ENZYMES AS PROCESSING AID by Dr. Malathy V.

One of the most sought after solutions in any industry is how to get the most out of their process. The same holds true in the fruit juice industry. Use of enzymes is one such solution for the fruit processor.

During the last decade, the concept of fruit juices has gained immensely on consumer popularity. The majority of new non-alcoholic and alcoholic fruit drink products were a combination of syrups, fruit juices and flavours.

The confectionery industry followed suit and new products incorporated fruit juices as part of their confectionery formulations and processes. Fruit juice concentrates of high solids are often used instead of normal or single-fold juices.

Juice concentrates are made of pure fruit juices. The process starts with pressing fruits and obtaining pure fruit juice; this is stabilised by heat treatment which inactivates enzymes and micro-organisms. The next processing step is concentration under vacuum up to 40-65° Brix or 4-7 fold. The concentrates are then blended for standardisation and stored

Enzymes

Enzymes are biological catalysts that promote most of the biochemical reactions which occur in the cell. As is typical for catalysts they speed up biochemical reactions without being consumed in the process.

Some properties of enzymes innately present in fruit and vegetable technology are the following:

- in living fruit and vegetables enzymes control the reactions associated with ripening;
- after harvest, unless destroyed by heat, chemicals or some other means, enzymes continue the ripening process, in many cases to the point of spoilage - such as soft melons or overripe bananas;
- because enzymes enter into a vast number of biochemical reactions in fruits and vegetable, they may be responsible for changes in flavour, colour, texture and nutritional properties;
- the heating processes in fruit and vegetables manufacturing/processing are designed not only to destroy micro-organisms but also to deactivate enzymes and so improve the fruit and vegetables' storage stability.

Enzymes have an optimal temperature - around 30-50°C where their activity is at maximum. Heating beyond this optimal temperature deactivates the enzyme. Activity of each enzyme is also characterized by an optimal pH.

In fruit and vegetable storage and processing the most important roles are played by the enzyme classes of hydrolases and oxidoreductases

The technology of enzyme preparations and the benefits of their use are moving at a fast pace. Enzymes are employed in a very small quantity during fruit processing and are completely inactivated during the process of heat treatment. In EU Member States enzymes are generally used and considered as processing aids since most are used using food processing. Current legal regulations on fruit and vegetable processing specify which enzymes may be used for a defined application. The products employed are not pure enzymes, they contain further secondary activities. Enzymes are usually used in combination with other enzymes. For example, pectinase is often used with cellulases, hemicellulases, and proteases. That is why various international organizations use the word enzyme preparations

Source organisms for food processing include bacteria, fungi, higher plants, and animals
While most of the enzymes used are from microbial sources, commercially, the three most important enzymes from fruit origin are papain (from papaya), bromelain (from pineapple) and ficin (from figs). Each is a protein-degrading enzyme used in food processes such as beer brewing, baking, meat tenderisers and other applications such as washing powders and leather tanning.

Pectin
Pectin — a polymer of repeating units of galacturonic acid, is one of the essential structural molecules found in fruits and vegetables.
Other polymers found with pectin might be composed sugars, such as repeating arabinose units (arabans) or chains of galactose (galactans). Pectins are frequently associated with cellulose and hemicellulose While adequate pectin is essential to create gels in jams, jellies and fillings, the presence of this soluble fibril in juice or juice concentrate is a problem for the production of clarified juices

Pectin degrading enzymes from fungal sources are useful processing aids in fruit juice industry.

In the commercial manufacture of pectic enzymes molds are preferred because the optimum pH of fungal enzymes is very near the ph of many fruits which ranges between 3 to 5. Commercial sources of fungal pectic enzymes have been used in fruit juice processing since the 1930's for clarifying fruit juices and disintegrating plant pulps to increase juice yields Commercial enzymes are similar to the naturally occurring pectinases, cellulases, and hemicellulases found in fruit during ripening. Most enzymes are marketed on the basis that they are generally recognized as safe (GRAS) for their intended use in the juice process.[2] GRAS affirmation can be based on common use in foods prior to 1958, or on publicly available studies that establish the safety of the enzymes. To obtain official FDA recognition, a GRAS Affirmation Petition was filed with the US Food and Drug Administration by the Ad Hoc Enzyme Technical Association, a forerunner of the Enzyme Technical Association (ETA), seeking GRAS affirmation of many enzymes based on common use in foods, including pectinases from *Aspergillus niger* and *Aspergillus oryzae*. This petition, GRASP 3G0016, provided supporting documentation in the form of published and unpublished studies attesting to the safety of enzyme use as an adjunct to the physical separation of juice from the fruit. In addition, data were provided that demonstrated the functional effects in the fruit matrix. The agency accepted this petition for filing on April 23, 1973. The agency does not have any concerns regarding enzyme safety.

Applications of enzymes in fruit processing is in juice extraction, clarification, wine clarification and production, cloud stabilization of citrus juices, extraction of citrus juices, and use in production of vegetable and fruit purees.
The selection of the enzyme best-suited to a particular fruit, problem or desired result is usually made by running a product test — first on the bench-top and then in the processing plant. The results of these tests can be somewhat misleading, since fruit changes in composition from year to year in response to weather and harvest conditions, and among different varieties of the same fruit. If a plant processes several types of fruit, a different enzyme might be used depending on the type of fruit, process, fruit's pH, the processing temperature, the ripeness or the plant personnel's past experiences

Specific Uses:

Increase in juice yield
Juice from fruits such as oranges and lemon can be easily extracted, but it is not possible to obtain juice from banana, guava mango, etc. Enzyme treatment results in degradation of the cell walls providing an increased percentage of juice yields versus conventional methods thereby reducing waste and energy use per unit of juice produced. The application of pectinase and other enzymes enables the entire fruit to be liquified,. Enzymes have the effect of additionally improving saccharification and thus sweetness

Treating grape must with enzymes has increased yield by 6-12 percent. The benefits of enzyme usage are partially dependent on the specific variety of grapes - and the growing conditions - on which the enzyme is used. Enzyme preparations can promote improved color extraction in the processing of red grapes, while decreasing off taste causing polyphenol extraction into white grape must by gentle but efficient release of juice from the fruit, In case of mango, treatment with enzymes has been particularly useful in varieties such as totapuri which require more manual as well as machine power to give efficient yield. In case of pineapple, enzyme treatment aids in release of juice from the tough fibre, Also yield of juice from waste fibre is also considerably enhanced resulting in profit for the processor.

Clarification
Although 70% of the juice can be extracted from fruits such as grapes by pressing it is difficult to filter and clarify such juice
Filtration is a necessary step in fruit juice processing to obtain clear juice before being processed further**.** In case of fruits such as apple, polymeric substances such as starch and arabans may make filtration difficult and cause post process cloudiness. A mixture of enzymes are necessary at this step in processing.
Because concentrates and purees can be stored several months, purees of fruits not widely available in a particular area, such as banana puree can be shipped there and then processed and blended with juices of home grown fruits
The objectives of concentration of fruit juices are mainly to reduce costs and to increase shelf life. Before concentration, pressed juice must be clarified. The process aims to eliminate insoluble solids and destroy pectin substances. The most efficient method is by using enzymes containing pectinases
Pomegranate processing is gaining importance recently. Enzyme treatment has proved to be an improvement over the conventional process of clarification involving use of gelatin.

The kiwifruit processing industry emerged in the 1970s but immediately experienced difficulties. It was found that kiwifruit was a difficult fruit to process, not behaving as do many other fruits. These included changes in flavour, loss of the green colour, development of brown pigments, formation of hazes and precipitates in liquid products, and the sensation of an irritation ("catch") in the throat when eaten. As with many forms of juice processing, commercial enzymes have been used successfully to aid juice extraction from kiwifruit pulp. A mixture of polygalacturonase and pectinase enzymes are added to assist with juice release from pulp. The use of enzymes permits the production of juices and concentrates of sparkling clarity once the pectins are sufficiently degraded.

Filtration

Ultrafiltration offers the possibility of filtering clear, sterile juices in one step, without the addition of clarifiers. With **ultrafiltration** membranes the separation capacity is characterised not by pore size but by the so-called separation limit. The low molecular weight constituents of the juice pass through the **membrane** whereas the high molecular weight substances are held back and concentrated. The liquid phase that passes through the **membrane** is usually termed the permeate, and the concentrated product stream the retentate. The flux of a cross-flow **membrane** is largely influenced by colloidal content of the juice being filterd. The quantity of colloids depends on the processing The further the pomace is processed the higher the colloid content and the lower the flux and capacity of the **ultrafiltration** unit **membrane** fouling is a particular important factor to take into account. This problem is caused by colloidal constituents of the juices, which build up and subsequently clog the membranes. Treatment with enzymes helps to guarantee the complete hydrolysis of pectic substances and starch and to minimize the risk of irreversible blockage of the costly membranes
The pulp rich in enzymes is generally pasteurized before recombined with the serum concentrate. Concentrations up to 42°Brix have been reported.

Other uses of enzyme treatment

Debittering- Naringinase is an enzyme that removes the glycoside groups from compounds causing bitterness such as naringin and limonin. The use of small amounts of this enzyme in citrus juices aids in improvement of flavour by degradation of bitter compounds and also increase in saccharification of the juice.

Flavour improvement -For white wines, especially muscatel or Gewürztraminer, cleaving of aroma precursors by beta glucosidase action has been shown to release the desired terpenols that improve flavor.

Cloud stability - Pectinases with lyase activity is useful for producing cloud-stable juice since the presence of methyl esters is important to maintain the stability of the cloud . A typical enzyme dosage before the press ranges from 40 to 80 ml of enzyme per ton, with more required for fruits that have been in cold storage

Peeling

Enzyme preparations were very effective, achieving nearly100% peel removal in citrus fruits. Fruit were infused with enzyme solution and incubated in water heated to 40 °C for 30 minutes. The enzyme penetrated into the peel albedo where the peel is digested to the point where it can be easily removed.

Vegetable processing

The main application of enzyme treatment in vegetable processing is for carrots to obrtain homogeneity, increased yield and optimum colour extarction. Two processes are employed, for manufacturing carrot juice or concentrate, and for manufacturing carrot purée.The combination of pectinase and cellulase is suitable for manufacturing juice or concentrate to increase the yield of juice and ß-carotene. A suitable combination is also useful for manufacturing vegetable juice concentrates e.g. from beetroot, celery, parsley etc

Superior tomato paste quality has been achieved by enzyme treatment. This is because enztyme treatnmentallows reduced holding time, particularly at the higher concentration at low tem[peratures. The viscosity of the paste is reduced therby reducing the cost of energy and time required in conventional processes.

Oil processing

Enzyme processing aids significantly improve both oil quality and yields in olive oil processing. They represent an important innovation in the extraction processes they markedly increase the efficiency of the current mechanical processing systems. The enzyme preparations contain exogenous pectolytic, cellulolytic end hemicellulolytic enzyme species together with minor ones are added to the olive paste at the beginning of the malaxation step during mechanical oil extraction

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They degrade the vegetable colloids (pectins, hemicelluloses, proteins, etc.) emulsifying the minute oil droplets and furthermore remove the oil-water emulsions. The rheological characteristics of the olivepaste are in addition improved. They are water-soluble and come out in the liquid effluent (wastewater) during the final step (oily must centrifugation) of the extraction cycle. Their effects on the parenchyma and hypoderm tissues increase the release of the minor components (biophenols, tocopherols, chloroplast colourings, etc.), thus enhancing the nutritional and healthful effects of VOO (Virgin Olive oil). They also increase the oil outputs (up to 2%, Olive weight basis) and furthermore decrease the environmental impact (-30%) of the liquid effluent (by lowering the values concerning COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), total solids, volatile solids, residual fat and suspended solids).

Herbal extraction

Extraction involves not only some method of using some liquid to remove some component from the herb, but then also some method of concentrating that liquid so that there is not a great deal of that liquid left in the final product.

Use of enzymes have been reported in extraction of herbs such as *Gingko biloba* and *Valeriana officinalis* to obtain an enhanced quantity of extractable substance from the botanical material. Use of enzymes allows cold extraction of important heat labile compounds efficiently and within a shorter time period.

One advantage of new technologies in enzyme manufacture is the availability of monocomponent enzymes of higher purity and strength. However the disadvantage of this technology is that the useful side activities that would otherwise be present with the principal enzyme is absent or negligible. This results in increase in cost with decreased efficiency of the enzyme preparations. Enzymes are now an integrated part of fruit processing and it would not be an exaggeration to say that soon many of today's processed fruits and vegetables, wines, and juices would not be possible without the use of enzymes

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