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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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FRUIT JUICE PROCESSING 1/

J. Hardenmark*

* Alfa Laval AB, Lund, Sweden.

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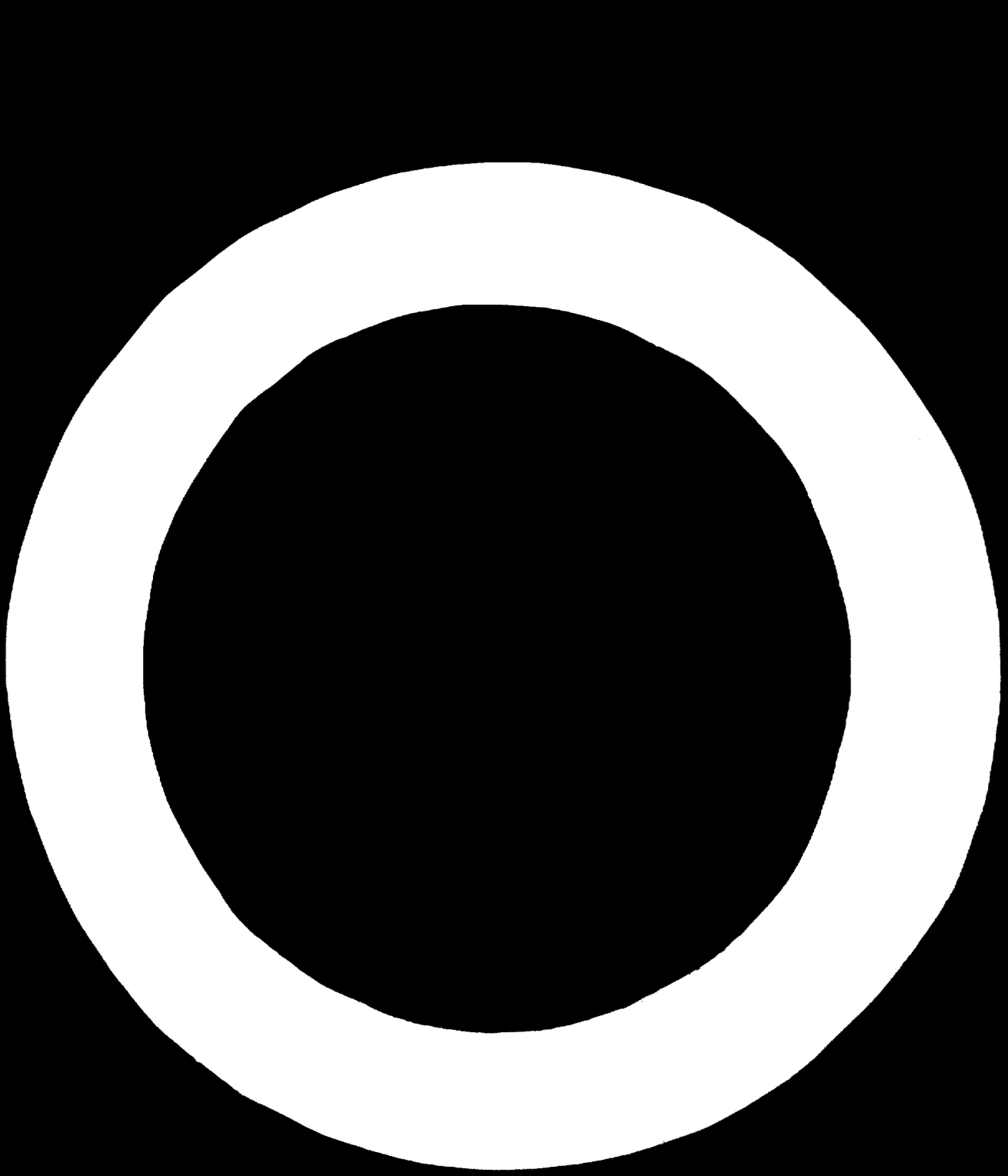


Processing Fruit Juice - the Quality Way

We all belong to one family - the great family of the United Nations. We need each other and must complement each other in order to survive and make progress. Our ultimate goal is to find the means for securing reasonable living standards and social security for every human being on this small planet. Every nation, every community, every one must contribute with all available resources. Proper use and development of natural assets is the best and easiest way.

Market Development

The last three decades have seen a phenomenal development of the fruit juice and soft drink industries. In less than 35 years the commercial output of fruit juices and concentrates increased from almost nothing to about 7,000,000 tons. The contributions of the different kinds of juices are roughly:

3,700,000 tons of orange juice
770,000 tons of apple juice
530,000 tons of grapefruit juice and other citrus juices
380,000 tons of pineapple juice
250,000 tons of grape juice
660,000 tons of tomato juice
260,000 tons of tropical fruit juice

A considerable expansion of the market is predicted. Although 75 per cent of the world output of fruit juices is produced in the USA, a remarkable increase is indicated in some of the developing countries. The continuous search for new products has opened large prospects for tropical fruit processing. The traditional markets for fresh fruit are getting so competitive that very often break-even prices cannot be obtained. In the near future, when the new plantations in both established fruit processing areas and among the newer ones come into production, the imbalance between supply and demand for fresh fruit will become even more pronounced. According to a forecast by FAO in Rome, even at reduced prices the market will be unable to absorb all the additional fruit that will become available.

On the other hand the demand for ready-to-consume "convenisnce beverages" is increasing, due to changes in living standards and drinking habits. Trends such as

- population growth
- higher average age
- increased communication
- social revolution (most notably the revolution of youth against parental traditions)
- more travel
- increased consumption outside the home
- rising personal incomes

are expected to cause an ever-increasing change in consumer habits as well as steadily increasing consumption. What we know for certain is that homo sapiens is the only creature that drinks when it is not thirsty. His basic organism is unchanged and still requires one and a half litres of liquid a day.

The steady increase in the consumption of beverages had led to a rapid development in the methods and ways of production which call for utilization of fruit juice concentrates because they are.

- easy to handle and transport
- easy to store
- easy to dose

This makes it possible to manufacture end products of consistently high quality.

As a result of this the industrialized countries today are importing increasing amounts of different varieties of fruit juice concentrates from countries with a high production. The modern and quality-conscious fruit juice industry can benefit from this trend.

In the countries around the Mediterranean for instance, which have natural conditions for good fruit cultivation (citrus, apricots, peaches, grapes, etc.) a large number of processing factories have been established during recent years.

The concentrates produced by most of these factories are mainly

intended as premium quality products for the export markets. It is also very common that these plants are completed with processing equipment for "ready-to-sell" juice products intended for the expanding home market.

Modern Technology

A modern multi-purpose plant for processing of fruit represents a considerable investment. When a new plant is designed, every point in the process should be tackled from various directions to reach an optimum engineering and economic solution. Quick return on invested capital depends, among other things, on utilization of the equipment over the longest possible periods. The best way to achieve a high degree of utilisation is to have production almost the whole year. In the northern hemisphere this can be done in the following way:

May - July - Nectar fruits (peaches, apricots, strawberries, etc.)
Aug. - Tomatoes
Sept.-Nov. - Apples, grapes
Dec.-April - Citrus

In this way much of the machinery existing in the process will be utilised for several products over a longer period, i.e. pasteurisers, separators, deaerators, pumps, tanks, etc. In this connexion, it is worth pointing out that optimization of a specific plant requires long experience and that local conditions and all other variables must be taken into consideration. The growing yet variable supply of fresh fruit, the overlapping seasons of ripening of the different varieties and the increasing demand for first-class products present a problem which requires a modern technological approach.

Modern technology is synonymous with:

1. Efficient processing
   a) continuous flow
   b) preserving the natural properties of the raw material (taste, flavour, colour, aroma, vitamins)
   c) easy change-over from one product to another without large losses in raw material and end product - no waste of time.
2. Easy-to-handle compact machines with flexible performance.

3. Highest sanitary standards through use of cleaning-in-place (CIP).
4. Remote control and automation to minimize the human error factor.

The investment for a modern multi-purpose plant is high from the initial cost point of view, but the returns can be decisive to the future of the whole operation. There is only one best possible solution for every case. In modern technology there is no place for weak points, and no compromise is accepted as far as quality of product is concerned.

Concentration

Concentration of fruit juice is fundamental to modern fruit juice handling. Without concentration the distribution to beverage manufacturers simply would not work.

The following principal advantages are achieved:

- Preservation during storage with small physical and chemical changes.
- Considerably reduced storage and transport cost.
- The weight of the concentrate is only 1/6 to 1/7 of the original weight of the juice. The volume is only about 1/10.
- Constant product quality.
- Allowing wider geographical distribution.
- Distribution problems if transport of aseptic juice was considered would be almost insoluble from both the technical and cost points of view.

Concentration is the heart of the process. The key to the high quality end product is based on the concentration step. In other words prime quality raw material, processed the best possible way, will be irreparably damaged by an inferior evaporator. Nothing can restore the lost quality!

In a good evaporator final concentration should be reached with as little thermal degradation as possible. The degree of thermal decomposition is a function of time and temperature. The reaction speed is proportional to time and dependent on the temperature in such a way that a 10°C increase leads to 2-3 times as fast a reaction.

There is an evaporator that makes a vital contribution to the quality

of the product. It embodies a combination of the two engineering principles - indirect heat exchange with thin-film liquid flow and centrifugal separation. The heating surface consists of a nesting stack of hollow conical discs rotating on a common spindle.

The juice is fed in and sprayed on to the undersides of the rotating cones, where centrifugal force immediately spreads it over the whole of the surface in a film only about one-tenth of a millimetre thick.

The juice crosses the cone surface in about one second. The entire evaporation process takes place in this short time, and what leaves the apparatus is finished concentrate.

The steam heats the cone surfaces, and the condensate is thrown off by rotation as soon as it forms. The vapour boiled off from the product is drawn off to the box condenser.

Extremely fast evaporation and low temperature add up to a very gentle form of treatment that guarantees the high quality of the end product.

This evaporator is the only evaporator incorporating centrifugal force with indirect heat transfer. This system has the following advantages:

- Concentration from single strength juice to 70° Brix takes place within <u>less than a second</u> - <u>in one pass</u> - ensuring retention of product characteristics (colour, taste, vitamin content, etc.)
- Products with high viscositites can be concentrated owing to the "spreading effect" of the centrifugal force
- No recirculation is needed: all in one pass
- Extremely compact installation: owing to very high heat transfer co-efficient (k-value), only a very small heating area is needed
- Almost no loss of product: operating parameters are reached very quickly after start-up. Shut-down is completed just as rapidly
- Minimum of supervision
- Cleaning-in-place.

Aroma Recovery

What degree of sophistication can be demanded from this unit? Although the above mentioned evaporator has a very low stripping effect, there is no doubt that the most volatile fractions are lost with the condensate, and to obtain a high quality end-product aroma recovery is necessary.

For fruit juice it is a well known fact that the first 10-30 per cent stripped off contains about 90 per cent of the aroma components. This first aroma fraction, which contains 1/3 - 1/10 of the original juice volume, now has to be concentrated to 1/100 of its original volume.

Earlier it was a commonly accepted opinion that the volatile components were not heat sensitive. Today we all know that the aroma is influenced by heat and that there is a time-temperature-relation about the same as earlier mentioned for concentration. Some aromas, e.g. passion fruit juice, are even very sensitive.

To avoid degradation of the aroma components, their holding time should be short. There was developed, a few years ago, a technique called PAR which utilizes the principle of repeated distillation. The advantage of this system is that the heat sensitive aroma vapours are condensed and cooled immediately after having been formed in the distillation unit.

The PAR unit consists of two plate heat exchangers. The lower plate pack acts as an evaporator. The vapour and juice leave the plate pack through the openings at the upper edge of the plate passages and hit the baffle plate which directs the flow downwards. The stripped juice is drawn off at connexion. The upper plate pack acts as a condenser where the vapour is condensed by cooling water.

You can build a two-stage aroma recovery unit or more by using standard models of the PAR system. Extension of capacity is obtained simply by adding more plates to the unit. The holding time of the aroma components is rated in seconds, and the results are excellent - just in line with modern fruit juice processing.

The combination of a PAR aroma recovery unit and a centrifugal

evaporator gives a concentrate which, when reconstituted, cannot even be told apart from the original juice - high quality products!

In accordance with the market's steady emphasis on quality regarding the end products the manufacturers of machinery have brought forth a series of new processing equipment. It is not only the demands on the equipment already existing that have increased. In certain cases quite new techniques have been required, and R + D are today intensively looking for new ways, methods and techniques.

What are the basic unit operations in fruit juice processing?

1. Fruit treatment and extraction of juice.
2. Recovery of essential oils (in the case of citrus).
3. Deaeration.
4. Pasteurisation.
5. Aroma recovery.
6. Clarification.
7. Concentration.
8. Preservation of the end product.
9. Packing.

Having already dealt with aroma recovery and concentration, there are other processing operations to be discussed.

Fruit Treatment and Extraction

The incoming fruit should be stored in well aerated bins made of wood or concrete for a maximum of 10-15 hours storage. For longer storage metal construction with metal screen walls should be used to permit adequate ventilation. The depth of the fruit container should prevent excessive pressure and crushing of the fruit at the bottom of the container. The fruit must be thoroughly brushed and washed before inspection for rejection of damaged and mouldy fruits, on the principle that "there is no product better than the raw material".

The juice is extracted from the clean fruit in special presses. (In the case of citrus the essential oils are liberated from the peel at this stage as well). Juice extraction is a complex process in itself.

Essential Oil Recovery

Especially when limes, lemons and grapefruit are processed, it is important to get the highest possible yield of oil with an extremely good purity on account of their high value.

This can be solved by applying two-stage separation. In the first stage a self-cleaning concentrator removes the pulp particles and most of the water. Further the oil is polished by a special separator called a polisher, resulting in a brilliantly clear oil free from impurities. The whole process is fully automatic and incorporates CIP.

Deaeration

Deaeration is an important operation in fruit juice processing, especially when citrus is processed, as immediately after the crushing of the whole fruit the natural anti-oxidation mechanism of the fruit is destroyed. Deaeration is a method of reducing the risk of oxidation and consequent undesirable changes in taste and vitamin content. The more pulp contained in the juice, the more difficult efficient deaeration becomes. This is due to the microscopic air bubbles clinging to the pulp particles. A question connected with deaerating has also been how to deaerate without losing the very valuable flavour. On the market today you will find very efficient deaerators with integral aroma retention. Without advanced knowledge one can never guess that such a simple and small vessel can do so much in helping to solve such an important problem.

A point to be remembered here is the importance of preventing air from re-entering the deaerated product. Correct design of pipework, pumps and agitators helps to avoid mixing in of air.

Pasteurisation

Pasteurisation is a method for killing micro-organisms which would cause undesirable fermentation, yeasts and moulds. In the case of citrus and some other cloudy juices it also inactivates the natural enzymes which would otherwise cause a breakdown of the desired cloudiness of the juice. A very gentle and short treatment has always been the goal of fruit juice processors.

High heat-transfer co-efficients, minimum pressure drop, small temperature difference between product and heating media, turbulent flows at low volocities, no burning on, efficient cleaning-in-place, ease of maintenance, etc. are some of the built-in features of modern pasteurizers. A recent refinement is the devel pment of a plate heat-exchanger using the "mixed theta" technique, in which the corrugation patterns of individual plates are varied for optimum thermal efficiency, according to the difference in temperature between the fruit juice and the heating or cooling media. Every plate heat exchanger is computer-optimized for the specific duty for which it is sold.

In most cases pasteurizers are equipped with automated heating and cooling systems. In some cases they are equipped with a safety circuit with a valve that automatically diverts the juice back to the pasteurizer inlet into an automatically activated cooling section, if the temperature drops below a set limit - or if, for example, there is a temporary stoppage in the line.

Clarification

The type of separator most widely used in the fruit juice industry - and indeed in all industries that demand high-speed sanitary separation equipment - is the self-cleaning clarifier. This machine is designed to remove pulp residues and other solids from a continuous product flow. The discharge mechanism is actuated either by an automatic timer set to operate at intervals matched to the rate of solids build-up or by a pressure-sensitive trigger that reacts when the solid holding space is filled to a certain point. In both cases the solids are ejected before they can accumulate to the point of interfering with further separation, so there is no fall-off in efficienoy during the production run. Self-cleaning separators are designed to work as an integral part of a continuous processing system. They can be cleaned-in-place by circulation without having to be opened, and all functions can be remote-controlled or automated.

A most important factor for efficient clarification is the gentle handling of the product prior to clarifioation. Correct pumping technique has a great deal to do with it.

Cleaning-In-Place,- CIP

CIP by circulation of detergents through the product line is the surest way of maintaining a high standard of plant hygiene. CIP systems can be supplied both in the form of permanent custom-built installations for complete plants and as small prefabricated CIP units for cleaning individual groups of equipment. Economical features, such as regenerative heat recovery and recovery of cleaning fluids for re-use (impurities picked up during circulation are removed when the fluid goes through a self-cleaning separator), are important factors when designing for CIP. Almost all types of equipment can be CIP treated by using hot water, detergents or cold sterilizing agents. The system can be made completely safe - no cleaning agents can be fed into the production process by mistake.

A CIP system can be fully automated and programmed to perform a series of different functions at pre-set times and temperatures.

Owing to the effectiveness of a properly designed CIP system the duration of the cleaning is relatively short.

Besides being labour-saving, CIP guarantees that every part of the plant will be properly cleaned and is therefore a must for a quality-conscious modern processor.

Automation

The results of properly executed automation should be better and more consistent product quality at less cost. Accompanying benefits are a high standard of hygiene, less risk of inadvertent product mixing, fewer manual operations (with consequent savings in labour and reduced equipment wear), more efficient equipment utilization, less complex buildings required and a more compact machine installation.

There can be no question that all these are objectives well worth striving for. What degree of automatic process control is desirable depends very much on such local factors as availability of skilled personnel. The chief criterion is what will be most economical from the processor's point of view. The pros and cons must be weighed up in each individual

case. A full and frank collaboration between the user and the supplier of the equipment will generally help to achieve maximum economy in plant design - both in conditions existing at the time of commissioning and for the future.

Automation is successively entering into juice processing lines. The self-cleaning separators with automatic timers mentioned earlier are an example of spot automation, and so is the programmable controller of the CIP system for controlling of the cleaning cycle through pneumatically operated valves. An example of a completely automated juice processing plant is that in Italy where the complete juice treatment, deaeration, pasteurization, clarification, concentration, etc. is controlled and regulated from the master control panel. Many are the processes that can be automated.

A sugar-flow plant for continuous production of liquid sugar for addition to still drinks or nectar juice has been developed. The concentration as well as the pasteurization temperatures are automatically kept constant within close toleranoes and are continuously recorded with a minimum of supervision.

Another example of complete automation is a continuous flow installation in Spain. This is a new system for continuous production of soft drinks. The new and advanced developments in mechanical engineering and electronics are here utilized to a great extent. The whole production - from input of sugar, juice concentrate, etc. up to filling - proceeds in a full continuous flow.

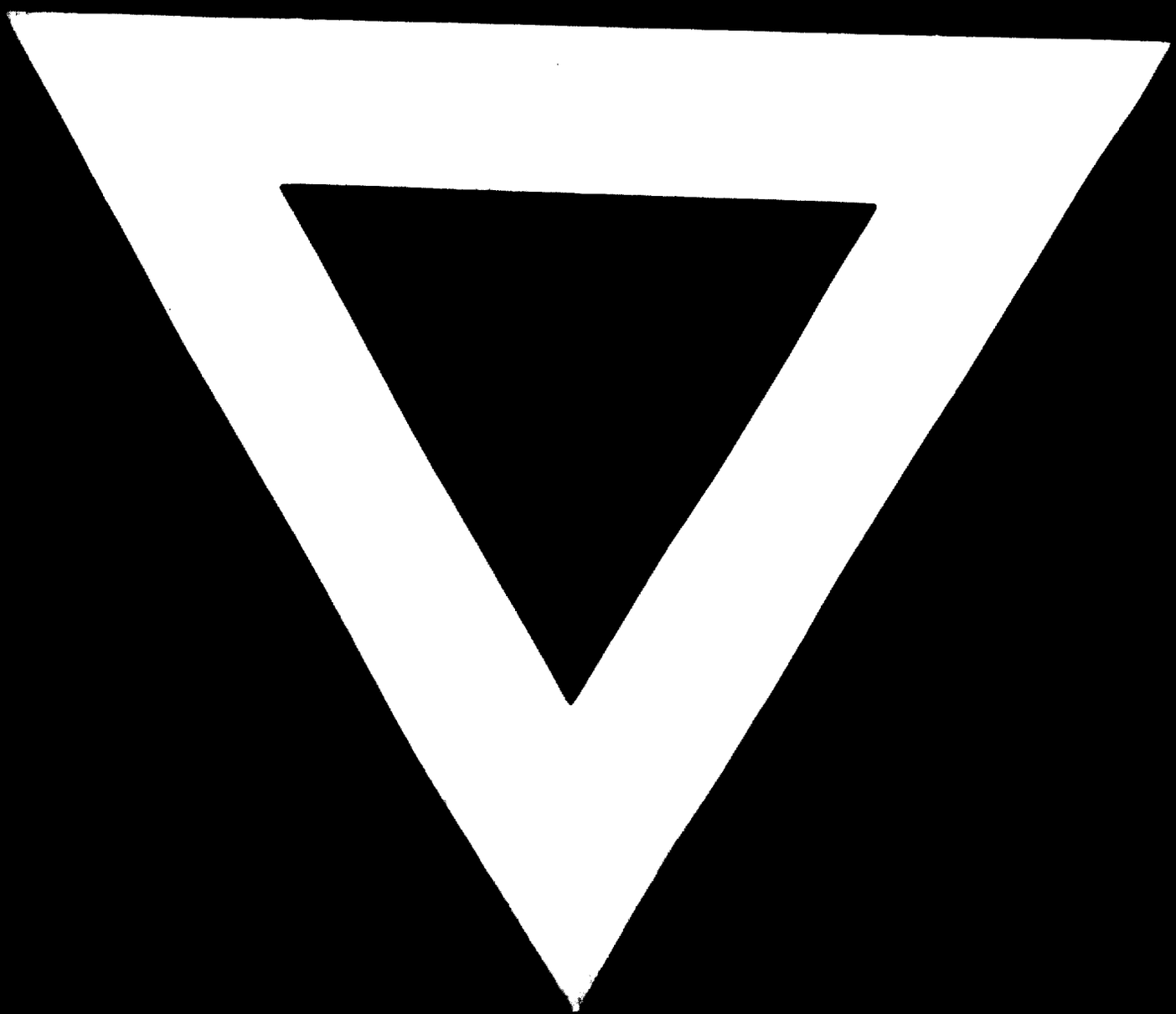
In the previous part, we have mainly dealt with the hardware side of a fruit juice plant - the actual processing equipment in place and ready to start producing.

Let's finally look at the software - the informative part. In order to secure proper function of a process line there are two further important factors - the operative and supervisory personnel. Sufficient instruction on how to operate and maintain the equipment is indispensible to the efficient running of a factory and production of good quality products. Not only should experts be on the spot during the running-in period of a new factory, but training should also take place long beforehand

at well established factories and training centres. Those who have the know-how must share it with anybody who wants to accept new ideas.

It should also be kept in mind that in addition to processing techniques and equipment design the quality of juices is naturally much influenced by the variety, cultivation methods, ripeness, freshness and quality of the raw material.

Correctly processed good fruit will yield the best possible products. Newcomers to the industry have to establish a market and a good reputation. High quality products are surely the best way to accomplish both. Quality products are in short supply and therefore readily accepteded at higher prices.



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