The processing of table olives in Greece

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Kerkira, Greece, 21 - 22 February 2014
World production of table olives

2011/12: 2,526,000 tonnes
Table olive production in the EU
2011/12: 828,500 tonnes
Table olive varieties- Conservolea

- Amounts to 51% of total olive production in Greece
- Average size: 180-200 fruits/kg
- Processed as Spanish-style green and naturally black olives
- Flesh-to-pit ratio: 8:1
- Oil content: 20-25% (w.b.)
- Fermentable material: 2-3% (w.b.)
- Similar to Manzanilla
Table olive varieties - Halkidiki

- Amounts to 26% of total olive production in Greece
- Average size: 120-140 fruits/kg
- Processed as Spanish-style green olives
- Flesh-to-pit ratio: 10:1
- Oil content: 19-20% (w.b.)
- Similar to Gordal
Table olive varieties - Kalamon

- Amounts to 20% of total olive production in Greece
- Average size: 220-240 fruits/kg
- Processed as naturally black olives
- Flesh-to-pit ratio: 8:1
- Oil content: 25% (w.b.)
- Fermentable material 3.1-3.5% (w.b.)
Table olive varieties - Thassos

- Processed as dry-salted olives
- Flesh-to-pit ratio: 6:1
- Oil content: 26% (w.b.)
- Fermentable material 3.5% (w.b.)
- Limited interest in the international market
- Consumed locally
Trade preparations of table olives

- Natural olives in brine (Greek style)
- Treated olives in brine (Spanish style)
- Olives darkened by oxidation (Californian style)
- Dehydrated or shrivelled olives

IOC, Trade Standard Applying to Table Olives
Treated green olives in brine (Spanish style)

Harvesting - Sorting (Size grading)

Lye treatment (1.8-2.2%, w/v, NaOH)

Washing step to remove excess of NaOH (normally 2-3 water changes within 24 hours)

Brining - Fermentation

Pitting and Stuffing - Packing
Untreated black olives in brine

- Harvesting - Transportation to the factory
  - Keeping in water
  - Brining
    - NaCl
    - Fermentation
      - Sorting and grading - Air exposure
        - Product ready for consumption or further processing
Olives darkened by oxidation
(black ripe olives)

Harvesting - Transportation - Sorting

Preservation in brine (2.5-5.0% salt) → Debittering treatment with NaOH

Darkening process - Air oxidation

Colour stabilization (Ferrous lactate or gluconate) – Brine addition

Packing - Sterilization
Dry salted olives

Harvest - Transportation to the factory

Sorting - Washing

Place in alternate layers with coarse salt (40%)

Solute loss - Shrivelling - Gradual debittering (curing)

Product ready for consumption (after 60-80 days)
Table olive fermentation

- Spontaneous process, carried out by the autochthonous microbiota.

- Anaerobic conditions, NaCl, and gradual pH decrease, have a selective impact on the microflora.

- After a successful fermentation, the dominating microorganisms are lactic acid bacteria and yeasts.

- Main metabolic products of the process: Lactic acid, acetic acid and ethanol.
Natural (directly brined) black olives in brine
(Greek-style table olives)

Advantages:
- Natural processing with minimum input of chemicals
- Simple processing (traditional anaerobic method)
- Low energy consumption

Disadvantages:
- Time consuming process (4-7 months)
- Possible damage to the crop before harvest due to early frosts
Processing - traditional anaerobic method

- Olives are placed directly in brine, 10-12% NaCl or even higher.
- Under these conditions, fermentation is carried out primarily by yeasts, gram-negative bacteria and sometimes lactic acid bacteria.
- Fermentation is both alcoholic and lactic (to a lesser extent).
- The final product has pH 4.5-5.5 and titratable acidity 0.3-0.5% (expressed as lactic acid).
Olives are placed directly in brine at 6-7% NaCl, which is kept constant throughout fermentation. These conditions favour the growth of lactic acid bacteria which become the dominant microbiota. Yeasts co-exist with lactic acid bacteria at lower population densities. Fermentation is primarily lactic and alcoholic (to a lesser extend). The final product has pH 3.8-4.0 and titratable acidity 0.8-1.0% (expressed as lactic acid). After fermentation, NaCl is adjusted to 8% to avoid spoilage. Brine acidification is usually carried out with lactic acid.
Effect of temperature and NaCl concentration on the course of fermentation
Effect of NaCl on population dynamics during fermentation at 25°C

-□- lactic acid bacteria, -O- yeasts, -△- enterobacteria -★- pseudomonads

Effect of NaCl on population dynamics during fermentation at 18°C

- □- lactic acid bacteria, -O- yeasts, -△- enterobacteria, -★- pseudomonads

Effect of NaCl level on pH and titratable acidity profile during fermentation
Fermentation tanks
Temperature control of fermentation tanks
Temperature control of fermentation tanks
Texture improvement with the use of calcium chloride
Texture improvement - Addition of 0.5% CaCl$_2$

SEM image of skin and outer flesh of Conservolea olive fermented in 4% NaCl with/without 0.5% CaCl$_2$

Control of fungal growth in natural black olive fermentation
Development of mycelial mat
Microbiological composition

Fungi

Yeasts

Bacteria
Bacillus spp., Micrococcus spp.

Natamycin (E 235) is a biological antimicrobial compound produced by *Streptomyces natalensis*.

The formulation consists of 50% natamycin and 50% lactose.

**Acute oral toxicity** $LD_{50} = 450$ mg/kg bw (for female guinea pigs).

Not absorbed or metabolized in humans (EFSA Journal 2009, 7(12):1412).

It has a broad spectrum of activity against fungi and yeasts. The minimum inhibitory concentration (MIC) < 0.010 g/l.

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<tr>
<th>E 235</th>
<th>Natamycin</th>
<th>Surface treatment of:</th>
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<tr>
<td></td>
<td></td>
<td>— hard, semi-hard and semi-soft cheese</td>
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<tr>
<td></td>
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<td>— dried, cured sausages</td>
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$1 \text{ mg/dm}^2$ surface (not present at a depth of 5 mm)
Efficacy of natamycin to control fungal growth

Control 8% NaCl

8% NaCl + 0.01% (w/v) natamycin

Log CFU/ml

Fermentation time (days)

Reduced salt natural black olives
Problem - excessive consumption of salt

• Sodium intake limit 2.4 g/day or 6 g NaCl/day (WHO, 2007).

• In many industrialized countries sodium intake ranges between 3600-4800 mg/day

• 75% of sodium intake comes from processed food, 10-12% is naturally occurring in foods, and 10-15% comes from food cooking or at the table.

• There is danger for (hypertension, strokes, cardiovascular diseases).

• Sodium intake reduction has the same importance as fat and sugar intake reduction.
NaCl substitution - Mixture experiments with potassium chloride and calcium chloride

Augmented simplex lattice design of 2\textsuperscript{nd} order
Microbiological changes of selected fermentations

Fermentation time (days)

log_{10} CFU/ml

8-0-0

4-4-0

4-0-4

0-4-4
Changes in pH and acidity of selected fermentations

- 4% NaCl - 4% KCl - 0% CaCl₂
- 4% NaCl - 0% KCl - 4% CaCl₂
- 0% NaCl - 4% KCl - 4% CaCl₂
- 2.6% NaCl - 2.6% KCl - 2.6% CaCl₂
- 8% NaCl

Fermentation time (days)

Acidity (%)

pH
Sensory profile of selected fermentations
Functional table olives
"PROBIOLIVES"

Table olive fermentation with selected strains of probiotic lactic acid bacteria. Towards a new functional food.

FP7-SME-2008-2-243471
Duration 3 years (1/3/10 - 28/2/13)
Total budget: 2 Meuros, For Greece: 700.000 Euros

Coordinator: Dr. Tassou Chrysoula
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<th>Participant no.</th>
<th>Organisation name</th>
<th>Short name</th>
<th>Country</th>
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<td>1 (RTDP, Coordinator)</td>
<td>National Agricultural Research Foundation, Institute of Technology of Agricultural Products</td>
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<td>2 (SME-AG)</td>
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<td>ASEMESA</td>
<td>Spain</td>
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<td>4 (SME-AG)</td>
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<td>14 (RTDP)</td>
<td>L'Institut National des Sciences Appliquées et de Technologie</td>
<td>INSAT</td>
<td>Tunisia</td>
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Scientific & Technological Objectives

- Isolation and characterization of probiotic lactic acid bacteria from the autochthonous olive microbiota
- Application of the selected probiotic lactic acid bacteria as starter cultures in small-scale controlled fermentations
- Evaluation of shelf life of the probiotic olives under different storage conditions
- Modelling the fermentation kinetics and survival during storage of the probiotic lactic acid bacteria
- Risk assessment & Consumer acceptance studies
- Application of the selected probiotic bacteria as starter cultures in medium or large-scale controlled fermentations by the participating companies
Thank you for your attention