CONCENTRATION OF FRUIT JUICES BY OSMOTIC DISTILLATION

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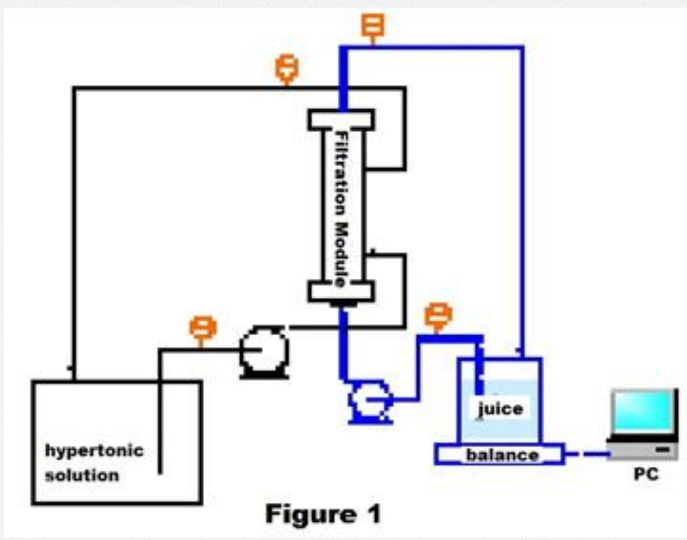


Figure 1

Increasing trend in Food Industry to supply safer, fresher, healthier and long-term products, with good taste and aroma at competitive prices can only be achieved processing the raw material with methods that maximize preservation of the original sensorial and nutritional properties and ensure quick production and optimal yield.

Avoid heating or substances that can origin secondary tastes when processing food it is a challenge in which the semipermeable membranes technology shows high potential.

This technology has important advantages for processing liquid foods. These advantages are related to economy, working conditions, product quality and environmental considerations. These processes save energy because they do not need a power source to produce phase changes, they allow better working conditions because do not use earths in the filtration, (handling earths is insalubrious and they must be disposed after use). Semipermeable membranes processes are a clean technology and they do not require a minimum size of plant to be used because the equipments are modular and easy to scale and it is a harmless processing method that allow optimal preservation of the nutritive, sensorial and functional properties of the raw material.

Nowadays membrane technology is increasingly being used in the clarification and concentration of fruit juices substituting traditional methods of filtration (earths, vacuum) and concentration in evaporators.

Concentration of fruit juices by reverse osmosis membranes (RO) is a well-established operation in the industry. However RO at high concentration factors has restrictions that oblige to use multi-stage RO at high operation pressures or to finish the concentration in evaporators.

Today a new membrane operation, Osmotic Distillation (OD), appears as very promising technique for fruit juices concentration. OD is also known as membrane evaporation, osmotic evaporation, isothermal membrane distillation or gas membrane extraction and it is an emerging membrane process that can remove water from aqueous solutions under atmospheric pressure and at room temperature. Recent works claim that it is possible to concentrate fruit juices up to 75 Brix.

A hydrophobic membrane is placed between two circulating aqueous solutions with different solute concentrations, one of them a hypertonic solution. The operating pressure should be lower than the capillary penetration pressure of liquid into the pores to avoid wetting of the membrane. The difference in water activity of both solutions generates a vapor pressure difference that it is the potential for a vapor transfer from the dilute solution to the stripping solution. The water evaporates at the dilute vapor–liquid interface, the vapor goes over the membrane pore by diffusion or convection and then condensates at the membrane/brine interface.

The size of the equipment or the operation time required to concentrate fruit juices by OD depends of the desired final Brix value, the characteristics of the membrane, the operation temperature, the feed and stripping solution properties, concentration and flux. Nowadays there is not much information about optimal operation conditions allowing industrial applications.

This work presents the results obtained when concentrating fruit juice by OD at bench scale in the equipment showed at Figure 1and using two types of membranes.

Orange juice was concentrated using a Hollow Fiber Capsule Filter (Fiberflo), MV-C-30-L, membrane of polypropylene, 0.03 µm and filtration area of 2.5 ft^2.

Different schemes for the circulation of the juice and the hypertonic solution were tested. Concentrates with 45 Brix were obtained and the recovery of total solids was higher than 65% when the juice was pumped to the lumen of the fibres and 60% when it was flowing in the shell of the filter. Besides these percentages, the recovery of C Vitamin was quantitative.

C Vitamin analyses in the different juices (raw, commercial and prepared from concentrates) showed that juices concentrated with membranes presented an important increase of the preservation of antioxidant activity along the time.
The most adequate pretreatments option for the juice entering osmotic distillation operation was a combination of micro and ultrafiltration (0.2 µ + 300 or 500 kDa).

The filtrate flux under concentration was almost constant with the time (slopes of the lines at Figures 2) and its value improved with the increase in the velocity of the hypertonic solution. The values of filtrate flux were in the order of those informed in the literature and augmented linearly with the operation temperature. To protect the quality of the orange juice it is no convenient to exceed the 25 C.

Presence of air in the solution increased significantly the resistance to the filtration. Vertical position of the filtration module and co-current upstream circulation for juice and hypertonic solution was the solution for air elimination.

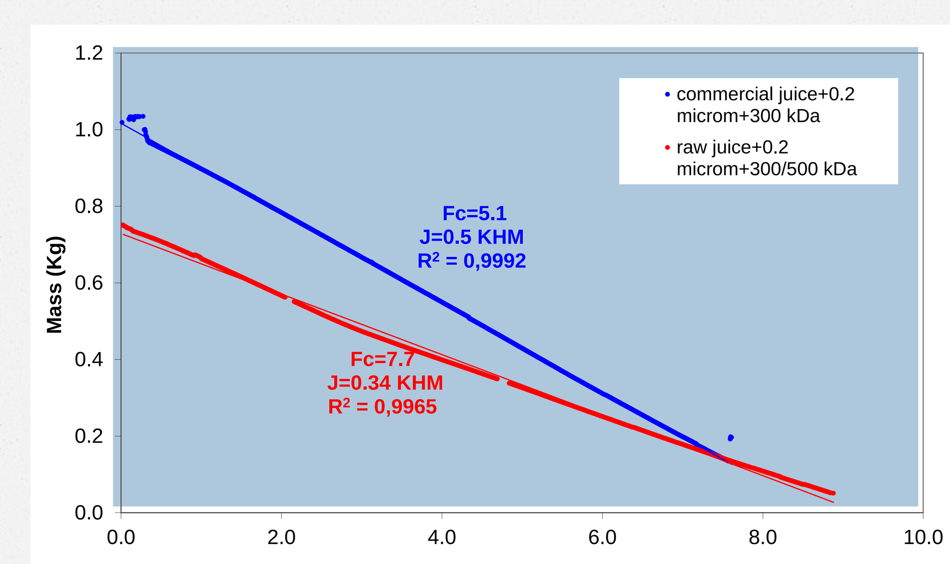
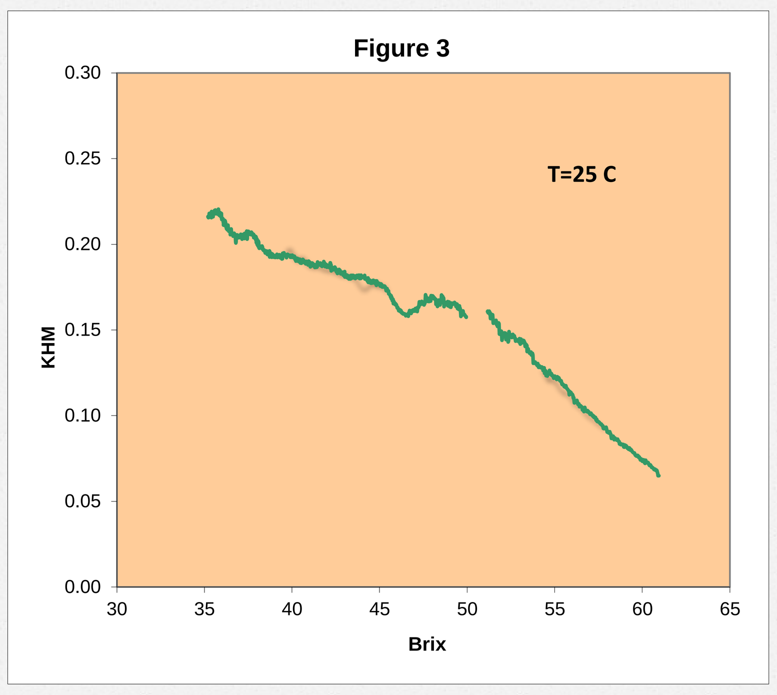


Figure 2

Figure 3



The hydrophobicity and the bubble point of the membrane were not enough to prevent its humidification when Brix degrees of the juice were higher than 45.

Apple juice was concentrated using a Liqui Cell (Celgard) module, membrane of polypropylene, 0.04 µm and filtration area of 1.4 m^2.

The most adequate pretreatments option for the juice entering osmotic distillation operation was a combination of micro and ultrafiltration.

The apple juice was pumped to the carcase and the hypertonic solution to the fibres.

Concentrates with 65 Brix were obtained and the recovery of total solids was higher than 80%.

Filtrate flux under osmotic distillation was almost constant with time until 40-45 Brix were achieved as it is showed at Figure 3.
The filtrate flux values were lower than those informed in the literature and augmented linearly with the operation temperature.

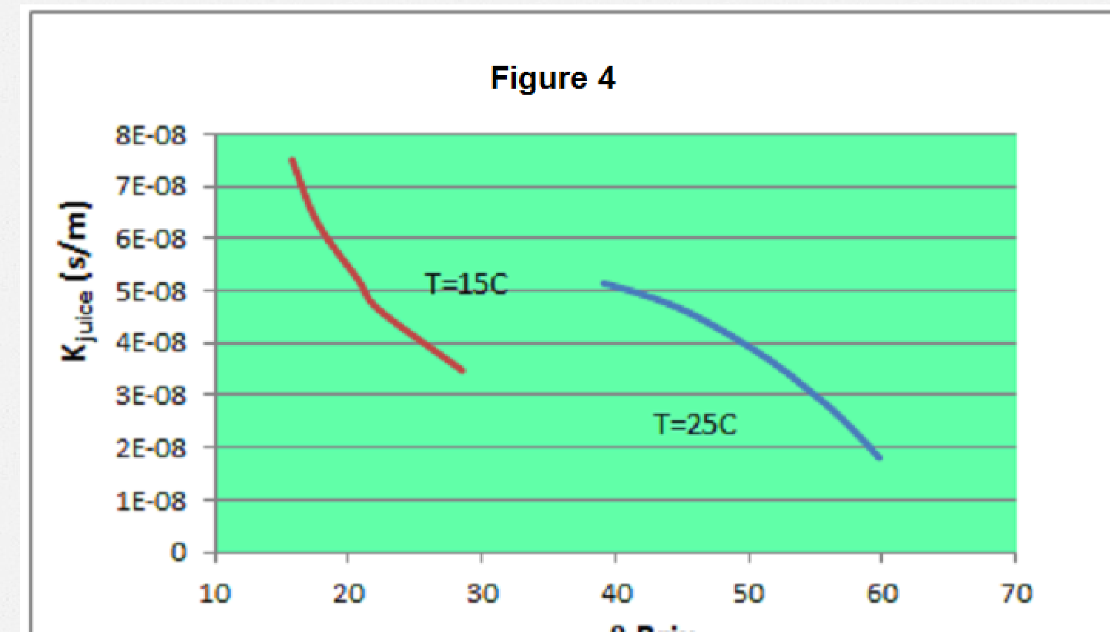
The evaporation flux can be written as:

$$J = \frac{dM}{d\theta} = K_{ov}\left[P_w(1.0477 - 0.0037Brix_0\frac{M_0}{M_\theta}) - P_{wH}\right]$$

where:

J: mass vapor flux (kg/hm^2)
P_w: water vapor pressure of pure water (Pa)
P_{wH}: water vapor pressure at the brine (Pa)
K_{ov}: overall mass transfer coefficient (kg/hm^2Pa) composed of three diffusion resistances: water diffusion in brine, vapour diffusion in the membrane and vapour diffusion in the juice. (Figure 4)

Figure 4



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