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Table Olive Production Manual

A practical guide for all table olive producers

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Foreword

This practical guide describes methods for both small-scale and large-scale processing and final packaging of various styles of green and black table olives. It includes an explanation of the equipment and testing methods used to assure good manufacturing practice.

The key objective of this work is to 'lift the bar' for Australian table olive producers in terms of improved quality product, food safety and productivity, and to deliver associated benefits to Australian consumers.

Publication of this practical guide to table olive processing also supports the implementation of a proposed new Voluntary Industry Standard for Table Olives in Australia, that is also to be incorporated into the Australian Olive Association Ltd's revised *Code of Practice for olive oil, table olives and other olive products*, that aims to guarantee the authenticity and quality of *Australian Table Olives*™ and distinguish these from imported products by providing consumers with a recognisable quality seal.

The benefits of industry adoption of the recommendations in this report will accrue to Australian table olive producers through greater productivity and associated development of domestic and export markets; to Food Standards Australia New Zealand (FSANZ) and other regulators through improved food safety, OH&S and environmental risk management; and to consumers through fostering increased confidence in and recognition of the quality and safety of Australian table olive products.

This publication was funded from RIRDC core funds, which are provided by the Australian Government.

This practical manual supplements RIRDC Project No UWA 59A, published as: *Establish Protocols and Guidelines for Table Olive Processing in Australia*, by Stan Kailis and David Harris, October 2004, RIRDC Publication No. 04/136, and the companion publication by the same authors, *Producing Table Olives*.

This report, an addition to RIRDC's diverse range of over 2000 research publications, forms part of our Olives R&D Program, which aims to:

- provide information which establishes the benefits of Australian olive products
- maintain the current high quality product while improving productivity, profitability and environmental management through all stages of the supply chain
- develop strategies for existing and new olive producers to reduce the effects of climate change and variability
- build and educate, collaborative, innovative and skilled industry workforce and a cost effective, well funded RD&E program.

Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation

About the Author

James (Jim) Smyth has worked for more than 50 years in the food industry in South Australia and Victoria. He has tertiary qualifications in industrial chemistry with experience in the following industries: pharmaceutical (analytical chemistry and microbiology), wine (quality assurance), edible oil (research and development) and since the beginning of 1972 in the olive industry in general management involving table olives and olive oil. In 1979 and again in 1981, Jim received training in table olive production from Dr MJ Fernandez Diez, head of the Department of Food and Biotechnology Instituto de la Grasa (CSIC) Seville, Spain. Upon retiring in mid 2003 from Viva Olives Pty Ltd, Jim became a consultant to the olive industry, serving for a number of years on the Committee of Olives SA Inc and one year on the Board of the Australian Olive Association Ltd (AOA). Jim received a national award from the AOA in 2008 for his services to industry.

Acknowledgments

Industry

The author wishes to thank the AOA, its National Table Olive Committee (NTOC), and state member association, Olives SA Inc, for their strong support and input to this publication, and table olive producers and processors who have worked with the author over many years, including Philip Henry (deceased) of Oliveholme Limited, Robinvale, Victoria (closed in 1982), Viva Olives and its previous owners Kasbah Olives Pty Ltd and the South Australian Olive Corporation Pty Ltd. Dennis Newell, managing director of The Newell Group at Murray Bridge SA is also acknowledged for his great assistance in co-operating in the design and manufacture of fibreglass table olive pickling tanks of far greater size and strength than the industry had ever considered possible. Professor Stanley Kailis is acknowledged for his help, understanding and his ongoing friendship over many years; as is Matias J Fernandez Diez (deceased) of Seville, Spain, for his help in teaching the author the finer points of producing table olives on a large scale, and for his friendship.

Financial

In addition to the substantial in-kind contribution by the author, financial support for this project has also been provided by AOA, Olives SA and the Rural Industries Research and Development Corporation (RIRDC).

Document preparation

James Smyth has prepared the text for this manual, with document proofing and formatting assistance by members of the NTOC.

Note: As there is a considerable difference in production techniques and equipment used between **small processors** (1 tonne or less) and **large processors** (1 tonne to several hundred tonnes), different instructions may be provided for each group from time to time in this manual.

Abbreviations

ABS	Australian Bureau of Statistics
AOA	Australian Olive Association Ltd
BLT	Bulk liquid transport
CFU	Colony forming units (microbes)
FB	Foldable (plastic) bin
FRP	Fibre-reinforced plastic
FSANZ	Food Standards Australia New Zealand
GMP	Good manufacturing practices
HACCP	Hazard Analysis Critical Control Point
IBC	Intermediate bulk container
MSDS	Material Safety Data Sheets
NATA	National Association of Testing Authorities
NTOC	National Table Olive Committee
OH & S	Occupational Health and Safety
PB	Plastic bin
PVC	Polyvinyl chloride
RIRDC	Rural Industries Research and Development Corporation
SG	Specific gravity
TNTC	Too numerous to count

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Executive Summary

What the report is about

This publication is a practical guide for all table olive producers. It includes an overview of Hazard Analysis Critical Control Point (HACCP) principles for table olives within the framework provided by the FSANZ Food Standards Code. It provides an overview of table olive processing equipment and materials, as used in both small-scale and large-scale production. In addition, it provides detailed descriptions of methods involved in the processing and packaging of both small and large batches of green and black olives, with references to the new Voluntary Industry Standard for Table Olives in Australia.

This practical manual supplements RIRDC Project No UWA-59A, published as: *Establish Protocols and Guidelines for Table Olive Processing in Australia*[1], by Stan Kailis and David Harris, October 2004, RIRDC Publication No 04/136, and the companion publication by the same authors, *Producing Table Olives*[2], publications to which the author has also contributed his expertise.

Who is the report targeted at?

This research report is targeted at all Australian table olive producers, and encompasses both small-scale and large-scale processing and final packaging of various styles of green and black olives.

Where are the relevant industries located in Australia?

Table olives are grown in all Australian states, with South Australia and Victoria being the major production areas. Currently table olive production in Australia represents less than 5per cent of total production from Australia's 6000 hectares of olives, comprising an estimated 900 productive groves.

Background

Australian table olive production in 2011 is estimated at 4000 tonne, with a gross value of production of A$12 million. In the main, Australian table olive growers are small boutique producers and number of producers is increasing, as demonstrated by the 2009 Australian Olive Industry R&D Survey that showed almost half of survey participants as being involved in table olives.

In Australia, varieties such as Manzanillo, 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, resulting in Sevillian-type olives.

Australian table olive export production in the 2010–2011 Australian Bureau of Statistics (ABS) reporting period was 441 tonne with a value of A$1.7 million (A$3.83 per kg). Whereas, table olive imports in the 2010–2011 reporting period (ABS 2011*)*, were 14 815 tonne with a value of A$42.1 million, comprising:

- black olives: 12 027 tonne with a value of A$33.6 million (A$2.79 per kg)
- green olives: 2788 tonne with a value of A$8.5 million (A$3.05 per kg).

[1] *Establish Protocols and Guidelines for Table Olive Processing in Australia,* by Stan Kailis and David Harris, October 2004: https://rirdc.infoservices.com.au/items/04-136

[2] *Producing Table Olives*, by Stan Kailis and David Harris ISBN 978 0 643092 03 7 2007, Landlinks Press 150 Oxford street (PO Box 1139), Collingwood Vic 3066.

Australian per capita apparent consumption of table olives (domestic production plus imports, minus exports divided by population) remains at around 0.9 kg/person, relatively high for a non-Mediterranean country, (but reflecting a large Mediterranean diaspora); with imported table olives comprising more than 80 per cent (14 815 tonne) of the total Australian consumption (18 370 tonne).

This practical guide to table olive processing arose from Australian industry recognition of the importance of documenting the expertise and many decades of experience of the author as a food technologist in the large-scale commercial production of various styles of table olives.

Aims/objectives

A key industry objective is to 'lift the bar' for Australian table olive producers, in terms of improved quality product, food safety and productivity, and to deliver associated benefits to Australian consumers. To facilitate this objective, the Australian Olive Association Ltd (AOA) has also recently developed a *Hazard Analysis Critical Control Point (HACCP) style Food Safety Plan for Table Olives* template for the use of Code of Practice signatories, to assist in identifying critical control points for table olive production.

Given table olives are a fermented food product, it is essential that producers be provided with the required information on good manufacturing practice (GMP), food quality and safety, as documented in this manual.

This *Table Olive Production Manual* also supports the implementation of a proposed *Voluntary Industry Standard for Tables Olives in Australia*[3], that will also be incorporated into the AOA *Code of Practice for olive oil, table olives and other olive products*[4], that aims to guarantee the authenticity and quality of *Australian Table Olives*™ and distinguish these from imported products by providing consumers with a recognisable quality seal.

Methods used

The table olive processing methods used in this manual have been developed over many years by the author working with some of Australia's largest table olive producers, with expert guidance from national and international colleagues as detailed in the acknowledgements.

Results/key findings

The quality of Australian table olives is considered to be as good as if not better than that of imported olives; although because ours is a relatively small industry made up of mostly boutique growers, it is limited greatly by the high costs of harvesting. There is room for more large-scale table olive producers to achieve the critical mass required to access the major table olive supply chains for Australian supermarket chains.

Implications for relevant stakeholders

GMP for processing table olives as described in this manual will assist Australian producers to improve their productivity and expand domestic production, with an associated increase in exports as well as import replacement.

This manual will assist table olive producers to meet the existing mandatory requirements of the FSANZ Food Standards Code and the proposed *Voluntary Industry Standard for Table Olives in Australia*, which is based on the CODEX Standard. By table olive producers adopting the GMP methodology described in this manual, it is also envisaged that regulators will be reassured in terms of

[3] *The Voluntary Industry Standard for Table Olives in Australia* (currently in preparation)
[4] AOA *Code of Practice for olive oil, table olives and other olive products* (under revision*):* http://www.australianolives.com.au/content/code-of-practice

improved food safety risk management.

This work will also assist in building consumer confidence in Australian table olives, through supporting the revised AOA Code of Practice that aims to guarantee the authenticity and quality of *Australian Table Olives*™ and distinguish these from imported products by providing consumers with a recognisable quality seal, with associated benefits to both consumers and the Australian olive industry.

Recommendations

The benefits of industry adoption of the recommendations in this report will accrue to Australian table olive producers through greater productivity, and associated development of domestic and export markets; to FSANZ and other regulators through improved food safety, OH & S and environmental risk management; and to consumers through fostering increased confidence in and recognition of the quality and safety of Australian table olive products.

Introduction

Food safety

This practical guide to producing table olives follows on from a useful monograph prepared in 2007 by the author titled, *Food Safety Requirements for Table Olives and Infused Olive Oil*[5].

A key industry objective is to 'lift the bar' for Australian table olive producers, in terms of improved quality product, food safety and productivity, and to deliver associated benefits to Australian consumers. To facilitate this objective, the Australian Olive Association Ltd (AOA) has developed a *Hazard Analysis Critical Control Point (HACCP) style Food Safety Plan for Table Olives*[6] template for the use of Code of Practice signatories.

HACCP analysis is a voluntary system used by many businesses to identify and manage potential hazards during production; it is particularly useful in a food business. HACCP certification is mandatory for supplying major food services businesses e.g. hotel groups and the major retailers (many of whom have their own HACCP-based certification requirements). HACCP is readily adaptable to the production of table olives.

Identified critical control points for table olive production include:

- **use potable water** only in the production of table olives
- **implement good hygiene practices** – prevent the introduction of spoilage organisms from external sources
- **manage physical hazards** – avoid the inclusion in olive products of solid materials such as stones, pips, glass fragments etc.
- **manage chemical hazards** – only apply chemicals according to label/permit instructions, and use only food-grade processing aids
- **manage microbiological hazards** – control by good manufacturing processes (GMPs) and monitoring of production processes, in particular for:
    - spoilage bacteria: Coliform bacteria, *Propionibacterium,* Zapatera spoilage (*Clostridium butyricum*), *Cryptosporidium*
    - food poisoning risks: *Salmonella, Escherichia coli, Listeria*
    - toxin producing microbes: *Clostridium botulinum, Staphylococcus*

Note: There are, however, relatively few recorded instances of food poisoning from table olives, although there have been some product recalls for suspect under processing with the associated risk of botulism.

- **avoid organic contaminants** – avoid fuel spills and lubricant leaks from on farm and processing machinery.

[5] *Food Safety Requirements for Table Olives and Infused Olive Oil,* A monograph prepared by Jim Smyth and published by Olives SA in 2007: http://www.olivessouthaustralia.com.au/images/foodsafetytableolives.pdf
[6] This *HACCP-style Food Safety Plan for Table Olives* template is only available to AOA Code of Practice Signatories.

Food Standards Australia New Zealand

The AOA National Table Olive Committee (NTOC) on which the author also sits has liaised closely with Food Standards Australia New Zealand (FSANZ), to discuss the application of FSANZ Food Standards for table olives to ensure food safety and high product quality.

Note 1: Any business that processes or packs olive products in Australia is deemed to be a 'food business'. All food businesses in Australia are already required to comply with the *Food Standards Code*[7], including *Food Safety Standard 3.1.1: Interpretation and Application*, *Food Safety Standard 3.2.2: Food Safety Requirements and General Practice*s, and *Food Safety Standard 3.2.3: Food Premises and Equipment*.

Note 2: *Food Safety Standard 3.2.1: Food Safety Programs*, which sets out the requirements for the control of food safety hazards during the production, manufacture and handling of food, is not mandatory for all food businesses. It applies to certain industry sectors that have been identified as being high risk. Also some state jurisdictions such as Victoria require **all food businesses** (including olive processors) to have a food safety program (except retail businesses selling low-risk pre-packaged food).

Note 3: As a fermented product, table olives are regarded as a medium food safety risk. Should there be a serious food safety incident with table olives, regulation may be imposed on the industry.

Note 4: Other jurisdictions may also require businesses to have HACCP-based food safety systems in place. Therefore, all food businesses need to check with their local authority for the requirements that apply in the state or territory where the business is located.

The Voluntary Industry Standard for Table Olives in Australia

The Australian olive industry also proposes to implement in 2012, a *Voluntary Industry Standard for Table Olives in Australia*, that will be incorporated into the AOA *Code of Practice for olive oil, table olives and other olive products*, that aims to guarantee the authenticity and quality of *Australian Table Olives*™ and distinguish these from imported products by providing consumers with a recognisable quality seal.

The Standard is a voluntary industry standard promulgated by the AOA that establishes an objective basis for the wholesale and retail trade in table olive products in Australia. Testing to this Standard will be undertaken by National Association of Testing Authorities (NATA) accredited laboratories.

Table olives and good manufacturing practice

Given table olives are a fermented food product, it is essential that producers be provided with the required information on good manufacturing practice (GMP), food quality and safety. This *Table Olive Production Manual* provides GMP methodology for both small-scale and large-scale processing and final packaging of various styles of green and black olives.

[7] *FSANZ Food Standards Code*: http://www.foodstandards.gov.au/foodstandards/foodstandardscode.cfm

Structure of this manual

Chapter 1 provides an overview of olive processing equipment and materials, as used in both small-scale and large-scale production of table olives. **Chapter 2** provides detailed description of how to process both small and large batches of green and black olives. **Chapter 3** describes the final processing and packaging of both green and black olives, with references to the new Voluntary Industry Standard for Table Olives in Australia. A comprehensive set of **Appendices** is provided, describing the formulation of active cultures, and testing of brine and lye solutions, including microbiological methods.

Chapter 1 Table olive processing equipment and materials

1.1 Tanks and containers

1. As a rule of thumb, olive tanks contain 2/3 to 3/4 of their volume of olives and 1/3 of their volume of brine. A 200 litre barrel would then hold 150 kg of olives and about 50 litres of liquid.

2. **Larger processors** prefer to use large tanks and **smaller processors** smaller containers. For large tanks it is important to note that a problem can occur with green olives which sink in brine. If the tank has too much depth, the olives low down in the tank can be flattened by the weight of olives on top and become less saleable. Black olives float and exert upward pressure and can also become flattened against the tank lid. This tends to limit the height of containers to about 2 metres for the larger processors.

3. **Smaller processors** tend to use 200 litre barrels or 1000 litre polyethylene containers – intermediate bulk containers (IBCs) or bulk liquid transport (BLT).

4. Fibreglass tanks are popular and these days are built strongly enough to support the weight of operators. These tanks can become very slippery when wet and it is advisable to construct a movable counterweighted platform that can reach to the centre of the tank and support one or two operators. Guard rails are needed along the platform walkway. Materials such as bags of salt should be delivered on a pallet close to the operator and be supported by a stationery forklift.

5. Fibre-reinforced plastic (FRP) tanks holding 16 000 litre or about 11 000 kg of olives are popular (*Figure 1*). Tanks holding 9000 litres or about 5500 kg of olives have also been used. FRP tanks are expensive and the cost of smaller tanks becomes prohibitive, although 2000 litre tanks holding 1500 kg of olives have been used for special production.

Figure 1: **New FRP tanks on sloping plinths being fitted out. Note power line on left-hand-side of tank.**

6. Polyvinyl chloride (PVC) tanks copying the design of common FRP tanks have also been used. These tanks are not strong enough to support people, and often become brittle as olive oil from black olives tends to extract the plasticiser from the PVC.

7. Stainless steel is not recommended for table olive tanks. The high salt and acid levels in table olive brines attack the welds in these tanks to such an extent that leaks eventually occur. Stainless steel, particularly Grade 316 is perfectly satisfactory for other purposes in table olive processing such as pipes and fittings, sorting tables and graders as the contact with corrosive brine is not continuous as occurs in storage tanks.

1.2 Pumps, fittings and hoses

1. **For large processors**, stainless steel pumps are ideal for table olive processing but are expensive. Plastic pumps can be used but care is needed in making sure that no weight is put on pump connections as hoses full of brine are heavy and fittings may not be strong enough to resist breakage. Cast iron pumps have also been used but these corrode rapidly with the possibility that the dissolved metal may reach significant levels in the product. 50 mm pumps and fittings are ideal for the large FRP tanks but are too large for smaller processors. If the pump can be connected to a 50 mm fitting in the tank wall near its base, no foot valve will be required.

2. **For small processors**, 1000 litre BLTs and barrels are common, so perhaps 40 mm pumps and fittings with 25 mm hoses are better for these. A foot valve will most likely be required as access to the vessel liquid will be through the top of the container. A length of PVC pipe is used, with the foot valve attached at one end and the inlet hose to the pump attached via a right angle elbow at the other.

All pumps need to be rinsed with clean water and left to drain after use. This can help reduce corrosion as well as preventing any undesirable fermentation in the brine residue left in the pump.

3. The use of 50 mm ‘Camlock’ fittings and 50 mm banded food-grade hose is recommended for **large processors.** Smaller Camlock fittings can also be obtained for **smaller processors**. As mentioned above, care should be taken and it is best to uncouple hoses from the pump when moving to another location. To attach hoses to fittings, stainless steel hose clamps should be used or a banding tool such as BAND-IT® which uses stainless steel bands and buckles.

1.3 Other processing equipment

1. **Salt dissolver:** A specially manufactured salt dissolver is very useful; using an FRP funnel with a fine mesh base. The edges of the funnel are curved so that they sit over the tank neck. Salt is loaded into the funnel and a stream of water from a hose is played on the salt. The salt is quickly dissolved into the tank.

2. **Olive sampler:** Once the tank is full and fermentation is underway, the olives need to be sampled for inspection, taste and smell. A sampler can be made from a short length of 75 mm PVC pipe attached to a 2.5 metre length of 30 mm PVC pipe. To complete the sampler, use two 75 mm end caps, one glued to the bottom of the 75 mm pipe length and the other attached to some strong nylon fishing line with a screw eye. Holes drilled in the bottom end cap let brine flow through readily.

To use the sample, simply loosely attach the lid and lower the sampler to the required depth in the tank. Pull the fishing line to remove the lid and olives from that part of the tank will fall into the sampler. Remove the sampler and examine the olives. Samples from different depths of the tank can be easily obtained.

1.4 Measuring equipment

1. It is most important not to allow glass instruments of any kind into any table olive receival or processing area. Should pieces of a broken hydrometer (salometer), thermometer, glass beaker etc. get into a quantity of olives, this would probably mean the necessary discarding of thousands of dollars worth of olives.

2. **Thermometers:** Measuring temperatures in the range of 0°–100°C is needed in both the factory and testing area. A digital or dial thermometer with a 1 metre stainless steel stem is ideal for measuring the temperature in the centre of olive bins or olive tanks. Other short-stem thermometers of the 'Tel-tru' type are satisfactory. Digital thermometers with attached probes tend to have a short life in the harsh conditions found in an olive factory.

3. **Tank volume measurers (for larger processors):** Homemade dip sticks are ideal, made from PVC pipe with short saw cuts at one cm intervals and slightly longer saw cuts at 10 cm intervals. The relation to volume for each style of tank needs to be calibrated. Because of the risk of contamination, sight levels on the side of tanks are not encouraged.

4. **Refractometer:** A portable (hand held) salt refractometer with a range of 0 to 26 per cent salt weight in weight (w/w) can be used for a wide range of salt concentrations in brine (see Appendix B). But, because olive tanks cannot be readily weighed, the w/w figure is not helpful. Multiply w/w per cent from the refractometer by specific gravity (SG) given in Table 2 to give w/v per cent required. (see Appendix B for further detail).

5. **Data logging instruments:** These are also available at increasingly reasonable prices to test brine percentages, pH (see Appendix F) and temperature. It is important to understand why we measure these parameters, to keep records and know the accuracy and reliability of these instruments. The importance of regular calibration of these instruments is also stressed.

1.5 Laboratory equipment

1. **Digital balance:** Needed for general weighing. Preferably 5 kg capacity, marked in 0.1 g intervals.

2. **Glass beakers** and **Erlenmeyer flasks:** Capacity of 250 ml, for titration vessels.

3**. Lidded polystyrene medical specimen containers:** Containers of 70 ml capacity are ideal for samples of brine etc. If they are purchased 'clean environment manufacture' they can be used for microbiological samples.

4. **Glass burettes**: Capacity of 50 ml, marked in 0.1 ml increments.

5. **Laboratory microscope:** 1000x magnification with 100x objective oil immersion lens. Aim Scientific, Prospect SA can supply a Leica microscope from Germany which is cheap (for a microscope) and adequate for the purpose. The cost of a Leica BME-4 in late 2011 was $860.

6. **Petri dishes:** Polystyrene 'clean environment manufacture', in packs of 10.

7. **Pressure cooker:** Used for microbiology and for starter-culture manufacture. An ordinary home kitchen model will suffice.

8. **Schott bottles:** For starter culture (refer to Appendix A).

1.6 Processing chemicals

1. **Salt (sodium chloride):** A ‘coarse refined’ and importantly, heat-sterilised grade is recommended. **For large processors**, the salt is supplied in pallet lots of 1.2 tonnes (48 reinforced plastic bags of 25 kg each). The coarse grade is recommended over the fine Dairy salt ‘flossy’ grade because it dissolves easily unlike the ‘flossy’ grade which clumps and will not allow water to flow through readily and is therefore difficult to dissolve. **For small processors**, single 25 kg bag purchases are possible.

Suppliers: Cheetham Salt or Olsen’s Salt

2. **Dextrose monohydrate (food grade):** Used to make additions of sugar as needed during fermentation. Dextrose monohydrate is an important ingredient of starter culture. It is used more with lye-treated green olives due to the lye process destroying significant amounts of the natural olive sugars and not leaving sufficient to complete fermentation**. For large processors**, pallet lots of 40 x 25 kg bags are the most economic purchase. **For small processors**, single 25 kg purchases are possible.

Suppliers: Consolidated Chemical or Redox

3. **Sodium hydroxide (caustic soda):** Used only in lye-treated green olives. Although it is never used as a food it is used as a food processing chemical and is therefore purchased as ‘food grade’. **It is vital that users be aware of the dangers of using this chemical and must follow Occupational Health and Safety (OH & S) regulations, particularly in wearing safety clothing, eye protection and gloves. Safety showers must be installed in the vicinity. Make sure Material Safety Data Sheets (MSDS) and sodium hydroxide danger signs are obtained from the supplier and displayed.**

Suppliers: Consolidated Chemical or Redox

4. **Lactic acid (food grade):** 85 to 88 g/100 g. Used to lower pH to safe levels (under pH 4.3) in slowly or non-fermenting olives or used when making fresh brine for packing olives. **This is a dangerous chemical in its concentrated form causing severe damage to eyes and burns to the skin if spilt. The wearing of protective clothing and eye protection is essential when handling this chemical.** When used in olive brines it is usually at a safe rate of about 0.5 g/100 ml.

Suppliers: Consolidated Chemical or Redox

5. **Calcium chloride dihydrate ($CaCl_2.2H_2O$) (food grade):** Used to improve the texture of soft olives in packing brines. Purchase in 25 kg bags from food chemical suppliers.

Suppliers: Consolidated Chemical or Redox

Note 1: Refer to Appendix A for contact details for chemical suppliers.

Note 2: Refer to Part 6 of the *Voluntary Industry Standard for Table Olives in Australia* for further detail on permitted food additives and processing aids.

Chapter 2 Table olive processing methods

2.1 Production of lye-treated green olives

2.1.1. Introduction

1. **For large processors**, it is very important that olives be handled carefully to prevent physical damage and bruising which if not at least minimised will render fruit unsalable or severely reduced in value. Green olives are particularly susceptible to bruising which appears as dark, almost black marking on the skin and is permanent.

2. **For small processors**, harvesting by hand is the norm (*Figure 2*), particularly for those who pick the olives themselves and absorb the cost of labour in their overall production costs.

Figure 2: Handpicked Jumbo Kalamata olives

3. **For large processors**, it is not possible to harvest green olives by hand and compete commercially with imported product.

4. Under normal circumstances, harvesting green olives mechanically would result in very severe bruising of the fruit, rendering it virtually worthless. Three actions, however, make it possible to use mechanical shaking without permanent irreversible damage to the fruit:

(i) **applying an abscission agent** before harvest so that olives can be relatively easily removed from the trees with minimal damage

(ii) **using a specialised harvester** such as a 'Coe' side-by-side machine (*Figure 3*) that has been modified by padding the catching areas to minimise the damage caused to the fruit when falling (this is also an important factor when harvesting black or ripe fruit)

Figure 3: Use of a Coe harvester at Rich Glen Olive Grove, Yarrawonga, Victoria

(iii) **placing the olives into lye solution** immediately after they are removed from the trees. The lye rapidly decomposes enzymes responsible for the bruise marks developing on the surface of the fruit. The fruit therefore remains unblemished.

Note: In regards to abscission agents, ethylene releasing agents, for example Galleon (Nufarm), Ethephon (Amgrow), Promote 720 (Farmoz), have been used with success but specialised application and a withholding period is required. The current permit PER12228[8] (expiry 30 November 2013) is held by AOA and specifies a withholding period of 7 days.

2.1.2. Harvest

1. Generally green olives are ready to harvest when they are a straw-green colour and when a drop of liquid can be squeezed out of the stem end of the olive when it is held between forefinger and thumb and pressure is firmly applied. When cut around the middle and twisted apart, the two halves should separate readily i.e. the 'freestone' effect.

2. The following method requires that an abscission agent be sprayed, under specified conditions, on trees that are to be mechanically harvested after about 7 days (trials on the ease of removal after applying the abscission agent may indicate more or perhaps less time is needed).

3. The olives are mechanically harvested by shaker, de-trashed by air blast during free fall immediately into lye solution and then transported to the factory within a limited time frame. This production manual deals with factory operations rather than harvest operations.

4. The harvested olives cannot be further inspected, graded, de-leafed or de-stemmed until after

[8] APVMA Minor Use Permit Number - PER12228: http://permits.apvma.gov.au/PER12228.PDF

fermentation is complete. The bins must be tipped as soon as possible into fermentation tanks without exposure to air.

2.1.3. Testing lye-treated olives

Olives for testing are removed from vessel, washed and sliced to show lye-treatment progress (*Figure 4)*. Tank samples are taken from top, middle and bottom. In *Figure 4*, the bottom sample shows correct depth, middle sample is acceptable, top sample is not ready as penetration is not deep enough. The processor must decide whether to continue the lye treatment and risk the bottom of the tank being too deep or remove the lye immediately. The writer's decision would be to remove the lye and begin rinsing. You might wait another 30 minutes but the time taken in obtaining the sample, washing the olives and cutting them and making a decision has occupied at least 15 minutes and it will be another 30 minutes to remove the lye and fill the tank with water (twice). This extra time must always be considered.

Figure 4: Testing lye-treated olives

2.1.4. Lye treatment – introduction

(Applies to both large and small processors)

1. Make sure tanks or smaller containers to be filled and equipment are all scrupulously clean and sanitised. It is important that the sanitiser is removed and the equipment and tanks are rinsed clean with potable water.

2. Obtain MSDS from sodium hydroxide (lye) supplier and follow safety directions exactly.

Note: Full safety garments, eye protection and gloves must be worn. An OH&S manual must be developed which covers preparation of the lye solution, dispensing it to the harvest bins, loading on to transport, unloading, the actual harvest operation, reloading the bins, travel to factory site, unloading, loading tanks and the processing operation.

3. Maintain a large open container of dilute household vinegar (about 25 per cent vinegar, 75 per cent water) close on hand for immediately neutralising lye spilt on the person. Ensure safety manual procedures are always followed.

4. Conduct trials using hand-harvested olives with various lye strengths in the week immediately prior to harvest. Decide on strength to be used from penetration times and absence of blistering or skin sloughing.

Note: Temperature, ambient, current and expected during the lye treatment period as well as process water temperature and current temperature of the fruit all have a huge effect on lye treatment severity and must always be taken into account.

5. Prepare sufficient harvesting lye the day before olives are to be harvested. For green Manzanillo the lye must contain 1 per cent salt. Prepare the lye containing salt, test and adjust if necessary using the methods specified in Appendix C. The salt is added to protect the skin of the Manzanillo variety as it tends to slough easily, particularly in temperatures above 22°C. The purpose of this lye is to prevent immediate bruising of the olives after harvesting but not to penetrate the fruit. Once sufficient olives are harvested to fill a tank all of the olives will be at the same level of lye penetration although some will have been harvested some hours before the last harvested. The lye strength is increased in the tank to completely penetrate the olives.

6. The exact lye strength to be used will be determined by:

(i) current and expected ambient temperatures during the period of the lye treatment

(ii) temperature of the fruit and the lye

(iii) maturity of the fruit being harvested.

7. **Trial before harvest:** To estimate the strength of lye required it is best to trial different strengths of lye in 5 litre containers about one week prior to harvest. For Manzanillo, lye of around 1 per cent should be trialled, i.e. 0.8, 1.0, 1.2, 1.4 per cent sodium hydroxide. For other varieties, trials of lye strengths between 1.5 to 2.5 per cent may be suitable. It will be necessary to carry the process for each trial to a day or two beyond the brining stage to determine the best result. It must be noted that the olives in a tank or barrel will mostly behave slightly differently from the small trials and caution is strongly recommended as a weaker or even a stronger lye solution may be needed when treating the larger quantity.

2.1.5. Lye treatment – preparation

(Applies to large processors)

1. For this operation a Chep plastic bin (PB7) or the half-size foldable plastic bin (FB3) which holds 250 kg of olives can be used. The advantage of the FB3 is that the reduced depth of 300 to 400 mm reduces the potential for bruising and crushing of the olives. Alternatively, the PB7 bin can simply be half filled. A Chep supplied plastic bag of 250 micron is used to line the bin. It is important to use a robust bag that will not leak from the seams (see *Figure 5*). However, using a bin liner can also be problematical when emptying the bin.

There are other types of containers that do not require a bin liner that may be suitable. These may have to be manually numbered. Flextank from Melbourne can supply a 1000 litre tank in a metal frame. These are fitted with a screw-on lid which needs a funnel or chute to direct the olives into the lye from the harvester.

2. Pump in the exact amount of lye specified, measured with a graded dipstick and seal the bag with a strong cable tie.

3. Weigh each bin of lye and record the gross weight and the bin identification number (the number is engraved on each Chep container).

4. Measure the temperature of each bin as it leaves the production area and record the temperature and lye strength with the corresponding bin number and weight as described above. These results should be downloaded as a production record on a suitable spreadsheet.

5. Deliver the bins to the grove and make sure they are handed over to the person in charge of the harvest along with a printed copy of the weights and temperatures you have recorded.

Figure 5: **Chep PB7 bins with polyethylene bag liners filled with fresh lye, ready to be taken to the olive grove for the next day's harvest**

2.1.6. Harvest and lye treatment

(Applies to small processors)

1. It is assumed for this process that olives will be handpicked. The olives should be carefully picked to avoid bruising and marking the fruit as any marks will be permanent. Once picked, the olives should be carefully transferred to vented crates and kept in shade until transferred to the processing area.

2. The lye treatment and subsequent rinsing takes from 12 to 14 hours to complete so if a system of cooling is available, it is better to store the olives overnight and begin the lye treatment process early the following morning.

3. Lye is best prepared the day before it is needed. This process uses a single lye treatment and the strength should be estimated by trials as described above in Points 6 and 7 of Part 2.1.4. Lye treatment should be done under cover, out of the sun. Temperature of both the fruit and the lye is critical and

ideally the final temperature of the lye and fruit should be between 20°C and 25°C.

4. Using 200 litre barrels you will need approximately 50 litres of lye and 150 kg of olives. Put 50 litres of lye in each barrel observing the safety requirements listed above. Weigh each crate of olives and tip each one carefully into the lye in the barrel. The empty crates should be weighed so that the net weight of olives tipped is obtained. When sufficient olives have been tipped in, top up the barrel with more lye and measure the final temperature of the olives and close the lid. Some barrels have a screen which will hold the olives under the lye surface, if such screens are not available fill the barrel to overflowing and then close the lid.

5. The ideal lye treatment time (without mechanical harvesting) is between 6 and 9 hours. Take samples from the barrel, wash and slice the olives. Arrange the sliced olives on a slicing board or bench top and place them in rows of zero to 1/3 penetration, 1/3 to 2/3 penetration, and 2/3 to full penetration. Ideally, most of the olives, say 7 out of 10, should be in the 2/3 to full penetration (refer to *Figure 4*).

6. Once it is decided that the lye penetration is sufficient the lye should be immediately removed by pumping out the lye.

7. Follow the procedures for lye removal, rinsing and brining as for large producers as described below under Part 2.1.10.

2.1.7. Starter culture – preparation

Note: Starter culture will be needed to inoculate the olives to ensure the lactic acid fermentation begins without delay.

1. Prepare sufficient starter culture on Day 1 to inoculate all of the tanks or barrels produced, but noting that the culture is not added till Day 3.

2. For 5000 litre tanks one 200 litre barrel of starter culture; for 16 000 litre tanks two 200 litre barrels of starter culture; for 200 litre barrels 5 litres of starter culture for each barrel.

3. The tanks or barrels produced on Day 1 will be inoculated on Day 3; those tanks or barrels produced on Day 2 will be inoculated on Day 4, etc.

4. It is essential that the starter culture be actively fermenting when it is needed. Severe spoilage may occur if the starter culture is not ready when required.

Note: See the preparation method for starter culture as described in Appendix A.

Lactobacillus plantarum (and a closely related strain *Lactobacillus pentosus*) is a widespread member of the genus *Lactobacillus*, commonly found in many fermented food products including brined olives, as well as anaerobic plant matter. The advantages of using this species is that it is a facultative anaerobic organism (i.e. it can function either as aerobic or anaerobic organism), it doesn't produce CO_2 bubbles, and it produces a good-flavoured processed olive.

2.1.8. Grove harvest – directly into lye

1. Harvest the olives into the bins of lye as recorded on the list delivered to you. Note that you may be required to adjust the lye strength as the day proceeds. Note also, that the harvest may be carried out at night if ambient temperatures are excessive.

2. Make sure that the bins are kept in shade prior to harvest and delivered promptly to the factory. **This is an essential factor and must be observed.**

3. Make sure that the cushioning devices on the catching area of the harvester are positioned correctly

and that no olives are allowed to fall on exposed hard surfaces.

4. Make sure that the trash removal air blast is always working with maximum efficiency and the maximum amount of trash is removed.

5. If using Chep bins with liners, as each bin is filled, close the bag with a tie and load the bin onto the trailer. As soon as the trailer is loaded with sufficient bins, deliver the trailer to the factory. **If a mechanical breakdown occurs, deliver all harvested olives to the factory immediately**. Try to schedule work breaks at the factory to fit with the delivery of harvested olives and the requirements of the processing cycle.

2.1.9. Lye treatment – after harvest

1. As bins of harvested olives are delivered to the factory, unload them immediately and weigh them and record the weight against the original weight of lye for the particular bin according to the bin number.

2. Deliver the bins to the tank area in order of their arrival from the grove.

3. Place the fibreglass funnel into the neck of the tank to be filled and make sure that it is stable and not able to tip sideways (*Figure 6*).

Figure 6: **Safety-clad operators ready to control lye-treated olives being tipped into a processing tank**

4. Make sure the valves in the bottom of the tank are closed and carefully untie each bag by cutting the cable tie (and disposing of it carefully) just before it is to be tipped. Make sure the bag is secured in the bin and will not fall into the tank when the bin is tipped.

5. Tip each bin slowly and carefully into the tank, making sure to observe all **safety instructions** for safety clothing, gloves, and safety glasses to be worn at all times. If using Chep bins with liners, the bags present a danger to operators (as they may have lye solution trapped in pockets or simply on their surface) and must be placed very carefully into rubbish collection skips immediately on emptying.

6. All the bins must be tipped without delay, do not interrupt the process for lunch or other breaks. For processors with 16 500 kg tanks, sufficient bins to make a total of 11 000 kg of drained weight of olives will be required.

7. The olives will tend to float but must not be exposed to air; otherwise they will turn black and will have to be discarded. A holding-down sieve must be immediately installed in the top of the tank and sufficient extra lye of the same strength added to raise the level above the holding-down sieve. If possible, a set of olive samples should be taken immediately prior to the sieve being placed in position. If this not possible to do immediately, then the sieve must be positioned and the samples taken as soon as possible.

8. To estimate the progress of lye penetration and to estimate if the harvest lye needs to be strengthened to complete the lye treatment correctly, samples of olives must be taken from the top, middle and bottom levels of the tank using a suitable sampling device. Progress will depend on the factors already mentioned such as lye strength, temperature of the lye, ambient temperature, time of harvesting etc.

9. Take the sampled olives to the laboratory. Wash the olives with water to remove lye. Before slicing the olives, dip hands in a dilute vinegar solution to neutralise the lye and thus reduce the tendency for the knife to slip and cut fingers or hands. A disposable blade ‘box cutter’ with ‘break off’ blade has proven suitable in the past. The olives are then sliced longitudinally to the stone on both sides and laid out on a cutting board with the side with most lye penetration uppermost. Slice about 10 olives from each level. Examine depth of lye penetration (dark green). Arrange the cut olives in rows in order of penetration (0 to 1/3 penetration, 1/3 to 2/3 penetration, 2/3 to full penetration), then estimate the average lye penetration (refer to *Figure 4*).

10. The lye treatment is complete when about 7 olives of the 10 are in the 2/3 to full range. The lye treatment is too deep if there are many olives with complete penetration to the stone and few with 2/3 penetration or less. These olives may blister or be already blistered or the final texture may be soft. It is important to leave some flesh which is not lye treated to allow the overall flesh to remain firm, to provide residual sugar for the fermentation and to retain some faint bitterness and olive flavour in the final product. If the lye penetration is not allowed to go far enough, then the olives will remain bitter and will probably not ferment as the bitter principal acts as a natural ‘antibiotic’ against the desirable lactobacilli population causing a ‘stuck’ fermentation. The colouring anthocyanin precursors may become activated due to the lye and cause the olives to turn black or brown when exposed to air.

Note: An average penetration over samples from the top, middle and bottom of the tank must be estimated.

11. If the average penetration level is low (which is expected because the harvest lye is used to prevent bruising of the fruit, not full penetration) the lye strength must be increased. **This is a difficult operation and must be carried out with great care to prevent aeration which would cause irreversible blackening or browning of the olives as described above.**

12. Slowly and carefully circulate the lye using a pump connected to the 50 mm sieved outlet with the outlet hose connected via a gate ball valve and returned to the top of the tank and held just under the surface. Firmly secure the hose outlet to the top of the tank so it cannot move and cause liquid to spill. A ‘bungee’ strap is useful to secure the hose. Take a sample of the lye to the laboratory and determine the lye and salt strengths. If an addition of lye (caustic soda, sodium hydroxide) is required then

estimate the amount of pearl sodium hydroxide required for 5500 litres. If the tank contains 11 tonnes of olives it will contain about 5500 litres of lye. If the salt level is not at 1.0 per cent but in the range 0.9 to 1.1 per cent it will not be necessary to adjust it, only the lye will require adjustment.

13. Adjusting with lye is a dangerous operation and must be carried out under full supervision with full safety equipment being worn by all people involved.

13.1. Weigh out the required amount of sodium hydroxide (lye) into a lidded plastic pail or pails. Connect a 25 mm hose to a separate outlet on the circulating pump using a Camlock connector.

13.2. Using a salt dissolver fitted carefully to the top of the tank, start the circulating hose flowing into the salt dissolver and carefully tip the sodium hydroxide (lye) into the liquid flow in the salt dissolver. **It is essential to anchor the hose securely so that it cannot escape and spill over the operators. The lye will generate a great deal of heat and may boil or spurt dangerous burning liquid. These burns can destroy eyesight and cause permanent or even fatal damage when spilt on people. Extreme care is required at all times. It is vital to make sure that the liquid flow always exceeds the amount of lye to prevent excess heat developing.**

13.3. Once the lye is all dissolved, turn off the 25 mm hose and continue the circulating of the lye carefully as described above at Point 12. After 10 minutes, resample the lye and test that the required strength has been achieved.

14. Take samples of the olives every hour as described above and slice and examine them as described under Points 9 and 10 above. As the lye penetration becomes closer to the required level, samples will need to be taken every half, perhaps every quarter of an hour. Remember that it will take about 20 minutes to remove the lye and apply the ‘quick rinse’. The lye penetration will continue during this time and only almost stop with the first rinse being applied.

15. Make sure that the pump for removing lye and the water for applying the rinses are all connected and available so that the above operations can be carried out immediately a decision is made to remove the lye.

2.1.10. Lye removal, rinsing and brining

Day 1

1. The lye is removed immediately by pumping. The lye may be re-used provided the strength is tested and adjusted with fresh sodium hydroxide. If re-use is required the lye should be pumped to an empty tank close by and adjusted. The pump should be run as fast as possible for the first few minutes to remove the lye quickly while there is full suction. Aeration will soon occur as the olives will prevent fast draining of the liquid. Slow the pump outlet by partially closing the gate valve to obtain the most efficient flow without losing suction. It is essential that the lye be all removed and the flow will need to be reduced to a trickle by adjusting the gate valve to achieve this. When all the lye is removed, close the gate valve and turn off the pump.

2. Apply a ‘quick rinse’ of fresh water, with the water added until it just covers the olives. The water is removed immediately using the same technique as described above.

3. Apply a first rinse of water, filling the container completely. The olives are then left for two hours.

4. After two hours remove the first rinse, again using the same operation as above, and apply a second rinse of water. This second rinse is left on until the next morning.

Day 2

5. The olives will be brined on Day 2 immediately after the second (overnight) rinse is removed. The brine strength used should always be 8 per cent (80 g NaCl/litre water) and is best made in situ in the

tank containing the olives. This avoids any remaining brine in a storage tank being left over and becoming contaminated. Disposing of strong brine to waste is often difficult.

Note: See method for salt determination in Appendix B.

6. Make sure that the olives are held under the surface of the brine (olives may float due to the higher specific gravity of the brine compared to that of water).

7. Cover the surface of the brine and leave the tank undisturbed until the next day (Day 3).

Day 3

8. Begin by circulating the brine to ensure that the brine strength and pH are uniform in the tank. Prior to inoculation the pH must be reduced by the addition of CO_2 to between pH 6 and 7 so that favourable conditions are created for the starter culture of lactobacilli.

9. **For large processors**, a CO_2 sparging unit is the best method of reducing the pH of the brine to an acceptable level. Sparging units are usually made from sintered stainless steel (finely cast stainless steel with a myriad of tiny holes in its structure) The sparging unit can be a enclosed in a stainless steel tube about 100 mm in diameter and about one metre long. Normal 50 mm Camlock fittings are attached to each end for attaching 50 mm hoses. A gas fitting attaches to the sintered stainless steel fitting. Food-grade CO_2 is connected from a cylinder or bank of cylinders to the gas fitting. If the CO_2 flow is large the gas regulator may freeze, in which case a 240V in-line CO_2 heater is required. Circulate the brine through the circulating pump and sparging unit and allow the CO_2 and brine to flow as quickly as can be achieved. The salt level will have reduced due to osmosis causing equilibrium between olive flesh and the tank brine. The salt level expected is about 3.5 per cent and this is normal and not adjusted as it will not inhibit the lactobacilli at this level but it will provide some protection against spoilage organisms becoming established. The lactobacilli should rapidly establish, multiply and dominate the fermentation.

10. After 10 minutes circulation, collect a sample of brine from the tank and measure the pH. If it is in the range of pH 6 to pH 7, turn off the pump and CO_2 and remove both systems from the tank.

11. **For small processors**, the same principle of sparging applies but the sparging unit is much smaller: about 15 cm long and 19 mm in diameter, attached to a length of 25 mm PVC pipe the other end of which is attached by a flexible hose to a single gas cylinder. The brine is circulated around the barrel or 1000 litre tank and the gas is applied.

12. **For large processors**, inoculate the tank with two barrels of 200 litres each of actively fermenting starter culture by using a small centrifugal pump with a 25 mm food-grade PVC pipe connected via a 25 mm flexible hose to the pump outlet. Place the outlet of the pump about 1/3 of the height of the tank from the bottom and fix it into position so that all the inoculating starter culture flows into the tank at about the same level.

13. **For small processors**, inoculation is best done by hand. Fit a plastic funnel about 20 cm wide at the top to a 1.5 metre length of 25 mm PVC pipe. Lower the outlet of the pipe to a depth of 1/3 up from the bottom of the container and simply pour the 5 litres of starter culture slowly into the barrel. Simply place the lid on the container or barrel without disturbing it and follow these instructions onwards from Day 4 below.

14. Carefully remove the pump outlet tube and cover the surface of the brine, which should be about half way up the neck, with food-grade polythene film, 150 micron. The film surface should be flat across the liquid surface and extend up the inside of the neck, flat against the wall, fold down over the outside of the neck and secured. A ‘bungee’ strap is useful for securing the film. A circular piece of marine ply or 50 mm polystyrene foam is useful to hold the film covering the tank neck surface flat, excluding air and preventing surface yeast from developing . Take no further action on Day 3.

Day 4

15. No action, leave tank as is. This allows the starter culture to multiply and take over the fermentation. **This is the most critical time of the whole process.**

Day 5

16. **Add 50 kg of salt** (approximately 5 kg per tonne of olives) to the salt dissolver and carefully dissolve the salt into the tank using a pump connected to the 50 mm sieved outlet with the hose from the pump directed carefully without splash onto the salt. When the salt is dissolved, circulate brine for 15 minutes holding the delivery hose just under the brine level so that the brine is circulated evenly throughout the whole tank. At the end of the circulation process take two brine samples in 70 ml yellow-topped sterile containers and **test one for pH, salt and sugar level, the other is for microscopic examination.**

16.1. **Microscopy:** Where the technical expertise is available, make a Gram-stained slide by placing a loopful of brine on a slide and carefully evaporating it and following the directions given in the Merck Gram-staining kit. Examine the slide under 1000x magnification (oil immersion objective). Some Gram-stained cells of lactobacilli should be present at this stage, make sure no Gram-negative organisms are present (refer to Appendix H).

16.2. **Results for pH:** If the brine pH is lower and the odour is normal and is starting to become slightly cloudy, no action other than salt addition is required (refer to Appendix F).

16.3. **Results for sugar:** If the sugar level is above 0.05 per cent, take no action. Add 1 kg of dextrose monohydrate per tonne drained weight of olives when sugar level falls to 0.05 per cent or below (refer to Appendix E).

16.4. **Results for salt:** On Day 5, always add 5 kg of salt per 1 tonne drained weight of olives. The salt level should initially fall to about 4 per cent. The salt equilibrates between the initial brine, 8 per cent, and the olive flesh, nil. Dissolve the salt through the salt dissolver (refer to Appendix B).

Note: Methods for the above tests including microscopy are available in the Appendices.

Day 6 onwards

17. If Day 5 was satisfactory, leave the tank alone; if pH had not changed on Day 5, recirculate brine and recheck pH. If there is no change in pH, a second inoculation of starter culture may be required. If the pH is higher than the pH attained on Day 4, consider bubbling through more CO_2 and inoculating again.

Day 7 onwards

18. Continue to circulate brine on alternate days. pH should fall rapidly to 4.3 (olives safe from spoilage organisms). At pH 4.3 the salt level can be increased gradually at the rate of 5 kg per tonne drained weight of olives over several circulations until it reaches 6 per cent.

19. Continue with **dextrose monohydrate additions** at the rate of 1 kg per tonne of drained weight of olives to keep the fermentation going until the pH falls to 3.8. No further additions of dextrose monohydrate should be made once pH 3.8 is reached. The objective is not to be left with either residual sugar or excessively low pH, which will impact negatively on the flavour of the olive.

20. Analyse total acid level. If very low, it may be adjusted immediately or adjusted when the olives are sold.

21. Brine circulation and analysis should continue on weekly basis while the pH is between 4.3 and pH 3.8 and fortnightly after pH 3.8 is reached. The sugar content should eventually reduce to zero.

Note: For long-term storage of greater than 3 months after fermentation is complete, it is important to prevent a secondary fermentation by propionic acid bacteria (these bacteria, if established, produce a slightly unpleasant and distinctive flavour). Increase the salt level to 8 per cent as soon as possible. When the olives are sold the salt level may be reduced to 6 per cent or maintained at 8 per cent depending on the client.

Final product should be bright green in colour with firm flesh and the pleasant taste characteristic of green olives.

Note: Environmental procedures need to be defined for individual processors. The discarding of spent lye and used brine should be discussed with the appropriate authorities.

2.2 Production of green natural olives

Green natural olives cannot be mechanically harvested as the marked skin and bruising which will occur cannot be eliminated without using lye. Green olives intended for sale as whole or pitted whole olives therefore must be hand harvested. Harvesting must be undertaken carefully so the fruit is not marked during harvesting or subsequent operations.

Once the fruit is delivered to the processing factory, the bins are tipped into a flooded hopper and can be de-trashed, spray washed and graded using a single-size grader to eliminate small fruit if desirable (*Figure 7*). It may be better to retain small fruit and to use it for tapenade when it is graded out across a full-size grader at the end of fermentation.

Figure 7: Hand sorting green olives before processing

Once the fruit is de-trashed, washed and small fruit eliminated if desired, the fruit is allowed to fall into bins half full of water and tipped onto water in the fermentation tank.

The procedure for **natural green** olives closely follows the method below for **black olive** processing. The flotation of green olives in brine is not as great as black olives but it is advisable to follow the instructions given at Part 2.3.4. Item 5.

This is not the author's preferred method for producing green olives. Producers who choose not to use lye will need to take particular care in harvesting fruit to avoid any unsightly bruising, and in managing what is a longer and more difficult fermentation process in order to ensure the final quality of the product meets market expectations.

2.3 Production of black olives, including Kalamata

2.3.1 Introduction

The following method deals with black olives mechanically harvested, usually dry, directly into Chep PB7 or FB3 and transported to the factory in these bins (*Figure 8*). These bins are vented to allow air flow through the olives and thus help the olives to remain cooler. Some growers may prefer to use the half-size FB3 bins or half fill the PB7 bins to reduce potential for bruising and temperature increase.

Figure 8: Using a Coe olive harvester for black Manzanillo into Chep PB7 bins

2.3.2. Harvest considerations

1. An abscission spray may be unnecessary and a decision regarding this should be made prior to harvest.

2. Black olives are harvested when the skin is completely black and still quite firm. A compromise

must be made between full blackening of the flesh to the pit and flesh firmness. The final product of olives that are allowed to over ripen (so that the flesh is fully black) will be too soft for sale and can only be used to produce tapenade. Generally, satisfactory firmness is achieved when the flesh is coloured about half way to the pit.

3. Black olives are harvested by mechanical shaking. The catching area of the harvester must be well padded to minimise bruising.

4. Maximum air flow de-trashing should be used as the olives free fall into the harvest PB7 or FB3 bins (open-top bins are satisfactory for black olives).

5. Black olives are stable in air and unlike partially lye-treated green olives, can be exposed to air. The olives are therefore spray washed, de-stemmed and de-trashed, and colour sorted prior to being put into tanks. Grading prior to fermentation is not required.

2.3.3 Reception line

1. **Weighing:** Empty bin weights (tare weights) and bin numbers are recorded prior to delivering to the grove. If bins remain on the property it should be possible to weigh and record weights and bin numbers prior to harvest. Filled bins received from the grove will only require weighing once, when full and the previously recorded tare weight is used to obtain the net weight.

2. The olives are then tipped from the PB7 or FB3 bins into a flooded hopper and elevated to the de-stemmer through high pressure water sprays mounted on the elevator. The sprays wash olives in clean water to remove any dust, mud, bird droppings from the grove.

3. The spray water acts as make up water for the flooded hopper which is drained at the same rate as the incoming water from the sprays. All waste from the de-stemmer is weighed at the end of each harvest day and the weight of waste per bin is calculated as an average**.**

4. The de-stemmer effectively removes all stems, leaves and twigs remaining attached to the olives, as well as any loose material which remains with the olives.

5. **Colour sorters: Large processors** may well find that significant savings in processing costs can be made by purchasing a colour sorter. A colour sorter can effectively remove light-coloured olives when processing black olives and can be used again when sorting olives for sale at the end of fermentation (a colour sorter would be best used at the end of fermentation for lye-treated and brined green olives). When receiving black olives for brining, from the de-stemmer the olives then pass through the colour sorter. Colour-acceptable olives exit in one stream and colour-rejected olives (used for oil production) exit as another stream, both streams being collected in PB7 bins. The PB7 or FB3 bins are reweighed and the net weights for olives in each tank as well as the weight of colour-rejected olives and discarded waste is recorded. The discarded olives and waste are apportioned evenly at the end of each shift to the tanks produced on that shift.

2.3.4. Black olive processing

Day 1

1. **Starter culture:** Is added immediately to new tanks of black olives and must be prepared two days prior to harvest to ensure it is actively fermenting when required for use. Starter culture is used in the same way as for green olives except there is no need for pH adjustment of the brine prior to its use. Whilst some processors of table olives do not use starter culture, industry experience is that **a starter culture provides certainty, consistency and better quality control**.

2. **Brine:** 10 per cent brine is always used and is best made in situ in the tank containing the olives. This avoids any remaining brine in a storage tank being left over and becoming contaminated. Disposing of strong brine to waste is often difficult.

Note: Determine exact brine strength of salt using the method specified in Appendix B.

3. **Loading tanks:** Always load tanks by tipping olives from PB7 or FB3 bins (these bins contain approximately half the weight of olives as PB7 bins and may be used if crushing of olives is of concern), into the tanks via the loading funnel onto sufficient brine to cushion their fall (6preventing bruising). Extra brine may have to be added as the tank is filled. Each of the 16 700 litre tanks should hold 11 000 kg of olives, equivalent to 22 PB7 or 44 FB3 bins approximately. Record the exact amount loaded from bin numbers and corresponding tare and gross weights.

4. **Starter culture:** When all of the olives are loaded but before the tank is filled, make sure there is sufficient volume left for the addition of two barrels of starter culture. Inoculate with two barrels of 200 litres each of actively fermenting starter culture by using a small centrifugal pump with a 25 mm food-grade PVC pipe connected via a 25 mm flexible hose to the pump outlet. Place the outlet of the pump about 1/3 of the height of the tank from the bottom and fix it into position so that all the inoculating starter culture flows into the tank at about the same level.

5. Black olives float readily in brine and need to be held under the brine surface. Once the starter culture pump outlet tube is carefully removed, the fibreglass holding plate is fitted. The plate has three slots cut into its edge about 120° apart. The slots fit over three stainless steel 12 mm threaded rod sections fixed horizontally through the neck of the tank. Once the slots in the plate are in line with the stainless steel rods, the plate is lowered and twisted one quarter of a turn to lock it in position. The upward pressure of the olives may make this difficult if the tank is filled completely before fitting the plate. Always fit the plate and then completely fill the tank.

6. After filling the brine surface in the tank neck, it must be covered. Cover the surface of the brine which should be about half way up the neck, with food-grade polythene film, 150 micron. The film surface should be flat across the liquid surface and extend up the inside if the neck, flat against the wall, fold down over the outside of the neck and secured. A ‘bungee’ strap is useful for securing the film. A circular piece of marine ply or 50 mm polystyrene foam is useful to hold the film surface flat, excluding air and preventing surface growth of film yeast.

Day 4

7. **Leave the tanks alone for 3 days**, then on Day 4 circulate the brine carefully and slowly for 10 minutes and take a sample for the laboratory. In addition, separately take a microbiology test sample directly from the delivery hose to overcome possible salt gradients within the tank.

8. The laboratory will test for salt, pH, residual sugar and check a Gram-stained slide from the microbiology sample. Black olives ferment more slowly than lye-treated olives and it is unlikely that much change from the original conditions will have occurred making any additions be necessary. Report any discrepancies.

9. Aerobic fermentation: An aerobic fermentation method may be used. However, because of the need to circulate large quantities of breathable air through the olives and maintain brine circulation with a suitable pump, the process is expensive to set up.

The **advantages and disadvantages of aerobic fermentation** are that the processed olives will be a brilliant black colour, and fermentation will be completed in 3 months, but the cost of suitable standard aeration equipment is much higher, and they don’t taste as good.

The **advantages and disadvantages of anaerobic fermentation** are that the olives will taste better, but the process is much slower (9 months).

10. **Reporting results:**

10.1. Set up a suitable spreadsheet for each tank.

10.2. Each tank will have recorded on its spreadsheet, the following information:

- designated tank number, the variety of olive, the weight of olives it contains
- date of harvesting, perhaps grove information such as section, row numbers etc.
- ambient temperature during harvest, the trash (leaves, stems and twigs) assigned to it and a date column to record the days from brining each time it is circulated.

10.3. The measured parameters are recorded including results of the microscopy. Any additions such as salt, dextrose or further inoculations must be made immediately if found necessary.

Day 5 onwards

11. Monitor the tank **twice weekly for the first month** after the tank is brined; circulating the brine with a pump to ensure it is uniformly mixed making sure that the outlet from the pump is held below the liquid surface in the tank neck without splashing or foaming. Always take a temperature reading of each tank after circulating and record the reading in the spreadsheet tank record. It is important that the container be kept between 15ºC and 25ºC to maintain fermentation. Advise the production manager if the tank temperature is outside this range. Take a brine sample and a microscopy sample to the laboratory to check salt level, pH, and temperature. Fermentation should occur as the population of lactic acid bacteria increases from the starter culture inoculation. If the pH rises above pH 4.3 and an increasing number of lactic acid bacteria are not evident from the Gram-stained microscope slides, then an addition of lactic acid or a second inoculation with starter culture may be required. It is vital that the pH quickly reduces to below pH 4.3, preferably to lower than pH 4.1.

12. Continue circulating the brine **twice monthly for the next three months** and **once monthly after that**.

13. The pH should begin to fall slowly and at the end of fermentation, should have fallen to pH 3.8 or less.

14. The salt level will also fall slowly and should stabilise at around 6 per cent salt (6 g salt in 100 ml of brine). If the salt level falls below this, additional salt should be added.

15. The process is slow and may take several months to complete; less if a starter culture is used.

16. The addition of the traditional vinegar for Kalamata is not recommended until the fermentation is complete and the olives are ready for packing or shipping. A combination of alcohol produced from natural olive sugars by the presence of yeast with acetic acid from vinegar can under certain circumstances lead to the production of ethyl acetate (nail polish remover) which has a pungent odour and taste. Olives contaminated with very small quantities of ethyl acetate are virtually inedible.

Chapter 3 Final processing and packaging olives for sale

3.1 Product selection

1. When fermentation is complete the olives are removed from the fermentation tanks or smaller containers for quality sorting and size grading.

2. It is important to select olives for packing according to customer requirements; this means that award-winning first grade olives are not used for making olives for pizzas etc.

3. Before a particular tank or IBC is selected for packing, it is important to firstly check the production record to ensure that all the parameters (salt, pH, and total acid) are within specification. A fresh sample of the olives is then inspected for such parameters as size, colour, flesh texture, odour and taste. Any adjustments are then made and the particular container or group of containers is then approved against the particular order.

4. All of this information should already be included on the production spreadsheet for the particular container or tank so that a decision regarding its suitability for a particular purpose of should have been made previously. It will then only be necessary to sample the olives and confirm the decision.

5. **For large processors**, the following process repacks the olives in clarified fermentation brine after the olives are washed during the sorting process. The process described will be that for removal of the olives from tanks via a bladeless impeller pump (such as 'Pomona' or similar) attached to the 150 mm valve at the base of the tank. A de-brining or de-watering screen will be used for this process.

Where olives have been transferred to IBCs, individual IBCs will be tipped directly on to the de-watering screen with the brine being collected in the tank underneath the screen. The olives tumble down the screen and are collected in a Chep PB7 or FB3 plastic bin.

6. **For small processors**, olives can be removed from individual barrels by using a plastic bucket with numerous holes drilled through the sides and bottom to allow rapid drainage, or if a number of barrels are to be sorted it may be profitable to tip barrels on to a de-watering screen as described for large processors above. If tanks are used, olives can be dipped out using a bucket with holes attached to a long handle.

3.2 Green lye-treated olives – final processing

3.2.1 Olive removal from tanks fitted with a 150 mm outlet and 150 mm valve

1. Connect the Pomona pump to the 150 mm olive tank valve with 150 mm food-grade PVC hose. Connect the bladeless impeller pump outlet to the de-watering screen and place a PB7 or FB3 bin underneath the chute to collect the olives. Connect a 50 mm pump to the collection tank outlet with 50 mm food-grade PVC hose and the outlet of this pump to the 50 mm valve at the base of the olive tank with another length of 50 mm food-grade PVC hose. The Pomona pump must be mounted as low as possible to maintain flooded suction.

2. Open the 150 mm tank valve and start the Pomona pump slowly until it begins to pump olives and brine. Never allow the liquid feed to the pump to run out as olives without liquid will be immediately crushed by the pump.

3. When the olives are feeding through the Pomona pump and being delivered to the de-watering screen, adjust the flow rate to suit by adjusting the pump speed (not by opening or closing the tank valve).

4. Start the brine return pump and return brine to tank as required.

5. When a PB7 or FB3 bin is nearly full, slow down the Pomona pump and close the de-watering screen briefly while the full bin is removed and replaced by an empty bin.

6. Record tank or IBC number, bin number, tare weight and gross weight, and record details on a spreadsheet designated for the particular tank.

3.2.2 Reception line

1. Lye-treated green olives were not de-trashed or de-stemmed when harvested so these operations are performed now.

2. Deliver the PB7 or FB3 bins to the flooded hopper of the reception line. The olives are then elevated to the de-stemmer/de-trasher via high pressure sprays which will remove any fermentation residue.

3. The de-stemmer effectively removes all stems, leaves and twigs remaining attached to the olives as well as any loose material which remains with the olives. Collect and weigh all discarded trash and assign it to the tank record for yield calculations.

4. The olives then travel across the colour sorter if available, otherwise over a hand sorting table where pale and dark olives are rejected. Production supervision is important in this area to make sure sorting is efficient and the highest throughput possible is maintained to achieve maximum sorting efficiency. Weigh and record the amount of discards. The rejected olives can be combined with small olives rejected from the sorting table and size grader and used to manufacture tapenade.

5. The olives then proceed across the sorting table where they are hand sorted for appearance and blemishes. Rejected olives are combined with other discarded olives as mentioned above and used to manufacture tapenade.

6. The olives are transported from the end of the sorting table to the size grader (*Figure 9*) via an elevator. Depending on sale requirements, the various size grades which need to be separated are defined and collection bins (PB7 or FB3) are arranged underneath the various outlets to collect them.

Figure 9: **A Greek table olive sorter and grader**

7. If the olives are required immediately for packing, they are transported to the packing area in PB7 bins. If not required immediately for packing, the olives in their various size and quality grades are filled into separate barrels or IBCs and re-brined with filtered fermentation brine and stored until required for sale or packing.

8. **Filtration of fermentation brine for packing sorted and graded olives:** The brine from the fermentation tanks will be cloudy and contain particulate matter such as dead cells of lactobacilli. This brine must be filtered before being used as packing brine. Connect the collected brine to a stainless steel plate filter which is fitted with a changeover plate. Connect the brine inlet to the coarse filter side and the outlet to the fine filtration side of the filter. The pre filter should be 5 micron, the polishing filter 1 micron.

9. If olives are soft, **calcium chloride dihydrate** $CaCl_2 .2H_2O$ (food grade) can be added to packing brine to help improve their texture.

Note 1: Calcium chloride dihydrate is difficult to dissolve so it must be added to the salt brine before adding any acid to encourage the formation of a fine colloidal suspension, (can be added to a maximum of 0.5 g/ litre).

Note 2: Quality and grading is assessed according to the CODEX Standard for Table Olives[9] or the Voluntary Industry Standard for Table Olives in Australia (see References).

Note 3: Containers' filling weights/volumes, and container labelling must meet the appropriate sections of the Australian New Zealand Food Standards Code.

[9] *CODEX Standard 66-1981 (Rev. 1-1987)*: ftp://ftp.fao.org/codex/Meetings/CCPFV/ccpfv22/pf22_10e.pdf

3.3 Black olives, including Kalamata – final processing

3.3.1 Olive removal from tanks

The method for removal of black olives and Kalamata is identical to that for green olives and is repeated below for convenience:

1. Connect the Pomona pump to the 150 mm olive tank valve with 150 mm food-grade PVC hose. Connect the Pomona pump outlet to the de-watering screen and place a PB7 of FB3 bin underneath the chute to collect the olives. Connect a 50 mm pump to the collection tank outlet with 50 mm food-grade PVC hose and the outlet of this pump to the 50 mm valve at the base of the olive tank with another length of 50 mm food-grade PVC hose. The Pomona pump must be mounted as low as possible to maintain flooded suction.

2. Open the 150 mm tank valve and start the Pomona pump slowly until it begins to pump olives and brine. Never allow the liquid feed to the pump to run out as olives without liquid will be immediately crushed by the pump.

3. When the olives are feeding through the Pomona pump and being delivered to the de-watering screen, adjust the flow rate to suit by adjusting the pump speed (not by opening or closing the tank valve).

4. Start the brine return pump and return brine to tank as required.

5. When a PB7 or FB3 bin is nearly full, slow down the Pomona pump and close the de-watering screen briefly while the full bin is removed and replaced by an empty bin.

6. Record tank or IBC number, bin number, tare weight and gross weight, and record details on a spreadsheet designated for the particular tank.

3.3.2 Colour intensity

1. The black (actually deep red) colour of black olives is pH dependent and at low pH the colour intensity may become quite pale.

2. Exposure of the olives to air overnight can allow the colour to darken and for this reason the olives are removed from brine storage and stored dry in half-filled PB7 bins overnight and sorted and graded for packing the next day.

3. Alternatively, the olives can be placed in small tanks in fermentation brine and air or oxygen bubbled through them for 24 hours prior to sorting and grading for packing. This is a more efficient method than simple air exposure and prevents exposure to insects etc. as is the case if the olives are placed in PB7 or FB3 bins.

3.3.3 Reception line

1. Black and Kalamata olives have been de-trashed and de-stemmed and this is not required a second time.

2. Colour sorting is necessary to remove pale and poorly coloured olives but to reach the colour sorter the olives are best tipped into the hopper at the beginning of the reception line to travel across the de-trasher to the colour sorter. Colour-rejected olives can be used for black tapenade. The weight of these waste olives must be recorded on the tank spreadsheet record.

3. Sorting the olives will be relatively easy as only blemished olives should need removal if the colour sorter is set for maximum efficiency. Production supervision is important in this area to

make sure is sorting is efficient and the highest throughput possible is maintained to achieve maximum sorting efficiency. Record the weight of rejected olives against the tank record.

4. If not required immediately for packing, the olives in their various size and quality grades are filled into separate barrels or IBCs and re-brined with filtered fermentation brine and stored until required for sale or packing.

5. **Filtration of fermentation brine for packing sorted and graded olives:** The brine from the fermentation tanks will be cloudy and contain particulate matter such as dead cells of lactobacilli. This brine must be filtered before being used as packing brine. Connect the collected brine to a stainless steel plate filter which is fitted with a crossover or changeover plate. Connect the brine inlet to the coarse filter side and the outlet to the fine filtration side of the filter. The grade of filter to be used is yet to be determined. Deliver the filtered brine to the packing area.

Note: Quality and grading is assessed according to the CODEX Standard for Table Olives or the Voluntary Industry Standard for Table Olives in Australia (see References).

Figure 10: Table olive judging lesson

Appendices

Important notice

Details of laboratory methods and various reagents are provided in the following Appendices. This information is given for internal quality control use only so that producers can follow the fermentation of their products and judge the suitability of the products for sale. The results of this testing cannot be used to issue certification on the suitability of products to comply with the Voluntary Industry Standard for Table Olives in Australia or customers' own standards.

If you are selling product to the consuming public, you will be required to have your olives tested by public laboratories having NATA accreditation.

List of Appendices

Appendix A: Starter culture formulation

A1: List of ingredients

Table 1: Starter culture ingredients

Ingredient	**Chemical formula** (if applicable)	**Supplier**	**g/l**	**500 ml recipe**	**200 litre recipe**
yeast extract powder	N/A	Amyl Media	4	2g	800g
dextrose monohydrate	$C_6H_6O_6$	Consolidated Chemical or Redox	20	10g	4kg
di potassium hydrogen phosphate monohydrate *anhydrous*	K_2HPO_4	Consolidated Chemical or Redox	2	1g	400g
di ammonium phosphate (DAP)	$(NH_4)_2HPO_4$	Consolidated Chemical or Redox	2	1g	400g
trisodium citrate dihydrate	$C_6H_5\ Na_3O_7 \cdot 2H_2O$	Consolidated Chemical or Redox	2	1g	400g
sodium acetate *anhydrous*	CH_3OONa	Consolidated Chemical	5	2.5g	1kg
magnesium sulphate	$MgSO_4.7H_2O$	Consolidated Chemical or Redox	0.2	0.1g	40g
manganese sulphate	$MnSO_4.H_2O$	Consolidated Chemical or Redox	0.04	0.02g	8g
salt, coarse, *heat sterilised*	NaCl	Cheetham Salt or Olssons Salt	40	20g	8kg
water, potable, sterile				to 500 ml	to 200 litre
lactic acid bacteria – freeze-dried culture *(Lactobacillus plantarum* also known as *L. Pentosus)* Produced by Hopeland Bio-Tech Co Ltd[10]	Available in aluminium triple foil bags thermo closed. (0.2, 0.5, 1.0, 2.0 kg/bag) or as required	Hopeland or The Olive Centre		0.5 g	5g

A2: Ingredient suppliers

- **The Olive Centre:** 74 Castle Road, Cabarlah, QLD, 4352, Phone: 07 4696 9845. Is able to advise table olive producers on the supply of the full range of processing equipment and chemicals.
- **Amyl Media Pty Ltd** (Melbourne Office): 39 Healey Rd, Dandenong South, VIC, 3175, Phone: (03) 9706 5666.
- **Chem Supply Pty Ltd** (Adelaide Office): 38–50 Bedford Street, Gillman, SA, 5013, Phone: 08 8440 2000.

[10] *Lactobacillus plantarum* culture is produced by Hopeland Bio-Tech Co Ltd: Contact sales@85xianji.com or icec0529@yahoo.com

- **Consolidated Chemical Company** (Head Office): 52–62 Waterview Close, Dandenong South, Victoria, 3175, Phone: 03 9799 7555.
- **Cheetham Salt** (Melbourne Office): Level 4, 565 Bourke Street, Melbourne, Victoria, 3000, Phone: 03 8624 6500.
- **Olssons Pacific Salt** (Head Office): 19–25 Nelson Rd, Yennora, NSW, 2161, Phone: 02 9632 0441.
- **Redox (Adelaide Office):** 178–180 Cavan Road, Dry Creek, SA, 5094, Phone: 08 8349 5299.

A3: Starter culture laboratory method – initial 500 ml sterilised batch

1. Dissolve yeast extract in about 1 litre of **sterile hot water**. Do not expose unused yeast extract to air as it will quickly absorb water and become lumpy.

2. Add remaining chemical ingredients and stir to dissolve adding more **sterile cold water** as required.

3. Make up to volume with **sterile cold water** to bring to 200 ml and measure temperature.

Note: The maximum temperature must be between 32°C and 40°C (preferably 35°C) and add actively fermenting starter culture.

DO NOT ADD FREEZE-DRIED LACTIC ACID BACTERIA CULTURE YET

4. Dispense solution to 4 x 500 ml Schott bottles, apply caps and tighten securely.

5. Place Schott bottles in pressure cooker containing sufficient water. Do not allow bottles to float.

6. Heat pressure cooker without steam ‘bob’ in place to boiling and allow steam to escape for a minute or two.

7. Place steam ‘bob’ on outlet and wait until steam begins to escape past the ‘bob’.

8. Continue heating for 15 minutes and remove from heat.

9. Allow to cool until pressure has reduced to ambient.

10. Remove lid and remove Schott bottles, place them on an insulated surface and allow them to cool to below 40°C.

11. Carefully open bottles and using a sterile spatula or spoon, add about 0.1 to 0.2 g of freeze-dried lactic acid bacteria culture to each bottle. Be careful not to contaminate either the liquid or the freeze-dried culture.

12. Replace lids and place Schott bottles in incubator at 35°C incubator.

13. Return unused freeze-dried culture to freezer.

14. Examine culture daily for signs of growth, shown by clouding of the culture.

15. Use the 500 ml bottles to inoculate larger quantities of starter culture.

Appendix B: Brine analysis

B1: Sodium chloride (salt) content by Volhard titration

Apparatus:

- pipette, 1.0 ml
- burette, 50 ml in 0.1 ml graduations
- Erlenmeyer flask, 250 ml

Reagents:

- silver nitrate solution, standard solution, 0.1N (0.1M)
- purified ('distilled') water
- potassium chromate solution, 5 per cent in purified water

Method:

1. Rinse burette with a small amount of standard silver nitrate solution (0.1N), drain and refill. Rinse Erlenmeyer flask with purified water and drain.

2. Rinse pipette with brine solution and refill, wipe outside of pipette with tissue and adjust brine level to zero mark. Transfer 1.0 ml of brine to the Erlenmeyer flask and touch pipette to the side of the flask for 3 seconds.

3. Add approximately 50 ml of purified water to the flask ensuring all brine is rinsed from the sides.

4. Add approximately 1 ml of the 5 per cent potassium chromate solution to the flask and titrate the solution by adding the standard silver nitrate solution from the burette after noting the initial reading.

5. The end point of the titration is reached when the first permanent red tinge is observed in the flask. Record the volume of titrant used.

Calculation(s):

per cent (g/100 ml) sodium chloride = silver nitrate ml used x 0.5845 (for a 1.0 ml brine sample)

B2: Brine analysis sodium chloride measurement by hand-held refractometer

Refractometer: A portable salt refractometer with a range of 0–28 per cent w/w can be used for a wide range of salt concentrations in brine. Instruments with ATC ratings have built-in temperature compensation systems (10°–30°C). Simple to use, it requires a couple of drops of solution placed over a prism surface. Readings can be made almost immediately by pointing the refractometer to a strong light source. Before using, the zero reading must be checked with distilled water and any adjustment to the zero reading made with the small screw driver supplied with the instrument.

Note: Salt refractometers give approximate values only and read in per cent by weight not weight in volume which is the standard to be used here. To convert a refractometer reading, either multiply the reading obtained by the refractometer in Column 2 (Table 2), by the brine density value (g/cm^3) (Column 1, Table 2), or read the answer in Column 3 (Table 2) in g/100 ml.

A refractometer works by reading the refractive index of the solution which it converts to an internal scale relating to the substance being measured. If other soluble substances are present (such as in fermenting olive brine or in lye solution containing salt) then the reading given may be quite inaccurate as some soluble substances depress or increase the refractive index of a particular solution.

Refractometer readings may be acceptable in the factory for approximate values but always use the titration method to obtain accurate values of salt content (refer to Appendix D).

Table: 2. Density and concentration of sodium chloride (NaCl)

Brine density (g/cm^3) @ 15ºC	Refractometer reading % NaCl g/100g	Conversion NaCl (g/100 ml)
1.0000	0	0.000
1.0053	1	1.005
1.0125	2	2.025
1.0196	3	3.059
1.0268	4	4.107
1.0340	5	5.170
1.0413	6	6.248
1.0500	7	7.350
1.0559	8	8.447
1.0707	10	10.71
1.0857	12	13.03
1.1009	14	15.41
1.1162	16	17.86
1.1319	18	20.37
1.1478	20	22.96
1.1640	22	25.61
1.1804	24	28.33
1.1972	26	31.13

Note1: Temperate corrections also become more critical as the strength of the brine increases.

Note 2: Whilst a salometer (hydrometer) may also be used to determine brine density, for food safety reasons **the use of glass equipment is not recommended** in food production areas.

Appendix C: Lye for green Manzanillo olives – preparation, testing and adjusting

Sodium hydroxide (caustic soda) universally known in the table olive industry as lye, is a **dangerous chemical** which can cause severe burns to eyes, skin and soft tissue. It can cause burns to eyes resulting in permanent blindness. If ingested, it can cause very severe, possibly fatal burns. When sodium hydroxide is mixed with water heat is generated. If too little water is present to absorb the generated heat, an explosive generation of steam and hot liquid can cause severe, often fatal, burns.

Small producers may mix a batch of lye solution by adding the calculated amount of sodium hydroxide to the required amount of water in a container, and stirring to mix and distribute the heat.

In the preparation of lye for **large producers**, a dilute solution of lye is required so a relatively small amount of lye is added to a large volume of water that is being rapidly circulated. Following this procedure will prevent an explosive generation of hot lye and steam from occurring. Rapid circulation also prevents solid caustic soda from falling to the bottom of the vessel and forming a solid mass which is almost impossible to dissolve.

Lye for green Manzanillo olives contains both lye for lye treatment and salt (sodium chloride) in solution. Salt is used to limit skin blistering or sloughing of newly harvested green Manzanillo, which has tender skins.

Make sure all actions required under OH & S regulations are in place and all personnel undertaking this task are fully briefed and wearing safety clothing, gloves and eye protection.

All personnel to have their own copy of the MSDS for sodium hydroxide which they have read and are familiar with, particularly regarding handling, hazards, safety precautions and handling spillages.

Preparation of lye/salt solution:

1. Decide on the batch size of solution required and calculate the amount of sodium hydroxide and salt needed.

2. Pump about 95 per cent of the water needed into the tank in which the solution is to be made.

3. Using a salt dissolver and circulating pump, dissolve the salt into the tank and circulate for a few minutes.

4. Arrange the return from the pump into the top of the tank with the outlet below the water surface and the hose held fixed in position with ‘bungee’ straps or rope.

5. Weigh out the required amount of sodium hydroxide pearl into a dry container, observing all designated safety precautions and transport the container to a position on a pallet above and slightly to the side of the tank neck opening.

6. With the pump circulating the tank water at as high a speed as possible without causing splashing, carefully tip the sodium hydroxide into the circulating water in a slow but steady stream so that it will rapidly dissolve and not cake on the bottom of the tank.

7. Once the lye and salt are dissolved and completely stirred, take a sample of the liquid to the laboratory for testing.

<u>Appendix D</u>: Analysis of lye for green Manzanillo treatment – sodium hydroxide strength and salt level

Note: This is a mixed solution which cannot be measured for salt level by refractometer because the lye (sodium hydroxide) content will interfere with the indicated reading. Use the titration methods described below.

Apparatus:

- pipettes, 1.0 ml and 5 ml bulb pipettes
- burettes, 50 ml in 0.1 ml graduations
- Erlenmeyer flask, 250 ml

Reagents:

- purified ('distilled') water
- hydrochloric acid, standard solution, 0.1N (0.1M)
- phenolphthalein solution, 1 per cent in alcohol (methylated spirit**)**
- silver nitrate solution, standard solution, 0.1N (0.1M)
- potassium chromate solution, 5 per cent in purified water
- dilute nitric acid, 10 per cent HNO_3

Method:

Sodium hydroxide (lye)

1. Rinse one of the burettes with a small amount of 0.1M hydrochloric acid (HCl), drain and refill. Rinse Erlenmeyer flask with a small amount of distilled water, drain and refill.

2. Fill 5 ml bulb pipette with the sample lye solution, drain and refill, wipe tip of the pipette with a tissue and drain to the zero mark. **An accurate measure is required for the result to be correct.**

3. Transfer the pipette to the Erlenmeyer flask and drain the pipette with the tip of the pipette touching the inside of the flask. Hold the tip of the pipette against the side of the flask for 3 seconds once draining appears to have stopped.

4. Add approximately 50 ml of purified water to the flask ensuring all brine is rinsed from the sides.

5. Add a few drops of phenolphthalein solution to the flask and titrate the solution with 0.1M HCl from the burette.

6. The end point is reached when the purple phenolphthalein indicator becomes just colourless. Record the burette reading as the number of ml used to neutralise the sodium hydroxide in the 5 ml sample.

Calculation(s):

Each ml of 0.1M HCl is equivalent to 0.004 g of sodium hydroxide. Sodium hydroxide percentage is given by:

burette reading (ml) x 0.004 x 100/5.0

or simply, if a 5.0 ml sample is taken the result is given by:

burette reading (ml) x 0.08 = sodium hydroxide per cent

Sodium chloride (salt)

1. Rinse burette with a small amount of standard silver nitrate solution (0.1N), drain and refill. Rinse the Erlenmeyer flask with purified water and drain.

2. Rinse pipette with brine solution and refill, wipe outside of pipette with tissue and adjust brine level to zero mark. Transfer 1.0 ml of brine to the Erlenmeyer flask and touch pipette to the side of the flask for 3 seconds.

3. Add approximately 50 ml of purified water to the flask ensuring all brine is rinsed from the sides. **An accurate measure is required for the result to be correct.**

4. Add a few drops of phenolphthalein indicator solution to the flask, the contents will turn purple due to presence of sodium hydroxide.

5. Add dilute nitric acid slowly to the flask, using a plastic transfer pipette, until the indicator just disappears.

6. Add approximately 1 ml of the 5 per cent potassium chromate solution to the flask and titrate the solution by adding the standard silver nitrate solution from the burette after noting the initial reading.

7. The end point of the titration is reached when the first permanent red tinge is observed in the flask. Record the volume of titrant used.

Calculation(s):

per cent (g/100 ml) sodium chloride = silver nitrate ml used x 0.5845, (for a 1 ml sample of brine)

The sodium chloride strength should fall between 0.97 to 1.03 per cent.

Adjustments:

1. The lye level should be adjusted first.

2. If the lye is stronger than is required and the volume of the liquid is known, simple proportion is used to adjust the volume to bring the lye value to the required level.

3. Once the adjustment to the lye is known, by again using simple proportion, the brine strength expected for the adjusted lye can be calculated. If this does not fall between the limits stated above, additional salt should be added.

4. Where the lye level is below the required strength, additional sodium hydroxide must be added.

5. Because the addition is likely to be small, the effect of the amount of either additional sodium hydroxide or of salt increasing the volume can largely be ignored.

Safety: Observe all OH & S requirements when making adjustments to or handling lye solutions. Be careful when dispensing the final solution into tanks or Chep bins.

Appendix E: Determination of reducing sugars in brine

Rapid approximate method

Apparatus:

- pipette,1.0 ml graduated
- Pyrex test tubes, approximately 13 mm ID x 145 mm

Reagents:

- Clinitest tablets with colour chart supplied (**see warning and first aid instructions below**)

Method:

1. Measure 0.5 ml of brine into a test tube and add one (1) Clinitest tablet. **Caution: heat is developed.**

2. When the reaction subsides, shake the test tube gently and compare the colour of the solution in the test tube with the Clinitest colour chart.

3. Record the result as given by the nearest matched colour on the chart.

Warning: Clinitest tablets contain sodium hydroxide (caustic soda). Avoid contact with skin, eyes, mucous membranes and clothing. Not to be taken internally.

Note: Clinitest tablets develop excessive heat when exposed to moisture. Do not remove quantities of tablets from their foil packing, unwrap one at a time and use each one immediately.

First aid:

- **Internal: Do not induce vomiting. Drink large quantities of water or milk. Call physician immediately.**
- **External: Flush with water for 15 minutes. Get prompt medical attention.**

Appendix F: Measurement of pH of olive brine

F1: Accurate method

Apparatus:

- bench-top pH meter with combination gel-filled glass electrode and automatic temperature compensation using a platinum thermometer type electrode
- glass beakers, 50–100 ml

Reagents:

- pH 4.0 standard buffer solution
- pH 7.0 standard buffer solution
- potassium chloride solution, 3M
- purified ('distilled') water

Method:

1. Turn on the pH meter and allow it to stabilise for 15 minutes.

2. The pH electrode is stored in 3M potassium chloride when not in use. Remove the electrode from this solution and rinse it with purified water.

3. Pour some pH 7.0 buffer into a clean beaker and immerse the pH electrode into the solution.

4. Adjust the reading to pH 7.0 using the provided screwdriver inserted in the small slotted screw on the left side of the meter face.

5. Remove the electrode from the pH 7.0 buffer and rinse it with purified water.

6. Immerse the electrode in some pH 4.0 buffer in a second beaker and when the reading has stabilised adjust the reading to pH 4.0, if necessary, using the provided screw driver in the small slotted screw on the right side of the meter face.

7. The meter is now standardised and ready to measure.

8. Place some of the brine to be measured in another clean beaker and insert the electrode into the brine. The reading displayed on the dial, once the display has stabilised, is the pH of the sample. The actual temperature of the sample may also be displayed by pressing the 'degrees C' button. The pH reading can be displayed again by pressing the 'pH' button.

9. Remove the electrode from the brine, rinse it in purified water and store it in clean 3M potassium chloride solution.

F2: Rapid method (use only for approximate results)

Apparatus:

- Merck universal indicator strips, non-bleeding, pH 0–14

Method:

1. Dip a single indicator strip in a sample of brine and compare the colour developed with the colour chart on the back of the box of strips.

2. The nearest colour match is the approximate pH of the brine

Appendix G: Determination of total or titratable acidity in olive brine

Equipment:

- bench-top pH meter with combination gel-filled glass electrode
- glass beaker, 150 ml
- pipette, 25 ml single mark
- pipette bulb
- burette, glass, 50 ml in 0.1 ml
- magnetic stirrer, adjustable speed
- stirring 'bobs', Teflon coated

Reagents:

- pH 4.0 standard buffer solution
- pH 7.0 standard buffer solution
- potassium chloride solution, 3M
- purified ('distilled') water
- sodium hydroxide standard solution, 0.1N (0.1M).

Method:

1. Turn on the pH meter and allow it to stabilise for 15 minutes.

2. The pH electrode is stored in 3M potassium chloride when not in use. Remove the electrode from this solution and rinse it with purified water.

3. Standardise the pH meter and adjust the slope with standard pH buffer solutions according to the manual supplied with the instrument.

4. Measure 25.0 ml of the brine using the 25 ml pipette into a 150 ml beaker containing a magnetic stirring 'bob'. Observe correct pipetting procedure by wiping the outside of the pipette with a tissue before adjusting the volume to the mark and allowing the pipette to drain by holding the tip against the side of the beaker for 3 seconds after the brine stops flowing.

5. Place the beaker on the magnetic stirrer, insert the pH electrode adding purified water, if necessary, to ensure that the electrode is clear of the 'bob'. Switch on the magnetic stirrer and adjust the stirrer to a suitable speed.

6. Rinse the burette with standard 0.1M sodium hydroxide solution and refill, adjust to mark.

7. Press the 'meas' button on the pH meter, the pH will be displayed. Add standard sodium hydroxide solution from the burette and observe the meter reading. Continue adding sodium hydroxide until the pH meter indicates pH 8.1.

8. The reagent will need to be added more slowly as the end point is approached.

9. Remove the electrode from the beaker, rinse the electrode with purified water and store it in 3M potassium chloride solution.

Calculation(s):

titratable acidity as g/litre = titration x 0.36032

(where sodium hydroxide is 0.1M and a 25 ml sample is used)

Appendix H: Fermentation progress – microscopy

A sample of fermentation brine is obtained from a fermentation tank and examined under a microscope for **microbial activity**.

Apparatus/equipment:

- sterile 70 ml lidded polystyrene containers
- Bunsen burner
- microscope slides, clear glass, 2.54 x 7.62 mm, 0.8–1.0 mm
- bacterial loops, sterile
- slide draining rack
- suitable precision microscope, 1000x magnification with oil immersion objective

Reagents:

- Gram's crystal violet solution (Merck 9218)
- Gram's safranin solution (Merck 9217)
- Lugol's solution (Merck 9261)
- ethanol, 95 per cent

Method:

1. Obtain samples of the brine to be examined in the sterile polystyrene sample bottles.

2. Thoroughly clean a microscope slide and sterilise it by drawing it three times through the upper portion of the Bunsen flame.

3. Transfer a sterile loopful of brine from the sample bottle to a microscope slide and spread it over an area approximately the size of a 10 cent piece carefully with the loop.

4. Dry the sample carefully using warm air from the Bunsen flame. When dry, fix the sample to the slide by drawing the slide three times through the upper portion of the Bunsen flame.

5. Allow the slide to cool and place it on the slide draining rack.

6. Stain the sample by covering it with Gram's crystal violet solution for exactly one minute, pour off excess dye.

7. Carefully rinse the slide with Lugol's solution and leave the sample area covered with Lugol's solution for exactly one minute.

8. Rinse the slide with purified water for 5 seconds.

9. Either dip the slide in ethanol (95 per cent) or apply carefully with a squeeze bottle until no more dye is released and the sample appears greyish–blue.

10. Rinse with purified water for about 5 seconds.

11. Cover the slide with Gram's safranin solution for exactly one minute.

12. Rinse carefully with purified water for 5 seconds. Shake the slide to remove excess water and allow to air dry.

13. Examine the slide under the microscope using 1000x magnification, i.e. using the oil immersion objective and immersion oil. Use the stage lock so that the objective is not damaged.

Results:

Gram-positive organisms stain blue violet

- Identify lactobacilli as Gram-positive rods – often joined in chains – these are the required species. Yeasts are also stained blue – violet but are much larger and usually oval shaped with buds.

Undesirable microorganisms that also stain blue violet

- Clostridia rods, Gram-positive with spores present. Spores may be situated at both ends or at one end of the rod or in the centre. Most undesirable, report presence to management immediately.
- If Clostridia (Gram-positive) are present, this can occur at a late stage of fermentation. Control by adding lactic acid to lower pH to less than 4.3 and adjust salt to above 6 per cent in the brine.

Gram-negative organisms stain pink to red.

- The presence of Gram-negative organisms in large numbers can destroy the olives completely. Urgent action is required – report presence to management.
- Corrective action will depend on the stage of the process. Lactobacilli are graded as:

  \+ small population (satisfactory if no undesirable (spoilage) organisms present and fermentation at an early stage) – consider lowering pH and re-inoculating with starter culture if condition does not improve

  ++ reasonable population – probably satisfactory if no spoilage organisms present.

  +++ satisfactory – no action required.

In all cases of spoilage bacteria being present, daily monitoring of microscopy and analysis is required for effective control.

Appendix I: Quality procedures

I1: Microbiological testing of packaged table olives

The following standards referenced in this section are owned by Standards Australia, copies can be purchased on-line from SAI Global[11]:

- **AS 1766.1.2–1991**: Food microbiology – General procedures and techniques – Preparation of dilutions, superseded by AS 5013.11.1–2004 (in part)
- **AS 1766.1.3–1991**: Food microbiology – General procedures and techniques – Colony count – Pour plate method, superseded by AS 5013.5–2004 (in part)
- **AS 1766.1.4–1991**: Food microbiology – General procedures and techniques – Colony count – Surface spread method
- **AS 1766.5–1994**: Food microbiology – Preparation of culture media, diluents and reagents
- **AS 1766.2.2–1997**: Food microbiology – Examination for specific organisms – Colony count of yeast and moulds.

The Voluntary Industry Standard for Table Olives in Australia includes microbiological criteria for table olives. This voluntary Standard is to be incorporated into the Australian Olive Association Ltd (AOA) revised *Code of Practice for olive oil, table olives and other olive products*, that aims to guarantee the authenticity and quality of *Australian Table Olives*™, and to distinguish these from imported products by providing consumers with a recognisable quality seal.

The Voluntary Industry Standard for Table Olives in Australia will apply to all table olive products whether from Australian or international sources for wholesale or retail trade.

Please refer to Parts 8 and 9 of the Voluntary Industry Standard for Table Olives in Australia that deals with microbiological criteria for the testing of table olive products for sale. In particular refer to Table 5 in Part 8, and the compulsory testing criteria as detailed in Part 9.2.1 of the voluntary standard.

Note: Testing to this standard will be undertaken by NATA accredited laboratories.

The following microbiological testing methodology provides table olive producers with practical guidance on in-house **indicative testing** and monitoring of the fermentation process.

Sampling procedures:

1. Representative sampling: collect sufficient samples from every production to ensure that the whole of the production run is represented.

2. Holding time: collect and maintain samples of olives and brine at ambient temperature for 5 days after filling prior to testing. This will allow time for equilibrium to establish between the olives and the packing brine. Whole olives packed without brine should also equilibrate for 5 days before testing.

3. Storage of samples: store samples at ambient temperature in the laboratory until the holding time has expired.

Preparation of samples:

1. **Olives in brine**: No preparation is required. Open the samples aseptically and perform tests on the undiluted brine as directed in the test method.

[11] SAI Global: http://infostore.saiglobal.com/store/

2. **Whole olives packed without brine:** Aseptically open the containers and remove several olives and place them in a tared, sterile 120 ml polystyrene, lidded sample container. Determine the weight of olives in the container and add an equal quantity of sterile peptone water 0.1 per cent (**AS 1766.5 – 1994**). Shake the container vigorously at intervals during the next hour and allow to stand for a further 30 minutes.

Aseptically open the container and perform tests on the peptone water.

Indicative microbiological tests:

The below indicative levels apply to pasturised product. Colony forming units is abbreviated to 'cfu'.

A. **Total plate count:** Indicative levels less than 100 cfu/ml of brine or 100 cfu/g olives without brine.

B. **Anaerobic bacteria count** (mostly lactic acid bacteria)**:** Indicative levels less than 100 cfu/ml of brine or 100 cfu/g olives without brine.

C. **Yeast and mould counts:** Indicative levels less than 10 cfu/ml of brine or 10 cfu/g olives without brine.

Methods for indicative microbiological tests:

A. **Total plate count:**

Pour plate method as per **AS 1766.1.3–1991**: Food microbiology – General procedures and techniques – Colony count – Pour plate method.

Culture medium:

Amyl Media Plate Count Agar Code AM 144 or equivalent which complies with **AS 1766.1.3 – 1991**. Prepare as directed; sterilise by autoclaving for 15 minutes at 121ºC. Cool to 47º–48ºC before using.

Apparatus:

- Petri dishes, 90 mm, disposable, sterile (Technoplas Cat. S9014 – S20 or equivalent)
- pipettes, 2 ml graduated, sterile, individually wrapped (Sterilin Cat. 40102 or equivalent)

Procedure:

1. Set out Petri dishes on a sterile, level bench top away from possible sources of airborne contamination. Label each Petri dish with an identifying number and the medium.

2. Keep the Petri dish lids in place at all times except when partially lifting to pipette in sample or when pouring the pates.

3. Do not exceed a time interval of 10 minutes between pipetting the sample and pouring the plate.

4. Aseptically transfer 1 ml of the required sample to each Petri dish using a separate sterile pipette for each sample, discarding the pipette after each sample.

5. Aseptically add approximately 15 ml of molten medium at 47º–48ºC to each Petri dish containing sample.

6. Immediately after pouring the medium, mix the medium and inoculum by 5 to-and-fro movements, followed by 5 circular anti-clockwise movements. Take care not to wet the lid while making the mixing movements.

7. Allow the plates to stand on the horizontal bench until the medium has set.

8. As soon as the medium has set, invert the plates and transfer them to the incubator. Incubate for 48 hours at 35ºC.

9. Count colonies and report as cfu/ml. If the number of colonies counted is greater than 250, record

the result as ‘TNTC’ (too numerous to count). Count each spreading colony as a single colony, rejecting plates where more than 25 per cent of the medium is occupied by spreading microorganisms. Tests giving this result should be repeated.

10. Record results as cfu/ml, rejecting samples with counts exceeding the specified limits.

11. Product represented by failing samples must be rejected and not despatched.

12. All used plates must be **autoclaved** or heated in a pressure cooker for 15 minutes before disposal.

B. **Anaerobic bacteria count** (mostly lactic acid bacteria)**:**

Pour plate method as per **AS 1766.1.3–1991**: Food microbiology – General procedures and techniques – Colony count – Pour plate method.

Culture medium:

Amyl Media MRS Agar Code AM 104 or equivalent. Prepare as directed; sterilise by autoclaving for 15minutes at 121°C. Cool to 47°–48°C before using.

Apparatus:

- Petri dishes, 90 mm, disposable, sterile (Technoplas Cat. S9014 – S20 or equivalent)
- pipettes, 2 ml graduated, sterile, individually wrapped (Sterilin Cat. 40102 or equivalent)

Procedure:

1. Set out Petri dishes on a sterile, level, bench top away from possible sources of airborne contamination. Label each Petri dish with an identifying number and the medium.

2. Keep the Petri dish lids in place at all times except when partially lifting to pipette in sample or when pouring the pates.

3. Do not exceed a time interval of 10 minutes between pipetting the sample and pouring the plate.

4. Aseptically transfer 1 ml of the required sample to each Petri dish using a separate sterile pipette for each sample, discarding the pipette after each sample.

5. Aseptically add approximately 15 ml of molten medium at 47º–48ºC to each Petri dish containing sample.

6. Immediately after pouring the medium, mix the medium and inoculum by 5 to-and-fro movements, followed by 5 circular anti-clockwise movements. Take care not to wet the lid while making the mixing movements.

7. Allow the plates to stand on the horizontal bench until the medium has set.

8. Overlay each plate with a second amount of approximately 15 ml of medium and allow to stand until set.

9. As soon as the medium has set, invert the plates and transfer them to the incubator and incubate for 48 hours at 35ºC.

10. Count colonies and report as cfu/ml. If the number of colonies counted is greater than 250, record the result as ‘TNTC’ (too numerous to count). Count each spreading colony as a single colony, rejecting plates where more than 25 per cent of the medium is occupied by spreading organisms. Tests giving this result should be repeated.

11. Record results as cfu/ml, rejecting samples with counts exceeding the specified limits.

12. Product represented by failing samples must be rejected and not despatched.

13. All used plates must be **autoclaved** for 15 minutes at 121ºC before disposal.

C**. Yeast and Mould Counts**
Refer to **AS 1766.1.4–1991**: Food microbiology – General procedures and techniques – Colony count – Surface spread method, and **AS 1766.2.2–1997**: Food microbiology – Examination for specific organisms – Colony count of yeast and moulds.

Culture medium:

Amyl Media Dichloran Glycerol Agar Base Code AM 50 for samples having water activity <0.95. Prepare the medium as directed adding 220 g of AR glycerol per litre of medium. Autoclave at 121°C for 15 min and cool to 45°–50°C before pouring.

Apparatus:

- Petri dishes, 90 mm, disposable, sterile (Technoplas Cat. S9014 – S20 or equivalent)
- pipettes, 2 ml graduated, sterile, individually wrapped (Sterilin Cat. 40102 or equivalent)
- bent spreaders (as per Technoplas 108 05 050 or equivalent)

Preparation of plates:

1. Set out Petri dishes on a sterile, level, bench top away from possible sources of air born contamination**.**

2. Pour about 15 ml of medium into the required number of plates and allow to set.

3. Remove excess moisture and condensation from the plates by incubating the plates open with the internal surfaces of both base and lid facing downwards and with the base resting on the lid, for the minimum time necessary to obtain plates free from condensate. This will be about 2 hours at 37ºC.

Method:

1. Set out Petri dishes on a sterile, level, bench top away from possible sources of airborne contamination.

2. Label each Petri dish with an identifying number and the medium.

3. Keep the Petri dish lids in place at all times except when partially lifting to pipette in sample.

4. Pipette 0.1 ml of sample to the surface of each plate. Discard the pipette. Immediately spread the inoculum gently and evenly over the surface of each plate with a bent spreader. Discard the spreader.

5. Allow the plates to stand until the inoculum has been completely absorbed into the medium surface, usually within 15 minutes.

6. Incubate the plates in an upright position for 5 days at 25ºC ± 0.1°C. Examine the plates after 72 ± 2 hr and then at 24 hour intervals and count the colonies on any plates likely to be overgrown before the full incubation period.

7. Record results as cfu/ml, rejecting samples with counts exceeding the specified limits. Product represented by failing samples must be rejected and not despatched.

8. All used plates must be **autoclaved** for 15 minutes at 121ºC before disposal.

I2: Quality assurance post fermentation

1. Sorting of olives:

A. **For large producers:** For large producers the use of a colour sorter will remove olives outside a normal colour acceptance range. Green olives that have been mechanically harvested will also need to be de-trashed and de-stemmed and this is usually done by machine. So far, there are very few colour-sorting machines that will also remove blemished fruit; they are either not available or extremely expensive. Mechanically harvested black olives should have already been de-trashed and de-stemmed

when delivered from the grove.

B. **For small producers:** All of the above operations will be performed by hand across a sorting table after size grading.

2. For green olives, the colour sorter's cameras will be set to remove very light (almost white) and dark coloured olives so that a uniform green colour is accepted. Blemished olives will not be removed and will require hand sorting across a sorting table.

3. Black olives require initial darkening in air prior to colour sorting. Darkening may be done by removing the olives from tanks, draining them and putting them in meshed crates overnight to darken. The olives will lose liquid overnight either by drainage or by evaporation if the weather is hot. If the olives are packed on site with hot brine, the fluid loss will be replaced but if packed without heating then the fluid loss will be permanent. The loss in weight may reach 20 per cent. Darkening is better done over a few days by placing olives in small tanks through which air in finely divided bubbles is pumped. The darkening occurs without loss of weight. The air supply must be rated 'Breathable', i.e. filtered to remove compressor oil and fumes. There is an Australian standard which covers air quality for this purpose.

4. Once colour sorted, the olives are run across a sorting table and hand sorted. This is an important process and can be costly if not well supervised.

Note: Refer to Part 2 of the Voluntary Industry Standard for Table Olives in Australia for further details on product description, and to Part 5 for further details on quality criteria.

Appendix J: Calculating the amount of sorbic acid or benzoic acid in a packaging brine

J1: Sorbic acid

The Voluntary Industry Standard for Table Olives in Australia Part 6 states that **sorbic acid** is the active ingredient (not potassium sorbate or sodium sorbate), with the maximum level of sorbic acid (expressed as m/m weight of flesh) being 500 mg/kg.

Given:
- the molar mass of sorbic acid, is 112.13 g/mole
- the molar mass of sodium sorbate is 134.11 g/mole
- the molar mass of potassium sorbate is 150.22 g/mole

Therefore a 500 mg/kg sorbic acid brine would be made by adding either: 589 mg of sodium sorbate/litre or 670 mg of potassium sorbate/litre.

However, when calculating the amount of sorbic acid required in a packaging brine we also need to consider that a 500 mg/kg sorbic acid brine will equilibrate to a lower level with the **moisture** in the olive flesh.

Given whole olives occupy 2/3 of the space in a container, 67 per cent of the space will be olives and 33 per cent brine. Most olives are about 80 per cent flesh and 20 per cent pit. The pit does not absorb any preservative so cannot be included in case the addition is above the allowable amount.

For a 1 litre olive package, we would then have: 330 ml of brine and 670 g of olive which has 134 g of inert material (pit) and 536 g of flesh.

In this container, an initial 500 mg/litre sorbic acid brine would equilibrate to: 500 x 330/(330 + 536) = 180 mg/litre

Therefore, to maintain a 500 mg/litre sorbic acid brine, the initial brine concentration would need to be 500 x (330 + 536)/330 = 1312 mg sorbic acid/litre

This concentration could be made by adding to the brine either: 1569 mg of sodium sorbate/litre, or 1758 mg of potassium sorbate/litre.

J2: Benzoic acid

The Voluntary Industry Standard for Table Olives in Australia Part 6 states that **benzoic acid** is the active ingredient (not potassium benzoate, or sodium benzoate), with the maximum level of benzoic acid (expressed as m/m weight of flesh) being 1000 mg/kg.

Given:
- the molar mass of benzoic acid is 122.12 g/mole
- the molar mass of sodium benzoate is 144.11 g/mole
- the molar mass of potassium benzoate is 160.21 g/mole

Therefore, 1000 mg/kg benzoic acid brine would be made by adding either: 1180 mg of sodium benzoate/litre or 1312 mg of potassium benzoate/litre.

However, when calculating the amount of benzoic acid required in a packaging brine we also need to

consider that a 1000 mg/kg benzoic acid brine will equilibrate to a lower level with the **moisture** in the olive flesh.

Given whole olives occupy 2/3 of the space in a container, 67 per cent of the space will be olives and 33 per cent brine. Most olives are about 80 per cent flesh and 20 per cent pit. The pit does not absorb any preservative so cannot be included in case the addition is above the allowable amount.

For a 1 litre olive package we would then have: 330 ml of brine and 670 g of olive which has 134 g of inert material (pit) and 536 g of flesh.

In this container, an initial 1000 mg/litre benzoic acid brine would equilibrate to: 1000 x 330/(330 + 536) = 381 mg/litre.

Therefore to maintain a 1000 mg/litre benzoic acid solution, the initial brine concentration would need to be 1000 x (330 + 536)/330 = 2624 mg benzoic acid/litre.

This concentration could be made by adding to the brine either: 3097 mg of sodium benzoate/litre, or 3442 mg of potassium benzoate/litre.

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Table Olive Production Manual

By JD Smyth

Pub. No. 12/100

This publication is a practical guide for all table olive producers. It includes an overview of Hazard Analysis Critical Control Point (HACCP) principles for table olives within the framework provided by the Food Standards Australia New Zealand (FSANZ) Food Standards Code. It provides an overview of table olive processing equipment and materials, as used in both small-scale and large-scale production. In addition, it provides detailed descriptions of methods involved in the processing and packaging of both small and large batches of green and black olives, with references to the new Voluntary Industry Standard for Table Olives in Australia.

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