed olives at low temperatures prevents their deterioration by decreasing their respiration rate and by retarding the action of spoilage organisms. As fresh olives are a living entity, they continue to respire and lose moisture causing the olives to lose weight and shrivel. Storing for prolonged periods leads to nail-head markings on the skin which are thought to be of bacterial origin.

Research in California has shown that green Manzanilla olives kept between 5 and 10^{o}C will keep from 4 to 8 weeks respectively before deterioration is significant. Storage temperatures below 5^{o}C cause browning reactions in the olive flesh radiating from the stone to the surface. Green olives can be stored for longer periods under controlled atmosphere conditions eg 5-7.5^{o}C with 2% oxygen and a relative humidity of 90 to 95%. More research is required in this area.

Grading Olives: Sorted and grade olives are more desirable for processors than delivering the olives "as is" off the orchard. With sorting and grading the expectations are that the batches will:

- be of single variety
- be of uniform size
- have no leaves, small, defective or damaged olives

Sorting and grading can be undertaken by hand or by machine. Olives can also be damaged during any vigorous grading procedures so appropriate precautions must be taken. Injuries such as bruising, when the olives pass through mechanical sorters and graders, can lead to the formation of brown spots, gas pockets or blisters during processing. Systems of grading based on differences in specific gravity of the olives at the different maturation stages have been developed, and proponents report that the olive quality of fresh olives is better preserved when compared to other grading systems.

3.12 Summary of Undesirable Qualities in Raw Olives

As mentioned earlier quality raw olives are essential for quality table olives. Undesirable qualities are listed in Table 3.5 and operations that need checking. Skin blemishes can be due to bruising of fruit by machinery, during harvesting or after post harvest handling and grading. Flesh damage can occur during harvesting and poor storage particularly at low temperatures. Shrivelled olives can occur if trees are stressed, particularly if irrigation is unavailable at times of excessively high temperatures. Olives soften on storage.

Changes in olive colour may be due to chemical sprays and some infestations. Deformed fruit occurs through nutritional problems such as boron deficiency and superficial insect damage whereas moulds can lead to changes in skin colour and partial dehydration. Insects such as fruit fly can mark the skin whereas olive fly, not yet found in Australia causes substantial damage to the flesh. If pests or

diseases are present, growers need to check their pest management program. Processed olives should be without stems unless in specialty products. If olives are small, confirm the variety, and apply thinning techniques.

Table 3.5. Undesirable qualities in raw olives

Defect	Description	Operations Needing Checking
Skin blemish	Superficial marks affecting the skin such as: bruises, blows, stains induced by brushing against branches, but do not penetrate into the flesh and are not the consequences of disease	• Cultural and agricultural practices • Harvesting • Post-harvest handling storage and transport
Flesh damage	Imperfection or damage to the flesh which may or may not be associated with superficial marks	• Cultural and agricultural practices • Harvesting • Post-harvest handling storage and transport
Shrivel	Here the olives are so wrinkled as to materially affect the appearance of the fruit. An exception is when shriveled olives are used for preparing dried olives.	• Cultural and agricultural practices • Post-harvest handling, storage and transport
Softness	Here the olives are excessively soft or abnormally flabby.	• Harvesting • Post-harvest handling, storage and transport
Fibrous or Woody	Means olives that are excessively or abnormally fibrous or woody.	• Variety • Harvesting time
Abnormal Colour	Olive colour is distinctly different from the characteristic colours of green-ripe, turning colour and naturally black-ripe	• Cultural and agricultural practices • Post-harvest handling storage and transport
Damage due to abnormal growing practices	The skin of fruit that has been accidentally burnt.	• Cultural and agricultural practices
Deformed fruit	Fruit deformed through factors including nutritional deficiencies and environmental damage	• Cultural and agricultural practices
Cryptogamic and mould damage	This includes lusterless fruits and those with scattered, more or less dark stains caused by the mycelium of certain fungi eg Macrophoma, Gloesporium, growing either within the olive and leading to dehydration of the tissues, or on the skin and affecting fruit colour.	• Cultural and agricultural practices
Insect damage	Deformed fruits and those with abnormal stains or whose flesh has an abnormal aspect. Exit holes are often present.	• Cultural and agricultural practices
Stems	Significant number of stems still attached to olives (unless this is for a specialty item)	• Harvesting practice
Small olives	Inappropriate size	• Check variety authenticity • If small thin out the crop

3.13 Physical Examination of Raw Olive Flesh

Physical analyses were undertaken on a number of olive varieties. Such data provides some base line levels on pressure, fruit weight, stone weight and flesh to stone ratio (Table 3.6). Most measurements were made on the two important table olive varieties Kalamata and Manzanilla. Measurements on the other varieties can be taken as indicative measurements.

3.14 Changes in Olive Flesh Resistance During Maturation

It is well known that olive flesh changes during maturation and ripening. With a simple pressure test we were able to show quantitatively pressure differences between different maturation states. Using a Shor 00 apparatus, measuring pressure in arbitrary units, we demonstrated that unripe green olives gave pressures of 100+ units. This data is not presented in Table 3.6.The green-ripe olives however, generally gave values between 80 and 90 units except for one sample of Picual variety that was yellow rather than green yellow, but had not started to accumulate pigment in the skin. Naturally black ripe olives with pigmentation to the stone gave values between 50 and 70 units whereas turning colour olives gave values in between. We therefore believe this test could be used as an indicator of flesh integrity.

As will be seen in a later section processed olives lose some of this integrity and have lower pressures than fresh olives. It is unlikely that if fresh olives record low pressures when processed, pressure values would increase. More elaborate testing with equipment, not available to the researchers could provide quantitative determinations of texture. In this project, texture was determined only on processed olives by organoleptic assessment and is reported in a later section.

3.15 Fruit and Stone Weight Measurements

Fruit and stone weight measurements were undertaken on the olive varieties indicated in Table 3.6. Fruit weight is a function of moisture and oil content, so that marked changes in these parameters will affect the weight of olives. Moisture content of olives is determined to a large extent by the availability of water to the olive tree. This matter has been illustrated by others, where olives grown under irrigation are generally larger than those grown under dryland conditions.

Olive weight is important in table olives, because consumers show a preference for larger olives than smaller ones except for specialty lines such as Ligurian Olives (Taggiasca variety) and the Arbequina variety. The olives examined in this study had weights within ranges expected for those varieties and within desirable olive weights of 2 to 6 grams (Table 3.6). The weight of olive stones reach their maximum weight well before the olive ripens. On its own then, the stone weight does not provide useful information.

When used to calculate the flesh to stone ratio this latter parameter is a crude indicator of the nutritional quality of the olive as there will be less flesh available per olive eaten. Knowing the weight of the olives and the flesh to stone ratio gives an indication of the processing time. Smaller olives with lower flesh to stone ratio (Verdale) process faster than larger olives with a high flesh- to- stone ratio (Jumbo Kalamata) especially by traditional methods. Ideally the flesh to stone ratio should be 5:1. The majority of olives tested were in excess of this and except for one sample of green-ripe Barnea variety olives were all within the limits of a minimum ratio of 3 for green-ripe olives and 4 for black ripe olives.

3.16 Proximate Analysis of Raw Olive Flesh

Proximate analysis is used to characterise the broad chemical nature of foodstuffs. It involves determining moisture, oil, protein and ash levels and then calculating the carbohydrate content by difference. The ash content represents non-combustible material and is an indication of the total mineral content. Reviewing the results in Table 3.7 reveals that moisture content of the flesh, except one of the raw olives in the study, were between 60%w/w and 7%w/w.

Similar trends were observed with additional varieties, not listed in Table 3.7, which included Barouni, Hardy's Mammoth, Hojiblanca, UC13A6, Verdale and Conservolea. The flesh of most varieties had an oil content of more than 20%w/w. Flesh from most varieties had protein levels of between 1%w/w and 2%w/w, whereas the total calculated carbohydrate value was mostly between 8%w/w and 12%w/w.

3.17 Oil Quality in Raw Olive Flesh

The quality of the oil in the raw olive flesh, was also evaluated in terms of saturated (SatFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid levels and oleic acid content (Table 3.7). Saturated fatty acid levels were mostly between 12%w/w and 16%w/w, MUFA levels between 60%w/w and 80%w/w and PUFA levels 5%w/w and 18%w/w.

The fatty acid profiles of the oil content of raw olive flesh are given in Table 3.10. Unlike olive oils there are no set limits for the different levels of fatty acids in the oil content of raw olive flesh. A major difference between the oil quality in raw olive flesh and olive oil is that the olive seed contributes to the fatty acid profile. In table olive flesh the bulk of the oil is made up of oleic acid whereas the much debated linolenic acid (cf olive oil) content was 1%w/w or less.

3.18 Soluble Sugar Levels in Raw Olive Flesh

The fermentative substrates for microbial fermentation during processing are found in the flesh. These include the soluble sugars, glucose, fructose and sucrose. A number of olive varieties were evaluated and the results are presented in Table 3.8. Soluble sugars were detected in all samples of olive flesh and across all varieties tested. Levels ranged from around 0.5%w/w to over 5%w/w. These levels are consistent with reported values by others. Most had a soluble sugar content of over 1%w/w with more than half levels greater than 2%. Sugar levels of 2%w/w or more in table olive flesh are favourable for fermentation. Points to note however, are that the sugar concentrations in the flesh would change with moisture content and if olives are subjected to prolonged soaking and multiple washing steps, much of this intrinsic sugar is lost and additional sugar may need to be added for fermentation to proceed.

3.19 Mineral Content of Raw Olive Flesh

The levels of 11 minerals both macro and micro in raw olive flesh are presented in Table 3..9. The macro elements are phosphorus; potassium, sodium, calcium, magnesium and sulphur and are expressed as percent or g/100g. The microelements (trace elements) are boron, copper, iron, manganese and zinc and are expressed as mg/Kg or parts per million (ppm).

3.20 Macro Elements in Raw Olive Flesh

***Phosphorus*:** The levels in the flesh of fresh olives ranged from 0.02 to 0.25 percent. The majority of the 20 olive varieties in Table 3.9 were at the lower end of the range. But three olive varieties (Verdale, UC13A6 and Hardy's Mammoth) had levels greater than 0.1 percent.

Potassium: The levels of potassium determined for the 20 varieties of fresh olives ranged from 0.53 to 3.39 percent. Again the majority (17) were grouped at the low end of the range and three varieties (Verdale, UC13A6 and Hardy's Mammoth) were at the high end of the range >1.6 percent.

Sodium: The levels of sodium in the olive varieties ranged from 0.01 to 0.22 percent but with this mineral only one variety (Hardy's Mammoth) had a high sodium level (0.22 percent).

Table 3.6 Physical parameters of raw olives

Variety	Maturation State	Processing Method	Pressure Units	Fruit weight Grams	Stone weight Grams	Flesh: stone Ratio
Barnea	Black	Fresh	55.68	4.28	0.53	7.08
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Barnea	Green	Fresh	91.38	2.18	0.59	2.72
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Barouni	Green	Fresh	90.34	6.59	1.19	4.54
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Frantoio	Green	Fresh	95.14	3.32	0.64	5.38
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Hardy's	St Deviation	Fresh	96.04	4.25	0.68	3.22
Mammoth	No of samples		1.94	1.94	0	0
			2	2	1	1
Kalamata	Black	Fresh	61.67	5.82	0.99	5.69
	St Deviation		5.53	4.47	0.79	1.44
	No of samples		3	7	5	7
Kalamata	Green	Fresh	90.1	7.44	1.74	4.1
	St Deviation		5.2	5.74	0.88	1.36
	No of samples		3	4	4	4
Kalamata	TC	Fresh	68.52	10.67	1.41	5.84
	St Deviation		13.84	6.29	0.97	0.92
	No of samples		3	5	4	4
Leccino	Black	Fresh	66.51	3.45	0.61	4.78
	St Deviation		5.02	1.38	0.23	0.23
	No of samples		2	2	2	2
Manzanilla	Black	Fresh	66.84	5.48	0.63	8.33
	St Deviation		19.94	0.37	0.05	0.58
	No of samples		4	4	4	4
Manzanilla	Green	Fresh	82.34	5.22	0.65	6.74
	St Deviation		14.74	1.1	0.07	1.52
	No of samples		6	5	5	5
Manzanilla	TC	Fresh	70.85	5.39	0.64	7.54
	St Deviation		10.42	0.93	0.05	1.95
	No of samples		5	5	5	5
Pendolino	Black	Fresh	67.97	3.48	0.53	5.57
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Picual	Black	Fresh	55.93	7.08	0.83	7.53
	St Deviation		0	0	0	0
	No of samples		1	1	1	1
Picual	Green	Fresh	73.86	5.96	0.76	6.84
	St Deviation		0	0	0	0
	No of samples		1	1	1	1

Table 3.7. Proximate analysis of flesh of raw olives

Variety	Maturation State	Moisture %w/w	Oil %w/w	Protein %w/w	Ash %w/w	Total CHO %w/w	Sat FA %w/w	Monounsat FA %w/w	Polyunsat FA %w/w	Oleic Acid%w/w
Banea	Black	59.58	27.97	1.99	0.42	10.03	16.30	65.60	60.10	61.40
	No of Samples	1	1	1	1	1	1	1	1	1
Frantoio	Green	68.08	21.40	1.91	0.36	8.25	14.70	77.00	8.40	72.70
	No of Samples	1	1	1	1	1	1	1	1	1
Kalamata	Black	56.35	27.22	1.21	1.06	9.43	13.78	72.30	13.95	68.53
	Stand Deviation	14.20	8.40	0.21	0.44	2.27	3.97	6.59	2.64	7.31
	No of Samples	6	5	4	4	4	4	4	4	4
Kalamata	Green	67.03	16.65	2.01	1.24	9.27	18.90	66.70	14.40	62.60
	Stand Deviation	2.36	8.10	0.72						
	No of Samples	3	3	3	1	1	1	1	1	1
Kalamata	**TC**	68.22	21.41	1.05	1.02	8.02	19.60	41.65	17.70	57.85
	Stand Deviation	1.08	0.54	0.15			0.28	33.45	3.96	3.61
	No of Samples	2	2	2	1	1	2	2	2	2
Leccino	Black	63.20	21.94	2.16	0.58	12.28	16.50	76.20	7.30	71.20
	Stand Deviation	3.25	3.65	0.61						
	No of Samples	2	2	2	1	1	1	1	1	1
Manzanilla	Black	67.82	22.29	0.96	0.35	8.59	16.83	76.93	6.23	71.80
	Stand Deviation	4.32	4.22	0.05	0.07	0.08	0.90	2.97	2.15	2.98
	No of Samples	3	3	3	2	2	3	3	3	3
Manzanilla	Green	64.88	22.46	1.02	1.07	8.30	16.53	78.00	5.33	73.67
	Stand Deviation	14.76	11.66	0.45	0.55	1.40	0.38	1.81	1.53	1.96
	No of Samples	5	5	4	3	3	3	3	3	3
Manzanilla	TC	68.24	21.63	0.94	0.58	8.62	16.88	76.36	6.76	71.66
	Stand Deviation	2.24	1.47	0.15	0.49	1.51	0.77	2.98	2.33	3.16
	No of Samples	5	5	5	5	5	5	5	5	5
Pendolino	Black	61.55	25.45	0.72	0.67	11.61	16.60	68.90	14.50	64.20
	No of Samples	1	1	1	1	1	1	1	1	1
Picual	Black	66.50	20.20	1.64	0.88	10.78	12.70	70.00	17.30	66.70
	No of Samples	1	1	1	1	1	1	1	1	1
Picual	Green	66.92	16.36	1.72	0.57	10.27	12.00	75.10	12.90	71.70
	Stand Deviation	5.96	0.02	0.05						
	No of Samples	2	2	2	1	1	1	1	1	1
Picual	TC	67.30	21.05	1.36	0.43	9.87	11.70	74.80	14.10	71.70
	No of Samples	1	1	1	1	1	1	1	1	1

Table 3.8. Sugar content of raw olive flesh in selected raw olives

Variety	Maturation State	Number of Samples	Sugar %w/w
Barnea	TC	2	2.49
Barouni	TC	1	2.85
Hardy's Mammoth	TC	1	5.61
Hojiblanca	Green	1	2.63
Kalamata	Black	4	2.16
Kalamata	Green	3	2.36
Kalamata	TC	1	1.48
Leccino	Black	1	0.83
Manzanilla	Black	1	0.95
Manzanilla	Green	5	1.77
Manzanilla	TC	3	1.22
Picual	Green	1	4.06
UC13A6	Green	1	4.61
Verdale	Green	1	3.45
Volos	Green	1	0.49

Calcium: The range of the calcium levels were 0.02 to 0.16 percent. Two of the varieties (Verdale and Hardy's Mammoth) had calcium levels of 0.1 percent and 0.16 percent respectively. The other olive varieties ranged from 0.02 to 0.055 percent.

Magnesium: The levels of magnesium ranged from 0.01 to 0.06 percent, only one variety had the high level of 0.06 percent and that was Hardy's Mammoth.

Sulphur: The sulphur levels in the fresh olives ranged from 0.01 to 0.13 percent. Two of the olive varieties had levels of 0.08 percent (UC13A6) and 0.13 percent (Hardy's Mammoth).

3.21 Micro Elements in Raw Olives

Boron: The levels of boron in fresh olives showed a range of 4 to 22 mg/Kg with only one variety at the high end (Hardy's Mammoth). The other 19 varieties were distributed over the range of 4 to 9.5 mg/Kg (Table 3.9).

Copper: The copper Levels ranged from 0.3 to 5.8 mg/KG. One variety was at the low end of the range (Barouni) and this may indicate a copper deficiency in the soil at this site. Only one variety (Hardy's Mammoth) was at the high end of the range.

Iron: The iron levels in fresh olives ranged from 3 to 95 mg/Kg. Three olive varieties had iron levels much higher levels than the other 17 varieties. These three varieties were Verdale (18.1mg/Kg), UC13A6 (19mg/Kg) and Hardy's Mammoth (95mg/Kg) **(**Table 3.9).

Manganese: The manganese levels ranged from 0.91 to 5.5 mg/Kg and again as with iron the same three varieties had much higher levels than the other 17 varieties (Table 3.9.).

Zinc: The zinc results as indicated in Table 3.9. were more variable and ranged from 1.4 to 33mg/Kg. The same three varieties (Verdale, UC13A6 and Hardy's Mammoth) had the higher zinc levels (9.65 to 33mg/Kg). However, there was a larger swing in levels for zinc in the other 17 varieties than that seen in the other minerals.

Table 3.9. Mineral content of raw olive flesh

Variety	Maturation State	Processing Method	Phosphorus %	Potassium %	Sodium %	Calcium %	Magnesium %	Sulphur %	Boron mg/Kg	Copper mg/Kg	Iron mg/Kg	Manganese mg/Kg	Zinc mg/Kg
Arbequina	TC	Fresh	0.07	0.79	0.04	0.04	0.02	0.04	8	2.1	5.7	1.8	4.7
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Barnea	Black	Fresh	0.03	0.65	0.02	0.02	0.01	0.02	5.85	1.37	8.22	1.17	3.36
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Barnea	TC	Fresh	0.05	0.89	0.02	0.05	0.02	0.03	9.50	1.85	7.00	1.45	4.40
		St Deviation	0.01	0.18	0.01	0.01	0.01	0.01	3.54	1.77	0.57	0.07	0.99
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Barouni		Fresh	0.05	0.61	0.01	0.04	0.02	0.02	7	0.3	4.9	1.3	3
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Frantoio	Green	Fresh	0.04	0.61	0.01	0.02	0.01	0.02	5.47	3.37	4.84	1.26	2.53
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Hardy's	Green	Fresh	0.25	3.39	0.22	0.16	0.06	0.13	22	5.8	95	5.5	33
Mammoth		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Hardy's	TC	Fresh	0.07	0.81	0.01	0.02	0.02	0.03	6	0.3	3.1	0.7	3.1
Mammoth		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Hojiblanca	Green	Fresh	0.06	0.6	0.01	0.05	0.02	0.03	4	1.3	4.4	2.2	5.3
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Kalamata	Black	Fresh	0.03	0.70	0.01	0.02	0.01	0.01	6.59	0.85	3.63	1.08	1.90
		St Deviation	0.01	0.09	0.003	0.002	0.0003	0.002	1.19	0.43	0.68	0.12	0.36
		No of Samples	4	4	4	4	4	4	4	4	4	4	4
Kalamata	Green	Fresh	0.15	2.19	0.06	0.10	0.05	0.08	18.33	2.26	27.36	4.02	15.35
		St Deviation	0.14	2.06	0.08	0.10	0.04	0.08	20.31	1.70	32.26	3.73	18.47
		No of Samples	5	5	5	5	5	5	5	5	5	5	5
Kalamata	TC	Fresh	0.04	0.59	0.01	0.02	0.01	0.01	5.05	1.80	3.06	1.02	2.21
		St Deviation	0.004	0.08	0.01	0.002	0.001	0.001	1.07	0.42	0.23	0.08	0.54
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Leccino	Black	Fresh	0.06	0.83	0.01	0.02	0.02	0.03	5.99	1.52	4.21	1.39	3.14

Variety	Maturation State	Processing Method	Phosphorus %	Potassium %	Sodium %	Calcium %	Magnesium %	Sulphur %	Boron mg/Kg	Copper mg/Kg	Iron mg/Kg	Manganese mg/Kg	Zinc mg/Kg
		St Deviation	0.05	0.14	0.00	0.01	0.001	0.01	0.01	0.74	0.02	0.02	1.35
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Manzanilla	Black	Fresh	0.02	0.53	0.01	0.03	0.01	0.01	6.10	1.52	3.56	0.91	1.78
		St Deviation	0.005	0.09	0.002	0.005	0.001	0.002	0.62	0.57	0.14	0.09	0.71
		No of Samples	3	3	3	3	3	3	3	3	3	3	3
Manzanilla	Green	Fresh	0.03	0.62	0.01	0.03	0.01	0.01	5.30	1.26	3.04	0.99	2.05
		St Deviation	0.02	0.05	0.002	0.01	0.004	0.004	1.59	0.48	0.29	0.31	1.04
		No of Samples	4	4	4	4	4	4	4	4	4	4	4
Manzanilla	TC	Fresh	0.02	0.56	0.01	0.03	0.01	0.01	6.17	1.34	3.60	0.93	1.89
		St Deviation	0.00	0.12	0.002	0.01	0.002	0.001	1.59	0.44	0.55	0.16	0.59
		No of Samples	5	5	5	5	5	5	5	5	5	5	5
Pendolino	Black	Fresh	0.02	0.72	0.04	0.02	0.01	0.02	6.76	1.13	4.94	0.91	1.43
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Picual	Black	Fresh	0.04	0.68	0.01	0.03	0.02	0.02	7.18	2.53	8.38	1.60	5.85
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Picual	Green	Fresh	0.03	0.92	0.02	0.03	0.02	0.03	8.07	2.27	5.03	1.53	2.55
		St Deviation	0.002	0.28	0.002	0.004	0.001	0.01	2.73	0.19	0.38	0.39	0.64
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Picual	TC	Fresh	0.03	0.64	0.02	0.03	0.02	0.02	7.34	2.33	5.36	1.28	2.68
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
UC13A6	Green	Fresh	0.15	1.83	0.05	0.055	0.035	0.08	6	1.2	19	3.35	9.65
		St Deviation	0.14	1.77	0.06	0.06	0.04	0.08	4.24	1.27	22.63	3.32	10.39
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Verdale	Green	Fresh	0.13	1.68	0.05	0.10	0.03	0.05	8.37	1.03	18.14	3.80	11.15
		St Deviation	0.10	1.38	0.06	0.09	0.03	0.05	4.76	1.03	18.59	3.11	10.96
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Volos	Green	Fresh	0.07	0.65	0.01	0.02	0.02	0.03	4	0.6	4.6	1.4	5.4
		No of Samples	1	1	1	1	1	1	1	1	1	1	1

Table 3.10. Lipid Profile Raw Olive Flesh

Variety	Maturation State	Processing Method	%w/w																	
			Oil	**SFA**	**MUFA**	**PUFA**	**C16:0**	**C16:1**	**C16:1**	**C17:0**	**C17:1**	**C18:0**	**C18:1**	**C18:1**	**C18:2**	**C18:3**	**C20:0**	**Cis-11eicosenoic**	**C22:0**	**C23:0**	**C24:0**
Barnea	Black	Fresh	27.97	16.3	65.6	60.1	13.8	0	1.1	0	0	2	61.4	2.5	17.4	0.6	0.4	0.2	0.1	0.3	0
		No of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Frantoio	Green	Fresh	21.40	14.7	77	8.4	12.4	0.1	0.7	0.1	0.1	1.6	72.7	2.7	7.7	0.6	0.4	0.4	0.1	0.3	0.1
		No of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kalamata	Black	Fresh	27.22	13.78	72.30	13.95	10.50	0.13	0.70	0.13	0.35	2.55	68.53	1.75	13.08	0.90	0.40	0.35	0.1	0.45	0.025
		St Deviation	8.40	3.97	6.59	2.64	3.22	0.05	0.34	0.10	0.10	0.81	7.31	0.17	2.60	0.08	0.08	0.10	0	0.44	0.05
		No of Samples	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Kalamata	Green	Fresh	16.65	18.9	66.7	14.4	14.6	0.1	0.6	0.2	0.3	3.3	62.6	1.7	13.4	1	0.6	0.3	0.2	1.1	0.1
		St Deviation	8.10																		
		No of Samples	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kalamata	TC	Fresh	21.41	19.6	41.65	17.7	15.65	0.1	1.1	0.2	0.2	3.15	57.85	2.1	16.75	0.95	0.45	0.2	0.1	1.1	0.1
		St Deviation	0.54	0.28	33.45	3.96	0.07	0	0	0	0	0.21	3.61	0	3.89	0.07	0.07	0	0	0	0
		No of Samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Leccino	Black	Fresh	21.94	16.5	76.2	7.3	14	0.1	1.5	0	0	2.1	71.2	2.8	6.7	0.5	0.3	0.2	0	0.3	0
		St Deviation	3.65																		
		No of Samples	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manzanilla	Black	Fresh	22.29	16.83	76.93	6.23	12.87	0.10	1.33	0.13	0.27	3.23	71.80	2.57	5.73	0.53	0.43	0.2	0.1	0.57	0.07
		St Deviation	4.22	0.90	2.97	2.15	0.85	0.00	0.15	0.06	0.06	0.31	2.98	0.12	2.15	0.06	0.06	0	0	0.06	0.06
		No of Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Manzanilla	Green	Caustic	16.83	19.10	73.34	7.56	15.12	0.04	1.40	0.12	0.28	2.88	68.20	2.78	6.74	0.82	0.48	0.24	0.1	0.56	0.06
		St Deviation	0.77	0.90	1.01	0.72	0.62	0.05	0.12	0.04	0.04	0.16	0.97	0.13	0.69	0.04	0.04	0.05	1E-09	2E-01	5E-02
		No of Samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Manzanilla	Green	Fresh	22.46	16.53	78.00	5.33	12.60	0.10	0.90	0.17	0.30	2.97	73.67	2.17	4.70	0.63	0.50	0.30	0.17	0.7	0.1
		St Deviation	11.66	0.38	1.81	1.53	0.61	0.00	0.10	0.06	0.00	0.50	1.96	0.25	1.47	0.06	0.00	0.00	0.06	0.1	0

Variety	Maturation State	Processing Method	%w/w																		
			Oil	**SFA**	**MUFA**	**PUFA**	**C16:0**	**C16:1**	**C16:1**	**C17:0**	**C17:1**	**C18:0**	**C18:1**	**C18:1**	**C18:2**	**C18:3**	**C20:0**	**Cis-11eicosenoic**	**C22:0**	**C23:0**	**C24:0**
		No of Samples	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Manzanilla	TC	Fresh	21.63	16.88	76.36	6.76	12.84	0.10	1.08	0.16	0.28	3.20	71.66	2.34	6.22	0.58	0.48	0.24	0.1	0.6	0.1
		St Deviation	1.47	0.77	2.98	2.33	0.89	0.00	0.08	0.05	0.04	0.32	3.16	0.21	2.23	0.08	0.04	0.05	<0.001	0.07	<0.001
		No of Samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Pendolino	Black	Fresh	25.45	16.6	68.9	14.5	14.8	0.1	0.9	0	0.1	1.4	64.2	3.1	13.5	0.9	0.3	0.3	0.1	0.2	0.1
		No of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Picual	Black	Fresh	20.20	12.7	70	17.3	9.9	0.3	0.5	0	0.1	2.4	66.7	2	16.1	1.2	0.3	0.4	0.1	0.2	0.1
		No of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Picual	Green	Fresh	16.36	12	75.1	12.9	10.2	0.2	0.4	0	0.1	1.4	71.7	2	11.8	1.2	0.3	0.4	0.1	0.3	0.1
		St Deviation	0.02																		
		No of Samples	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Picual	TC	Fresh	21.05	11.7	74.8	14.1	9.3	0.2	0.4	0	0.1	1.4	71.7	1.8	13	1.1	0.2	0.4	0.1	0.3	0
		No of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

***General Comments**:* The mineral levels in the flesh in fresh olives (Table 3.9) revealed that three varieties had consistently higher levels than the other 17 varieties. These three varieties were Hardy's Mammoth, UC13A6 and Verdale. In the case of Hardy's Mammoth only one sample was available for analysis and with the other two varieties two samples were analysed. The standard deviations given in for these two varieties (UC13A6 and Verdale) show that there was probably strong variation in the Table 3.9. results for these two samples. These variations could be due to soil conditions and orchard fertiliser regimes. To gain a more detailed understanding of the variation in the Hardy' Mammoth a much larger sampling would be required to see if the high levels were due to the variety or an effect of soil type or fertiliser regime used on the farm. The other olive varieties showed a close range of mineral levels.

3.22 Concluding Remarks

In the setting up of an olive orchard for the production of olives for the olive market, a number of important strategies need to be taken into account. The first is the average rainfall and the availability of irrigation water for the growing of olives. This may be from dams on site or from scheme water. The rainfall for good olive growing should be between 100mm and 1000mm. The regional temperature patterns also need to be taken into consideration, frost factors, wind strength and finishing temperatures. The soil structure and the lay of the land is important as this will decide the lay out of the olive orchard so that the trees are able to receive maximum light, be protected from hot dry winds and the soil does not waterlog. The consideration of olive varieties is one of personnel selection but the most popular are Kalamata and Manzanilla. It is recommended however, that growers have a number of table olive varieties in their orchards. Pollinator trees are important and these should be distributed around the orchard. A number of agronomic parameters need to be considered, planting density, plant nutrition, training of the trees, pruning, tree thinning, tree protection and pests and disease management.

The harvesting of olives for table olive production is important, as the fruit should have no blemishes. The best way to harvest is by hand however this is expensive. Advances in mechanical harvesting are in the pipeline and these newer machines should improve harvesting efficiency and lower the cost. The transport and storage of the olives is an important factor at harvest time. The recommended time after harvesting for processing the olives is one to two days. The harvested olives need to be kept cool and in well ventilated crates. The storage of olives should be at temperatures below 5°C and they should only be stored for up to four weeks, but it is recommended that the processing be commenced immediately the olives are picked. This is possible on a vertically integrated operation. But with offsite processing the olives are best transported to the processing unit at night.

The chemical and physical aspects of fresh olives were studied and the recommended flesh to stone ratio is 5:1, but this can be varied to as low as 3:1 and as high as 7:1. The olive varieties have shown typical varietal variations in the proximate analysis and there is no data that rules any variety out of a production system. The mineral content of the flesh has shown some variation and this may be accounted for by soil type, orchard fertiliser regime and possible varietal variation.

4. Establishment of Table Olive Enterprises

4.1 Introduction

Processed table olives, being a manufactured food require to be produced with acceptable technologies under safe conditions for consumers and workers. The olives to be processed need to be grown, harvested, stored and transported by methods that minimise physical damage, chemical and microbiological contamination.

Raw olives at all stages of maturation are bitter and mostly inedible and require processing before being suitable for consumption. Processing involves debittering and preservation without loss of nutritional qualities. As with other types of food processing, table olives should be processed *under Good Hygienic and Manufacturing Practices*, using quality assured ingredients. Raw and processed olives must meet quality standards including varietal authenticity and the physical, chemical and microbiological standards to ensure safe and nutritious products.

Table olive processing should be approached systematically. Processing facilities must be appropriate for the production and storage of the table olive products, meeting food regulations, good manufacturing practice, occupational health and safety and environmental requirements. All processing must be undertaken in ways whereby environmental impacts are minimised by using fewer washing steps and where possible reusing brine solutions.

Producing high quality table olives requires:

- Potable water (drinking standard)
- Quality fruit
- Food grade chemicals
- Food grade herbs, spices and condiments
- Food grade cleaners and sanitisers

All material used in table olive processing such as water, salt, lye (sodium hydroxide), acetic acid, lactic acid, citric acid, hydrochloric acid, dextrose, sorbic acid, ferrous gluconate, herbs and spices must meet, food grade standards. Equally important in table olive processing is the water used for washing and processing, as it can be a source of contamination. Only potable water meeting microbiological, chemical and physical standards must be used to prevent consumer health problems and product spoilage

When olives are transformed into edible table olives, they are rendered less bitter by soaking in water or a brine solution with or without treatment with lye (caustic soda). The final flavour of the olive depends on the variety, fermentation, processing solution and the final packing solution. Adding vinegar, marinades, herbs and spices extends the flavour of the olives. Spanish Style Green olives are prepared by treating with lye (caustic soda) as are green or turning colour olives prepared by the Californian methods. Most other green style olives are not treated with lye and rely on leaching out the bitters and a weak fermentation. Addition of food acids such as vinegar (acetic acid), lactic acids or citric acids are used to optimise shelf life and flavour of the olives.

Unlike olive oil production, where the technology is well defined and the processing automated, table olive production needs careful planning as to the size of the operation, the processing styles to be used and the products to be made. Safety issues are a high priority because processing requires a combination of preservation modalities such as microbiological fermentation, salting, acidification,

heat, pasteurisation, sterilisation and refrigeration which if not controlled effectively can lead to spoilage of the olives and possibly food poisoning.

4.2 Olive Processing Methods and Varieties

During the planning phase decisions need to be made as to the types of olives to be produced and which varieties to use. Such information is given in Table 4.1.

Table 4.1. Olive Processing Methods and Suitable Varieties

Processing Method	**Varieties**
Green	
Untreated in brine	Conservolea, Chalkidiki, Manzanilla, Hojiblanca, Barouni, Picual, Verdale
Spanish-style green (treated)	Manzanilla, Hojiblanca, Sevillana
Black	
Naturally ripe in brine	Conservolea, Frantoio, Leccino, Ascolana, Picual
Kalamata style	Kalamata, Hojiblanca, Leccino
Californian/Spanish style	Manzanilla, Californian Mission, Hojiblanca
Salt dried	Thrubolea, Manzanilla, Frantoio, Kalamata, Leccino
Heat dried	Manzanilla, UC13A6, Kalamata, Leccino
Turning Colour	
Ligurian Olives	Taggiasca or Frantoio
Specialty Products	
Marinated	Processed destoned green/black olives (any variety)
Destoned- stuffed	Manzanilla, Sevillana
Pastes & Tapenades	destoned green or black olives of any variety

4.3 GMP – Good Manufacturing Practice

Processors need to develop corresponding procedures to ensure the olives to be processed are of the correct variety, not damaged or defective and of a size relevant to market standards. Additional sizing and grading is undertaken manually or by machines. Processing should be commenced as soon as possible preferably within 1-2 days after harvesting. Olives must be washed in potable water prior to entering the processing line. Process control (microbiological, chemical and physical) is essential during table olive production. Procedures must be developed and documented according to the processing steps including the HACCP procedure. Product profiles must also be developed for each olive style produced eg Kalamata, Greek style black or green, Spanish-style green olives, Californian black, Castelvetrano, Ligurian, Throumbes or sun-dried bulk and for olives packed for the consumer. All inputs eg olives, water, chemicals, herbs and spices, container cleaning agents must have profiles and be under inventory control. A system allowing for product recall, an essential element in food production, must also be in place.

4.4 Water Requirements for Table Olive Processing

Water is required for all washing procedures as well as preparing brine and lye solutions. As water can contain a number of contaminants eg physical, chemical or microbiological, all water used for table olive processing must meet drinking water standards ie potable water. The general characteristics of potable water are summarised as follows.

•Physical - minimal particulate matter
• Chemical - salts, iron, heavy metals and organic chemicals are within health safety limits
• Microbiological - no harmful organisms are present

Scheme water (water from municipal authorities) is generally of potable water quality and so can be used as is. However this water source should be tested at the point of entry into the plant and thereafter, should be tested annually. Ground water and rainwater (tank) can contain a number of contaminants so water from these sources should be tested and treated before use.

Groundwater, tank-water as well as water from dams, lakes and rivers can typically have one or more of the following types of contaminants.

- Physical - particulate matter, mineral, organic matter
- Chemical - herbicides, pesticides, industrial chemicals, naturally occurring salts and metals
- Microbiological - faecal and/or plant origins

Water of unknown quality needs testing at an accredited laboratory and must be treated before use. If contaminated with microorganisms the water must be sanitised eg UV irradiation using the following protocol.

- If coliform/thermotolerant coliform organisms are present

  or
- If there are no coliforms/thermotolerant coliform organisms present but the Heterophilic Plate Count is >500cfu/ml

Successfully sanitised water should have Heterophilic Plate Count of <100cfu/ml.

4.5 Processing Facilities

As indicated in a previous section table olive enterprises in Australia fall into a number of categories. Raw olives are either sold through fresh food markets to processors or processed by the grower. Processed olives are often packed or purchased for third party packaging or further processing.

- Olive farms for raw olive production
- Table olive processing facilities
- Enterprises with combined raw olive production and processing
- Table olive packaging facilities

All olive growers, even those specialising in olive oil production, can on sell their best fruit for table olive processing, undertake primary processing themselves and on-sell the processed olives in bulk quantities or undertake vertical integration - growing, processing and marketing or any combination of these.

Table olive activities can be divided into four broad categories listed below which are embedded in the table olive production to marketing chain.

- Producing raw olives
- Primary processing of raw olives
- Secondary processing of primary processed olives
- Packing and marketing olive products

4.6 Planning Processing Facilities

The Australian table olive industry is in a position to implement the latest practices in table olive processing. Much of the recent international research effort has been directed to the control of table olive production. Emphasis has been placed on the prevention of spoilage due to poor quality fruit, contaminated inputs, lack of documented procedures, use of unhygienic premises and equipment, unhygienic staff practices as well as poor packaging and storage of final products.

Processing facilities require careful planning with respect to processing methods and capacity. Facilities and processing procedures must meet occupational health, safety and environmental standards. All equipment must be constructed of food grade material that can be easily cleaned and sanitised. Processing tanks and containers vary in size with some exceeding 15 Tonnes. Some boutique table olive processors use recycled barrels that previously contained imported olives or pickled vegetables.

A small processing plant with a capacity of 20 Tonnes of olives can cost from as little as, Aus$50,000 to Aus$100,000 to establish whereas large scale facilities of 500 Tonnes or more will cost between one and two million dollars depending on the level of sophistication. Ancillary equipment and facilities for large scale processing such as waste disposal, pumps, sorting tables, graders, depitters, bottling lines and testing laboratory can account for at least a further Aus$300,000. Key considerations, decisions and understandings for establishing a table olive processing facility include the following : -

• Understand the industry - products, markets
• Decide the size of operation
• Determine the environmental issues
• Determine where quality fresh olives will come from
• Consider how quality fruit will be delivered to processors
• Establish sources for acquiring quality water and food grade ingredients
• Plan functional and hygienic processing plants
• Employ trained operatives
• Establish procedures to document processing procedures with controls
• Adherence to occupational and health safety requirements
• Establish procedures to maintain product profiles
• Establish procedures for a product recall system

4.7 Functional Table Olive Processing Facility

Processing facilities must be appropriate for the production and storage of table olive products. They must meet statutory food regulations, good manufacturing practice as well as occupational health and safety and environmental requirements. The plant design should ensure that all operations can be undertaken effectively without the risk of contamination. All areas and equipment must be kept clean, hygienic and free from insects, rodents and other pests.

Facilities should be designed and built for easy cleaning and maintenance and the minimisation of the entry of contaminants. Makeshift facilities should be avoided as in the long term it may be more practical and cost effective to construct new purpose built facilities rather than trying to alter existing structures. The table olive processing facility should be divided into a number of physically or functionally delineated areas.

• Management and service area
• Laboratory - records, testing
• Receiving raw materials – fresh olives, chemicals
• Raw material storage• Pre-processing operations
• Primary processing
• Bulk storage of processed olives
• Secondary processing
• Packaging operations
• Storage of packed products
• Loading area - finished products

The main equipment items required for table olives are sorters, graders, tanks (stainless steel or food-grade fibreglass), pumps and packing equipment. Storage areas, chemical stores, wash-up and toilet facilities should be segregated and away from receiving and production areas. All chemical materials should be under inventory control to prevent errors, mix-ups or contamination. All equipment must meet food grade standards and of a design that allows for safe use by workers, easy cleaning and maintenance.

Plant Maintenance and Sanitation: As table olive processing is a food processing activity, sanitation is important to prevent consumer illness and spoilage of the olives. Cleaning procedures should be defined and records kept, particularly for chemical agents used. Pest control of the facility is best left to a licensed third party that can provide records to ISO standards for inspection by health surveyors. Workers must conform to stringent hygiene protocols. Cleaning procedures should ensure against microbiological, physical and chemical contamination. Records should be kept so that an effective maintenance program can be developed.

Trained Operatives: Persons working in the processing plant must have an understanding of all the activities within the facility, particularly as they relate to occupational health and safety. More specifically they should understand the importance of personal hygiene so that the risk of contamination or cross contamination of the olive products is minimised. Those workers involved more directly in processing must understand the procedures and controls to produce olives that meet quality and safety standards. The table olive processing facility must have personnel trained to the level of the operations required especially in the areas of hygiene, food handling and record keeping. Workers must be provided with information for the safe handling of toxic and microbiological materials and on other possible hazards that may be encountered when using equipment and machinery. As processing table olives involves the use of salt, lye and concentrated acids, workers must be trained to handle chemicals, prepare solutions and be able to handle spills and emergencies especially for personal and third party safety. Workers must be aware of Material Safety Data Sheets (MSDS) for all chemicals used in the processing of table olives. Health and safety implications and decontamination procedures need to be documented and brought to the attention of operating personnel. Processing procedures should include pre-calculated quantities of raw materials for safety and quality purposes.

Operator Health and Hygiene: Adverse medical conditions, such as food borne problems, should be reported to management and a clearance obtained before returning to food handling operations. Unsanitary practices such as smoking, eating and drinking should not be undertaken in production areas. Clothing must be clean and suitable for the task and the wearing of cosmetics and jewellery is prohibited.

Recall Procedures: Table olive processing facilities must have a system of recall for unsafe or contaminated products. The recall process must be compatible with government agencies responsible for public health surveillance.

4.8 Table Olive Processing

Table olives are prepared from the sound fruits of suitable varieties of the cultivated olive tree (*Olea europaea sativa* Hoffg, Link). When treated or processed the olives are ready for consumption. Olives used for processing are harvested at the appropriate level of maturation and processed so that microbiologically safe and edible products are produced. For international trade in olives, individual countries are required to indicate the varieties considered suitable for processing.

Sources of Inputs: Sources of olives should be secured well ahead of processing and contingency plans put into place in case there are shortfalls in supply. Processors must ensure that the olives used meet quality and safety (ie not contaminated) criteria. The source of potable water must be secured and that the amounts required for processing (washing, processing, packing) are available. Water

sources other than from water authorities or agencies should be tested for physical, chemical and microbiological contaminants and treated to potable water standards before use. All chemicals, cleaners, disinfectants and ingredients used must meet food safety standards. Salt, sodium hydroxide and acids must be of food grade quality and only dried herbs; spices and condiments of satisfactory microbiological quality should be used.

Olive Methods and Styles: Numerous table olive processing methods are available. These depend on olive variety, degree of ripeness, processing technology, cultural and traditional factors. Most olive varieties can be processed by using the different methods, however from a commercial viewpoint, specific varieties are preferred because of technological and organoleptic factors and consumer preference. Examples are given below. Manzanilla variety are used for Spanish Style Green Olives, Kalamon variety are used for Kalamata style, Californian Mission variety for Californian green and black ripe olives and Conservolea for Greek naturally black ripe olives.

• Kalamata - Kalamon
• Greek style black or green - Conservolea
• Spanish style-green (Sevillian) - Manzanilla
• Californian black - Mission (Californian)
• Sicilian Green - Nocellara Etnea
• Ligurian - Taggiasca
• Dried Olives - Throumbes

Important international table olive products (the International Olive Oil Council/Codex Alimentarius) are given below. All listed products are currently available in Australia either loose or packed in containers from fresh food markets, supermarkets, delicatessens and specialty food shops. Collectively Australian table olive processors are currently producing most of these products, in competition with imported products, albeit in relatively small quantities,. Furthermore, the IOOC have defined a number of olive methods/style for trade purposes. Australian growers/processors should be familiar with these, especially if they are to enter the international table olive trade or compete against imported table olive products.

Processed table olives can be classified according to the colour of the fresh olives and final product (IOOC/Codex Alimentarius). These includes:

• Black olives
• Turning colour olives
• Green olives

A brief summary of these is given below

4.9 Black Table Olives

Untreated Black Olives in Brine: Here naturally black ripe olives are harvested when the olives are nearly or fully ripe. Depending on the region such olives can be reddish black, violet black, deep violet, greenish black or deep chestnut with both skin and flesh being coloured. Most naturally black ripe olives are processed by placing them directly into brine where they undergo spontaneous fermentation. The finished product retains some fruity and bitter flavours. During processing often the olives lose their intense black purple pigments resulting in pale to dark brown coloured olives. Their colour can be partially restored by exposing them to air after processing. They are preserved in brine, sterilisation or pasteurisation or by addition of a preservative.

Treated Black Olives in Brine: Naturally black ripe olives can also be processed by an initial alkaline treatment with lye followed by natural fermentation in brine. They are preserved in brine, by sterilisation or pasteurisation or by addition of a preservative.

4.10 Shrivelled Black Olives

Shrivelled black olives are popular with consumers. Variations in preparing these include processing naturally black-ripe or nearly black-ripe with or without lye treatment in brine or with dry salt. During processing the olive flesh dehydrates resulting in a soft moist shrivelled product. With salt drying, processing is undertaken in containers where the liquid drawn out of the olives by the salt is allowed to drain away

Shrivelled black olives: Nearly fully black ripe olives are briefly immersed in a weak lye solution, washed free of lye, and then preserved by sprinkling them with dry salt and regular mixing.

Untreated naturally shrivelled black olives: Olives are allowed to partially dehydrate on the tree and then treated in brine.

Untreated black olives in dry salt: Fully ripe black olives are processed by packing them in alternating layers with dry salt or sprinkling them with dry salt (mixing regularly).

Treated black olives in dry salt: Firm practically black ripe olives are briefly immersed in a weak lye solution, washed free of lye, then packed in alternating layers of dry salt or sprinkled with dry salt (mixed regularly).

Untreated naturally shrivelled black olives in dry salt: Fully ripe black olives allowed to shrivel on the tree are processed by packing them in alternating layers with dry salt or sprinkling them with dry salt.

Untreated pierced black olives in dry salt: Fully ripe black olives are pierced with a sharp object, then processed by packing them in alternating layers with dry salt or sprinkling them with dry salt (mixed regularly).

Dehydrated black olives: olives are blanched briefly with hot water then partially dehydrated in salt with gentle heating. Sun dried or heat-dried olives: are popular because of their natural flavours and low salt content. The finished product from all methods is dark brown to black in colour, with a shrivelled or furrowed appearance and an intact skin. Depending on the method the olives retain varying degrees of fruitiness and bitterness

4.11 Turning Colour Olives

Turning colour olives are ones which have started to develop colours such as rose, wine-rose or brown before the olives are fully ripe. Internationally turning colour olives are used predominantly for olives darkened by oxidation. Lesser quantities of turning colour olives are processed by other methods such as fermentation in brine.

Olives Turning Colour Treated in Brine*:* After treatment with lye the olives are preserved by natural fermentation in brine, by heat treatment, or in brine and by heat.

Untreated Olives Turning Colour in Brine*:* Turning coloured olives are placed directly in brine and preserved by natural fermentation.

Olives Darkened by Oxidation: Here green-ripe or turning colour olives are debittered in an alkaline solution, darkened by oxidation, washed free of lye then packed in brine and preserved by heat sterilisation.

4.12 Green-Ripe Olives

Green olives are prepared from olives at the green-ripe stage. The olives are harvested when they are yellow-green to straw in colour. Only firm, sound, unmarked olives are used for top quality table olives.

Treated Green Olives in Brine: Here green-ripe olives are treated in a lye solution, washed free of lye, then packed in brine where they undergo a complete lactic fermentation (Spanish or Seville style) or partial natural lactic fermentation. Where olives have not undergone a complete natural fermentation, and the pH value is within the required limits, preservation may be ensured by: sterilisation and pasteurisation, the addition of preservatives, refrigeration or exposed to nitrogen or carbon dioxide treatments without brine.

Untreated Green Olives in Brine: Here green-ripe olives are placed directly in brine and preserved by natural fermentation.

4.13 Specialty Olive Products

Specialty products made from processed whole olives includes:

• Green olive paste
• Tapenade
• Stuffed olives
• Olives in marinades

After the primary processing, olives of any style can be destoned then sliced, stuffed, or crushed into a paste. Large sized olives called "Queens" are most suited to pitting and stuffing.

4.14 Bruised Olives

Bruised olives are prepared from fresh green-ripe or turning colour olives or olives that have already undergone primary processing. Here the olives are struck with a blunt object or by some other device so that the flesh is exposed without removing or breaking the stone. If fresh, the olives are processed with or without treatment with lye. The olives are packed into brine where they may undergo a natural fermentation. Where lye is used the olives are washed before placement into brine. Once processed, herbs, spices, vinegar and olive oil can be added to extend their flavour. Products include bruised:

• Green olives, untreated
• Untreated green olives, bruised
• Treated green olives
• Olives turning colour

4.15 Split Olives

Split olives are prepared from fresh olives – naturally black ripe, green-ripe or turning colour olives or olives that have already undergone primary processing. Here the olives are slit longitudinally with a knife or by some other device so that the skin is breached and the flesh is penetrated. Fresh olives are processed with or without treatment with lye. The olives are packed into brine where they may undergo a natural fermentation. Where lye is used the olives are washed before placement into brine. Once processed, herbs, spices, vinegar and olive oil can be added to extend their flavour.

4.16 Presentation of Olives

When packed in containers olives can be presented as:

• Whole or divided - pitted, halved, quartered, sliced, divided, chopped, minced or broken
• Pitted and stuffed with various fillings such as pimento, anchovy, onion, garlic or almonds, celery, orange or lemon peel, hazel nuts and capers.
• Packed orderly or randomly into containers. Most products are packed randomly.

4.17 Common Table Olive Styles and Methods

Common table olive styles and methods are summarised in Table 4.2. They are the types of products imported into Australia and sold to consumers. Australian table olive producers have developed similar products and these are indicated by (*). Products are sold in their primary processed form or as specialty products (secondary processing). Australian table olive growers/processors can select products from this table.

4.18 Plant and Process Control

Controlling table olive processing by using documented procedures and relevant tests ensures the quality of the final products is maximised. Microbiological, pH and salt tests are used to monitor fermentation during processing as well as for quality management purposes. Microbiological tests are used to test for the presence and absence of pathogens and spoilage organisms.

4.19 Specifications

Specifications must be drawn up prior to starting manufacturing of table olives. From our experience, most table olive processing in Australian is being undertaken by persons with minimal knowledge of food production and table olive processing, with or without the help of consultants, and often on an experimental basis. Methods used are often obtained by word of mouth from a variety of sources. Workshops conducted by one of the authors of this report have provided valuable technical information to prospective table olive processors around Australia.

4.20 Primary Processing Specifications

Primary processing involves any process used to debitter and preserve the olive eg fermentation, drying. The product may or may not be suitable for immediate consumption at this point.

Process specifications must be clearly documented and should include:

• Product specifications – intermediate or final
• Amounts of olives to be processed
• Quantities of chemicals and adjuvants
• Information for operators on the safe handling of chemicals
• Alerts on health and safety matters during processing
• Testing procedures

Table 4.2. Common table olive styles and methods

Olive Styles	Processing Method
Black Olives (Primary Processing)	
Naturally black ripe olives in brine (Greek Style)*	Whole or slit naturally black ripe olives are processed by spontaneous fermentation in 8-10% salt solution for 3 to 6 months. Exposing processed olives to air returns some of the original black colour. Preserved by one or more – brine immersion, sterilisation or pasteurisation, and addition of preservative.
Kalamata Style*	Whole or slit naturally black olives, usually Kalamata variety, are either debittered in water & brine or subjected to spontaneous fermentation in brine followed by the addition of wine vinegar and olive oil.
Heat dried naturally black olives*	Whole naturally ripe black olives are: • Sun dried until bitterness has reached an acceptable level • Ripe fruit is blanched then oven dried at low temperatures ($50^{O}C$) for a few days until bitterness disappears
Californian Style Black Olives (Olives Darkened by Oxidation)	Whole turning colour olives treated with several lye solutions, of different strengths, to remove bitterness, washed, transformed to a black colour by oxidation in alkaline an medium with air and then packed in brine. Processed olives are heat sterilised in their final containers
Treated Black Olives (Primary Processing)	Whole black olives are given a short treatment with lye solution followed by natural fermentation in brine. Preserved by one or more – brine immersion, sterilisation or pasteurisation, and addition of preservative.
Untreated naturally black olives in dry salt (Thrumba Style)*	Whole naturally full ripe black olives, fresh or partially dried are packed in alternating layers of dry salt until debittered.
Green Olives (Primary Processing)	
Untreated Green Olives in Brine*	Whole, slit or bruised green-ripe olives are processed by a natural fermentation in an 8-10% salt solution for 6 to 12 months
Spanish Style Green Olives (Sevillean Style**)	Whole green-ripe olives are treated for a short period with 1-2% lye solution, washed and then partially or completely fermented (lactic) in brine. Olives are then preserved at a specified pH by sterilisation or pasteurisation, adding preservatives, refrigeration or inert gas without brine
Turning Colour Olives (Primary Processing)	
Untreated Turning Colour Olives in Brine*	Whole, slit or bruised green-ripe olives are processed by a natural fermentation in an 8-10% salt solution for 6 to 12 months
Treated Turning Colour Olives in Brine	Whole olives are treated with lye, then preserved by natural fermentation or heat treatment.
Specialty Products (Secondary Processing)	
Marinated Green or Black Olives*	Marinades added to processed olives – Untreated Green, Turning Colour or Naturally Black Ripe Olives in Brine, Spanish Style Green, or Kalamata Style Olives
Destoned olives*	Green or black olives destoned by hand or machine
Stuffed olives*	Processed green or black olives destoned then stuffed with garlic, pimento, onion, almonds, celery, anchovy, citrus peel, hazel-nuts and capers
Olive pastes and tapenades*	Destoned processed green or black olives crushed to a paste with or without the addition of other foodstuffs (eg capers, anchovies, olive oil, garlic)

4.21 Secondary Processing Specifications

Secondary processing can involve the preparation of the packing solution and additions such as vegetable oil (olive, sunflower, and canola), wine vinegar, herbs, spices and aromatics. Process specifications must be clearly documented and should include:

- Product specifications – intermediate or final
- Amounts of olives to be processed
- Quantities of chemicals and adjuvants
- Information for operators on the safe handling of chemicals
- Alerts on health and safety matters during processing
- Testing procedures

4.22 Finished Product Specifications

Here the olives are ready for consumption but may require an additional preservation method such as the addition of a preservative, pasteurisation or sterilisation.

- Packing solution details
- Additives
- Additional preservation method
- Packaging information
- Labelling information

4.23 Generic Processing Protocol

There are a number of procedures common to all processing methods/styles. Specifics relate to the actual method/style. Furthermore most persons confuse the nature of the final product with the method/style particularly in the case where the olives are embellished with spices, fillings and marinades. A question often asked is for olive recipes. It is best to separate the actual processing procedure as primary processing and recipes relate to the embellishments of olives that have undergone primary processing. Trying to process olives when the embellishments are included at the beginning will result in anomalous products and should not be practiced.

The generic processing protocol in Fig 4.1. should be used as the template for all processing methods. Specific procedures are added for the different olive methods/styles.

Process control (microbiological, chemical and physical) is essential during table olive production. Procedures must be developed and documented as to the processing steps including the HACCP. Product profiles must also be developed for each olive style produced.

4.24 Processor Accepts Quality Raw Olives

Each batch should be examined for quality - olive size, shape, damaged olives and leaves. Processors should ensure that they are able to recognise and distinguish between varieties eg Manzanilla vs Sevillana or Kalamata vs Barnea. Knowing the growing region and the technologies used eg irrigated vs non-irrigated can relate to skin and flesh properties and hence processing conditions used. Olives from irrigated trees, because of their higher water content, are more sensitive to salt damage than those from unirrigated olive trees. The chemical use diary should include chemical names, dates of application and that recommended withholding periods have been met. Processors should not accept olives where olives or orchards have been treated with non-approved chemicals.

Protocol for accepting olives: At the processing facility olives should be assessed for variety, ripeness and soundness before acceptance. With each olive batch or load, the following information should be provided by the grower and checked by the processor.

- Suppliers name
- Receipt date
- Harvesting method and date
- Variety
- Maturation state
- Growing region
- Growing technologies
- Chemical use diary

Fig 4.1. Generic processing protocol for table olives

Regardless of the processing method, using GAP principles, growers should be able to provide quality fruit for processing. Fruit must be of authentic variety; sound without disease and/or environmental or pest damage; and with chemical contaminants within the required health standards.

4.25 Store Raw Olives Correctly at the Processing Facility

Careful post harvest handling of olives is essential to achieve quality table olive products. Olives, particularly naturally black ripe olives, are sensitive to damage during handling and storage must be processed as soon as possible after harvesting and certainly within 24 hour of delivery to avoid deterioration and poor table olive products. Bruised or marked raw olives fetch low prices compared to good quality olives.

Protocol for General Storage of Raw Olives: Olives should be stored at temperatures between 5°-10°C for no more than 24hours in shallow ventilated crates under clean and hygienic conditions to minimise the risk of contamination or damage. Green-ripe olives generally store better than naturally black ripe olives.

Protocol for Storing Raw Olives in Brine: The most commonly used brine solutions for pre-process storage of olives contain 8-10%w/v sodium chloride. Storage tanks are partially filled with the salt solution, before the olives are introduced to prevent bruising or pressure damage. Quantities required to prepare salt brines are given in Table 4.3.

Table 4.3. Quantities required to prepare salt brines

Sodium Chloride %w/v in potable water	Brine Volumes		
	100 Litres	**500 Litres**	**1000 Litres**
5	5kg	25kg	50kg
6	6kg	30kg	60kg
7	7kg	35kg	70kg
8	8kg	40kg	80kg
9	9kg	45kg	90kg
10	10kg	50kg	100kg
Potable water to	100 Litres	500 Litres	1000 Litres

To reduce the risk of the olives shrivelling lower strength solutions starting at 5 to 7.5% food grade sodium chloride in potable water are used initially. The olives are submerged ensuring that there is minimal air space above the brine and tightly sealed to ensure anaerobic conditions. After a few days more food grade salt is added to increase the strength of the brine to 8-10%. The brine should be mixed manually or circulated with pumps initially every 3 days then weekly to ensures homogeneous mixing and prevent uneven salt levels within the tank.

If anaerobic conditions are not achieved oxidative yeasts and moulds develop on the surface of the brine releasing enzymes that attack the fibrous elements of the olives causing them to soften. This can be avoided by carefully controlling the brine strength, having well filled tanks with minimal air space between the lid and brine surface. If yeasts or moulds start to develop they should be skimmed off regularly.

With prolonged storage, a weak spontaneous fermentation occurs typical of processing olives in brine without initial lye treatment or the addition of starter cultures. Under these conditions the pH of the brine falls and the free acid levels reach equivalent to 0.4-0.45% lactic acid. The brine conditions need to be controlled for pH and salt levels to prevent spoilage such as olive softening and gas pocket formation by Gram-ve bacteria. Ensuring the salt concentration is at least 8% w/v and ensuring a pH of around 4 can prevent spoilage. If a rapid lowering of pH is required a food grade acid is added to give tank concentrations of lactic acid 0.5% or acetic acid 0.25%.

Protocol for Storing Raw Olives in Salt Free Solutions*:* Salt free storage solutions, have been developed for a number of reasons. Such solutions have environmental advantage such as avoiding the need dispose of large amounts of salt solution. Research has shown that salt free storage solutions do not support fermentation and there is no deterioration in organoleptic qualities when processed. A typical salt free solution is presented in Table 4.4.

4.26 Raw Olives Enter the Processing Line

Special care must be taken when unloading and handling the olives. With small enterprises most operations are undertaken manually, whereas in large-scale operations these procedures are mechanised from collection areas to the sorting and washing facilities by belts and conveyors. Individual varieties should be processed separately to avoid variable products.

Table 4.4. Quantities for Preparing Free Olive Storage Solutions

Chemical Component	%	100 Litres	500 Litres	1000 Litres
Lactic Acid	0.67	0.67kg	3.35kg	6.7kg
Acetic Acid	1.0	1.0kg	5kg	10kg
Sodium Benzoate	0.3	0.3kg	1.5kg	3kg
Potassium Sorbate	0.3	0.3kg	1.5kg	3kg
Potable Water to		100 Litres	500 Litres	1000 Litres

Protocol for Washing Raw Olives: Olives should be washed with potable water before entering the processing line. Spray washing is more effective than static washing. The olives are washed with spray rinsing machines, to remove contaminants such as leaves, orchard dust, dirt, chemicals and soil microbes such as *Clostridia*, *Bacilli* and coliforms reducing the risk of spoilage during processing and harm to consumers. Washing does not remove the natural microorganisms on the skin that are required for any processing procedure that requires natural fermentation. Water from other sources, such as rainwater tanks and bores should be checked routinely for coliform organisms.

In some centres, where olives are processed with lye (caustic soda), the initial washing step is omitted as multiple washes with water are used during processing. Here the olives are washed in the same tanks as the lye treatment.

Protocol for Preliminary Size Grading of Raw Olives and Removal of Damaged Olives: Before the olives are placed in the processing tanks or containers they should be size graded into 3 to 4 sizes and sorted to remove undersized and defective fruit using a grading machine and sorting table. Small size, misshaped or damaged olives are culled, and if the culls are of sufficient quantity, they can be used for olive oil production. The grower and/or the processor undertake these operations. Preliminary grading and sorting has a number of advantages.

- Similar sized olives process at the same rates
- Increased efficiency because reject olives are not processed
- Facilitates final sorting and packaging operations

4.27 Placement of Table Olives into Processing Tanks

Processors should have a selection of different sized tanks made of food grade material (food grade plastic fibreglass or stainless steel) eg 250kg barrels to 15 Tonne and develop a processing plan for the season eg quantities, varieties and styles.

Processing media include potable water, brine (salt 8-10%w/v in potable water) and lye (caustic soda) depending on the method used. Tanks are partly filled with water or appropriate processing medium, then filled with olives. This procedure prevents bruising and pressure on the olives. The tank filling procedure should be undertaken as quickly as possible especially with green-ripe or turning coloured olives, certainly in less than 20 to 30 minutes, so that olives are not damaged eg by pressure or by exposure to air (discolouration). When filled with olives the tanks are topped up with water or processing medium.

During processing, particularly with brine, the liquid should be well mixed (eg by circulating brine with a pump or stirring) to allow an even reaction in the tank and prevent the formation of salt gradients.

Tanks should be filled to capacity with only olives of the same variety, maturation stage and size before processing commences. This favours even processing of olives. Once processing has commenced further additions of raw olives should not be made. Processing temperatures should be maintained between 20^{O}C and 25^{O}C. If temperatures are too low, processing time is prolonged. Tank temperatures higher than 30^{O}C can lead to the growth of anomalous organisms and spoilage.

Once covered with brine, the process of debittering commences. If the brine is too strong or the olive variety particularly sensitive, shrivelling and fruit damage occurs.

4.28 Processing Table Olives

Table olive processing involves the transformation of bitter inedible olives into an edible foodstuff. Processing methods also preserve the olives from natural deterioration and so the olives can be stored and consumed as required. As well as being palatable, when processed, the transformed olives must be safe to eat and have retained their nutritional attributes. Additional preservation techniques such as pasteurisation or heat sterilisation are also used for some packaged olive products.

Olives are processed using one of the following procedures that removes the bitter principles.

- Repeated soaking in water followed by placement in brine
- Fermentation in brine
- Lye treatment with or without fermentation in brine
- Drying with salt or heat

The first three methods involve a fermentation process, albeit weak in some cases, whereas the latter uses heat. Fermentation is a common feature of most table olive processing methods.

When raw olives are debittered by multiple soaking in water, where the water is changed daily, and then placed in brine, a weak fermentation may proceed. With olives placed directly in brine a spontaneous yeast/bacterial anaerobic fermentation proceeds, initiated by native organisms on the fruit. With lye treated olives eg Spanish style green olives, after washing out the excess lye, the olives are placed in brine where they undergo a bacterial lactic fermentation. In the latter case starter cultures are often required as lye treatment destroys the natural flora on the olives that are required for fermentation.

When lye methods are used eg Spanish Style Green Olives, cultures of *Lactobacillus plantarum* are added after lye treatment, to facilitate fermentation. Californian Style Black Ripe Olives are produced by chemical processing with lye and then brined without fermentation. Olives processed with lye generally require pasteurisation or sterilisation for preservation (increasing the need of additional facilities, time and cost) which are unnecessary steps when olives are fermented directly in brine. A disadvantage of straight brine fermentation is the time it takes to process the olives, generally 3 to 12 months for black ripe olives and green ripe olives respectively, whereas lye treated olives can be on the market within 4 weeks from commencing processing.

Processing can be divided into primary and secondary operations. After primary processing the products are edible whereas secondary processing involves operations such as pitting, stuffing with foodstuffs or aromatising and marinading with aromatics, herbs and spices.

4.29 Fermentation and Olives

Fermentation of olives involves the action of lactic acid producing bacteria eg Lactobacillus species and/or yeasts on fermentable substrates, such as sugars, released from the olives during soaking. During fermentation acids such as lactic and acetic acid are produced which increase the acidity level of the brine and lower its pH. The combination of high salt and low pH greatly reduces the risk of microbial spoilage of the olives. Here controls are essential to reduce the risk of overgrowth of undesirable or harmful microbes that can lead to product deterioration or food poisoning. Process control involves maintaining the salt and acid levels by targeted additions of sodium chloride and food acids respectively. Such processing, generally undertaken at ambient temperatures between $20^{O}C$ and $25^{O}C$, requires negligible energy input.

A simple debittering process for any olive, green-ripe, turning colour or black, is placing them in 10% brine. Here fermentation takes place in the processing, flavour compounds are formed, through the interaction of microorganisms as well as textural changes in the fruit. If the process is well controlled then safe nutritious olives are produced and the fermentation brine can be used to prepare the final packing solution. Fermentation brines can be reused to prepare packing solutions for naturally black Greek-styles olives, untreated green or turning colour olives and Kalamata style olives. Attention needs to be paid to loading and unloading olives. Continuous records should be kept and the process controlled especially pH, salt levels, microbiology, organoleptic changes and spoilage. All operatives need to be trained in food processing methods, handling chemicals and processing olives. Total quality management and HACCP systems should be in place.

4.30 Environmental Considerations in Table Olive Processing

All processing must be undertaken in ways that environmental impacts are minimised. Methods that use less energy and water and produce lower volumes of waste-water, such as natural fermentation in brine or the use of dry salt are more favourable than methods involving lye treatments or heat. Olives treated with lye require multiple washes and can use up to 5 times the amount of potable water compared to natural methods. Furthermore energy requirements increase general costs and possibly labour costs. Even so, lye methods have a number of advantages including shorter processing times than the brine methods and the specific organoleptic characteristics that result.

4.31 Specific Processing Methods

Processing with water (Water-cured): Traditional processing methods involve many water changes over 7-10 days until the olives, either green-ripe, turning colour or naturally black ripe olives are debittered. Here the bitter oleuropein is leached out of the olives and removed from the tank when the soaking solution is discarded. Generally no fermentation occurs. Once debittered the olives are stored in 10% brine. The advantage of this method is that olives are ready to eat within a few weeks.

The disadvantages are that large amounts of water are required which ultimately need disposal and the risk of spoilage increases because microbial contaminants may be introduced through water changes and handling. Over-soaking leads to soft olives with a “washed out” taste. Adding red wine vinegar and olive oil to naturally black ripe Kalamata variety olives that have been debittered by this method gives the traditional Kalamata style olive. Hojiblanca, Leccino and Barnea varieties can also be processed as Kalamata style olives. With some traditional recipes eg Ligurian (Benedictine Style) the olives are soaked in water for weeks to months. When the olives have debittered, salt, herbs and spices are added.

Processing with brine (Brine-cured): Here washed olives are placed directly into brine (10% w/v food-grade sodium chloride in potable water) where over time they take up salt and undergo a weak fermentation. After 6 to 8 weeks the salt in the brine equilibrates with that in the fruit and should be maintained at around 8 to 10% during processing. During brining, water-soluble oleuropein and other phenolic compounds, sugars, vitamins and minerals leach out of the olive flesh, The net result is debittering of the olives. During fermentation sugars are converted to lactic and acetic acid, alcohol and other substances which contribute to the taste of the olives. Processing takes at least 3 months and up to 12 months depending on the variety, maturation level of the fruit, temperature, salt and pH levels of the brine. Green- ripe olives take longer to process than naturally black ripe olives. Processing time can be reduced by subjecting the olives to blanching with hot water or a short soak in lye solution. Slitting or bruising the olives, particularly green-ripe ones, speeds up the debittering process. After processing the olives can be packed in either the fermentation brine, in new brine or a combination of the two.
Green-ripe olives processed by this method gives products similar to Greek style green or Sicilian style olives. Flavours are further enhanced by adding herbs spices and aromatics eg lemon, garlic and oregano or mixed herbs, mustard seed and chilli.

Naturally black ripe olives processed by this method give the traditional Greek style black olive. Adding red wine vinegar and olive oil to Greek style black olives gives a product similar to Kalamata style olives.

Bulk Product of Naturally black olives in brine - pH=4.5 to 4.8; free acidity 0.1-0.6% w/v as lactic acid; sodium chloride 10%w/v. Need to maintain salt levels - if salt levels are lower - need to acidify to 4.0-4.2.

Packed Kalamata style olives - pH=3.8 to 4.0; Free acidity 0.74-1.2% w/v as lactic acid; sodium chloride 6-8%w/v.

Packed Greek style black olives - pH=3.6 to 4.5; Free acidity 0.3-1.0% as lactic acid w/v; sodium chloride 8-10%w/v. A small quantity of residual sugar is present.

Turning colour olives of the varieties, Taggiasca or Frantoio varieties processed by this method give a Ligurian type olive. Turning colour Jumbo Kalamata olives processed by natural fermentation in brine - then packed in brine, olive oil and herbs and spices - is a popular Australian olive product. Large olives such as Jumbo Kalamata should be slit or bruised before processing.

Advantages of this method are its simplicity and that it requires only water for initial washing and fermentation, particularly if the fermentation solution is used as the final packing solution. The major disadvantage is the processing time.

Processing with Lye (Caustic Soda): The most common olive produced by this method is the Sevillian-style also known as Spanish-style green olives. Here washed olives, generally green-ripe, are placed into tanks and soaked in a lye solution (1-2% w/v food grade sodium hydroxide in potable water) for up to 8 to 12 hours to debitter. The lye is allowed to penetrate through three-quarters of the flesh, leaving a small volume of flesh around the stone unaffected. This part of the flesh provides the necessary sugars for subsequent fermentation and contributes a slight bitter taste to the olives.

When olives are pre-treated with lye, the level of lye penetration should be monitored by slicing the olives and observing colour changes in the olive flesh. The degree of lye penetration can be easily visualised by placing several drops of phenolphthalein solution onto the cut flesh changing its colour from green-brown to red.

The olives are drained of lye solution then washed several times with potable water to remove excess lye. Over washing results in loss of sugars required for subsequent fermentation increasing the risk of “stuck fermentations” ie nothing is happening.

Tanks with the lye treated olives are then drained of washing water and filled with brine (10% w/v food-grade sodium chloride in potable water). A lactic fermentation step proceeds. If fermentation becomes “stuck”, then the cause is determined as insufficient sugar, too high a pH or lack of fermentation microorganisms and the appropriate steps taken.

Olives prepared in this way are ready to eat within 4 to 5 weeks although a longer period of standing (up to 3 months) is recommended so that the olives equilibrate in the fermentation brine enhancing the taste. The main disadvantage of this method is the large amount of water required and the amount of wastewater produced. Also significant technical skills are required to process olives with lye such as chemical skills. The processed olives can be packed in the fermentation brine, new brine or a combination of both. Where low salt concentrations are used in the packing brines the olives need to be pasteurised. The above fermentation step can be eliminated. Here the olives, drained and washed of lye, are packed in salt/food acid brine and pasteurised as necessary.

Bulk fermented product - pH=3.8 to 4.2; Free acidity 0.8-1.2%w/v as lactic acid, combined acidity 0.09-0.11N; Sodium chloride 7-8%w/v.

Packed Products pH=3.2 to 4.1; Free acidity 0.4-0.6%w/v as lactic acid, combined acidity 0.02-0.07N; Sodium chloride 5-7%w/v (salt can be reduced to 2% if pasteurised).

Green Olives processed by the Spanish method, usually Manzanilla and Sevillana and packed in glass jars, are often sold in the destoned form or stuffed with pimento, sun-dried tomato, anchovy, nuts or cheeses. They are also placed in marinades of herbs and spices and sold loose as gourmet items.

A variant of the method eliminates the fermentation step. Here after the excess lye is removed, the washed olives are placed in 5-6% salt brine for 2 days. The olives are drained and placed in salt brine with food acid (Citric) to lower the pH. The olives are packed in brine with a final salt content of 7% and a pH of 4.5. Refer also to Tables 4.5 and 4.7

4.32 Anaerobic Fermentation

Anaerobic fermentation is commonly used in table olive production either as the main process or after debittering with lye. Processing olives by fermentation in brine involves a number of sequential stages.

The process of fermentation involves the splitting of organic compounds by microbial enzymes into simpler substances eg sugars are converted to lactic acid. Fresh olives have a natural microflora, with Gram negative bacteria; homofermentative and heterofermentative lactic acid bacteria (LABs) and/or yeasts; oxidative yeasts and moulds; Clostridia, Propionibacteria and Bacillus species. Some of these microorganisms are integral to processing and fermentation whereas others if not controlled adequately lead to soft and malodorous olives. The exact combination of microorganisms varies with the olives maturation stage, but the principles above apply.

Olives are generally fermented in brine (10% w/v food grade sodium chloride in potable water). The initial brine has a pH of around 6.5 to 7.5. Initially Gram negative bacteria predominate even in the nutrient poor brine. These bacteria produce copious amounts of carbon dioxide, as does the fruit that is still technically alive. The carbon dioxide released dissolves in the brine producing carbonic acid. The net result is a moderate increase of the brine acidity and a fall in pH to around 5 which helps establish anaerobic conditions in the brine ie no air. This process generally takes 3 to 4 days. If the pH does not fall, then Gram negative bacteria persist and the olives can develop gaseous spoilage – gas pockets and soft olives. An initial addition of food acid eg lactic acid so that the brine pH falls to around 5 can bypass this stage and hence avoid the problem. The salt levels in the brine should be maintained between 8 to 10% during processing.

Depending on the final product homofermentative and heterofermentative lactic acid bacteria (LABs) and/or yeasts are able to proliferate under these anaerobic conditions and lowered brine pH. Normally faster growing heterofermentative species dominate at this stage utilising sugars and other fermentable substrates released into the brine from the olive flesh producing carbon dioxide, lactic acid, acetic acid and ethanol. A further lowering of brine pH occurs and anaerobic conditions are established which prevents further proliferation of Gram negative bacteria. By ensuring that strict anaerobic conditions are maintained during processing, the growth of surface moulds and yeasts is inhibited. Otherwise these organisms would consume acids produced during fermentation hence reducing the stability of the olives.

As the acidity of the brine increases, heterofermentative species are replaced by homofermentative lactic acid bacteria eg *Lactobacillus plantarum* that produce predominantly lactic acid. Heterofermentative bacteria do not produce as much acid as the homofermentative bacteria. If the brine sugars are low or depleted, insufficient acid is produced and preservation problems can occur. During natural fermentations, yeasts are often present with the LABs (ie mixed flora) and in some

cases (eg Greek style olives) yeasts predominate. If well controlled the final products have desirable organoleptic qualities. If poorly controlled the olives soften, change colour and become gassy.

Table 4.5. Basic table olive processing procedures

Processing in Brine	Debittering with Lye
• Prepare Brine - 8 to 10%	• Prepare Lye - 2 %
• Pack olives in tanks with brine	• Pack olives in tanks with lye
• Processing temperature between 15-30^{O}C	• Treat for 8-10 hours
• Check pH and salt levels	• Check penetration levels
• Establish anaerobic conditions	• Drain lye
• Intermediate fermentation	• Rinse with potable water
• Late fermentation	• Follow with one or two washes - 12 to 24 hours
• Bulk storage of processed olives	• Pack into brine and adjust pH
• Sort and size grade olives	• Continue as for processing in brine
• Pack olives into containers	
• Store olives (10% brine)	

In the case of olives treated with lye, the natural microflora on the fruit is destroyed. In long standing processing facilities, fermentative organisms in the immediate environment are sufficient to establish fermentation. In new facilities starter cultures of LABs need to be added to the brine. When fermentation is complete, the olives can be stored in the same brine for up to 2 years, particularly if the salt level is maintained at 10%w/v. Careful monitoring of pH and salt levels are required during processing.

Californian/Spanish Style Black Ripe Olives: This method/style of olive originally developed in California, has also been adopted in Spain and some north African table olive producing countries. Here fresh green olives/turning colour olives, usually Manzanilla variety, are soaked in several caustic (lye) solutions of different strengths until the lye penetrates the flesh through to the stone and they debitter. During lye treatment air is passed through the tanks and the olives turn a brown/black colour through the oxidation of polyphenols in the flesh. After the olives are drained and washed of residual lye, they are immersed in an iron salt, 0.1% w/v of ferrous gluconate, which stabilises the colour. The olives are washed to remove excess iron, then packed in a 2-3% w/v food grade sodium chloride solution and sterilised. The IOOC stipulates that residual iron in the olives should not exceed 150mg/kg.

Final Products of Californian Style Black Olives - pH = 5.8 to 8 and Sodium Chloride = 1 to 5%w/v depending on commercial product. This product is sterilised**.**

No fermentation is used with this method. Advantages are that the olives retain the firmness of green-ripe/turning colour olives and as processing only requires a few days, they are ready for the market within 1-2 weeks of harvest. Disadvantages are the large volumes of water required for lye treatments and washing and the disposal of the resulting waste-water. Australia currently imports large amounts of these olives. They are commonly available on supermarket shelves and the destoned form is frequently used in cooking and on pizzas. At this point of time this style is not being produced in Australia.

4.33 Processing Dried Olives

Dried olives are popular with consumers. Here the olives are heat dried or salt dried by packing them in alternating layers of dry salt. Here the salt used draws out water and the bitter principles from the olive fruit. Resulting olives have a low water activity that renders them self-preserving. Dehydration is an effective means of inhibiting the growth of microorganisms. Most moulds can grow on foods with as little as 16% moisture. Much fewer will grow at moisture contents of 5%. Bacteria and yeasts generally require higher moisture levels to grow eg greater than 30%. Fruits dried to 16-25% moisture are susceptible to mould if exposed to high humidity and air. Some pathogenic toxin-producing bacteria can withstand the less than favourable conditions of dried foods.

Heat Dried Olives: Heat dried olives are dehydrated by placing naturally black ripe olives in the sun or in an oven set to give gentle heat (40 and 50^{O}C). Higher temperatures will cook the olives. Here the olives lose water and their bitterness by evaporation resulting in a slightly bittersweet product.

A variation of heat dried olives is preparing Ferrandina olives, a traditional style from Italy, which involves blanching naturally black ripe olives in (boiling water), at 95^{O}C for 1-2 minutes to soften. After draining, the olives are soaked in salt brine for a few days (or packed in dry salt for 2-3 days). Olives drained of the brine solution are dried with gentle heat as above, over a few days until their bitterness reaches an acceptable level. The residual moisture is around 13-15% and water activity of less than 0.8.

Salt Dried Olives: Salt dried olives are prepared by packing naturally black ripe olives in alternating layers with dry coarse salt, equivalent to 10-20% w/w of the weight of olives, in slatted containers that allow drainage of vegetable water drawn out by the salt. The resulting olives are shrivelled (date olives) in appearance and have a salty bittersweet taste. Salt is also taken up by the olive, which acts as a preservative. Processing time is around 4 to 6 weeks and the olives should be eaten within 3 months of processing. Addition of olive oil enhances the flavour of the olive, however oxidation of the oil can give the olives a slight rancid flavour.

Both fresh and processed olives can be dried by heat methods, however the salt levels of the olive flesh increase as the olives are dehydrated. Using highly salted processed olives will yield an inedible product. To avoid this problem the olives can be pre-soaked in potable water eg 24hours.

Here the salt used draws out water and the bitter principles from the olive fruit. Subjecting olives to a heat, sun or oven, causes water and bitters to evaporate, resulting in olives with low water activity that are self-preserving.

4.34 Final Product

The final product may be preserved by one or more of the following procedures : brining, pH control, pasteurisation, sterilisation or drying to prevent microbiological spoilage.

Safety Issues: Safety issues are a high priority because processing requires a combination of preservation modalities such as microbiological fermentation, salting, acidification, heat, pasteurisation, sterilisation and refrigeration which, if not controlled can effectively lead to spoilage and possibly food poisoning. Final products should be subject to physical, chemical, microbiological and organoleptic evaluation against available international standards. Potential hazards (Table 4.6) associated with table olive production include hazards such as physical (eg particulate matter in water, glass fragments, stones in pitted olives), chemical (eg contaminants from the environment and in raw materials such as salt & water) and microbiological (problems associated with foodborne disease - coliforms in contaminated water, bacterial and microbiological toxins).

Table 4.6. Potential Hazards and Table Olive Processing

Hazards	Examples
Physical	• Particulate matter in brine • Glass fragments, foreign objects, hair, insects • Stones in pitted olives
Chemical	• Environmental contaminants in olives - heavy metals, agricultural and industrial agents • Contaminated raw materials - water, salt, sodium hydroxide, aromatics
Microbiological	• Bacteria and protozoa - eg Coliforms, Cryptosporidia • Food poisoning - eg Salmonella, Clostridial • Toxins - eg Staphylococcal, Clostridial, fungal • Spoilage organisms - eg Propionibacteria

Spoilage: Spoilage organisms can be introduced through unhygienic procedures or proliferate if processing is poorly controlled. Monitoring of brine pH, salt levels and microorganism levels (also flesh) is important throughout processing, especially in the early stages, to reduce the risk of harm to consumers and spoilage.

Testing for enterobacteriacae (a marker organism) is used to monitor the potential for food poisoning; lactic acid producing bacteria and yeast counts are indicators of fermentation; and mould counts are used to detect fungal contamination. Growth of abnormal microorganisms during processing will lead to “off” flavours and at worst produce toxins causing harmful consequences when the olives are eaten.

The use of high quality olives, having low levels of contamination (ie olives are washed; and stored to prevent contamination and infection from dust, insects, rodents and other animals) and processed under hygienic condition reduces the risk of microbial contamination.

4.35 Packaging and Labelling Olive Products

All table olives require food standard labelling which includes energy rating, carbohydrate, fat, protein and salt content of the flesh. The energy rating and oil content will increase when the olives are packed in or have olive oil or other edible oil added to the brine.

4.36 Specialty Olive Products

Specialty products such as green olive paste and tapenade are prepared from processed olives. Stuffed olives or olives in marinades using fresh material eg fetta cheese, anchovies, vegetables, herbs and spices, generally reduces the shelf life of the final product and increases the risk of contamination.

Where possible additives such as garlic, chilli, basil, oregano are used they should be dried and free of microbes. All raw materials and processing chemicals used require profiles and specifications.

Processed table olives should retain some level of bitterness and fruitiness. The final salt and pH levels of packed olives depends on the style, variety and ripeness of the fruit as long as safety requirements are met. In all cases processed table olives should be determined as microbiologically safe, by an accredited laboratory, before being offered for sale. Procedures should have checkpoints for calculations, quantities used and monitoring procedures for pH and salt levels.

Table 4.7. Protocol for Processing Olives

Operation	Activity	Indicative Testing
Receipt of olives at Processing Facility	**Check Growers Documentation** • Verify variety • Check Fruit Quality • Check Chemical Diary	**Check condition of fruit** - Maturation state - flesh pigmented - Firmness - Damage **Sample Fruit - 20 to 40 pieces** • Average weight • Size variability • Stone size • Flesh to Stone ratio
Washing and Cleaning	**Remove leaves, orchard dust and dirt**	**Check water** • Potable water tests • Coliforms **Visual check for** • Fruit quality • Clean fruit • No leaves
Processing Period	**Prepare Tank/Container** **Pack Olives into Tank/Container** **During Processing** **Check Fruit**	**Salt** - Check for food quality **Check water** • Potable water tests • Coliforms **Prepare 10% brine** **Check Brine** • salt concentration • pH **Microbiology Tests** • Cloudiness • Microorganism screen - Lactobacillus and yeast counts - E coli - Salmonella **Fruit Tests** • Skin Integrity • Taste - Level of Bitterness • Smell
Processed Olives	**Check Brine** **Check Fruit**	Check Brine - salt concentration - pH Microbiology Tests • Cloudiness • Microorganism Screen - Lactobacillus and yeasts - E coli - Salmonella **Fruit Tests** • Skin Integrity • Texture • Salt levels • Microorganism Screen - E coli - Salmonella **Organoleptic Tests** • Colour - Hue - Abnormalities • Taste - Level of bitterness - Positive and negative attributes • Smell **Chemical tests** • Heavy metals • Chemicals • Mycotoxins **Nutritional Tests %** • Salt • Protein • Fat - saturated fatty acid

4.37 Secondary Processing

Here the objective is to embellish primary processed olives with additional flavours and additional nutritional qualities.

Such additions include:

- Olive oil, vinegar, wine, herbs, spices and aromatics.
- Stuffing materials - anchovy, fetta cheese, peppers, chilli, sun-dried tomatoes, almonds,

Adding Vinegar and Oil: A simple secondary processing procedure is to add vinegar and oil to the olives eg olive oil, canola oil and sunflower oil. Vinegars make the olives more acid, adding to their flavour and improving their keeping qualities.

Different styles of vinegar will obviously add different flavours to the olives.

- White vinegar (Supermarket - essentially Acetic Acid)
- Malt vinegar
- Cider vinegar
- Wine vinegars - red and white
- Balsamic vinegar (may contain sugar which can recommence fermentation and create problems after packaging)

Lighter coloured vinegars are generally used with green olives whereas coloured vinegars are used with black olives.

Olive oil is the preferred oil to be added, although other seed oils eg canola, high oleic sunflower oils are used when the olives are to be stored under refrigeration.

4.38 Preparing Packing Solutions with Brine and Vinegar

- Make up a 10% brine solution (a 7-8% brine can also be used if the 10% brine is considered too salty).
- Use 3 parts of this brine and add 1 part of vinegar of choice.
- One litre of the Brine/Vinegar solution will require 750ml of 10% brine and 250ml of vinegar.
- Pack the olives in the containers eg bottles and add the brine/vinegar solution nearly to the brim of the container.
- Add a layer of oil enough to cover the surface of the solution.
- Seal the container and store in a cool place

Adding Herbs and Spices: It is best to use dried herbs rather than fresh herbs to prevent spoilage and the development of off flavours particularly if the processed olives are to be stored for more than a month or so. Olive oil and herbs and spices can also be added to salt-dried, sun-dried and heat dried olives (Table 4.8).

The flavours of the herbs and spices should be subtle and balanced. Also the full effect of the additions can take up to a few weeks to stabilise.

Although taste is an individual element as a guide 3-5grams (about a heaped teaspoon full) of an individual herb or spice can be added to a 2kg container of olives ie olives + brine. The following are some of the herbs spices and aromatics that can be used to embellish processed table olives.

Table 4.8. Herbs spices and aromatic substances added to olives

Herbs, Spices and Aromatics		
Basil	Cinnamon quills	Lemon oil
Bay leaf	Coriander seeds	Preserved lemon Peel
Black pepper	Fennel seed	Preserved orange peel
Capers	Garlic	Marjoram
Cardamom seed	Ginger	Mustard seed
Chilli	Lemon grass	Oregano

Simple combinations that can be added to the processed olives are:

• Chilli + mixed herbs
• Garlic + Oregano + Lemon slices – fresh or preserved
• Whole pickled peppers, salted capers, pickled onions, sun dried tomatoes
• Asian flavours - Chilli, ginger, cardamom seed and lemon grass

Stuffed Olives: Stuffing materials can be inserted into olives by hand or machine. Large destoned processed green olives are ideal for preparing stuffed olives. All operations should be undertaken under hygienic conditions and disposable gloves worn by operators to prevent physical and microbiological contamination of the olives. The following are common stuffings.

Pimento
Pickled chilli
Pickled green peppers (jalapa)
Pickled onion
Blanched almonds
Cheeses
Sun dried tomato
Nuts - almonds

4.39 Tapenade and Olive Pastes

Tapenade is one of the popular spreads and dips at the moment, deliciously salty and lovely with strips of crisp fresh vegetables. The basis of tapenade is the flesh of processed green, turning colour, or black olives to which other foods and spices are added. Californian style olives, because of their low salt content, give a less salty product.

5. Quality and Safety Aspects of Table Olives

5.1 Introduction

Processed table olives must be edible, tasty, nutritious and safe to eat. These objectives can only be achieved if processors follow practices that ensure such qualities are retained. As indicated in earlier sections of this report, quality starts at the planning stage so that; appropriate varieties relevant to processing method, style and consumer preference are used; olives selected for processing are produced by using Good Agricultural Practices (GAP); processing is guided by the principles of Good Manufacturing Practice (GMP) ie product specifications, controlled methods and the use of potable water and food grade ingredients; and premises, and equipment and personnel should comply with Good Hygienic Practices (GHP).

As indicated in Section 5 there are different methods for producing table olives. The end product of each method has specific characteristics that can be assessed by laboratory tests (physical, chemical and microbiological) and sensory evaluation. Furthermore as there is also the risk of introducing physical, chemical or microbiological contaminants during processing and packaging careful control during these processes backed up by specific testing procedures can minimise risk. Control of microbiological quality is of major importance in the prevention of food-borne illness and to reduce the risk of spoilage.

In Australia, Food Standards Australia New Zealand (FSANZ) is responsible for national food-product standards. Although there are no specific standards for table olives, this authority also sets limits for certain ingredients, regulates food additive use and sets tolerance limits for contaminants such as toxins, heavy metals and pesticide residues.

The International Olive Oil Council and the Codex Alimentarius has prescribed standards specific to table olives,. As Australia has encompassed the IOOC quality standards for olive oil, they should also follow the international standards for table olives. Other table olive producing countries such as Spain, Greece and the United States of America have prescribed standards administered through specific agencies responsible for foodstuffs. If Australia intends exporting olives they will need to meet the necessary international standards .

5.2 Quality and Safety Evaluation of Processed Olives

Table olive processors must be familiar with the accepted general quality characteristics of processed table olives. These characteristics are presented and elaborated in Table 5.1. Important characteristics include the flesh to stone ratio where olives with a higher flesh to stone ratio are preferred and the general appearance of the olives. Olive size is important and here uniform size is critical. Processed olives should be firm and retain the textural characteristics of the flesh, a positive organoleptic characteristic, whereas olives that are soft, have a fibrous or granular flesh are less desired. Olives should have colours consistent with maturation and style. Consumers expect black olives to be dark brown to black. Buff coloured to pale brown table olives is an indication that the olives had not ripened to the black ripe stage.

5.3 Physical Evaluation of Processed Table Olives

In this study the investigators assessed the firmness of olives by pressure measurements, recorded the weight of olives and stones, and determined the flesh:stone ratio of a number of processed table olive samples. These samples included olives processed by investigators, table olives purchased at random and ones supplied by Australian olive-grower/processors. Olives that had been processed by brine

fermentation are presented in Table 5.2. Regardless of variety the general trend in pressure measurements were greater for green olives than black olives with turning coloured olives having intermediate values. It is possible that olives with lower flesh to weight ratios may give higher than expected values, however insufficient samples were tested to assess this hypothesis.

Table 5.1. General quality characteristics of processed table olives

Characteristic	Description
Flesh: stone ratio	Must be no less than 3 (75% flesh) in black olives and 4 (80% flesh) in green olives.
Size (uniformity)	No more than 4-5% of the lot may be less than 14 mm crosswise diameter. The remainder should fall into 3-4 sizes.
Flesh texture	Fine, not fibrous or granular, good aroma and flavour.
Firmness	At processing should be firm enough to prevent damage from handling.
Colour	Green olives: strawy green colour; olives turning; pale pink colour; black olives; black or magenta colour.
Stone	Small, preferably smooth, easily detached from the flesh. (freestone)
Appearance	Sound, no injury and/or defects.

In Section 4 pressure measurements were reported for raw olives and in comparison, the pressure values, obtained for raw olives were higher. This indicates that during processing a degree of the olives firmness is lost. The majority of olives processed in brine had favourable flesh: stone ratios values when assessed against the criteria in Table 5.1. Exceptions were green Barnea, Hardy's Mammoth and Verdale. Flesh to stone ratio is a function of variety and agricultural practices.

Table 5.2. Physical measurements made on processed table olives prepared by brine fermentation.

Variety	Matura-tion	Process	Pressure Units	Fruit weight Grams	Stone weight Grams	Flesh: stone
Barnea	Black	Brine	62.56	4.24	0.75	4.64
		St deviation	11.78	1.24	0.20	0.65
		No	4	4	4	4
Barnea	Green	Brine	73.8	3.01	0.63	3.71
		St deviation	3.25	0.71	0.08	0.55
		No	6	6	6	6
Barnea	TC	Brine	68.63	3.58	0.66	4.43
		St deviation	2.96	0.49	0.05	0.37
		No	2	2	2	2
Barouni	TC	Brine	55.69	5.47	0.99	4.53
		St deviation	0	0	0	0
		No	1	1	1	1
Black	Black	Brine	56.67	4.74	0.82	4.78
		St deviation	0	0	0	0
		No	1	1	1	1
Donkey	Green	Brine	63.24	9.21	1.3	6.06
		St deviation	3.98	0.47	0.18	0.76
		No	2	2	2	2
Hardy's Mammoth	Green	Brine	77.87	4.5	0.98	3.69
		St deviation	1.27	2.46	0.53	0.14
		No	4	4	4	4
Hardy's Mammoth	TC	Brine	69.09	10.38	1.79	4.8
		St deviation	0	0	0	0
		No	1	1	1	1
Kalamata	Black	Brine	60.76	4.33	0.74	5.58
		St deviation	10.68	0.96	0.51	0.91

Variety	Matura-tion	Process	Pressure Units	Fruit weight Grams	Stone weight Grams	Flesh: stone
		No	40	42	40	40
Kalamata	Green	Brine	68.09	8.2	1.21	5.23
		St deviation	13.6	3.68	0.41	1.36
		No	7	7	7	7
Kalamata	TC	Brine	58.71	8.2	0.94	7.71
		St deviation	0	0	0	0
		No	1	1	1	1
Leccino	Black	Brine	70.25	3.77	0.79	3.77
		St deviation	0.67	0.2	0.06	0.14
		No	3	3	3	3
Manzanilla	Black	Brine	58.63	5.68	0.72	7
		St deviation	8.47	0.96	0.15	0.75
		No	25	26	25	26
Manzanilla	Green	Brine	76.26	4.35	0.68	5.39
		St deviation	4.57	0.42	0.08	0.55
		No	29	31	29	31
Manzanilla	TC	Brine	64.61	4.65	0.6	6.89
		St deviation	4.48	0.3	0.06	0.98
		No	12	12	12	12
Mastoides	Green	Brine	55.26	9.6	1.38	6.73
		St deviation	11.26	1.54	0	0
		No	2	2	1	1
Pendolino	Black	Brine	74.48	3.86	0.59	5.45
		St deviation	2.8	0.91	0.11	0.29
		No	3	3	3	3
Picual	Green	Brine	72.29	4.25	0.78	4.46
		St deviation	19.22	0.46	0.04	0.46
		No	5	5	5	5
Sevillana	Green	Brine	69.54	6.81	1.13	4.93
		St deviation	4.16	1	0.13	0.51
		No	6	7	6	7
UC13A6	Black	Brine	50.17	12.18	1.62	6.54
		St deviation	1.56	0.03	0.14	0.65
		No	2	2	2	2
UC13A6	Green	Brine	65	8.23	1.16	6.13
		St deviation	11.16	0.47	0.05	0.41
		No	5	5	5	5
UC13A6	TC	Brine	55.24	10.48	1.29	7.11
		St deviation	2.79	1.96	0.11	0.85
		No	2	2	2	2
Verdale	Green	Brine	70.54	4.56	1.03	3.54
		St deviation	4.84	0.73	0.24	0.74
		No	20	21	21	21
Verdale	TC	Brine	56.36	6.71	1.37	3.89
		St deviation	0	0	0	0
		No	1	1	1	1
Volos	Black	Brine	60.26	7.1	0.93	6.71
		St deviation	10.97	1.81	0.17	0.86
		No	4	4	4	4

When pressure measurements were made on olives that had been treated in lye, the values found were similar to those for green olives in brine (Table. 5.3.). There were some exceptions; for instance, a low value was obtained for one sample of Chalkidiki. This may have been an isolated case, however prolonged lye treatments result in soft olives. The black Manzanilla olives had a favourable pressure value which was expected considering this style of olive is produced from green-ripe olives with lye treatment and subsequent oxidation. Again all but one of the samples had favourable flesh:stone ratios. The samples that had values less than 4 were a mixture of Sevillana and Verdale variety olives. When olives are dried, as structural changes occur, pressure measurements become meaningless and the flesh to stone:ratio decreases because of the loss of moisture.

Table 5.3. Physical measurements made on processed table olives prepared with lye treatment.

Variety	Maturation	Process	Pressure Units	Fruit weight Grams	Stone weight Grams	Flesh: stone
Black	Black	Lye	74.96	3.91	0.68	4.75
		St deviation	0	0	0	0
		No of samples	1	1	1	1
Chalkidiki	Green	Lye	55.37	7.83	1.13	6.84
		St deviation	10.02	4	0.07	0.24
		No of samples	5	5	2	2
Donkey Olives	Green	Lye	67.82	9.68	1.18	7.18
		St deviation	0	0	0	0
		No of samples	1	1	1	1
Green	Green	Lye	77.27	3.76	0.76	4.96
		St deviation	0	1.11	0	0
		No of samples	1	2	1	1
Manzanilla	Black	Lye	77.41	6.01	1.05	4.73
		St deviation	0	0	0	0
		No of samples	1	1	1	1
Manzanilla	Green	Lye	68.92	5.78	0.79	6.39
		St deviation	1.6	0.82	0.08	0.97
		No of samples	4	5	4	4
Mixed Olives	Black/Green	Lye	25.52	3.47	No data	No data
		St deviation	0	0	No data	No data
		No of samples	1	1	No data	No data
Pendolino	Black	Dried		2.4	0.46	23.08
		St deviation		0.95	0	0.45
		No of samples		2	2	
Sevillana	Green	Lye	67.17	5.63	1.04	4.41
		St deviation	0	0	0	0
		No of samples	1	1	1	1
Verdale + Sevillana	Green	Lye	74.98	5.5	1.27	3.34
		St deviation	2.4	0.38	0.04	0.43
		No of samples	3	3	3	3

5.4 Chemical Analysis of Olives

Table 5.4. (olives in brine) gives the proximate analysis and fatty acid levels for table olives that were prepared by the project researchers and those that were commercially available in Australia. The chemical analysis indicates that the key analyses of moisture, protein, oil, ash and total carbohydrates vary for the different varieties that are used in the table olive industry.

5.5 Proximate Analysis and Fatty Acid Analysis

The moisture results in Table 5.4. range from 57.83 to 77.7 percent. This variation would be expected and the moisture would be higher as the olives are stored in brine. The variation in the other chemical components is most probably due to species variation. Some of the varieties of olive have quite large variations (oil 11-26 percent, protein 1.18-2.49 percent and ash 1.65 – 5.23 percent). The ash content of the olive is an indirect measure of the mineral content in the table olives.

The fatty acid levels in Table 5.1. show variations in the saturated fatty acids, monounsaturated and polyunsaturated fatty acids but these variations are variety dependent, however, the major fatty acids present in the table olives are monounsaturated and of these oleic acid is over 90 percent of the monounsaturated fatty acid content in table olives. The saturated fatty acids in the olives ranged from 12.5 to 21.3 percent. The polyunsaturated fatty acid levels ranged from 4.28 to 23.85 percent.

Table 5.5. gives similar data for table olives that were processed in lye (caustic soda). The number of samples analysed and the species of olives were lower than in Table 5.4. This represents the use of brine processing in the Australian table olive industry. The comments made for the levels in Table 5.4. apply for the results reported in Table 5.5. The only difference is that the oil level in the lye treated olives is lower than in the brine treated olives. This may indicate that some oil is lost in the larger number of washings that are required when doing lye processed olives.

The olives that were dried using salt and heat showed similar results to those in Table 5.4. and Table 5.5. but the moisture level was lower (20 to 60 percent).

The results in Table 5.4. and Table 5.5. give processors an idea of the levels that they can expect when processing table olives by either processing with brine or lye. Parts of the proximate and fatty acid analyses are required for the nutritional label that is required by legislation to be placed on the commercial product.

5.6 Sugar Levels in Processed Olives

The free sugar levels that were determined in the table olives that were prepared by the research staff and purchased from commercial outlets are given in Table 5.6. The range of the sugar levels is from 0.0 to 0.88. Three olive varieties (Kalamata turning colour, Sevillana green and Volos black) had no free sugars after processing. The other varieties ranged from low sugar levels to 0.88 percent. The variation in the levels of free sugars could be a result of the efficiency of the processing procedure. It can be observed from the standard deviation that for some varieties there is a large variation in free sugar levels. Again the variation within the varieties is probably due to the method of processing.

The free sugar level is also required on the nutritional label.

5.7 Minerals of processed olives

The levels of 11 minerals both macro and micro in processed olive flesh are presented in Table 5.7, 5.8 and 5.9. The macro elements are phosphorus; potassium, sodium, calcium, magnesium and sulphur and are expressed as percent or g/100g . The microelements (trace elements) are boron, copper, iron, manganese and zinc and are expressed as mg/Kg or parts per million (ppm).

5.8 Minerals of olives processed with brine (Table 5.7. and 5.8.)

In this section information on various macro elements in processed table olives are presented.

5.9 Macro Elements

***Phosphorus*:** The levels in the flesh of processed olives ranged from 0.01 to 0.05 percent. The phosphorus levels found in the processed olives do not vary as much as that shown in raw olives. This lack of variation is probably due to the processing procedure.

Potassium: The levels of potassium determined for the olive varieties and types of table olives ranged from 0.05 to 0.51 percent. The majority of the table olives were grouped at the higher level. Two varieties had potassium levels below 0.1percent and two varieties had levels greater than 0.5 percent, however, it should be noted that the potassium level is lower in processed olives than in the raw olives.

Sodium: The levels of sodium in the olive varieties ranged from 1.07 to 2.55 percent. As expected the sodium level in the brine-processed olives is high as compared to the levels in raw olives.

Calcium: The range of the calcium levels was 0.02 to 0.17 percent. One of the varieties that was denoted as black and was a commercial table olive had a calcium level of 0.17 percent. The other olive varieties ranged from 0.02 to 0.07 percent. The calcium values did not vary much from those found for raw olives.

Magnesium: The levels of magnesium ranged from 0.004 to 0.01 percent. Again the processed olives had lower magnesium levels than the raw olives.

Sulphur: The sulphur levels in the processed olives ranged from 0.01 to 0.03 percent. The sulphur levels in the processed olives were similar to the majority of the raw olives except for the two high sulphur levels containing raw olives.

5.10 Micro Elements

Boron: The levels of boron in processed olives showed a range of 1.31 to 6.72mg/Kg. The boron levels in the processed olives were less than in the raw olives.

***Copper*:** The copper levels ranged from 0.43 to 3.6mg/Kg. The copper levels in the processed olives were similar to the copper levels found in the raw olives.

Iron: The iron levels in processed olives ranged from 1.82 to 11.7mg/Kg. Again, the iron levels in the processed olives were similar to the raw olives except that the three varieties in the raw olives that had high levels were lower in the processed olives.

Manganese: The manganese levels ranged from 0.53 to 1.37mg/Kg. The manganese values were similar to the majority of the raw olive levels.

Zinc: The zinc levels in the processed olives ranged from 0.95 to 4.06mg/Kg. As in the raw olives the zinc levels fluctuated within the varieties. The zinc levels in the processed olives are slightly lower than in the raw olives.

5.11 Minerals of Olives Processed With Lye (Table 5.9.)

***Phosphorus*:** The levels in the flesh of processed olives ranged from 0.01 to 0.02 percent. The phosphorus levels found in the processed olives do not vary, as was shown in the raw olives. This lack of variation is probably due to the processing procedure.

Potassium: The levels of potassium determined for the olive varieties and types of table olives ranged from 0.02 to 0.06 percent. It should be noted however, that the potassium level is lower in processed olives than in the raw olives.

Sodium: The levels of sodium in the olive varieties ranged from 0.94 to 2.17 percent. As expected the sodium level in the lye-processed olives is high when compared to the levels in raw olives.

Calcium: The range of the calcium levels was 0.05 to 0.12 percent. The calcium values did not vary much from those found for raw olives.

Magnesium: The levels of magnesium ranged from 0.004 to 0.02 percent. Again the processed olives had lower magnesium levels than the raw olives.

Sulphur: The sulphur levels in the processed olives ranged from 0.01 to 0.05 percent. The sulphur levels in the processed olives were similar to the majority of the raw olives except for the two varieties that had high levels of sulphur.

5.12 Micro Elements

Boron: The levels of boron in processed olives showed a range of 1.44 to 6.34mg/Kg. The boron levels in the processed olives were less than in the raw olives.

Copper: The copper levels ranged from 0.66 to 2.4mg/Kg. The copper levels in the processed olives were similar to the copper levels found in the raw olives.

Iron: The iron levels in processed olives ranged from 3.40 to 150.57mg/Kg. The exceptionally high iron result was on a commercial black olive the olive had been treated with ferrous gluconate. This level of iron in the table olive will not cause any harm when consumed. The other iron levels were similar to those in the raw olives.

Manganese: The manganese levels ranged from 0.57 to 1.88mg/Kg. The manganese values were similar to the majority of the raw olive levels.

Zinc: The zinc levels in the processed olives ranged from 1.23 to 3.01mg/Kg. As in the raw olives the zinc levels fluctuated within the varieties. The zinc levels in the processed olives were similar to the majority of values in the raw olives

5.13 General Comments

In general it would appear that the processing technique has a greater effect on the macro minerals than the micro minerals. The sodium levels in both the brine and lye treatments increase, as would be expected, however with phosphorus, potassium and magnesium, there appears to be a leaching of the mineral from the olives. Calcium and sulphur are maintained at similar levels. This could indicate that the calcium is strongly bound and the sulphur is involved with the sulphur amino acids in the olives. The micro minerals in the table olives are at levels comparable with those found in the raw olives, except for one lye treated olive that had an extremely high iron level. This was due to the processing of the olive in the Californian style with the use of ferrous Gluconate.

5.14 Nutritional Labelling

The Food Standards Australia New Zealand (FSANZ) control what needs to be put into a nutritional label. To develop a nutritional label the chemical analysis needs to be carried out. The main analyses are protein, carbohydrate, total sugar, fat (total), fatty acids as saturated, monounsaturated and

polyunsaturated, energy and sodium. The amount is determined as g/100g and g per serving size. Listed below is the main structure of a nutritional label.

If there is any allergenic material that is used in the processing on value adding steps then it needs to be mentioned on the label (eg peanuts).

Nutritional Information for Table Olives

Servings per package: (Insert number of servings)

Serving size: g

	Quantity per Serving	Quantity per 100g
Energy	kJ	kJ
Protein	g	g
Fat, total	g	g
- Saturated	g	g
- Monounsaturated	g	g
- Polyunsaturated	g	g
Carbohydrate, total	g	g
- Sugars	g	g
Sodium	g	g
(Insert any other nutrient or biologically active substance to be declared)	g, mg,μg (or other units as appropriate)	g, mg, μg

This and other labelling information can be obtained from the FSANZ web site (www.foodstandards.gov.au/foodstandardscode).

Table 5.4. Proximate analysis data of olive flesh olives processed in brine

Variety	Maturation State	Moisture %w/w	Oil %w/w	Protein %w/w	Ash %w/w	Total CHO %w/w	Sat FA %w/w	Monounsat FA %w/w	Polyunsat FA %w/w	Oleic Acid%w/w
Banea	Green	63.98	22.84	1.25	1.65	10.17	16.55	75.45	7.95	72.35
	St Deviation	2.96	2.68	0.15	0.54	0.77	0.07	0.21	0.21	0.21
	No of Samples	6	4	4	4	2	2	2	2	2
Barouni	Black	71.34	16.78	1.34	4.45	6.09	19.30	56.80	23.85	52.70
	St Deviation	0.65	0.44	0.25	0.21	0.17	0.57	11.17	10.54	12.02
	No of Samples	2	2	2	2	2	2	2	2	2
Barouni	Green	69.56	14.11	2.49	2.79	11.05	18.60	71.90	9.80	67.30
	St Deviation	1.66	1.07	0.03	1.30	1.86	0.00	0.85	0.42	0.85
	No of Samples	2	2	2	2	2	2	2	2	2
Black	Black	57.83	26.04	1.92	1.68	12.53	12.50	79.10	8.40	75.50
Unknown	No of Samples	1	1	1	1	1	1	1	1	1
Hardy's	Green	68.17	17.56	1.74	3.61	8.82	21.33	60.80	17.90	57.93
Mammoth	St Deviation	0.73	1.25	0.24	1.94	2.65	1.12	1.41	0.70	1.65
	No of Samples	4	4	4	3	3	3	3	3	3
Kalamata	Black	60.96	25.62	2.11	3.90	7.99	12.51	74.04	13.83	70.63
	St Deviation	7.24	6.35	1.06	2.14	3.44	1.52	3.31	3.76	3.40
	No of Samples	40	28	25	36	23	27	27	27	27
Kalamata	Green	66.07	20.01	1.81	5.23	8.19	15.50	77.40	7.20	73.60
	St Deviation	2.91	3.31	0.26	0.88	0.74				
	No of Samples	7	4	3	6	3	1	1	1	1
Kalamata	TC	68.45	20.85	1.25	4.86	4.59	15.30	71.80	12.90	68.40
	No of Samples	1.00	1	1	1	1	1	1	1	1
Manzanilla	Black	69.68	19.18	1.10	4.24	5.86	18.53	71.10	10.14	65.58
	St Deviation	5.79	5.86	0.16	3.55	1.05	1.74	4.08	2.91	4.64
	No of Samples	26	18	14	20	11	16	16	16	16
Manzanilla	Green	69.71	18.36	1.21	3.58	7.13	17.81	76.53	5.68	71.45
	St Deviation	4.26	4.23	0.15	1.31	2.10	1.77	2.38	1.34	3.29
	No of Samples	28	22	18	19	11	21	21	21	21
Manzanilla	TC	70.72	18.39	1.21	2.82	6.13	16.87	76.43	6.73	71.54
	St Deviation	3.63	3.03	0.09	1.91	1.72	1.40	4.35	3.04	5.29
	No of Samples	12	10	5	8	3	7	7	7	7
Picual	Green	61.55	26.65	1.35	4.37	6.71	16.98	78.75	4.28	73.90
	St Deviation	1.54	2.00	0.04	0.08	0.48	0.17	0.90	0.75	0.75
	No of Samples	5	4	4	3	2	4	4	4	4
Sevillana	Green	72.51	15.04	1.48	5.14	4.53	17.88	71.25	10.90	66.88
	St Deviation	6.74	7.34	0.34	0.34	0.28	1.72	2.08	2.86	1.73
	No of Samples	7	5	5	3	2	4	4	4	4
UC13A6	Green	69.64	14.55	1.18	3.32	No Data	17.60	70.18	12.25	65.18
	St Deviation	2.23	2.55	0.49	1.45		1.50	3.40	2.10	4.57
	No of Samples	5	4	2	3.00		4.00	4.00	4.00	4.00
Verdale	Green	77.70	11.03	1.52	4.07	5.77	18.48	65.05	16.47	60.52
	St Deviation	3.26	2.42	0.16	1.90	1.49	0.79	2.13	2.24	2.19
	No of Samples	20	16	14	12	8	14	14	14	14
Volos	Black	65.22	21.23	1.58	4.50	7.39	17.70	66.20	16.15	61.00
	St Deviation	4.52	3.86	0.05	1.62	2.24	0.42	8.34	7.85	8.06
	No of Samples	4	2	2	4	2	2	2	2	2

Table 5.5. Proximate analysis data of olive flesh from olives processed in lye

Variety	Maturation	Process Method	Moisture %w/w	Oil %w/w	Protein %w/w	Ash %w/w	Total CHO %w/w	Sat FA %w/w	Monounsat FA %w/w	Polyunsat FA %w/w	Oleic Acid %w/w
Black	Black	Californian Caustic	76.32	14.27	1.08	2.41	5.92	18.10	78.30	3.70	73.60
	No of samples		1	1	1	1	1	1	1	1	1
Chalkidiki	Green	Caustic	67.29	15.16	0.40	5.69	7.75	17.20	72.10	10.70	68.10
	St Deviation		9.20	0.00	0.00	1.71					
	No of samples		6	1	1	6	1	1	1	1	1
Donkey	Green	Caustic	72.59	17.36	1.24	2.18	6.62	14.50	77.50	8.00	71.20
	No of samples		1	1	1	1	1	1	1	1	1
Green	Green	Caustic	80.59	6.74	1.70	4.61	6.36	19.15	74.30	6.55	69.30
	St Deviation		4.75	3.85	1.05	0.45	0.61	1.63	0.71	2.33	0.99
	No of samples		2	2	2	2	2	2	2	2	2
Manzanilla	Black	Caustic	77.38	11.90		1.32		18.60	74.30	7.10	70.30
	No of samples		1	1		1		1	1	1	1
Manzanilla	Green	Caustic	73.96	16.83	1.17	2.36	5.68	19.10	73.34	7.56	68.20
	St Deviation		1.30	0.77	0.21	0.68	1.42	0.90	1.01	0.72	0.97
	No of samples		5	5	5	5	5	5	5	5	5
Sevillana	Green	Caustic	78.61	11.11	1.35	2.29	6.64	18.40	68.60	13.00	62.80
	No of samples		1	1	1	1	1	1	1	1	1
Verdale &	Green	Caustic	74.24	16.39	1.08			17.70	70.87	11.40	66.27
Sevillana	No of samples		1	1	1			1	1	1	1

Table 5.6. Sugar content of olive flesh from olives processed in brine

Variety	Maturation State	Sugar %w/w	Variety	Maturation State	Sugar %w/w
Barnea	Green	0.09	**Manzanilla**	Green	0.31
	St Deviation	0.02		St Deviation	0.33
	No of Samples	4		No of Samples	9
Barouni	Black	0.35	**Manzanilla**	TC	0.76
	St Deviation	0.19		St Deviation	0.01
	No of Samples	2		No of Samples	2
Barouni	Green	0.42	**Picual**	Green	0.73
	St Deviation	0.26		St Deviation	0.05
	No of Samples	2		No of Samples	2
Hardys	Green	0.18	**Sevillana**	Green	0.00
Mammoth	St Deviation	0.10		St Deviation	0.00
	No of Samples	3		No of Samples	4
Kalamata	Black	0.12	**UC13A6**	Black	0.88
	St Deviation	0.21		St Deviation	0.03
	No of Samples	22		No of Samples	2
Kalamata	Green	0.51	**UC13A6**	TC	0.78
	St Deviation	0.16		St Deviation	0
	No of Samples	3		No of Samples	1
Kalamata	TC	0.00	**Verdale**	Green	0.01
	No of Samples	1		St Deviation	0.03
Manzanilla	Black	0.24		No of Samples	8
	St Deviation	0.40	**Volos**	Black	0.00
	No of Samples	9		St Deviation	0.00
				No of Samples	2

Table 5.7. Mineral content of olive flesh from olives processed by fermentation in brine

Variety	Maturation State	Processing Method	Phosphorus %	Potassium %	Sodium %	Calcium %	Magnesium %	Sulphur %	Boron mg/Kg	Copper mg/Kg	Iron mg/Kg	Manganese mg/Kg	Zinc mg/Kg
Barnea	Black	Brine	0.01	0.21	1.07	0.03	0.01	0.01	3.63	1.11	4.24	0.53	0.95
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Barnea	Green	Brine	0.02	0.24	1.63	0.06	0.01	0.02	3.21	0.99	4.51	0.97	2.21
		St Deviation	0.004	0.047	0.31	0.01	0.002	0.004	0.85	0.58	0.87	0.31	0.72
		No of Samples	4	4	4	4	4	4	4	4	4	4	4
Barnea	TC	Brine	0.02	0.27	1.31	0.04	0.01	0.02	3.88	1.26	4.13	0.77	1.72
		St Deviation	0.004	0.04	0.15	0.005	0.001	0.001	0.53	0.84	0.74	0.03	0.36
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Barouni	Black	Brine	0.02	0.24	1.77	0.04	0.01	0.02	3.14	0.66	4.14	0.83	1.48
		St Deviation	0.002	0.03	0.09	0.01	0.0001	0.0003	0.53	0.16	2.11	0.05	0.23
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Barouni	Green	Brine	0.03	0.21	2.10	0.02	0.01	0.03	1.31	0.43	3.44	0.66	3.45
		St Deviation	0.007	0.005	0.13	0.002	0.003	0.001	0.05	0.07	0.58	0.15	1.05
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Barouni	TC	Brine	0.02	0.20	1.41	0.03	0.007	0.02	3.41	0.47	4.00	0.71	1.29
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Black	Black	Brine	0.01	0.08	1.97	0.17	0.01	0.03	3.39	2.58	11.77	0.66	1.94
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Hardy's	Green	Brine	0.02	0.20	1.82	0.03	0.01	0.02	2.21	0.58	3.48	0.66	1.91
Mammoth		St Deviation	0.003	0.01	0.39	0.01	0.00	0.00	0.18	0.07	0.90	0.10	0.27
		No of Samples	4	4	4	4	4	4	4	4	4	4	4

Hardy's	TC	Brine	0.02	0.21	1.73	0.02	0.01	0.02	2.24	0.57	3.36	0.55	1.40
Mammoth		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Kalamata	Black	Brine	0.02	0.29	1.90	0.05	0.01	0.03	10.88	2.88	5.13	1.11	2.38
		No of Samples	24	24	24	24	24	24	24	24	24	24	24
Kalamata	Black	Water	0.03	0.51	0.04	0.03	0.02	0.02	10.33	1.79	4.85	1.27	2.64
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Kalamata	Green	Brine	0.02	0.24	1.68	0.04	0.01	0.02	2.76	0.58	4.55	0.74	1.91
		St Deviation	0.002	0.05	0.07	0.004	0.002	0.004	0.70	0.14	0.45	0.15	0.25
		No of Samples	3	3	3	3	3	3	3	3	3	3	3
Kalamata	TC	Brine	0.01	0.05	1.86	0.02	0.004	0.02	1.93	3.10	1.82	0.46	4.06
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Leccino	Black	Brine	0.05	0.50	2.55	0.03	0.01	0.03	5.01	1.48	6.01	1.27	3.34
		St Deviation	0.02	0.21	1.19	0.01	0.005	0.02	2.37	0.45	2.84	0.59	1.33
		No of Samples	2	2	2	2	2	2	2	2	2	2	2

Table 5.8. Mineral content of olive flesh from olives processed by fermentation in brine (Continued)

Variety	Maturation State	Processing Method	Phosphorus %	Potassium %	Sodium %	Calcium %	Magnesium %	Sulphur %	Boron mg/Kg	Copper mg/Kg	Iron mg/Kg	Manganese mg/Kg	Zinc mg/Kg
Manzanilla	Black	Brine	0.01	0.15	2.23	0.03	0.01	0.02	3.60	2.38	3.44	0.76	1.90
		St Deviation	0.008	0.08	1.83	0.01	0.002	0.01	1.72	2.48	1.57	0.40	1.13
		No of Samples	15	15	15	15	15	15	15	15	15	15	15
Manzanilla	Green	Brine	0.02	0.21	1.81	0.04	0.01	0.02	4.54	1.52	3.15	0.65	2.21
		St Deviation	0.006	0.07	0.26	0.009	0.001	0.002	1.77	0.60	0.74	0.18	0.66
		No of Samples	18	18	18	18	18	18	18	18	18	18	18
Manzanilla	TC	Brine	0.02	0.21	2.12	0.03	0.01	0.02	2.98	1.62	3.10	0.61	2.21
		St Deviation	0.002	0.01	0.11	0.01	0.0003	0.003	0.30	0.29	0.40	0.11	0.30
		No of Samples	5	5	5	5	5	5	5	5	5	5	5
Pendolino	Black	Brine	0.02	0.46	1.19	0.03	0.01	0.02	6.26	0.98	5.88	0.61	1.12
		St Deviation	0.00	0.05	0.11	0.01	0.001	0.003	1.02	0.13	0.01	0.13	0.11
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Picual	Green	Brine	0.01	0.32	1.71	0.03	0.01	0.02	3.85	3.60	6.14	0.91	1.16
		St Deviation	0.002	0.02	0.11	0.01	0.0003	0.001	0.10	0.69	6.09	0.05	0.20
		No of Samples	4	4	4	4	4	4	4	4	4	4	4
Sevillana	Green	Brine	0.01	0.14	1.67	0.07	0.01	0.02	3.03	1.53	3.47	0.74	1.64
		St Deviation	0.005	0.08	0.50	0.05	0.003	0.004	1.46	0.48	0.86	0.33	0.55
		No of Samples	5	5	5	5	5	5	5	5	5	5	5
UC13A6	Black	Brine	0.02	0.19	1.55	0.02	0.01	0.01	1.75	0.47	3.53	0.59	1.10
		St Deviation	0.00	0.03	0.26	0.004	0.001	0.003	0.26	0.14	0.12	0.12	0.22
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
UC13A6	Green	Brine	0.02	0.32	2.20	0.03	0.01	0.02	6.72	1.00	3.59	0.78	1.46
		St Deviation	0.002	0.03	0.08	0.000	0.002	0.003	3.32	0.09	1.03	0.20	0.18
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
UC13A6	TC	Brine	0.01	0.20	1.71	0.02	0.01	0.02	2.76	0.82	3.50	0.57	1.04
		St Deviation	0.002	0.04	0.15	0.01	0.0005	0.003	1.78	0.24	0.37	0.05	0.07
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Verdale	Green	Brine	0.02	0.24	1.71	0.05	0.01	0.02	3.43	1.46	3.71	0.72	2.02
		St Deviation	0.01	0.09	0.49	0.01	0.003	0.004	1.44	0.64	0.91	0.37	0.45
		No of Samples	14	14	14	14	14	14	14	14	14	14	14
Verdale	TC	Brine	0.03	0.28	2.39	0.04	0.01	0.02	3.28	0.57	5.14	1.37	2.29
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Volos	Black	Brine	0.02	0.18	2.48	0.03	0.01	0.02	3.52	4.53	3.20	0.85	2.89
		St Deviation	0.002	0.06	0.02	0.001	0.01	0.003	0.23	1.66	0.32	0.18	1.39
		No of Samples	2	2	2	2	2	2	2	2	2	2	2

Table 5.9. Mineral content of olive flesh from olives processed with lye

Variety	Maturation State	Processing Method	Phosphorus %	Potassium %	Sodium %	Calcium %	Magnesium %	Sulphur %	Boron mg/Kg	Copper mg/Kg	Iron mg/Kg	Manganese mg/Kg	Zinc mg/Kg
Black	Black	Caustic	0.02	0.02	0.94	0.05	0.01	0.02	2.35	1.79	150.57	1.88	3.01
		St Deviation	0	0	0	0	0	0	0	0	0	0	0
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Chalkidiki	Green	Caustic	0.01	0.06	2.17	0.12	0.005	0.03	1.60	2.40	3.77	0.57	1.26
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Green	Green	Caustic	0.02	0.05	1.95	0.11	0.02	0.05	2.20	1.79	5.08	0.73	1.27
		St Deviation	0.01	0.02	0.03	0.02	0.03	0.06	1.59	0.66	0.72	0.33	0.64
		No of Samples	2	2	2	2	2	2	2	2	2	2	2
Manzanilla	Green	Caustic	0.01	0.06	1.76	0.04	0.01	0.01	6.34	0.66	2.78	0.98	1.62
		St Deviation	0.002	0.02	0.31	0.02	0.005	0.01	3.07	0.38	0.39	0.42	0.28
		No of Samples	5	5	5	5	5	5	5	5	5	5	5
Sevillana	Green	Caustic	0.01	0.06	1.78	0.10	0.01	0.02	1.75	0.94	4.11	0.58	1.23
		No of Samples	1	1	1	1	1	1	1	1	1	1	1
Verdale + Sevillana	Green	Caustic	0.01	0.03	1.58	0.03	0.004	0.01	1.44	1.17	3.40	0.74	2.89
		St Deviation	0.001	0.01	0.10	0.003	0.0005	0.002	0.19	0.31	0.21	0.01	0.30
		No of Samples	3	3	3	3	3	3	3	3	3	3	3

5.15 Chemical Evaluation of Table Olive Brines

Brine salt concentrations, pH and acid levels are important parameters used to monitor the olives during and after processing. Lactic fermentation produces more free acid and a lower brine pH than mixed fermentations producing lactic and acetic acid. The balance of salt, pH and acid are also important in the preservation and safety of the olives. The salt and pH levels stipulated by the IOOC/Codex Alimentarius for different table olive products is given in Table 5.10. A brief analysis of these requirements indicates that, depending on the salt level, the pH of the brine should be between 4 and 4.5 for green olives whereas for black olives in brine at 5%w/v salt the pH could be up to 5.5. At a brine salt content of 7%w/w no pH levels are specified.

Table 5.10. Salt and pH levels of brines and packing solutions for trade preparations of table olives

Olive Preparation or Style	Minimum Sodium Chloride (%w/v)	Maximum pH
Treated green olives (with a minimum acid level of 0.4%w/v as lactic acid) in brine		
• in hermetically (airtight) sealed containers	5	4.0
• in non-hermetically sealed containers	6	4.5
Seasoned (marinated) green olives (all types)		
• in hermetically (airtight) sealed containers	4	4.0
• in non-hermetically sealed containers	6	4.5
Turning colour olives (all preparations)	6	Non specified
Black olives		
• in brine	5	5.5
	7	Non specified
• in dry salt	10	Non specified
Pasteurised olives (includes low salt) all types	2	4.3
	Non specified	4.0
Sterilised olives	Non specified	8

In the current study brines were evaluated chemically and the results are presented in Table 5.11. The first series of data relate to olives processed by the investigators. The data refers to the over 70 brines sampled one year after processing. The original brine concentration was 10%w/v and the brine pH values were between 6.5 and 6.8. No salt or acid additions were made. Under these conditions mean brine pH values were between 4.6 and 4.76 and the mean salt levels had stabilised to between 6.63 and 6.85%w/v. All values for black and turning coloured olives were within the limits of safety. From a practical point of view the green olives had salt levels greater than those indicated in Table 5.10. so the limit of pH is less critical. In fact when olives or brine were tested microbiologically no harmful organisms were present. From a standards point of view, food grade acid could be added to give the desired pH and free acid values.

For 28 samples of bulk olives processed by olive-grower/processors pH and salt levels were consistent with values in Table 5.8. as were 50 or so Australian processed olives in consumer packs. Imported bulk and loose olives tended to have salt levels between 7 and 8%w/v and pH values greater than 4.5.

The free acidity levels of the solutions ranged from 0.34 to 1.07 percent weight volume as lactic acid. This showed that the experimental solutions were in good agreement with the solutions from commercially produced products. The free acidity of the experimental brines was lower than the levels determined in the commercial products. These results show that if the appropriate controls are exercised during the manufacturing of table olives then the quality will be at a similar level to the international market.

The Codex Alimentarius has specified composition factors for brines in trade preparations (Table 5.10.). Although these levels are consistent with safe edible products processors must send batch samples to a certified chemical and microbiological laboratory for testing.

Table 5.11. Chemical evaluation of table olive brines

Source	Statistical Parameters	pH	Salt %w/v	Free Acidity as %w/v Lactic Acid
Olives Processed by Investigators				
Green	**Mean**	**4.64**	**6.73**	**0.34**
	St Deviation	0.40	0.69	0.24
	Median	4.5	6.71	0.26
	Number of Samples	49	55	56
Turning Colour	**Mean**	**4.6**	**6.85**	**0.4**
	St Deviation	0.19	0.47	0.06
	Median	4.55	6.87	0.43
	Number of Samples	6	7	7
Black	**Mean**	**4.71**	**6.63**	**0.40**
	St Deviation	0.76	0.76	0.21
	Median	4.7	6.82	0.37
	Number of Samples	15	19	19
Australian Processed Olives Bulk	**Mean**	**4.04**	**5.95**	**0.68**
	St Deviation	0.46	2.9	0.41
	Median	3.95	4.99	0.62
	Number of Samples	28	28	28
Australian Processed Olives Packaged Olives	**Mean**	**3.71**	**5.60**	**0.81**
	St Deviation	0.35	1.20	0.48
	Median	3.70	5.66	0.70
	Number of Samples	50	51	51
Bulk Imported Olives	**Mean**	**4.42**	**7.49**	**0.50**
	St Deviation	1.05	0.91	
	Median	4.40	7.28	0.39
	Number of Samples	5	5	5
Loose Olives Imported	**Mean**	**4.19**	**7.75**	**1.07**
	St Deviation	0.18	0.41	0.39
	Median	4.18	7.73	1.19
	Number of Samples	4	4	4
Australian Processed Olives In Progress	**Mean**	**4.55**	**7.45**	**0.37**
	St Deviation	0.26	1.69	0.39
	Median	4.6	6.82	0.22
	Number of Samples	24	23	28

5.16 Microbiological Evaluation of Table Olives

During routine monitoring, levels of indicator organisms for hygiene, food hazard potential, processing and spoilage are assessed (Table 5.12.). Such organisms are ones that are likely to survive under the processing conditions and ones that are easy to assess. Prescribed limits for these tests are given in Chapter 6.

Enterobacteriaceae (a marker organism) or *Escherichia coli* are used to monitor the potential for food poisoning; lactic acid producing bacteria and yeast counts are indicators of fermentation; and mould counts are used to detect fungal contamination. For routine monitoring, levels of indicator organisms for hygiene, food hazard potential, processing and spoilage are assessed. Such organisms are ones that are likely to survive processing and are easily assessed. During processing brine pH and salt levels should be monitored regularly.

The tests listed in Table 5.12. should be undertaken at the end of processing, however if problems occur during processing such as stagnant initial pH levels or stuck fermentations these tests should be undertaken as part of the management of the processing. Samples of olives packed in containers without pasteurisation should be tested to ensure the absence of harmful organisms, yeasts and moulds. The addition of 300ppm of sorbic acid (as potassium sorbate) reduces the chance of yeast or mould growth during storage/and or after opening. Where packed olives are pasteurised, testing for *Escherichia coli* is undertaken for health and safety purposes. E. coli should be destroyed by pasteurisation as its presence in a pasteurised product indicates either inadequate heat treatment or post-pasteurisation contamination.. *Clostridium perfringens* is an indicator for microbial spoilage as well as a food hazard; yeast counts are an indicator of pasteurisation effectiveness and mould counts are an indicator of microbial contamination. Several tests are recommended for dried olives and an additional physical test, water activity, indicates the level of moisture remaining in the flesh after drying.

Table 5.12. Microbiological testing for table olives

Test	**Background Reason for Testing**	**Olives in Process Tanks** ***Brine***	**Processed Olives in Brine Packed** **Olive Flesh**	**Processed Pasteurised Olives Packed** **Olive Flesh**	**Processed Dried Olives Loose** **Olive Flesh**
Enterobacteriaceae	Indicator of Hygiene Food hazard	yes	Optional		
Escherichia coli	Contamination Food hazard		yes	yes verification for health safety	
Coagulase positive staphylococci	Food hazard-toxin		yes	Other tests indicate microbe activity	yes
***Clostridium perfringens* (Spore forming – more resistant)**	Anaerobic spoilage bacteria Food hazard-toxin		yes	yes	
Clostridium botulinum	Can Cause serious illness But not tested routinely	no	no	no	no
Listeria monocytogenes	Potential food hazard		yes		yes
Lactic Acid Bacteria	Processing	yes	Optional		
Yeasts	Processing	yes	yes	yes indicator of pasteurisation effectiveness	yes
Moulds	Contamination	yes	yes	yes	yes
Water Activity Estimation					yes
		Do if there is a problem Do at the end of process			

During the microbiological evaluation of table olives selected samples of brines and olive flesh were tested for the organisms listed in Table 5.12. and these are presented in Table 5.13. The limits for brine and olive flesh are Cfu/ml and Cfu/g respectively. Note that generally higher levels are permitted in the flesh. Table 5.13. provides a summary of all tests undertaken. A detailed analysis of the data for LAB, yeasts and moulds is given in tables 5.13 to 5.18.

Here it is important to comment on the bacteria associated with food poisoning. Of all the samples tested, brine and flesh all met the limits for *Escherichia coli*, Coagulase positive streptococci, *Listeria monocytogenes* and clostridial species especially the most harmful, *Clostridium botulinum.*

The levels of Enterobacteriaceae organisms in some of the brines collected from processors were above the prescribed limit. It should be noted that these organism are present early in processing and/or if the pH is around 6. Only one brine sample out of 25 samples from olives packed in consumer size containers had values above the limit. When samples of olive flesh were tested all had levels of Enterobacteriaceae organisms within the prescribed limits.

With reference to the microbiology of bulk olives (Table 5.14.) most had values for LAB and yeast levels above the lower limits of testing. The LAB levels ranged from 10^4 and 10^6 (Cfu/ml) in brine and 10^6 and 10^7 (Cfu/g) for olive flesh. Yeast levels ranged from 10^2 and

Table 5.13. Summary and use of microbiological tests

Microorganisms	**Levels** **Brine Cfu/ml** **Flesh Cfu/g**	**Brine** Number of Tests	**Olive Flesh** Number of Tests
LAB	**<10**	16	
Lactic acid bacteria	**<100**	23	45
	>100	19	33
	Total number of tests	(58)	(78)
Yeasts	**<10**	14	
	<100	8	25
	>100	36	53
	Total number of tests	58	78
Moulds	**<10**	39	
	<100	13	70
	>100	6	8
	Total number of tests	58	78
Microbiological Tests Important for Health and Safety			
Enterobacteriaceae	**<1**	43	
	<10	**14**	58
	>10	**1**	
	Total number of tests	58	58
E coli	**<3**	3	60
	Total number of tests	3	60
Cl. perfringens	**None Detected**	2	
	<100	3	60
	Total number of tests	5	60
Cl Botulinum	**None Detected**	2	60
	Total number of tests	2	60
Cl species	**<10**	16	
	<100		18
	Total number of tests	16	18
Coagulase positive	**<100**	3	60
staphylococci	Total number of tests	3	60
List.Monocytogenes	**None Detected**	3	60
	Total number of tests	3	60

10^6 (Cfu/ml) in brine and 10^2 and 10^4 (Cfu/g) for olive flesh. Moulds were detected in two samples. LAB and yeast organisms are involved in the anaerobic fermentation of olives whereas moulds are a contaminant, generally due to the brine surface in tanks or barrels being exposed to air, and grow on the surface of the brine. Excessive mould growth gives olives a mouldy taste and can cause spoilage by consuming the acids produced during fermentation.

Table 5.14. Microbiology of bulk olives

Sample	Container Size	Variety	Specimen	LAB	Yeasts	Moulds
Bulk imported	250kg barrel	Kalamata Black Volos Black Chalkidiki Green Donkey Green	Brine	<10 (1) $1.3x10^5$ to 1.8×10^6 (4)	6.5×10^2 to 4.4×10^5 (5)	<10 (5)
Australian Processed 1	250kg barrel	Manzanilla Green	Fruit	<100 (1) 4.3×10^6 to 1.2×10^7 (3)	2.2×10^4 to 8.9×10^4 (4)	<100 (1) 1.3×10^3 to 3.5×10^3 (1)
Australian Processed 2	250kg barrel	Kalamata Black	Brine	3.2×10^5 to 3×10^6 (4)	2.0×10^4 to 3.6×10^5 (4)	< 10 (3) <100 (1)
Bulk Local Processed 2	250kg barrel	Manzanilla Green	Brine	<10 (3) 2.3×10^4 to 3.1×10^5 (4)	2.6×10^3 to 1.5×10^6 (7)	<10 (3) <100 (3) 100 (1)
Australian Processor 3	20kg barrel	Verdale Green	Brine	<10 (2) 1.3×10^4 to 1.6×10^5 (4)	2.8×10^3 to 6.7×10^4 (6)	<10 (6)
			Flesh	<100 (1) 1.3×10^6 to 2.4×10^6 (5)	7×10^2 to 2.4×10^4 (6)	<100 (6)
Australian Processor 3 Northern Rivers	250kg barrel	Manzanilla	Black	2.4×10^4 to 9.8×10^5 (3)	1.3×10^3 to 1.8×10^4 (3)	<100 (3)

*** Number of samples with detectable organisms levels above baseline**

Brine samples from one processor were assessed where a number of olive batches were debittering slowly (Table 5.15.). Initially levels of LAB and yeasts were at levels below prescribed limits of the tests over a period of 6 months. Discussions with the processor indicated that average daily temperatures at the processing plant were around 10^{o}C, well below the fermentation temperatures required. Subsequent batches were processed at temperatures between 20^{o}C and 25^{o}C (achieved by installing a reverse cycle air-conditioner) where growth was achieved.

Table 5.15. Table olive microbiology of olives with stalled fermentation

Sample	Container Size	Variety	Specimen	LAB	Yeasts	Moulds
Bulk Processed Olives	100kg barrel	Manzanilla Green	Brine	<100 (8)	<100 (8)	<100 (8)
	100kg barrel	Manzanilla Green	Brine	<10 (8)	<10 (8)	<10 (8)
	100kg barrel	Manzanilla Green	Brine	<100 (4)	6.1×10^3 to 3.2×10^4 (4)	<10 (2) $5.5x10^1$ to 9.5×10^1 (2)
	100kg barrel	Manzanilla Black	Brine	<100 (2)	2.6×10^4 to 4.6×10^4 (2)	<10 (1) 8×10^1 (1)
	100kg barrel	Manzanilla Turning Colour	Brine	<100 (2)	7.4×10^2 to 1.3×10^5 (2)	1.9×10^3 to 4.1×10^3 (2)

With reference to the microbiology of packaged olives (Table 5.16.) most samples of brines and olive flesh had values below the prescribed test limits. This may be due to pasteurising practices particularly undertaken by commercial packagers of table olives. Samples with significant LAB and yeast levels were from boutique/small Australian processors which had values above the lower limits of testing. None showed excessive mould growth.

Table 5.16. Microbiology of packaged table olives

Sample	Variety	Specimen	LAB	Yeasts	Moulds
Australian 1	Manzanilla (B)	Brine	<100	2.7×10^3	<10
Australian 2	Manzanilla (G)	Brine	3.8×10^6	<10	<10
Australian 3	Manzanilla (B)	Flesh	4.4×10^6	<100	<100
Australian 4	Manzanilla (TC)	Flesh	3.1×10^6	<100	<100
Australian 5	Sevillana/Verdale (G)	Flesh	<100	6.6×10^3	<100
Australian 6	Sevillana/Verdale (G)	Flesh	<100	<100	<100
Australian 7	Sevillana/Verdale (G)	Flesh	<100	1.7×10^4	<100
Australian 8	Manzanilla (B)	Brine	<100	<10	<10
		Flesh	<100	<100	<100
Australian 9	Manzanilla (B)	Brine	<100	<10	<10
		Flesh	6.9×10^3	<100	<100
Australian 10	Manzanilla (B)	Brine	<10	8.2×10^3	<10
		Flesh	<100	3.6×10^5	<100
Australian 11	Manzanilla (B)	Brine	<10	8.2×10^3	<10
		Flesh	<100	7.7×10^3	<100
Australian 12	Sevillana (G)	Brine	2.3×10^2	1.4×10^4	<10
		Flesh	4.8×10^6	1.3×10^4	<100
Australian 13	Sevillana (G)	Brine	1.9×10^2	1.2×10^4	<10
		Flesh	2.1×10^6	4.0×10^4	<100
Australian 14	Kalamata (B)	Brine	<100	<10	<10
		Flesh	<100	<100	<100
Australian 15	Kalamata (B)	Brine	<100	<10	<10
		Flesh	<100	<100	<100
Australian 16	Sevillana (G)	Brine	<100	<10	<10
		Flesh	<100	<100	<100
Australian 17	Sevillana (G)	Brine	<100	<10	<10
		Flesh	<100	<100	<100
Commercial 1	Kalamata (B)	Flesh	<100	<100	<100
Commercial 2	Kalamata (B)	Flesh	<100	<100	<100
Commercial 3	Kalamata (B)	Flesh	<100	<100	<100
Commercial 4	Black *	Flesh	<100	<100	<100
Commercial 5	Black*	Flesh	<100	<100	<100
Commercial 6	Manzanilla (G)	Flesh	<100	<100	<100
Commercial 7	Green*	Flesh	<100	<100	<100
Commercial 8	Green*	Flesh	5.1×10^5	1.5×10^4	<100

When loose olives were assessed most had LAB and yeasts containing low levels of moulds (Table 5.17.). The latter were not obvious in the samples and only picked up by laboratory testing. The LAB levels ranged 10^2 and 10^6 (Cfu/g) yeast levels ranged from 10^2 and 10^6 (Cfu/g) in the olive flesh. Moulds were detected in two samples.

With samples processed by the fermentation by the investigators under conditions simulating typical processing conditions in the field, it is obvious that yeasts (Table 5.18.) facilitated fermentation. Levels were 10^2 to 10^5 Cfu/g. Lye treated and non-lye treated olives were used. Three of the 18 samples showed some mould growth on testing. Lye treatment involved soaking the olives in 2% lye, followed by washing to remove the excess lye, then placing them in 10% brine. Non treated olives were placed in 10% brine. Olives were tested around 3 months after processing.

5.17 Food-borne Disease

Consumers expect processed table olives and table olive products to be safe and suitable for consumption. The objective of table olive processors is to aim for zero risk for foodborne illness and injury. Under most circumstances contaminated or spoilt foodstuffs will produce discomfort or temporary debilitation and at worse they can produce fatal circumstances. Outbreaks of food-borne illness are not uncommon. Consequences for sufferers are inability to work or attend school as well as loss of jobs and earnings. In the bigger picture consumer confidence is reduced, affecting trade. In the

case of olives implications to the tourist industry could be overwhelming. Circumstances where food spoilage occurs during or after processing is not only wasteful but can reduce commercial viability.

Table 5.17. Microbiology of loose table olives

Sample	Variety	Specimen	LAB	Yeasts	Moulds
Imported Loose 1	Kalamata Black	Flesh	6.3×10^5	6.9×10^4	<100
Imported Loose 2	Kalamata Black	Flesh	8.8×10^4	3×10^2	3.5×10^2
Imported Loose 3	Manzanilla Black	Flesh	6.9×10^6	2.9×10^4	<100
Imported Loose 4	Volos Black	Flesh	1.7×10^5	4.1×10^3	<100
Imported Loose 5	Volos Black	Flesh	<100	1.8×10^4	<100
Imported Loose 6	Greek Donkey Green	Flesh	7.1×10^3	4.9×10^3	<100
Imported Loose 7	Greek Donkey Green	Flesh	3×10^5	3.4×10^6	<100
Imported Loose 8	Giant Kalamata Green	Flesh	1.1×10^6	3.3×10^6	<100
Imported Loose 9	Mastoides Green	Flesh	8.6×10^4	2.7×10^4	<100
Imported Loose 10	Mastoides Green	Flesh	4.5×10^5	1.4×10^3	<100
Imported Loose 11	Kalamata Black	Flesh	<100	<100	<100
Imported Loose 12	Kalamata Black	Flesh	3.9×10^5	4×10^2	<100
Imported Loose 13	Black	Flesh	4.9×10^3	3×10^2	<100
Imported Loose 14	Mixed Black and Green	Flesh	2×10^2	3.4×10^4	<100
Imported Loose 15	Chalkidiki Green	Flesh	<100	<100	<100
Imported Loose 16	Chalkidiki Green	Flesh	<100	5.8×10^4	<100
Imported Loose 17	Chalkidiki Green	Flesh	2.6×10^5	5.9×10^4	<100
Imported Loose 18	Manzanilla Green	Flesh	1.4×10^3	6×10^5	<100

Table 5.18. Microbiology of table olives processed by investigators Kailis and Harris

Variety	**Specimen**	**LAB**	**Yeasts**	**Moulds**
Kalamata Black	Flesh	<100	3.2×10^4	5.8×10^3
Leccino Black	Flesh	<100	1.3×10^4	<100
Manzanilla Black	Flesh	<100	5×10^2	<100
UC13A6 Black	Flesh	<100	3.2×10^4	6×10^2
Barnea Green	Flesh	<100	<100	<100
Hardy's Mammoth Green	Flesh	<100	2.1×10^3	<100
Jumbo Kalamata Green	Flesh	<100	1.7×10^3	2×10^3
Manzanilla Green	Flesh	<100	5.4×10^3	<100
Manzanilla Green	Flesh	<100	6.5×10^5	<100
Manzanilla Green	Flesh	<100	3.8×10^5	<100
Picual Green	Flesh	<100	3.7×10^3	<100
Sevillana Green	Flesh	<100	1.6×10^6	<100
Sevillana Green	Flesh	<100	4.3×10^5	<100
Sevillana Green	Flesh	<100	4.2×10^5	<100
Sevillana Green	Flesh	<100	4.6×10^5	<100
Sevillana Green	Flesh	<100	4.4×10^5	<100
Verdale Green	Flesh	<100	8.1×10^4	<100
Barouni TC	Flesh	<100	<100	<100

In the past the problems indicated above would have affected only local regions, but now with globalisation and international trading in food, foreign travel makes the spread of illness more likely. To reduce the risk of food-borne illness and spoilage attention must be focussed on, good practices in agriculture (GAP), hygiene (GHP) and manufacturing (GMP). Thus all persons involved with the table olive chain from growers to consumers must ensure the suitability and safety of the end products.

5.18 Organoleptic Evaluation of Table Olives

Organoleptic analysis of the processed table olives serves a number of functions.
• provides a description of the product
• provides a starting point for the evaluation of product abnormalities, defects and spoilage

Changes in organoleptic characteristics are more easily discerned by consumers rather than objective, physical, chemical or microbiological assessment. Official table olive criteria are currently being developed by the IOOC using statistically robust methodology based on defined attributes and intensity measurements on a 10 point scale. When these are implemented at the international level, consideration must be given to include these as part of the official assessment of olives in Australia.

In this study a modified system along the lines of IOOC evaluation, based on the work of Marsilio, has been used. Five olives from each sample were tasted and a value assigned. The data collection sheet is given in section 6.

The following attributes were assessed and the olive products graded on a scale of 1 to 10.

For positive attributes- *appearance, colour, aroma, acid/vinegary/winey, salty, bitter, sweet, firmness, crispness, flesh/stone attachment, stone size*

For defects - *poor appearance, skin hardness, off odour, rancid, mouldy, off flavour, texture*

Median defect scores are used to indicate the quality of the olives. The highest numerical value of an individual negative attribute was taken as the score for a particular sample even if there were no other defects. Attribute scores of:

<1.5 = extra,
>1.5 $\leq$ 3.5 = first,
>3.5 $\leq$ 5.5 = second,
>5.5 $\leq$ 7.5 = third and
>7.5 not suitable for consumption are being used to identify olive quality.

Tables 5.19. and 5.20. summarise the organoleptic evaluation of 174 table olive samples undertaken by the investigators. For appearance and colour scores of 10 would reflect perfect skin appearance and colour intensity and homogeneity. Scores for aroma and taste reflect intensity and very high values would indicate imbalance. Table 5.23. and 5.24. are further elaborations on organoleptic characteristics.

The results for positive attributes indicate that appearance and colour of the olives was generally acceptable, Some individual samples were pale or had darkened through interaction with air whereas others were marked and lacked lustre. On average aromas were weak to moderate. Those with very weak aromas were probably repacked in brine after processing. Salt levels were satisfactory for the styles. Those with scores above 8 were inedible. All olives had some degree of bitterness albeit weak in olives treated with lye. Few olives had a sweet taste indicating the absence of sugars, these would have been consumed during processing. Although on average the olives were firm on squeezing, they generally lacked crispness. The flesh came off easily from many of the samples, but this was a function of variety. For example with green-ripe UC13A6, Verdale and Jumbo Kalamata varieties processed in brine removal of flesh was more difficult. Flesh of black table olives generally came off more freely than green table olives.

With respect to negative attributes higher quality olives have lowest scores. Olives with scores of less than 2 would be considered excellent for a particular attribute. The frequency of defects in the olives is presented in Table 5.21. and 5.22. Note some olives had more than one defect. The major problems

were related to the skin and texture (soft olives). Many samples showed degrees of shrivelling probably due to processing/storing in brines with a high salt concentration. Off flavours were of a chemical nature rather than mouldiness or rancidity. These included solvent like aromas and tastes due to ethyl acetate formed during processing, soapy tastes due to lye treatments and lactic tastes probably due to the addition of lactic acid to brines during pH adjustment.

Table 5.19. Positive attributes for all olives in the study (174)

Attribute	Parameter	Mean	St Deviation
Appearance	Skin appearance	7.43	1.59
	Shape	7.80	1.30
	Size	7.50	1.40
Colour	Intensity	6.63	1.69
	Homogeneity	6.60	1.90
Aroma	Strength	4.50	1.40
	Acid/winey/vinegary	3.00	1.60
Taste	Acid/winey/vinegary	3.00	2.00
	Salty	7.00	1.8
	Bitter	2.63	1.95
	Sweet	0.1	0.23
Texture	Firmness	7.19	1.71
	Crispness	5.80	2.35
Flesh:Stone	Stone flesh detachment	6.60	2.31

Table 5.20. Positive attributes for olives in consumer packs (77)

Attribute	Parameter	Mean	St Deviation
Appearance	Skin appearance	7.09	1.81
	Shape	7.50	1.50
	Size	7.40	1.50
Colour	Intensity	6.76	1.81
	Homogeneity	6.6	2.10
Aroma	Strength	4.10	1.40
	Acid/winey/vinegary	3.00	1.50
Taste	Acid/winey/vinegary	3.00	2.00
	Salty	5.60	1.70
	Bitter	1.60	1.10
	Sweet	0.05	0.22
Texture	Firmness	6.51	1.85
	Crispness	4.86	2.14
Flesh:Stone	Stone flesh detachment	6.95	2.65

Table 5.21. Negative attributes for all olives tested (174 Samples)

Attribute	Parameter	0	1	2	3	4	5	6	7	8	9	10
Appearance	Spots		9	11	11	4	18	1	9			
	Blistering		1		1	1	2				1	
	Sloughing		1		2	2	1	1	1			
	Shrivelling		4	10	11	2	6	5	3		1	7
	Holes		2	2	1	1		1	3			
	Shape		34	20	12	1	9	6	5	2	3	4
	Size		16	20	16	4	13	3	11	1		
Aroma	Rancid		4	3		2						
	Mouldy		2	2								
Taste	Rancid		6	8	3	1						
	Mouldy		1	2	2	1						
	"off flavour"		13	5	4	4	1	1	5	2	3	2
Texture	Soft		29	18	24	17	16	9	6	8	7	
	Woody		5	3	2	2						
	Fibrous		13	8	3					1		

Included in the 174 samples were 77 samples of olives that had been packed for sale. These were sourced from Australian processors and randomly purchased from retail outlets. It was interesting to note that all parameters followed a similar pattern except that the salt attribute gave a lower score. The data presented here are baseline values and more extensive studies are required to differentiate the influence of variety and processed olive sources.

Table 5.22. Negative attributes for olives in consumer packs (77)

Attribute	Parameter		1	2	3	4	5	6	7	8	9	10
Appearance	Spots		3	5	9	1	7	1	3			
	Blistering		1		1	1						
	Sloughing		1		1	2	1	1				
	Shrivelling		2	5	4	1	4	4	2			
	Holes		1	1	1	1		1				
	Shape		12	10	7		2	3	1	1		
	Size		10	7	6	2	3	2	5	1		
Aroma	Rancid		1	1								
	Mouldy		2									
Taste	Rancid		2	1	1						1	
	Mouldy		1	1	1							
	"off flavour"		9	1	1							
Texture	Soft		10	14	14	9	9	5	1	2	3	
	Woody		1		1							
	Fibrous		1		2							

5.19 Table Olive Spoilage and Deterioration

The principle causes of spoilage in olives are growth of microorganisms, such as bacteria, yeasts and moulds; enzyme action; or oxidation – either through direct action or indirectly through microorganisms.

These microorganisms are introduced during processing through unhygienic procedures or by proliferation of undesirable microorganisms if processing procedures are poorly controlled. Monitoring brine pH, salt and microorganism levels (also flesh) is important throughout processing, especially in the early stages, to reduce the risk of harm to consumers and avoiding spoilage. The chief types of deterioration in table olives are summarised in Table 5.25.

For example, oxidative moulds growing on the surface of fermentation brines release metabolites that can taint the olives. Also exposing green olives processed in brine to air changes their colour to a dull grey-green colour. Dried olives can develop a rancid taste because of the oxidation of fats in the flesh.

Growth of micro-organisms and level of olive spoilage are influenced by factors such as:
- Temperature
- Moisture
- Oxygen levels
- Available nutrients
- Degree of contamination
- Presence or absence of growth inhibitors

Spoilage organism levels can increase with temperature hence during processing fermentation brines should be maintained between 15^{o}C and 25^{o}C. Low temperatures can impair fermentation increasing the processing time. Correctly processed heat dried, sun dried or salt dried olives, because of their lowered water content are less prone to microbial spoilage. The higher the initial levels of a contaminating microorganism, the greater the risk of spoilage. Ensuring hygienic practices throughout processing and packaging can markedly reduce levels of contaminating organisms.

Table 5.23. Organoleptic attributes of olives

Parameter		Attributes	Comment
Appearance	**Sight** **Colour (intensity and homogeneity, size, shape, firmness, glossiness**	**Positive** Intact skin, uniform fruit size and shape Colour relevant to variety, ripeness and method **Negative** abnormal colour, non uniform fruit size and shape, sloughing, skin spots, insect punctures, sloughing, shrivelling (relevant to method), gas pockets	Ripening Stage Type Processing Technology Keeping Qualities
	Touch	**Positive** Firmness	Processing Technology Measure of keeping Qualities
Aroma	**Olfactory**	**Positive** Olfactory intensity of the olives– primary fermentation, esters, alcohols, aldehydes, ketones and hydrocarbons Acids – Acetic, Lactic Negative Off odours -sensation of disagreeable or anomalous odour • putrid •butyric •Zapateria (bad leather) Mouldy (eg mouldy foods) Rancid aroma of aged fats	Fermentation Type Homerfermentative – lactic acid Heterofermenative – lactic & ethanol +carbon dioxide (gas) Metabolites Olive variety Enzymatic reactions Process conditions -control salt and pH levels Ensure anaerobic condition Turn over products as quickly as possible
Taste	**Acid**	**Positive** Acid taste typical of fermented foods Olive Fruit Metabolites– lactic, malic, citric and succinic Fermentation – lactic, acetic Corrective Measures – lactic, acetic, citric Negative Too vinegary	Apparent to Consumer Ensure fruit is at correct maturation Control any additions of food acids to adjust pH
	Salt	**Positive** Typical of sodium chloride in salty foods Negative Too salty	 Reduce salt levels and maintain pH levels
	Sweet	Positive Sensation completely devoid of bitter notes Due to sugars, alcohol & glycerol Due also to absence of bitters Weak salt solutions	Ensure primary processing is complete so that olives are debittered.
	Bitter	**Positive** Bitter taste similar to caffeine or quinine Phenolics such as oleuropein and related compounds **Negative** Potassium Salts - bitter	Stimulates appetite and a characteristic sought after by consumers Ensure processing end point is monitored
	Other	**Positive** Hot/Spicy – Spiced olives Negative Californian Black – Ferrous gluconate – metallic taste Off flavours – of unpleasant or spoiled food - butyric acid taste, sour or sickly milk taste, solvent taste (ethyl acetate)	Specific to olive processing method Use acetic acid to adjust pH of brines rather than lactic acid
	Balance	**Aroma and Taste Combinations**	Occurs if a one taste characteristic overpowers others. Too acid Too salty

Table 5.23. Organoleptic attributes of olives (Continued)

Parameter		Attributes	Comment
Touch **Finger** **Mouth**	**Firmness**	**Positive** Force needed to press olive fruit between thumb and index finger and to bite the olive fruit with incisors Skin should be fine (not tough) **Negative** Sensation of thick hard skin Soft olives Grainy, woody, fibrous flesh	Consistency • olive variety • ripeness • processing method • storage conditions Reduced with lye Consistency Tests - Compression Test - Penetration Test
Mouth **Texture**	**Crisp**	**Positive** Greater force required to crunch the fruit with the back molars Negative Soft olives with no texture	Use olives at correct maturation Control fermentations conditions
Other	**Oily**	**Positive** Smooth feel when eating **Negative** Unpleasant if oil is rancid	Use quality oil
	Woody	**Positive** Flesh is smooth, non granular and not to chewy **Negative** Granular woody feel	Use olives at correct maturation Use alternative variety
	Flesh & stone detachment	**Positive** Tendency of olive flesh to detach from stone easily **Negative** Flesh hard to remove from stone	Use freestone varieties Ensure processing is complete

Naturally occurring growth inhibitors in the olive, such as polyphenols provide some degree of protection against microorganisms, however with prolonged soaking with water, this advantage can be lost. Such inhibitors can also affect the activity of fermentative microorganisms. Many spoilage microorganisms are also inhibited by high salt levels and low pH levels, hence the need for careful control of these two parameters during processing and storage.

Addition of herbs, spices and marinades can introduce unwanted microorganisms, particularly if fresh herbs are used. Additives used should be treated for microorganisms and sourced from reliable sources. More detailed information on table olive deterioration follows.

5.20 Olive Softening

Reasons for olive softening are:

• Over-ripe olives
• Overheating of picked olives in the orchard
• Fruit enzyme action due to prolonged storage of the olives before processing
• Microorganisms –moulds, yeasts and some types of bacteria

As microorganisms are the most likely cause of softening, by carefully controlling pH and salt levels of the brine, the extent of olive softening can be reduced.

Table 5.24. Summary of organoleptic characteristics of table olives assessed during the study

Variety	Maturation State	Process Method	Colour after Processing	Observed Positive Attributes	Observed Negative Aspects
Barnea	Black	Brine	Dark brown		Blush, granular
	Green	Brine	Yellow-green to dark green		Fibrous
	Turning Colour	Brine	Green/Maroon/Brown	Liqueur Aroma, Nutty flavour	
Barouni	Black	Brine	Light brown to dark brown		
	Green	Brine	Yellow-green to green brown		Too Chewy
	Turning Colour	Brine	Green brown		Gas pockets
Chalkidiki (Donkey)	Green	Caustic	Yellow-green	Suitable for stuffing	
Hardy's Mammoth	Green	Brine	Yellow-green to light brown	Winey/sweet aroma	Fibrous texture, lactic taste
	Turning Colour	Brine	Light brown to dark brown	Sweet syrupy aroma	
Jumbo Kalamata	Green	Brine	Green to light brown	Liqueur aroma, nutty	Gas pockets
	Turning Colour	Brine	Light brown to mid brown	Large size	Salt shrivel, stone long and sharp
Kalamata	Green	Brine	Grey green	Nutty flavour	Fibrous texture
	Black	Brine	Light brown to dark brown	Firm texture and distinctive, nutty, fruity flavour	Patchy skin, white spots, soft
		Salt dried	Dark brown to black	Firm texture	
		Heat dried	Brown colour		Tough skin, chewy
Leccino	Black	Brine	Mid brown to dark brown	Honey liqueur aroma	
Manzanilla	Green	Brine	Green to green brown	Weak honey aroma	Ammoniacal
		Spanish	Greeny yellow	Firm	Loss of texture
	Turn Colour	Californian	Black		Chemical, metallic
		Brine	Grey green to green brown		
	Black	Brine	Purple to dark brown	Winey, fruity, liquorice aroma and taste	Astringent, chemical, soft, ethyl acetate taste
		Salt dried	Dark brown to black	Fleshy sightly bitter	Slight rancid
		Heat dried	Dark brown		Thick skin, chewy
Mastoides	Green	Caustic	Green		
Pendolino	Black	Brine	Dark brown	Sweet bitter taste	Rancid defect, chewy
Picual	Green	Brine	Yellow green	Sweet liqueur aroma	Mottled
Sevillana	Green	Brine	Green brown	Firm good texture	Salt shrivel
		Caustic	Green Yellow	Firm	Yeast spots, soft
UC13A6	Green	Brine	Green to green brown	Weak honey, liqueur, liquorice aroma	
	Turn Colour	Brine	Green to brown		Metallic, fibrous, chemical
	Black	Dried	Black	Sweet	Tough skin
Verdale	Green	Brine	Light yellow green to grey green	Firm, nutty,	Large stone
	Turn Colour	brine	Light green brown to pink to maroon		Ethyl acetate taste, insect spots
Volos	Black	Brine	Light brown to mid brown to blue purple	Fleshy	Soft

5.21 Skin Sloughing

Here blisters form between the skin and flesh of the olives. Such blisters can be associated with fish-eyes. Blisters may also form in green olives when they are being treated with too strong a lye solution. The latter problem can be prevented by testing different strengths of lye with a sample of olives and choosing the most appropriate concentration.

Table 5.25. Chief types of deterioration in table olives (after Marsilio 1993)

Deterioration	Signs & Symptoms	Cause	Prevention
Softening	Flesh loses firmness due to excessive pectin loss in cell walls	Yeasts and moulds that breakdown pectin in the olive flesh; irrational processing technology	Correct timing of olive harvest; good processing techniques Avoid too many water changes during processing
Sloughing	**Skin lifts or is shed**	Coliforms; bacteria that breakdown cellulose in the fruit; inappropriate processing technology Strong lye solutions can also cause sloughing during debittering	Brine acidification; Brine adjustment so that NaCl ≥ 8%w/v; pasteurise olives
Cloudy brine	Brine looks streaked and mucilaginous	Uncertain cause – possibly due to microorganisms or substances leaching out into the brine	Replace brine; acidify; NaCl ≥ 8%w/v
Yeast spots	White to cream spots appear on the skin around fruit stomata	Some species of yeast	Control of yeast development by adjusting brine and pH levels
Gas pocket formation	Formation of gas pockets, fish eyes, fissures and cavities in the flesh	Coliforms; spore forming bacilli; yeasts that breakdown pectin in the olive flesh Occurs early in processing	Ensure strict anaerobic conditions. Scrupulous standards of hygiene; brine acidification with acetic or lactic acid; Brine adjustment so that NaCl ≥ 8%w/v
Putrid-butyric fermentations and 'zapateria'	Malodours of varying intensity eg faeces, rancid, old leather	Bacteria including anaerobic spores; bacilli; moulds. This type of problem occurs late in processing	Good processing and storage techniques; scrupulous standards of hygiene; Brine adjustment so that NaCl ≥ 8%w/v
Galazoma or cyanosis (bluish)	Unpleasant smells; black olives turn bluish-ashen colour	Presence of ferrous (Iron) salt; low salt concentration; high pH; aerobiosis, excessive orchard irrigation	NaCl ≥ 8%; right irrigation; good processing techniques; fruit pasteurisation

5.22 Skin Marks

Skin marks such as bruising are more likely to be caused by rough handling of the olives during harvesting, transporting and processing. Skin marks are less likely to be caused by microorganisms.

5.23 Darkening

All olives during or after processing darken in colour on standing in air. This is advantageous in the case of black olives. However with green olives and in particular Green Spanish style olives darkening reduces their visual appeal because they turn grey-green in colour. Ways of overcoming this problem includes undertaking all operations as quickly as possible especially during sorting and grading.

5.24 Cyanosis

Cyanosis is characterised by black olives turning a dark blue colour in contrast to the expected brown to black. *Cyanosis* is often associated with unpleasant odours. Obviously both problems impact on the organoleptic qualities of the olives, reducing their consumer appeal and commercial value. Strict control of salt concentrations in the brines above 8% and pH less than 4.5 reduces *cyanosis.* Other factors may also be involved.

5.25 Green Stains

Patches of green staining due to copper sprays are observed when green ripe olives are placed into lye as part of the preparation of Spanish-style green olives. At the time of delivery growers should reveal if copper sprays such as *Bordeaux* ie copper spray or copper oxychloride have been used in the orchard. Best practice is to stop copper treatment well before processing and ensure that the olives are well washed at the beginning of the processing cycle.

5.26 Surface Yeasts and Moulds

Surface yeasts and moulds, that can utilise atmospheric oxygen close to the brine surface, can grow in the upper levels of the fermentation tank lowering the brine acidity and so raising the pH. As high brine pH values promote deterioration, such a condition must be avoided. Fermentation tanks with well sealing lids with minimal sized air pockets between the lid and the brine surface prevents this problem.

5.27 Yeast Spots

Yeast Spots are small pinhead size white spots that are easily visible from the surface of green olives after processing. They are due to microorganisms, such as yeasts, forming colonies under the skin around small stomatal structures that the fruit uses for respiration. *Yeast spots* reduce consumer appeal and commercial value of the olives.

5.28 Gas Pocket Formation

Gas pockets, also known as fish-eyes, are pockets or blisters in the olive flesh filled with gas produced by microorganisms. Gas pockets can form in both green and black olives during processing. Culprit gas producing organisms are Gram-negative bacilli in the case of Spanish Green Style Olives and yeasts in the case of black olives.

This problem needs to be prevented from occurring, as there is no correction method. Preventive measures include using:

- Potable water quality especially its bacteriological state
- Good hygienic practices by operators and workers
- Clean uncontaminated equipment
- Food quality ingredients that are protected from contamination
- Good manufacturing practice - acidification, inoculation, and appropriate salt concentration.

The fermentation process is critical and when the appropriate controls are in place gas pocket formation can be reduced to 5%. Microorganisms present at the beginning of fermentation can dictate the effectiveness of the process.

With Spanish-style green olives lowering the pH of the brine to pH 5 or less, with food grade acids (acetic, lactic or hydrochloric) or carbon dioxide, or the addition of a *Lactobacillus* inoculum, will

inhibit the growth of Gram negative bacilli. Acidifying as well as inoculating with a starter is advantageous. Salt concentrations should be maintained from 5-7%w/v sodium chloride. Other factors that will promote gas pocket formation include olive variety and abnormally elevated brine temperatures at the beginning of the fermentation process.

The above factors also apply to black olives. Undertaking processing of black olives under aerobic conditions with initial acidification can also markedly reduce gas pocket formation because harmful yeasts are inhibited. But care must be taken at the end of the process so that the late formation of gas pockets does not occur.

5.29 Malodorous Deterioration of Processed Olives

Bacteria of the Clostridia species cause malodorous fermentations. Organoleptic qualities of the resulting olives, such as aroma and taste, are compromised rendering them inedible. Clostridial bacteria are relatively common in the environment eg water, orchard dust. Because they can produce spores that can survive under harsh environmental conditions, such as high temperature and humidity, they have a latent potential for spoilage. Clostridium botulinum, a specific member, is harmful to health and life. Using good hygienic and manufacturing practices reduces malodorous deterioration. Stagnant water, organic waste and contaminate reticulation systems and pumps are possible sources of clostridia. In plants where olive oil is also produced, olive oil processing and its associated wastes must be kept separated from the table olive processing section. Once a contaminated tank is identified it must be quarantined from the rest of the processing operations.

Dregs at the bottom of the fermentation tanks can harbour *Clostridial* organisms. So tanks should be cleaned between batches.

Putrid Spoilage: Putrid spoilage results in the product having the aroma of decomposing organic matter.

Butyric Spoilage: Butyric spoilage results in the product having the aroma and taste of rancid butter

Zapateria*: Zapateria* spoilage results in the product having the aroma of old leather. This type of deterioration is also characterised by increasing pH and volatile acid levels.

Putrid and butyric spoilage occurs early in the process. A raised brine pH is a signal that spoilage may occur. To prevent these problems from occurring, the pH is lowered initially by adding a food acid with or without inoculation with lactic acid bacteria.

Zapateria on the other hand appears at the end of the process when the olives are being preserved. The pH levels must be under 4.2 and preferably pH 3.8 to 4. If necessary food grade acid is added to the brine to reach the required level of acidity. Sodium chloride levels must be kept between 5 to 7%w/v during fermentation. The levels are raised to above 8.5%w/v sodium chloride especially during hot weather. These problems can be prevented by the following actions.

- Remove dregs from the bottom of the tank
- Monitor and adjust the brine pH
- Monitor sodium chloride levels in the brine

If deterioration is suspected, then partial correction can be attempted by removing a portion of the brine, followed by the addition of fresh brine with enough salt and acid to stop the problem.

6. Materials and Methods

6.1 Introduction

Analytical methods used in this study are outlined below.

6.2 Fresh Olives

Fresh olives were collected from a number of sites in Western Australia for processing as well as physical and chemical evaluation. Because of quarantine implications fresh olives were not sought from other Australian states. Varietal confirmation was undertaken by using nursery information and comparing the physical characteristics of the fruit and stone against data presented in the World Catalogue of Olive Varieties.

Generally 10 kg of olives was harvested by hand from at least 5 olive trees. The trees were aged 5-8 years planted in a regular olive grove patterns. Most of the trees were grown under managed irrigation. Olives were collected at three stages of ripeness – green ripe, turning colour and black ripe. Immediately after harvesting the olives were delivered to the laboratory where they were sorted and undersized and damaged olives removed. All olives were tested and processed within 48hours of harvesting.

For each batch of olives a sub-sample of 20 sound olives was removed for physical and chemical testing.

6.3 Processed Olives

Processed olives evaluated in this project were from several sources (Table 6.1.).

Table 6.1. Sources of the processed olives evaluated in the project

Olive Sources	Products Tested
Processed by investigators	Olives processed by brine fermentation, drying and lye treatment
Australian processors	Bulk olives and commercially available packed olives of several styles
Imported products	Bulk olives and commercially available packed olives of several styles

6.4 Physical Tests on Olives

Representative samples of 20 olives were used for physical and chemical testing.

6.5 Pressure Test

The firmness of olives was determined using a Shor OO pressure tester. The probe was lowered to the surface of the olive and measurement commenced over a 4 second period. The mean pressure and standard deviation was determined for each olive sample.

6.6 Moisture

The olive flesh, approximately 100g sample from each olive batch, was placed in a sealed food quality plastic container and frozen and maintained at a temperature of -30^{O}C. The lid of the container was removed and the container with the frozen olive flesh was placed in a freeze dryer chamber and a vacuum applied. When the olive flesh had lost its moisture, Approximately 24 hours later, the freeze-dried olive flesh was weighed and the percentage moisture calculated.

6.7 Fruit Weight and Flesh to Pit Ratio

For each batch of olives tested, 20 olives were weighed and destoned with a hand destoner. The stones were then cleaned of flesh with a sharp knife and wiped thoroughly with a paper towel to remove any flesh adhering to the stones. The pooled flesh and the twenty stones were then weighed and the flesh to stone ratio calculated.

6.8 Chemical Tests on Olive Flesh

All solvents, acids and chemicals used in the analysis of the olives and pickling solutions were analytical grade. Where the solvents were not of analytical grade they were redistilled before use.

***Fat Content**:* Ground freeze-dried olive flesh, approximately 6g, was placed in a Soxhlet thimble and placed in a Soxhlet apparatus. The oil was extracted with hot hexane for 8 hours. The residue in the thimble was removed, ground and re-extracted with hexane for a further 8 hours. The two hexane extracts were pooled and the hexane removed *in vacuo* and dried at 105^{O}C for two hours, cooled and weighed. The fat was then calculated as % dry matter and using the % moisture content, the % fat in flesh was calculated.

Fatty Acid Profiles: The distribution of fatty acid methyl esters was used to determine the fatty acid profile for each batch of olives. Here 10-20mg of fat was hydrolysed to free fatty acids under reflux with alkali-methanol. The free fatty acids were then esterified with boron trifluoride reagent in methanol under reflux. After the addition of hexane and saturated sodium chloride solution, the methyl esters partitioned to the organic phase. The organic phase was then dried over anhydrous sodium sulphate. The individual fatty acid methyl were then separated by GC using a fused silica column and flame ionisation detection,

Milling: The dried and defatted olives were milled to a fine powder using a coffee grinder. The samples were stored in glass jars until required for analysis.

Free Soluble Sugars: Soluble sugars levels were determined in olive flesh that had been freeze-dried and defatted. Samples of each batch (0.25g) were weighed into plastic tubes and extracted using an acetonitrile/water mixture (50:50). The tubes and contents were centrifuged and a portion of the extract was analysed using HPLC with refractive index detection. External sugar standards, of fructose, glucose and sucrose were used to detect and quantify the sugar levels in each sample.

Minerals: Here defatted dried olive flesh (400-500mg) was digested in nitric/perchloric acid at 200-210^{O}C. Upon cooling the digest was diluted with deionised water and the elements P, S, Na, K, Cu, Mg, Mn, Fe, Zn and B quantified using inductively-coupled plasma-atomic emission spectroscopy.

Protein Content: The nitrogen content was determined by the complete combustion of the milled sample (Dumas Method, AOAC method 4.2.04). The percentage nitrogen was then multiplied by 6.25 to give the crude protein level of the olive.

***Ash**:* Ash was determined by the AOAC method No 4.1.10. The freeze-dried and defatted olive flesh, approximately 1.5g/batch, was ashed in a silica crucible over 12hours at 550^{O}C. The ashed material was weighed and the percentage ash calculated.

Total Carbohydrate: The total carbohydrate of the olive flesh was calculated by difference, ie subtracting the sum of the moisture, oil, protein and ash levels from 100.

6.9 Physical Tests on Brines

pH Levels of Brine: The pH of brines was measured using digital pH meter. Laboratory pH measurements were made using an intermediate junction pH/redox/ reference electrode (ionode pty Ltd model IJ44/IJ64/IJ14). The pH meter was calibrated using to standard buffers having pH 4.0 and 7.0 respectively. The brine solution was stirred with a magnetic stirrer during the measurements. The pH electrode was rinsed between readings with distilled water. Field pH measurements ie barrels, tanks were made using hand held pH meters.

Free Acidity of Brines: The acidity of brines was determined by volumetric analysis by titrating samples with a standardised solution of 0.1M sodium hydroxide solution using phenolphthalein indicator and expressed as %w/v of Lactic Acid.

Sodium Chloride Levels of Brine: Levels of sodium chloride were measured by volumetric analysis titrating samples with a standardised solution of silver nitrate (0.1M) with potassium chromate as the indicator and the results expressed as %w/v sodium chloride.

Residual Sugar Levels in Brine: Residual sugar levels in brine were assessed using Clinistix.

6.10 Microbiological Analyses of Olive Flesh and Brines

Levels of various microorganisms in brine and olive flesh were determined by the procedures outlined in Table 6.2. Sampling steps were undertaken using aseptic procedures. Results were expressed in colony forming units per ml (cfu ml^{-1}) or (cfu g^{-1}) for brine and olive flesh respectively.

Table 6.2. Levels of microorganisms in brine and olive flesh

Organism	**Brine Limits cfu ml^{-1}**	**Olive Flesh Limits cfu g^{-1}**	**Test Method**
Lactic Acid Bacteria	<10	<100	American Public Health Association 15.413
Yeasts	<10	<100	Australian Standard 1766.2.2
Moulds	<10	<100	Australian Standard 1766.2.2
Clostridium species		<100	
Clostridium perfringens		<100	Australian Standard 1766.2.8
Clostridium botulinum		None	American Public Health Association 36.6
Coagulase positive *Staphylococcus aureus*		<100	Australian Standard 1766.2.4
Escherichia coli		<3	Australian Standard 1766.2.3
Enterobacteriaceae	<1	<10	Australian Standard 1766.2.3
Listeria monocytogenes		None	Australian Standard 1766.2.15
Sample Size	100ml	100g	

Sampling Procedure for Olive Brine: Ensuring that the contents of tanks or bulk containers were well mixed, samples were removed aseptically into sterile or previously unused containers. Brine from small containers was removed aseptically for testing. The samples were kept cool for transport to the laboratory.

Sampling Procedure for Olive Flesh: Olives from tanks or bulk containers were removed aseptically into sterile, or a clean, previously unused jars. The samples were kept cool for transport to the laboratory.

6.11 Organoleptic Evaluation of Processed Table Olives

Because of the large number of samples requiring evaluation and the lack of a trained panel, processed olives were assessed by two experienced investigators and a consensus evaluation was reached (Table 6.3). At least 5 olives from each batch were tasted to ensure consistency.

Table 6.3. Organoleptic evaluation of processed table olives

Quality Attributes		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Appearance	Skin											
	Shape											
	Size											
Colour	Yellow to green											
	Light brown to dark brown											
	Intensity											
	Homogeneity											
Aroma		None		Weak		Moderate			Strong		V.Strong	
	Strength											
	Acid/winey/vinegary											
Taste	Acid/winey/vinegary											
	Salty											
	Bitter											
	Sweet											
	Metallic											
Texture	Firmness											
	Crispness											
Flesh Stone	Pit - flesh detachment											
Other												

Negative Attributes

Appearance	Spots											
	Blistering											
	Sloughing											
	Shrivelling											
	Holes											
	Shape											
	Size											
Aroma	Rancid											
	Mouldy											
Taste	Rancid											
	Mouldy											
	‘Off’ flavour											
Texture	Soft											
	Woody											
	Fibrous											
Other												

7. References

Protein, Fat and Ash

AOAC (2000). In: Horwitz,W, (Ed.) Official Methods of Analysis of the AOAC International. 17th Edition Volumes 1 and 2. AOAC International, Gaitherburg, MD, USA.

Fatty Acid Profile

AOAC (2000). In: Horwitz,W, (Ed.) Official Methods of Analysis of the AOAC International. 17th Edition Volumes 1 and 2. AOAC International, Gaitherburg, MD, USA.

Conacher, H. B. S. (1975). Gas-liquid chromatographic determination of docosenic acid in fats and oils. Collaborative Study. Journal of the Association of Official Analytical Chemists 58, 488-91.

Firestone, D. and Horwitz W. (1979). IUPAC gas chromatographic method for determination of fatty acid composition. Collaborative study. Journal of the Association of Official Analytical Chemists 62, 709-21.

Minerals

McQuacker, N. R., Brown, D. F. and Fluckner P. D. (1979) Digestion of environmental materials for analysis by inductively coupled plasma – atomic emission spectrometry. Analytical Chemistry, 51, 1082-1084.

Food Composition and Safety Data - FSANZ

www.foodstandards.gov.au/foodstandardscode/

Olive Composition

McCance and Widdowson's "The Composition of foods" Sixth Summary Edition, Food Standards Agency, Royal Society of Chemistry, Cambridge 2000.

Olive References

Anon. (2003) Table olives and the world market. Olivae No 99:45-47.

Baxter, P. (1997) 5th edition. The Complete Guide to Growing Fruit in Australia. Pan Macmillan Australia, Sydney.

Codex Standard for Table Olives Codex Stan 66-19891 (Rev. 1-1987).

Ferguson, L., Sibbett, G and Martin, G. eds (1994) Olive Production Manual. University of California Division of Agricultural and Natural Resources Publication 3353.

Garido Fernandez, A., Fernandez Diez, M.J. and Adams, M.R. (1997) Table Olives - Production and Processing. Chapman & Hall, London.

Hobman, F. (1995) Economic study into irrigated olive growing and oil processing in southern Australia. RIRDC Research Paper 95/5

Hobman, F. (1995) Economic study into dryland olive growing and oil processing in southern Australia. RIRDC Research Paper 95/17.

IOOC: Table Olive Processing. (1990) Olive trade data - International Olive Oil Council Madrid, Spain.

Kailis SG, and Considine JA. (2003) The olive Olea europaea L. in Australia:2000 onwards. In Advances in Horticultural Science 16 (3-4):299-306.

Kailis, S.G. and Harris, D. (2001) Growing olives in Australia for table olive processing - part 1. Australian Olive Grower, Issue 23: pp 4-7.

Kailis, S.G. and Harris, D. (2001) Growing olives in Australia for table olive processing - part 2. Australian Olive Grower, Issue 24: pp 9-12.

Kailis, SG and Sweeney, S. (2000) Olives in Australia. Proceedings of the 4th Olive International Symposium on Olive Growing.Valenzano, Bari, Italy, 385-388.

Marsilio V. (1993) Table olive production, processing and standards. Olivae No 49:6-16.

McEvoy, E., Gomez, E., McCarrol, and Sevil, J. 1989 Potential for establishing an olive industry in Australia. RIRDC (DAQ-210 98/5)

Nuberg, I. and Yunusa, I. (2003) Olive water use and yield. RIRDC Publication No 03/048 RIRDC Project NoUA-47A.

O'Sullivan, G. (2003) Olive variety assessment for summer rainfall regions. RIRDC Publication No 03/021 RIRDC Project OAP-1A.

Smyth, J.(2003) Perspectives of the Australian olive industry. In Advances in Horticultural Science 16 (3-4):280-288.

Sweeney, S. (2003) NOVA - the national olive variety assessment project. RIRDC Publication No 03/054 RIRDC Project SAR 23A.