Appropriate Technology Juice Pasteurizer

The “tubular juice pasteurizer,” as it is formally called, strikes me as an “appropriate technology” with unusual promise.

It is designed for situations where a large quantity of fruit is available for a limited period of time and for which there is no ready market or where marketing is not feasible because of difficulties in transporting the fruit to market. It also assumes a segment of the population would benefit either financially or nutritionally if it could produce an inexpensive pasteurized fruit drink.

It was developed in the late 1980’s by Dr. Phil Crandall and colleagues while he was with the University of Florida’s Lake Alfred Experiment Station. Dr. Crandall’s team developed the pasteurizer specifically for difficult Third World situations. His criteria included: low cost, no moving parts, easy to build, easy to move, rugged, and provide agitation (for even heating). Heating is hard on quality, so an emphasis was placed on what he called HTST (high temperature short time). The result is a pasteurizer which can be carried by one person to the most remote site.

ECHO “sat” on this innovation for several years in hopes that the pasteurizer would become available commercially. It now appears that this will not happen. We had a volunteer, Dale Fritz, make four units for ECHO and are convinced that this simple device can be made in any country with no special tools or mechanical skills for a little over $100 counting accessories. So here are the details.

Pasteurization of fresh citrus juice requires a temperature of 90°C (194°F) for a few seconds. Calculations showed that an acid fruit juice could be pasteurized by passing it through a stainless steel coil of precise dimensions that was immersed in a container of boiling water. Dr. Crandall bent a 6 m (20 ft) length of stainless steel tubing into nine coils 19 cm (7.5 in) in diameter by wrapping by hand around a cylinder of the appropriate size (he said the cylinder could be something as simple as a log). The tubing used was grade 316 seamless, 9.5 mm outside diameter and 7.7 mm inside diameter. Inlet and outlet tubes protruded 30 cm over the sides of the can and were connected to plastic tubes. The coil rested on a block of wood to prevent it from touching the bottom of the can.

The length of time the juice is in the coil is controlled by hydrostatic pressure. The inlet tube is attached via a tube (he used tygon) to a plastic funnel into which the juice is poured. The higher the funnel is placed the greater the pressure and so the faster the juice flows. In practice it is usually fastened about 1 meter above the coil. The temperature of the juice as it leaves the coil is periodically checked. If it is too low, the funnel is lowered to reduce the flow rate; if too high, it is raised.

Juice is collected in recycled bottles. Dr. Crandall used brown beer bottles, but soft drink bottles would also work well. After attaching a cap, bottles are laid on their side for 3 minutes to sterilize the cap, then are cooled in running water (if available).

Dr. Crandall says that juice can be stored without refrigeration for some months. Pasteurization did not significantly decrease vitamin C content, but 3 months' storage at 21°C did, by about the amount that would be expected for pasteurized juice stored at that temperature. However, each bottle (375 ml) still contained over three times the US recommended daily allowance of 60 mg. Effects on color were similar. An instrument that measured the vacuum in the bottle showed that no fermentation had occurred after 3 months. Though there is no microbial degradation, chemical oxidation of canned or pasteurized foods still occurs. So the lower the storage temperature the better.

To keep the water boiling efficiently, construct a simple oven with loose bricks (see illustration). Dr. Crandall built it from used housing bricks to make a 40 cm diameter circle with an air draft in the front and out the top. An iron grate at 55 cm supported the fire and another at 75 cm supported the can.

A tasting panel of 21 experienced assessors graded juices from 1 (dislike extremely) to 9 (like extremely). The fresh orange juice was rated 7.2 (liked moderately); pasteurized 4.2 (disliked slightly). Dr. Crandall suggests this may be due to the panel's familiarity with commercial juice, which has flavoring oils added after heating. I tasted the orange juice while visiting the Small Farm Resource Development Center in Belize (Christian Reformed World Relief Committee). Tom Post took me to a small store operated out of a home. If I recall correctly, the owner spent about 10¢ on juice and labor and sold the juice for 30¢, about half the price of a bottle of cola. I found the taste similar to other pasteurized orange juice, which is always a much different taste than fresh juice. The next season Tom took the pasteurizer to different communities which kept the bottles for their own use during the Christmas season. This was perhaps 3 years ago.

I called Tom for an update. He was assigned outside the country for some time and is now back. The pasteurizer is not being used. He cited three reasons. Belize is relatively well off for a Third World country; the cost of a drink is not prohibitive for most. So they are not that motivated to use the pasteurizer. "If I had been around promoting it, they would have been happy enough to use it. But their interest is not great enough to take the initiative in seeking it out." Also there are fewer oranges around than appears at first sight, especially when large quantities are picked for processing. Finally, the season of excess ripe fruit is extremely short there, only a couple weeks or so. The pasteurizer would have been much more successful if there was some juice available for processing at many other times of the year.

This brings up the subject of what other juice can be processed. About the only limit is that it must be an acidic juice (pH < 4.5; safer to say <4.0). This includes apple, some tomatoes, lemon, lime, passion fruit, cashew etc. Dr. Crandall only experimented with orange and apple juice and a drink similar to one liked in Nepal called "orange squash" (25% orange concentrate, 42.5% sugar and 32.5% water).

The apple juice only required a temperature of 80°C, so the height of the funnel was raised accordingly. The taste panel rating was essentially unchanged (7.0 and 6.7 for fresh and pasteurized juice respectively). The "orange squash" was not evaluated.

If someone was willing to do some "recipe developing," it should be possible to come up with some very tasty juices. Different fruits, mixtures of fruits, and adding sugar or flavorings could all be tried. Concentrates to be mixed with water or lemon juice and sugar by the consumer might be popular. If the juice is not quite acidic enough, it could be adjusted with a bit of lemon, lime or passion fruit. How about: Andes raspberry, guava/passion fruit, tamarind, grapefruit, soursop, red mombin, etc. etc.

Dale Fritz said it cost him $25 to make a coil (made from seamless stainless steel 3/8 inch od x 20 ft long, type 316 tubing). He checked out the current retail price of other accessories that would be needed. Input and outflow tubing $1.60; thermometer $11.90 $19.95; bottle capper $29.95; bottle caps, 10 gross for $19.00; a potato ricer/fruit press, $8.99; funnels about $1.50. You would also need a 5 gallon metal bucket with lid, bottles, container for the extracted juice, a pitcher for pouring, a stick to support the funnel and material for the fire box. He points out that the USA and Canada use different sized beer bottles, so one must be sure the size of caps and bottle capper is right for the country. [Dr. Crandall has never found this to be a problem.] He said that both are readily available in stores that sell supplies to people who make their own beer (a source that will be unfamiliar to many of our readers).

I phoned Dr. Crandall to clarify some points. The interview follows.

Q. Your article states that orange juice was heated to 90°C and apple to 80°C. How do we know what temperature a juice will require? A. I would just recommend that every juice be heated to 90°. The microbes in orange juice are probably killed at a lower temperature, but it must reach that temperature to inactivate an enzyme called pectin esterase. Have you noticed that a couple days after you extract fresh orange juice there is a clear layer on top and "crud" on the bottom? When this enzyme breaks down esters in the juice, some complex acids are formed. These combine with calcium to make something that at the molecular level might be described as a 'fish net,' which settles to the bottom. Apple juice does not have this enzyme, so it does not need the extra temperature. Solids still settle out in apple juice for a different reason. This is going to happen even with the most sophisticated equipment.

Q. What is the margin for error in temperature? A. This depends on how great a content of microbial life is in the juice and on the pH. A target temperature of 90°C allows some margin for error. The pH (a measure of acidity) is really important. Below 4.5 clostridia spores will not germinate even if they are present. Over pH 4.5 one bottle could kill a person! You should have some pH test paper which turns different colors based on pH. With simple equipment, it might be well to shoot for a pH of 4.0 for an extra margin of safety.

Q. How is the pH lowered? A. Just add lemon or lime or any other very sour juice. Be sure not to have acidic juices in contact with lead, aluminum or copper containers as the acid can react to produce toxic heavy metals compounds.

Q. At what pH is food too sour to enjoy? Give us a perspective. A. Apple and pineapple juices are less than 4.5.Tomato juice is borderline (caution!). Most citrus juice is about 3.5; lemons and limes are about 2.0.

Q. Are all citrus equally suited for pasteurizing? A. The citrus that are easy to peel, like mandarins, make terrible juice. A chemical is formed (a lactone) that tastes like kerosene. That is why you almost never see pasteurized tangerine juice on the market. Use oranges that are difficult to peel. Always run the raw juice through a strainer or colander to remove larger particles, which might plug up the coil. We chose a small diameter coil because it makes the "ride" through the coil more turbulent for the juice. This assures that every bit of it is in con tact with the hot sides of the tube and reaches 90°C.

Q. Do you have any thoughts on mixtures of juices and flavorings? A. Almost any culture will prefer a colored, sweet and acidic juice. Add some passion fruit for color, acid and flavor and sugar to make sweeter. For a first test, heat some juice in a pan on the stove, let it cool, then taste. If you like it, you will love it when pasteurized in the coil (which is a lot gentler treatment than heating in a pan).

Q. Where do you buy bottle caps in the Third World? A. I recommend recycling bottle caps. You can simply flare out the sides on an appropriately sized rock, then cap it down tightly on the bottle with the bottle capper.

Q. Is there danger of using bottles in which chemical poisons have been stored? A. Every bottle must be cleaned in hot, soapy water. After that if the human nose cannot detect a smell it is very unlikely that enough of something will be present to cause a serious health problem.

ECHO recommends that you purchase all the parts that you can in the country where you work. Dale is putting together 4 complete kits for ECHO. One we will set up at ECHO (and demonstrate during our agricultural missions conference!) and one we are sending to Haiti where we are helping with a Small Farm Resource Center (at Bohoc near Pignon). We are willing to sell any extras to visitors.

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