



Recycling citrus waste into animal feed

More than two million tonnes of pulp, peel and rag remain each year after citrus fruits are processed into juice, frozen concentrate and sections. In the past, solid waste, the culls and surplus fruit, were dumped on wastelands or used as soil conditioners on cultivated land, while liquid waste was ponded or flushed into streams, lakes or sewers. However, all such solutions have since proven unsatisfactory and dangerous, since a pile of rotting orange peels soon begins to smell, underground water supplies become contaminated and the increased biochemical oxygen demand kills aquatic life or exceeds the capacities of sewage-treatment plants.

Following thorough investigation of the mounting problem by industrial and research organisations, several economically viable solutions in the form of secondary products have arisen from their efforts. Now, 80 to 90% of citrus waste is converted into usable products, such as dried pulp, molasses, pectin, essential oils, brined peel, citric acid, limonene, feed yeast and biologically active materials.

Feed solution for solid waste

From the waste peel, rind and seed from processing lines, researchers developed dried pulp, which is used extensively for feeding dairy and beef cattle and is also suitable for feeding other animals.

“Although it must be supplemented with some other feed, it contains significant amounts of the protein, fats and minerals”

It contains about 8% moisture, 6% ash, 6% crude protein based on total nitrogen, 6% crude fat, 14% crude fibre and 66% nitrogen-free extract. Although it must be supplemented with some other feed, it contains significant amounts of the protein, fats and minerals required in animal feed. About one tonne of feed is obtained from 10 tonnes of cannery waste.

To make dried pulp, fresh peel is first ground in a hammer mill, to which 0,5 to 1% of lime is immediately added. Lime neutralises the acids and catalyses the de-esterification of the pectin in the peel to form calcium pectate, which facilitates pressing and drying. The

amount is carefully measured in order to get the best pressing characteristics. Formerly, the peel was allowed to stand in bins for about 45 minutes before pressing or drying to allow time for the lime to react. Now the reaction time is shortened to 15 minutes by continuously stirring the peel while it moves slowly through a pug mill. Continuous presses then remove as much liquid as possible, and in some processing plants the pulp is heated by direct steam injection to about 50°C to facilitate the pressing. The weight of liquid removed is about equal to the weight of the pressed pulp.

Direct-fired or steam-heated rotary kiln driers are then used to remove the remaining moisture from the pulp. In some mills, the pulp is given a preliminary drying in direct-fired units and finished in steam-heated units. Careful control of the drying rates and temperatures is necessary to produce the fluffy, light-coloured feeds that are considered desirable.

Over the past 10 years, production of dried peel has increased to approximately 200 000 tonnes per year.

Processing liquid waste

Press or drain liquor from citrus peel contains 5 to 7% sugar and a total of 10 to 12% soluble solids. It cannot be flushed into sewers or ponded, unless care is taken to reduce the biochemical oxygen demand or to prevent bad smells. As a result, most of the press liquor is concentrated to produce molasses.

Citrus molasses is dark brown, bitter and contains about 57% total digestible nutrients. It is used mainly in cattle feeds, generally mixed with other materials, although it can be fed full strength. Some is mixed with wet citrus pulp and then dried to make a feed. It can also be used as a fermentation substrate in the production of alcohol.

Citrus molasses is most commonly extracted through a process of multiple-effect evaporation, with the first stage completed under positive pressure and the last stage under negative pressure. Intermediate stages may be used to increase the number of kilograms of water evaporated per kilograms of fuel consumed. The evaporators used for the purpose of producing citrus molasses may be constructed of mild steel, although corrosion is something of a problem if not all of the acid is neutralised by the lime.

“Citrus molasses is most commonly extracted through a process of multiple-effect evaporation, with the first stage completed under positive pressure and the last stage under negative pressure”

A more serious problem is scaling of the heat-exchanger tubes in the evaporators, because the scale builds up rapidly and interferes with heat transfer and circulation, and must be removed about twice a week by boiling with lye. The exact nature of the scale has not been determined, but it is most probably composed largely of calcium and fibrous material.

Another use for press juice is in the production of yeast, particularly *Torulopsis utilis*, which grows rapidly and is therefore less susceptible to contamination than other yeasts. It is rich in vitamin B and is a good supplement in feeds.

About half the dried yeast is crude protein, but it is deficient in methionine, one of the essential amino acids, which is present in cereal proteins. A ration containing this yeast with some cereal would provide all the essential amino acids required in animal feed. **M&J**