

BUCHER

INNOVATION **TECHNOLOGY**

Food Technology – Information No. 2

Extracting vegetable juices with *HPX 5005 i* fruit presses

The growing health consciousness of consumers has led to an increasing demand for vegetable juices as beverages or as ingredients in foodstuff. For many years, presses have been used to extract vegetable juices. The BUCHER HP and HPX *i* fruit presses play an important role in this process. This article deals with recent experience gained when pressing vegetables.



HPX 5005 i: the optimal technology for the processing of vegetable juices

Vegetable juices are low in calories, and are very important sources of vitamins and minerals. Depending on their nature and on the desired end product, vegetables cannot always be processed easily into high-quality juices. For example, it is very difficult to achieve cloud stability which characterizes naturally cloudy juices. Another problem is caused by the often low pH value of these juices, which favours the growth of microorganisms and necessitates particular attention to cleanliness and sanitation during processing.

BUCHER has been supplying HP presses for vegetable processing since 1965. Since 1994, BUCHER is offering a press which uses a computer (PC) to optimize itself to achieve maximum yield and performance, the model *HPX 5005 i*. This new press represents significant improvements over the earlier HP press, not only for fruit but also for processing vegetables.

New findings

Experience with the use of this new *HPX 5005 i* press for extracting vegetable juices has been growing since 1994. The knowledge acquired relate primarily to the following criteria:

- Universal application for various vegetables and fruit
- Improved yield-to-capacity ratio
- Improved beta carotene yield when pressing carrots
- Better hygienic conditions
- Greater economy

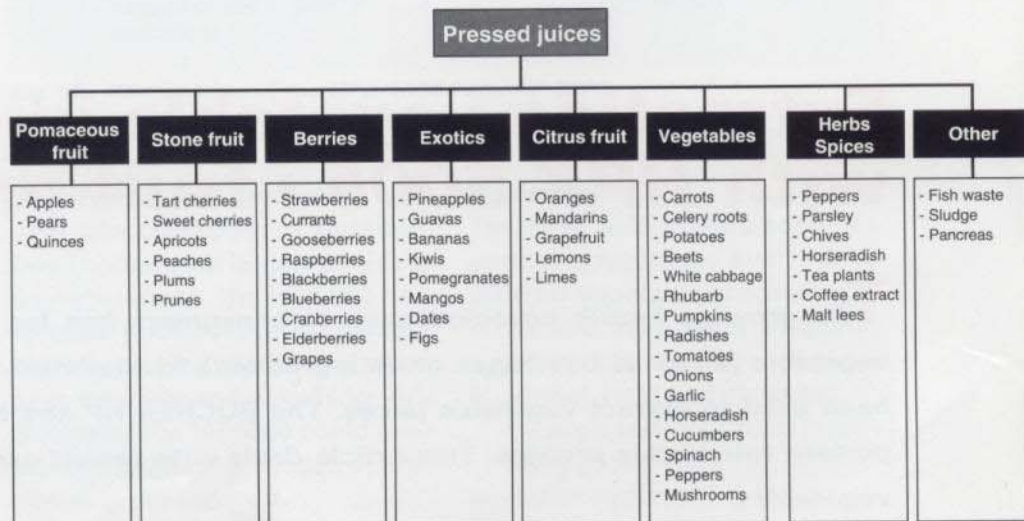


Fig. 1 Examples of uses for *HPX 5005 i* fruit presses.

Universal use of the press

The *HPX 5005 i* is a universal press, and like the HP 5000 it offers a great variety of applications (Figure 1). Processors of vegetables usually need a high degree of universality in their juice extraction process. There are companies who process not only a variety of vegetables, but also core fruit and berries in various quantities. The advantages of the *HPX 5005 i* are evident in its ability to adapt rapidly to the product, resulting in improved performance. The ability to handle a great many varieties is especially important when processing vegetables.

Pressed vegetable juices

Pressed vegetable juices (Figure 2) are processed not only into beverages, but also into ingredients for foodstuffs or for other applications. The universality of the juice extraction procedure in these other branches of the industry is also of importance.

Objectives of the pressing process

The objectives when pressing vegetables are similar or equal to other pressed products. However, certain criteria have priority when processing vegetables:

- High juice yield
- High yield of additional components
- Optimal juice extraction process
- High economic efficiency

These objectives can be readily achieved with the *HPX 5005 i*.

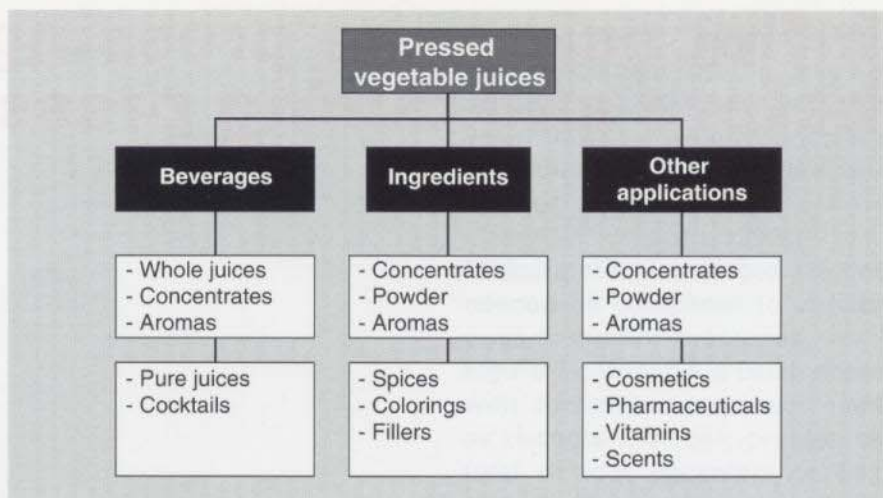


Fig. 2 Applications for pressed vegetable juices.

Factors influencing the process

Juice yield, press performance and juice quality are greatly influenced by the sequence of the individual steps in the processing line. Different processing lines can be found in the industry. Figure 3 shows some variants using the example of carrots, which can vary depending on how the pressed juices will be used.

A very important factor in determining the sanitary requirements for the line is whether or not the carrots are acidified during processing. Acidification is usually accomplished by adding vitamin C and/or citric acid during the grinding process. Occasionally the acidification is achieved through malolactic fermentation of the mash. Additionally, mash heating and the temperature, at which it is pressed, are of importance. Acidifying the mash or processing at higher temperatures reduces the need for special hygienic measures during processing. Studies conducted by BUCHER focus on the process, peeling and blanching the carrots before the preliminary chopper. Some of the mash was slightly acidified with vitamin C.

To evaluate additional aspects of processing we focused on

- yield-to-capacity relationship
- the proportion of suspended solids in the pressed juice
- the yield of additional ingredients
- the hygienic aspects of the process.

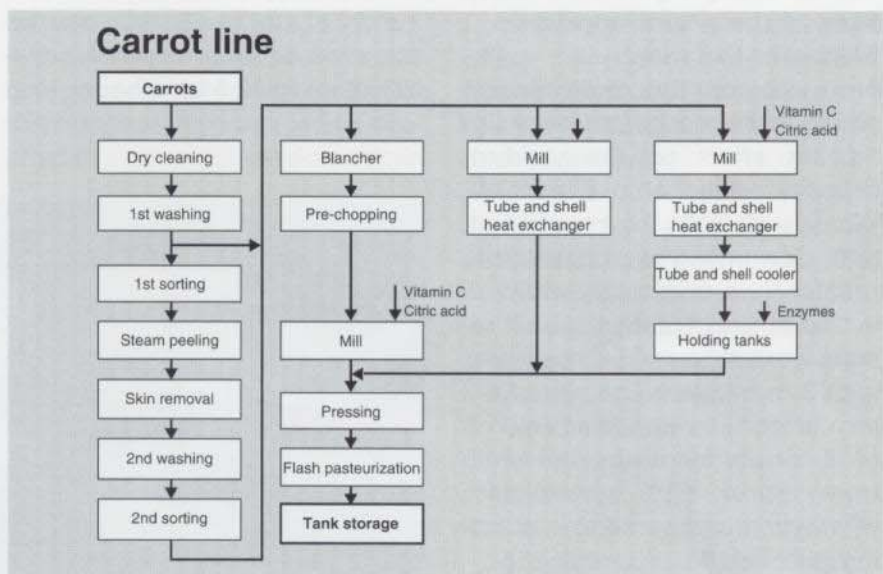


Fig. 3 Process sequence of a carrot line.

Yield-to-capacity relationship

The yield/capacity relationship can be affected by

- the pre-treatment of the raw materials (such as blanching)
- the size of the pre-chopped pieces
- the effect of enzyme in the mash
- the pressing temperature
- washing of the pomace or post-extraction
- and especially, through the automatic optimization of the operating parameters by means of the computer.

The blanching and pressing temperature

Varying the temperature at which the carrots are blanched has a direct effect on the relationship of yield to capacity.

The yield drops if the temperature is too low or too high. Considering juice yield alone, a blanching temperature of 50°C to 60°C for carrots would be ideal. For better juice quality, however, it is often necessary to do the blanching at over 80°C, in order to deactivate natural enzymes and microorganisms. An almost identical behavior can be seen based on the influence of the pressing temperature during constant blanching. The highest yield is reached at about 40°C. Carrots are pressed today anywhere from cold to hot, depending upon the objectives.

Influencing the pressing process before and during pressing

Size of the pre-chopped pieces in the mash

The size of the pre-chopped pieces in the mash has a very significant effect on the yield-to-capacity relationship (Figure 4). What is new is the recognition that this effect is substantially greater than originally assumed. In this series of tests, the best results were achieved with a grater with 3 mm holes. The use of a 3 mm grater at a constant volume of 8 tons/h increases the yield from approx. 65% w/w to 84% w/w, when compared to a grinding mill with 6 mm teeth.

When comparing the yield-to-capacity relationship for various vegetables without addition of water and without enzyme treatment, the *HPX 5005 i* can achieve a similar performance as that shown in Figure 5. The shaded fields show the range of variation in pressability, depending on the quality of the raw material. The best pressability is achieved with cucumbers.

If the mash is heated in a tubular heat exchanger, it is customary to add about 10 W% of water in order to improve its pumping quality; for natural juices, about 10 W% of juice is added. It turns out that a leaching effect takes place when water is added to the mash (Figure 6). That, in combination with the effect of the reduced juice viscosity, significantly increases the yield, and above all the press capacity.

Yields of up to 88 W% can be achieved with carrots at a capacity of up to 12.5 tons/hour.

Pomace washing and post-extraction

If the objective is an even higher yield of valuable ingredients,

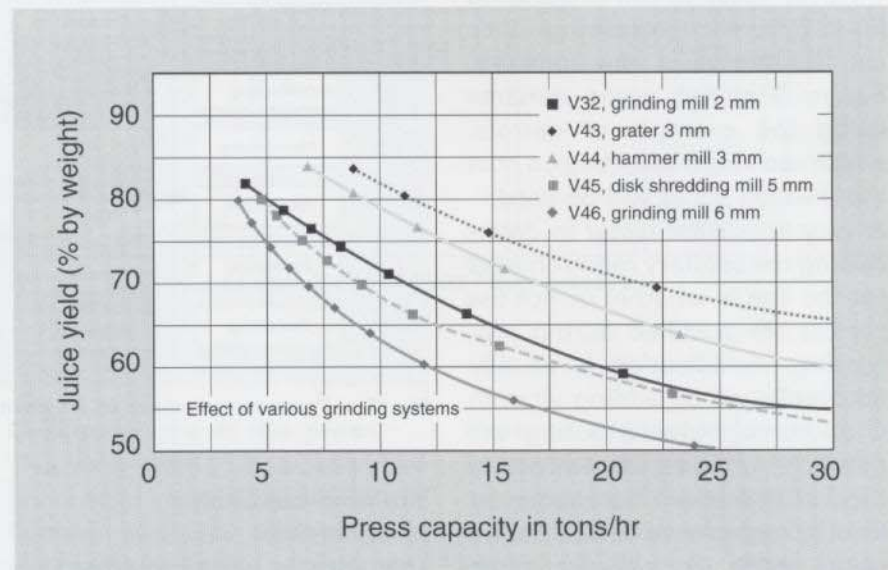


Fig. 4 *HPX 5005 i*, Carrots - effect of pre-chopping on the yield/capacity relationship when pressing.

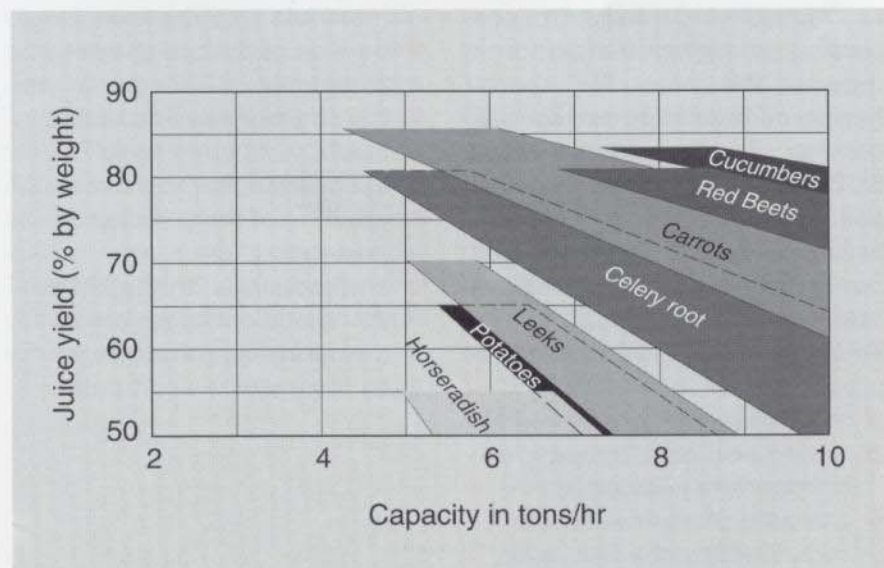


Fig. 5 Yield/capacity relationship of the *HPX 5005 i*, when pressing vegetables.

then the pomace can be washed in the same press in one or more stages, with or without enrichment of the soluble solids in the pressed juice. Instead of water,

other solvents can be used (alcohol, acid, etc.) to recover specific components (aromas, etc.). For this purpose the press can be supplied in a gas-tight version. When

applying pomace washing without enrichment of the soluble solids, the hardware needs are very modest: a water connection and a water dosing unit are sufficient.

Multiple machine stages are not needed as compared to continuous separation processes.

Figure 7 compares a batch press with continuous processes such as decanters or belt presses. A total of four decanters or belt presses is needed for a three-stage leaching in a continuous system. A single press is sufficient for a similar three-stage effect using post-washing. This also means that the batch process can be integrated easily into the desired process.

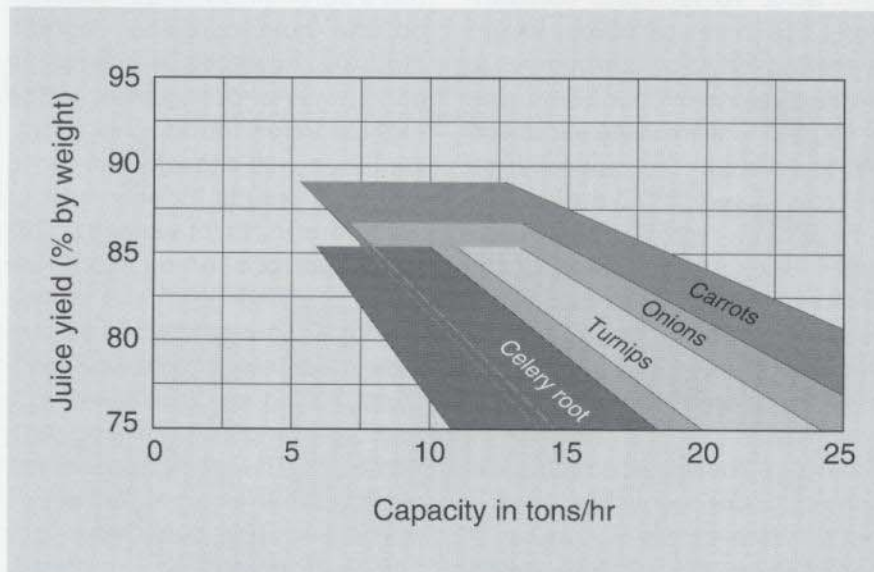


Fig. 6 Yield/capacity relationship of the HPX 5005 i, when pressing vegetables with 10% water added to the mash.

The HP or HPX 5005 i is ideal for post-washing of the pomace. The advantages are:

- Very good mixing of the liquid phase into the remaining pomace
- Good separation of the various phases, high efficiency
- Low consumption of water or solvents, low evaporation costs
- A simple way to enrich soluble solids
- Only one juice extraction unit for any number of post-extractions
- Low expenditures for equipment
- Simple process modification.

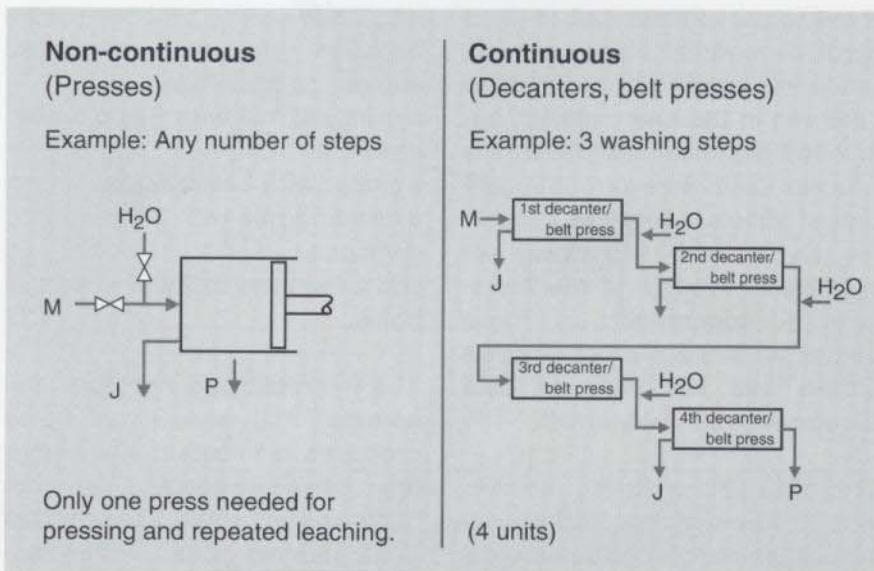


Fig. 7 Comparison of the number of dejuicing devices for non-continuous and continuous processes.

Self-optimizing pressing

A significant contributor to the improved yield/capacity ratio of the HPX 5005 i is the computerized self-optimization of the press. Closed-loop control circuitry automatically optimizes all of the variable process parameters for the highest possible yield and performance at one-second intervals. This also results in advantages when changing products. Only the termination criteria for the end of each batch need to be defined.

Influencing factors for optimizing the beta carotene content

Proportion of suspended solids in the pressed juice

Along with the yield/capacity relationship, another important variable is the proportion of suspended solids or pulp in the pressed juice.

The goal is:

- A proper amount of solids in cloudy vegetable juice
- A low proportion of solids in vegetable juice concentrates.

The amount of suspended solids can be controlled by the technology of the process. The influencing factors are:

- Type of vegetable, pre-chopping, and operating parameters
- The filling mode of the press
- The mesh size of the drainage filter (the draining elements can be exchanged rapidly thanks to the quick lock connector)
- The number of rotations of the press (more or fewer rotations while filling and during loosening of the pomace).

If desired, these measures can be applied to achieve a higher proportion of suspended solids, and thus a pressed juice with a thicker, creamier taste.

Yield of substances, such as beta carotene in carrots

The yield of important components such as beta carotene in carrot juice is important. BUCHER has conducted extensive studies in this area. First came a market

analysis in 1995. In that study, the commercially available carrot juices from four different producers were analyzed for their content of beta carotene, Brix degree and acid. To facilitate comparison, the beta carotene values were converted to correspond to an equivalent extract content of 8°Bx. There were wide variations in the beta carotene found: from approx. 25 mg/l to 55 mg/l.

Juice 1 (25 mg/l), was produced with an HP press, juice 2 (36 mg/l), with a decanter, juice 3 (38 mg/l), with a decanter and juice 4 (55 mg/l), with an HP press.

Claims in the literature that decanted juices generally have a higher beta carotene content in comparison to pressed juices, were not borne out by these studies. A likely assumption was that these great differences in beta carotene content were not only influenced by the amount of beta carotene in the raw material, but also to a significant degree by the process itself. Beta carotene content of carrots is between approximately 60 and 110 mg/kg according to reports in the literature. A comparison of these values with the market analysis shows that the yield of beta carotene is relatively small.

The objective of further studies was to find the procedural techniques which make a higher yield of beta carotene possible by using presses.

The influence of the method of pre-chopping on the beta carotene content

The degree and the manner in which the carrots are pre-chopped has a surprisingly large influence on the beta carotene content. Figure 8 shows the beta carotene content as a percentage of the highest value found. This representation was chosen in order to compare results independent of variations in carrot varieties. This test used one grade from the same planting. With the exception of the pre-chopping, all process parameters were kept constant, including juice yield rate and blanching and pressing temperatures. The best value was obtained with a hammer mill with 1 mm holes. The mash was very fine and greatly disintegrated. The poorest value came from a disk shredding mill with 5 mm holes. The following processes were between the two mentioned above:

- a grinding mill with 6 mm tooth divisions
- a grater with 3 mm holes
- a grinding mill with 2 mm tooth divisions
- and a hammer mill with 3 mm holes.

It is interesting to note that the hammer mill with 3 mm holes produces a substantially higher beta carotene content than the 3 mm grater. The reason for this is the beating effect of the hammer mill, which opens up a substantially larger number of cells.

The level of beta carotene obtained is only about 40% of the best possible value, if an inappropriate chopping method is used.

To achieve an adequate separating effect, the decanter depends upon a very fine mash. Consequently, the material is usually ground much finer when com-

pared to pressing. In addition, the mash is opened up further in the separation chamber of the decanter by the shearing forces in the scroll. This observation explains why it is supposedly easier to obtain beta carotene with a decanter. If the mash is opened up to a similarly fine degree before processing in *HPX 5005 i* presses, the various juice extraction systems produce no differences in beta carotene yield. A suitably fine mash preparation before pressing is therefore recommended, both to increase the beta carotene yield and to improve the yield-to-capacity relationship.

Influence of juice yield on beta carotene content

An additional factor greatly influencing the amount of beta carotene obtained (Figure 9) is the juice yield. The illustration shows the beta carotene content of the discharged juice as a percentage of the original value in relationship to the juice yield.

It is obvious that the first discharge of juice has the highest beta carotene content. Toward the end of the pressing procedure, the level of beta carotene present is only about 40% of that in the first discharge of juice. This means that „the higher the yield of juice, the greater the drop the average content of beta carotene”.

It follows therefore that other separating processes with 10% to 15% poorer juice yields compared to *HPX 5005 i* presses, only appear to produce higher levels of beta carotene. It is possible to raise the average beta carotene content in the juice to equivalent values by using the HP or *HPX 5005 i* presses to achieve the same low yields.

Pomace leaching and the beta carotene content in the pressed juice

A third possibility for raising the beta carotene content in the car-

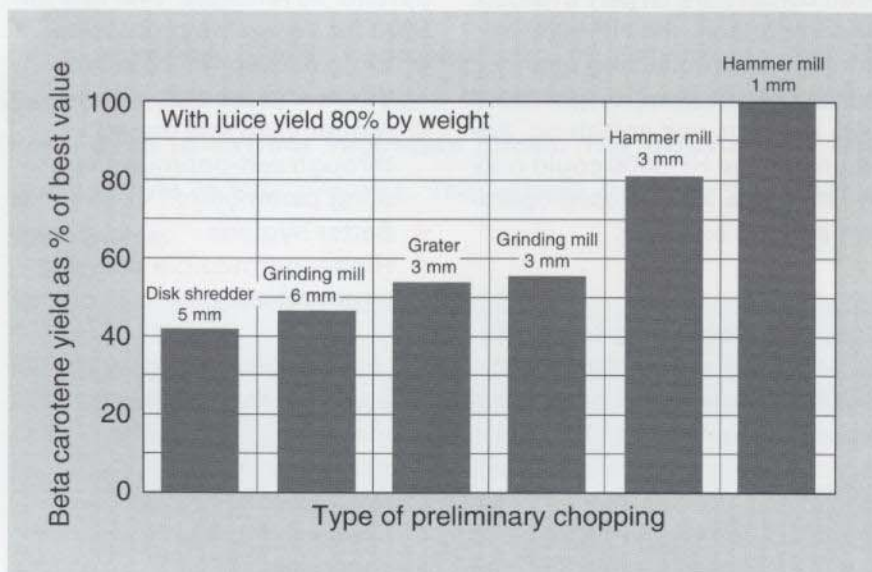


Fig. 8 Effect of pre-chopping the carrots on beta carotene content of pressed juice.

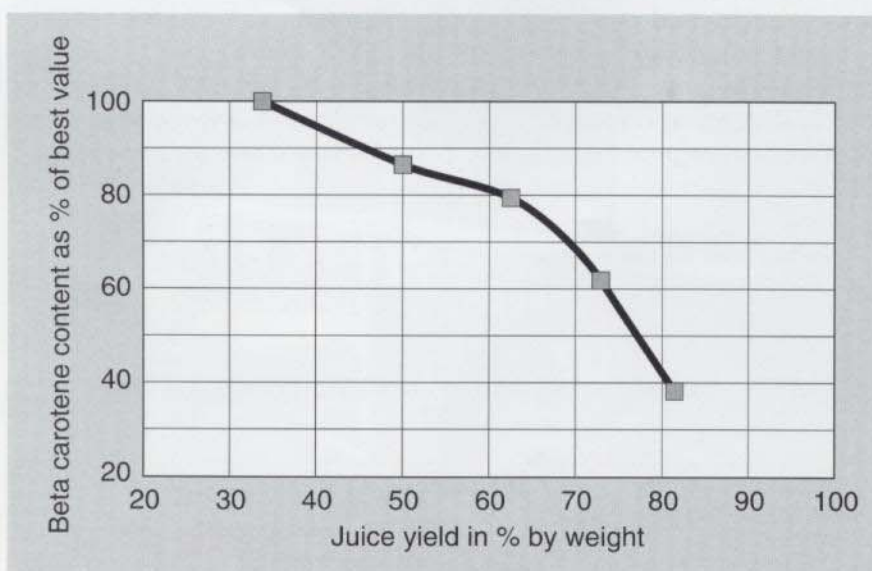


Fig. 9 Effect of juice yield on beta carotene content when pressing carrots.

rot juice is pomace leaching. A simple leaching step, for example with 20 W% water, can increase the beta carotene content in the carrot juice by an additional 10 to 15%.

Hygiene

The objectives of hygienic measures used in pressing vegetable are:

- To avoid propagation of spoilage-inducing and spore-producing microorganisms.
- To avoid the formation of nitrites in vegetables which are tainted with nitrate
- A general improvement of sanitation.

In this connection, it is especially important to thoroughly clean the raw material by washing it and to cull out spoiled fruit.

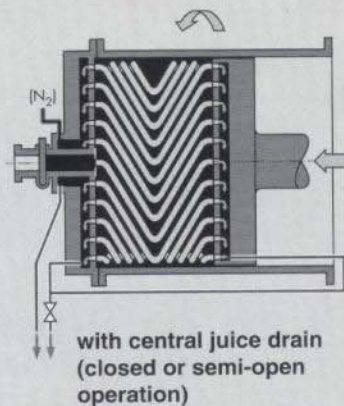
The following procedural improvements were made in our pressing procedures:

- Pressing temperature between 80°C and 90°C
- Largely or completely enclosed processing
- Improved self-cleaning (avoidance of dead corners)
- Improved automatic CIP cleaning, intensive washing, intensive rinsing.

With the *HPX 5005 i*, largely or enclosed processing is possible (Figure 10). During rotation, the pressed juice is discharged via a central juice outlet. When rotation stops, juice is also discharged via a gate valve. Semi-

Juice yield from pressing

HP 5005 / HPX 5005 i



HP 5000

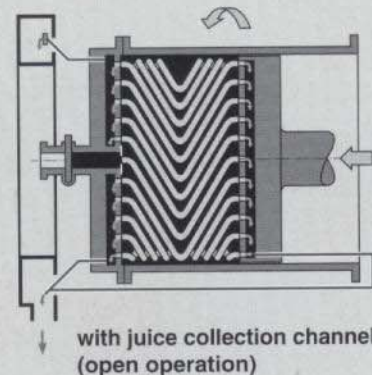


Fig. 10 Comparison of the *HPX 5005 i* and *HP 5000* for closed and open operation.

open or enclosed processing with inert gas blanketing is possible. Dead corners are largely avoided. By comparison, the HP 5000 had an open juice collecting channel. This tended to lead to unwanted juice deposits and splashing. Additionally, the HP 5000 could only be retrofitted for enclosed operation at great expense.

Necessary cleaning intervals

Hygiene is no problem with the *HPX 5005 i*, also when processing vegetables, provided the necessary cleaning intervals are observed.

One chemical cleaning per week is sufficient when pressing fruit either cold or hot. There are some variations when pressing a short rinse is performed every second to fourth batch, and a chemical cleaning daily or weekly*. A chemical cleaning once a week is sufficient, if vegetables are hot pressed.

* depending upon the raw material

Summary

The *HPX 5005 i* offers some important advantages over the HP 5000 for vegetable processing:

- Simple, even faster adaptation to the product
- Higher yield and capacity through self-optimized operating parameters
- Better hygiene
- Higher permissible pressing temperature.

We have shown, using carrots as an example, that the yield of beta carotene can be influenced very substantially by

- raw material
- fineness of preliminary chopping
- yield and
- subsequent leaching of the pomace.

This makes the *HPX 5005 i* a very attractive and innovative possibility for vegetable processing.

Lecture of E. Hartmann, BUCHER-GUYER LTD., presented at the 36th International Fruit Juice Week '96 in Karlsruhe, Germany.

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