Olive wastewater: Turning salty into sweet

A project funded by the Water Research Commission, which involved the development of a pilot treatment system for table olive brine wastewaters, has shown that the technology is effective for treating such highly polluted brine wastewaters. Debbie Besseling speaks to project leader Dr Clive Garcin of the Centre for Bioprocess Engineering Research (CeBER), at the University of Cape Town, to learn more.

Olives are produced in large quantities and present environmental disposal problems. They are exceedingly bitter, and need to be cured to make them palatable before consumption. The curing process involves placing the olives in a brine solution whereupon a spontaneous lactic acid and/or yeast fermentation takes place.

The brining process takes from 3 to 12 months, depending on cultivar and type of olive (green or black), and is associated with various washing and rinsing steps. This results in noxious darkly-coloured and acidic wastewaters with a high organic load (COD < 70 g/ℓ), high phenolic content (< 5 g/ℓ), and high salinity (~10% NaCl, three times more than sea water). It is a water-intensive process, where up to 10 kℓ of water is consumed per ton of olives processed.

The high polyphenolic content makes the wastewaters toxic to microbial communities and plants, which means they cannot be disposed of in municipal treatment systems or the environment, or used for irrigation. They are generally disposed of in evaporation ponds, where the water is lost and problematic sludge accumulates. The wastes do, however, contain high concentrations of valuable low molecular weight antioxidants with diverse beneficial properties on human health.

Specific objectives of the project were to:

- Recover the antioxidants as a value-added product for beneficiation of the wastewaters
- Recover purified brine water for re-use in the table olive production process
- Minimise the amount of waste for disposal.

The pilot plant constructed was constructed at the Buffet Olives farm in Dal Josaphat, near Paarl. It is one of the biggest and oldest commercial olive farms in South Africa. Conceptualisation, design and construction of the pilot plant were performed during the first year. Installation, plumbing, commissioning, operation and evaluation took place during the second year. Six months of operational data was collected to satisfy the project requirements, although the plant remains running to this day.

ABOUT THE MODULAR TREATMENT SYSTEM

Dr Garcin explains the modular treatment system and its two

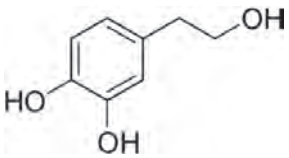
main unit operations: membrane separation and chromatographic adsorption: "Wastewater coming from the olive production factory is diverted from the evaporation ponds and collected in temporary storage tanks. The wastewater is then pre-filtered to remove suspended solids, after which it is processed through the membrane system using a high pressure pump. The membrane system retains the high molecular weight darkly-coloured polyphenolic compounds, while the water, antioxidants, salt and other organic compounds (such as organic acids) pass through as permeate.

"The concentrated polyphenolic compounds are discarded to waste in the evaporation ponds in a minimised volume, and the permeate stream is then passed through a chromatography column containing a selectively adsorbent resin, to which the antioxidants attach. The water, salt, and other components pass through the column. After ozonation, to remove residual organics,

Below: *The containerised olive wastewater treatment plant set up at Buffet Olive Farm, outside Paarl.*

Bottom: *The processing equipment inside the container.*

ABOUT HYDROXYTYROSOL



Hydroxytyrosol (3,4-dihydroxyphenylacetic acid) is the predominant antioxidant component in the crude extract. It is one of the most powerful known naturally occurring antioxidants, and occurs in high quantities only in olives. It is thought to be at least partially responsible for the beneficial aspects of the 'Mediterranean diet', where there is a low incidence of cardiovascular disease and cancer. Besides for powerful antioxidant activity and free radical scavenging, it has been extensively researched and has been shown to have a diverse array of beneficial effects upon human health, including cardioprotection, anti-cancer, neuroprotective and anti-inflammatory properties.

"The elegance of the process is that the same two basic unit operations produce purified water for recycle, a valuable by-product, and a minimised waste stream."

this brine solution is suitable for re-use in the factory."

"The antioxidants are then released and recovered from the column by passing an ethanol solution through it; this is evaporated to obtain a crude antioxidant extract, and the ethanol solution is condensed and recovered for re-use. The crude extract is then purified and processed in the laboratory into a market-ready powdered product. The elegance of the process is that the same two basic unit operations produce purified water for recycle, a valuable by-product, and a minimised waste stream," says Dr Garcin.

Processing capacity for a given plant size and wastewater feed composition were determined, as were product yields and quality.

CHALLENGES ENCOUNTERED

There were many challenges during the project as Dr Garcin explains: "Obtaining costly equipment from overseas was tedious and subject to many bureaucratic delays. Installing the container in which the system was built in an olive orchard without damaging any of the trees was difficult, but was successfully achieved. Testing and commissioning of the system presented the usual problems of identification, fixing, and re-testing."

There was quite a complicated programmable logic controller (PLC) system devised to operate valves, pumps, and other equipment, such that the plant could operate automatically, while manual operation of the system was also possible. Foul rainy weather made the collection of factory discharge difficult, and extreme heat was encountered during some particularly hot summer months (the record was 48°C outside and 56°C inside the container).

Being a natural product, the wastewaters from olive processing were highly variable in terms of their composition, depending on olive cultivar, fermentation process, whether the olives were green or black, and a whole host of other factors. This made the processing and analysis thereof difficult.

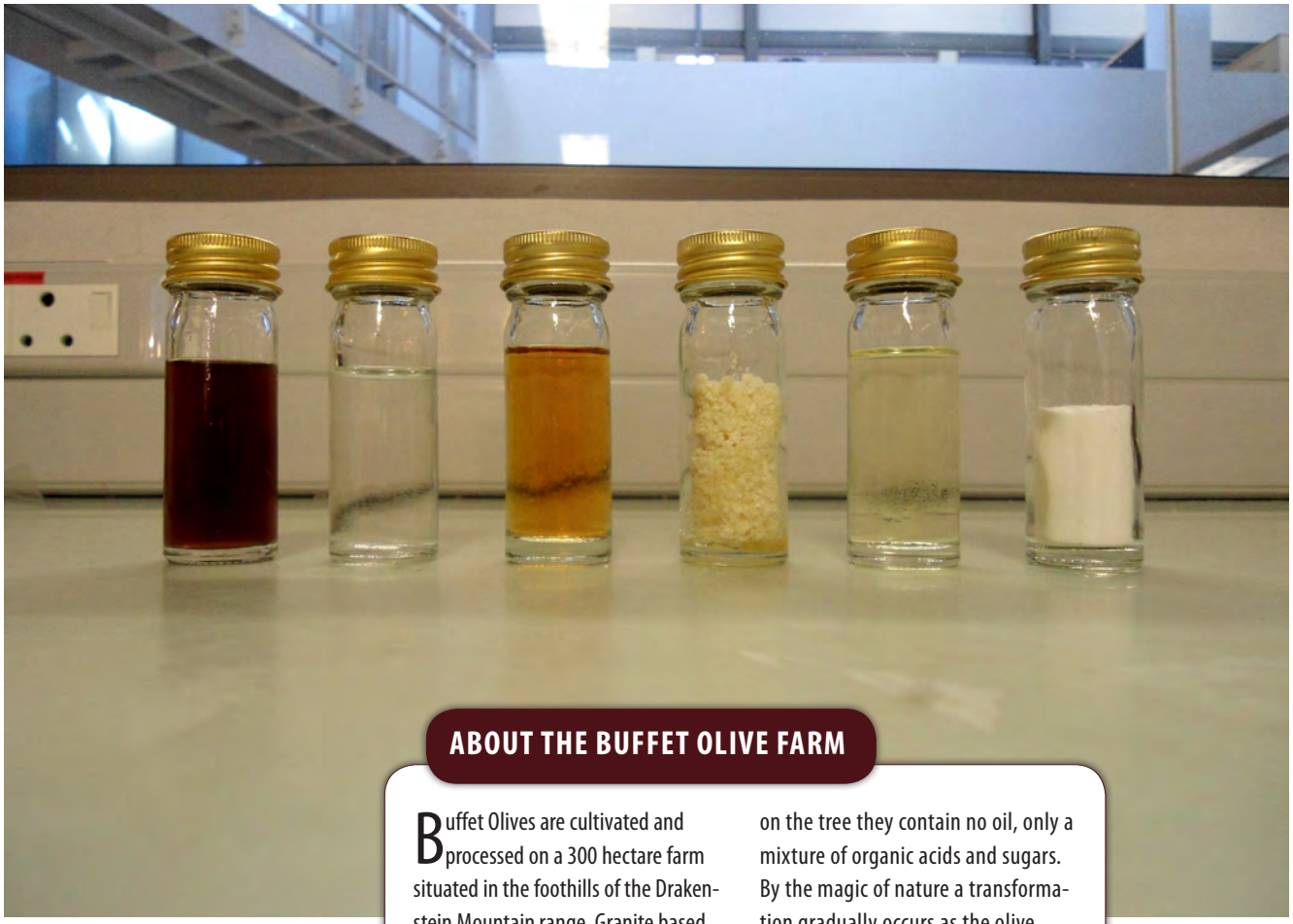
The pilot plant demonstrated that the process is feasible and financially viable, and therefore the overall objectives were met.

The olive wastewater storage and pretreatment unit.

THE PROJECT TEAM

A number of parties were involved in the project. The proprietors of the Buffet Olives farm graciously hosted the research project on-site (and continue to do so); they made space available and access to their wastewater possible through infrastructure modifications, and provided free electricity and clean water. The WRC provided funding for the project. Atl-Hydro (a local consulting firm) assisted with the construction, installation and commissioning of the system. The whole project was executed under the auspices of CeBER, who also provided the laboratory and analytical facilities necessary for process evaluation and downstream processing of the antioxidant product.

The material, equipment and construction (capital) cost of the



Left to right: Brine wastewater feed, recovered purified brine, crude liquid antioxidant extract, crude powdered extract, purified liquid extract, purified powdered extract.

plant was approximately R350 000.

Commenting on the future plans for the technology Dr Garcin says: "A spin-out company has been established to exploit the intellectual property technology generated during the project and commercialisation thereof is well underway".

Thereafter it is intended to roll out the technology to other olive producers, and investigate other possible applications of the technology. The process is, however, only feasible if there are value-added products to be obtained from a waste stream.

To order the final project report, *Pilot-scale treatment of table olive brines: Beneficiation, purification and water recovery for re-use* (**WRC Report No. 2010/1/12**) contact Publications at Tel: (012) 330-0340; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy. ❑

ABOUT THE BUFFET OLIVE FARM

Buffet Olives are cultivated and processed on a 300 hectare farm situated in the foothills of the Drakenstein Mountain range. Granite based soils in combination with a Mediterranean climate create the ideal conditions to grow the superior olives.

Five main cultivars are grown commercially by Cape Olive Trust, namely Sevillano or Gordal, Barouni, Manzanilla, Kalamata and Mission.

When the olives first start to form on the tree they contain no oil, only a mixture of organic acids and sugars. By the magic of nature a transformation gradually occurs as the olive ripens. A chemical process, called lipogenesis, slowly turns the acids and sugar into oil, as the olives turn from the palest green through to rose and violet and black. Olives can be picked at any stage during the process, and the degree of ripeness will determine its taste.