

FRUIT WASTE UTILISATION

Processing of fruits produces two types of waste - a solid waste of peel/skin, seeds, stones etc - a liquid waste of juice and washwaters. In some fruits the discarded portion can be very high (eg mango 30-50%, banana 20%, pineapple 40-50% and orange 30-50%). Therefore, there is often a serious waste disposal problem, which can lead to problems with flies and rats around the processing room, if not correctly dealt with. If there are no plans to use the waste it should be buried or fed to animals well away from the processing site.

Solid wastes

There are a number of possibilities for use of some types of solid fruit wastes but there is as yet no evidence that any of these are economic. *It is stressed that a full financial evaluation should be done before attempting to introduce any of the ideas below.*

One of the main problems in using fruit wastes is to ensure that the waste has a reasonable microbiological quality. Only waste produced during the same day should therefore be used - it is not advisable to store-up wastes to use for example at the end of a week's production. Even with this precaution the waste is still likely to contain mouldy fruit, discarded during processing, insects, leaves, stems, soils etc which will contaminate any products made from it.

Therefore, it is necessary to ensure that some preliminary separation takes place during processing (eg peel and waste pulp into one bin, mouldy parts, leaves, soil etc to another which is discarded, stones, seeds etc into a third bin).

Possible products

The six main products that can be considered are as follows:

- Candied peel
- Oils
- Pectin
- Reformed fruit pieces
- Enzymes
- Wine/vinegar

Candied peel

Peel from citrus fruits (orange, lemon, grapefruit) can be candied for use either in baked goods or as a snack food. In addition, shreds of peel are used in marmalades and the process to make these is similar to candying. In summary, the process involves boiling the slices or shreds of peel in 20% sugar syrup for 15-20 minutes and then progressively increasing the sugar concentration in the syrup to 65-70°Brix (% sugar by refractometer) as the food is soaked for 4-5 days. It is then removed, rinsed and given a final drying in the sun or a hot air drier. This can therefore form a second product for a fruit juice or jam processor especially if larger food companies are available and willing to buy the candied peel as an ingredient for their foods. In one application candied melon skin has been used to substitute for sultanas in baked goods and in another, candied root vegetables have found a similar market.

Oils

The stones of some fruits (eg mango, apricot, peach) contain appreciable quantities of oil or fat, some of which have specialised markets for culinary or perfumery/toiletry applications. Palm kernel oil is well established as both a cooking and industrial oil. In addition some seeds (eg grape, papaya and passion fruit) contain oil which has a very specialised market. The main problems are to identify the import/export agents who would buy such products, producing the oil in sufficient quantities for them, meeting their very stringent quality standards and finally, obtaining the equipment needed to produce the oils at low cost.

The process in summary involves grinding the seeds/nuts to release the oil without a significant rise in temperature which (with the exception of palm kernel oil) would spoil their delicate flavours. Generally, a powered hammer mill is needed for nut/kernels. A press is needed to extract the oil but, to our knowledge, the existing manual presses have not been tried in this application and a certain amount of experimentation is needed to establish oil yields and suitability of the equipment. Solvent extraction is not recommended for small-scale applications. However, steam distillation of citrus peel oils is well established at a small-scale.

The crude oil may be sold for refining elsewhere, but it is likely that at least preliminary (or part) refining would need to be carried out by the producer. At present, we know of no detailed publications on the special refining requirements for these oils. It would seem necessary to contact the end-user to determine the quality required.

It is also possible that the sale of seeds or stones to larger oil processors could generate additional income for small-scale fruit processors. This should be explored.

Pectin

This is a gelling agent used in jams and some sweets found to a greater or lesser extent in most fruits. Commercially, pectin is extracted from citrus peel and apple pomace (the residue left after apple juice has been removed). Some other tropical fruits contain high levels of pectin, passion fruit being a notable example. The utilisation of the 'shells' remaining after pulp removal offers possibilities for pectin extraction.

In most developing countries pectin is imported from Europe or USA and superficially at least there would seem to be a good market for supplying local fruit processors with pectin to substitute for imports. However, there are major problems:

- In countries where this has been tried, it has not been possible to produce pectin at a cost which is lower than the imported products.
- It is difficult to produce pectin powder on a small-scale although liquid pectin is possible.
- There is not one type of pectin but many types - each of which has specific properties that make it suitable for its intended application (eg jam that is to be used in baked goods requires a different type of pectin to normal jam sold in jars).

A detailed knowledge of pectin and its properties is needed to ensure that a producer is supplying the right product.

However, in essence the process of pectin extraction is not too complex. The shredded fruit peel or de-juiced pulp is soaked in hot water (60-70°C), or the hot water is recirculated through the material, and the pectin is extracted into the water (along with sugars and other fruit components). This is continued, often passing the same water through several batches of material, until the pectin concentration increases to around 5% (in larger industries the concentration may be increased by vacuum evaporation).

The pectin is then precipitated as a gel from solution by adding one of a number of chemicals. The most common are hexane or spirit alcohol which are then recovered by distillation and reused (the % recovery and cost of this step are often the most critical in determining profitability). It is also possible to use ammonium sulphate (a component of fertiliser) but this cannot be recovered and the higher cost therefore prevents its use commercially in large-scale operations.

The pectin gel is then washed and redissolved in water to produce a concentrated pectin solution. It is at this stage that it is standardised or modified to give the specific properties required. On a large-scale, it is usually dried to a powder, but on a small-scale it is possible to add sodium benzoate preservative and sell the concentrated liquid in bottles.

Reformed fruit pieces

Fruit pulp can be recovered and formed into synthetic fruit pieces. It is a relatively simple process but the demand for this product is not likely to be high and a thorough evaluation of the potential market is strongly recommended before any work is undertaken.

In summary the process involves boiling the fruit pulp to concentrate and sterilise it. Sugar may also be added. A gelling agent, sodium alginate is then mixed with the cooled pulp this is then mixed with a strong solution of calcium chloride. All ingredients are safe to eat and are permitted food additives in most countries. The calcium and the alginate combine to form a solid gel structure and the pulp can therefore be re-formed into fruit pieces. The most common way is to pour the mixture into fruit-shaped moulds and allow it to set. It is also possible to allow drops of the fruit/alginate mixture to fall into a bath of calcium chloride solution where they form small grains of reformed fruit which can be used in baked goods. Commercially, the most common product of this type is glacé cherries.

Enzymes

Commercially, the three most important enzymes from fruit are papain (from papaya), bromelain (from pineapple) and ficin (from figs). Each is a protein-degrading enzyme used in such applications as meat tenderisers, washing powders, leather tanning and beer brewing. However, it is unlikely to be economic to obtain these from waste fruit. Even the more efficient collection from fresh whole fruit is no longer economic and changes in both large-scale production (higher quality standards and use of biotechnology to produce 'synthetic' enzymes) mean that small-scale producers will be unlikely to compete effectively. In addition, there are moves to phase out the use of these enzymes in food products in Europe and USA and their market is therefore declining. *In summary, these are not recommended as a means of income from waste utilisation.*

Wine/vinegar

Although these products should be produced from fresh, high quality fruit juices in order to obtain high quality products, it is technically feasible to produce them from both solid and liquid fruit wastes. Solid wastes should be shredded and then boiled for 20-30 minutes to extract the sugars from the fruit and to sterilise the liquid. Several batches of waste may be boiled in the same liquid to increase the sugar concentration. This is then filtered through boiled cloth to remove the solids and cooled ready for inoculation with yeast.

Liquid wastes should be separated during production to ensure that fruit juice is kept separate from washwater (eg the juice could be drained from a peeling/slicing table into a separate drum). The juice is then boiled for 10-15 minutes and treated as above.

The liquid is then inoculated with a wine yeast (not a bread or a beer yeast) and fermented in the normal way for wine production. This can then undergo the normal second fermentation to produce fruit vinegar.

In summary, each of the above uses for fruit waste requires:

- a good knowledge of the potential market for products and of the quality standards required
- a careful assessment of the economics of production
- a certain amount of additional production knowledge
- a certain amount of additional capital investment in equipment
- a fairly large amount of waste to make utilisation worthwhile

At very small-scales of operation, where pollution or waste disposal is more important than process economics, the most likely solution is to use wastes as animal feeds.