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# Concentration of sea buckthorn (*Hippophae rhamnoides* L.) juice with membrane separation

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**Abstract**

In our "plastic" world the role of the herbs and the medical products is rising. One of the important herbs is sea buckthorn. The main goal of our work was to examine the possibility of using membrane separation to concentrate sea buckthorn juice and to give the basis of further products (e.g. instant tea) with it. During our experiments the concentration of the juice was examined with the combination of microfiltration (MF) and reverse osmosis (RO1), with nanofiltration (NF) and with reverse osmosis (RO2) without clarification. The operating parameters were determined during the measurements, and the concentrations were carried out on them. The analytical assay of the juice such as the determination of the solid content, Vitamin C content, antioxidant activity, was also done. The modelling of the process was based on the mathematical model which was worked out previously for instant coffee. The modelling was done only for reverse osmosis.


*Keywords:* Sea buckthorn; Microfiltration; Reverse osmosis; Nanofiltration

## 1. Introduction

The sea buckthorn (*Hippophea rhamnoides* L. *Elaeagnaceae*) is a 2–3 m tall bush or tree, which belongs to the family of the Elaeagnaceae [1]. Sea buckthorn is a native of Eurasia and is domesticated in several countries including India, China, Nepal, Pakistan, Myanmar, Russia, Britain, Germany, Finland, Romania and France at a high altitude of 2500–4300 m [2]. It has been used as a medical plant in Tibet already in AD 900 [3]. Its fruits are berries of orange to red colour and have an acid, lightly bitter taste. They contain many vitamins (B, C, E, K and provitamin A). The content of oil in fruits varies from 2 to 17 wt.% on dry basis. The oil occurs not only in seeds but also in the pulp of fruit [4]. The volatile oil consists of mainly aliphatic esters, alcohols and hydrocarbons. The major components of volatile fruit aromas are ethyl octanoate, decanol, ethyl decanoate and ethyl dodecenoate [5]. The berries can be processed into, e.g. juice and jam as well as used for flavouring of dairy products [3]. The leaves of the bush are used for tea, and instant tea can be made from the berries, too. The sea buckthorn can be proposed to cure several diseases such as cancer and cardiovascular disease [6].

An instant product consists of independent, softly spread particles; and these particles dissolve in liquid better than the original product. The most remarkable features of instant products are that they water smoothly. After all we get a dispersed product which has liquid impression; and it has the same features the original product [7,8].

Beside the instant coffee and fruit juice products, the instant tea is also an important part of the market of instant beverages. Hot water soluble and cold water soluble instant teas can be found in the shops, but the development of instant tea is much slower than producing instant coffee. The process of product of instant tea consists of the following operations: selection of raw materials, extraction, aroma stripping, cream processing, concentration and drying. The liquor has to be concentrated to 20–40% of solids before drying. Historically concentration was carried out by evaporation under reduced pressure. Techniques such as reverse osmosis and freeze concentration have also been documented [9]. It is known that the concentration of fruit juices by evaporation determines a loss of most volatile aroma compounds with a consequent remarkable qualitative decline. Commercial freeze concentration systems permit to preserve the volatiles during the water removal process but require a remarkable energy consumption [10].

Membrane separation is widely used in food industry, because this is a gentle process and there is little waste. There are three primary areas where membranes can be used in the pro-

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cessing of fruit juices: clarification, concentration, and deacidification [11].

The main goal of our work was to examine the concentration of the sea buckthorn with different membrane separation methods. The concentrated juice can be used for instant tea production. The evaporation can be replaced by the membrane separation, and the energy costs and heat-damage can be reduced. After the measurements the results were fitted using a model previously derived for instant coffee.

## 2. Materials and methods

The sea buckthorn berries and the juice were provided for the experiments by the Bio-Berta Ltd. (Fajsz, Hungary). The 100% juice was produced from frozen berries with squeezing, which includes the plump and the skin of the berries, too. The pressed juice was sterilized by steaming and stored in 4 L—size jars.

The concentration experiments were carried with and without a prior clarification of the juice. The clarification step was carried out using microfiltration and the clarified juices was concentrated with reverse osmosis, and the concentration of the juice without clarification was performed using either reverse osmosis or nanofiltration.

A Millipore multi-tube ceramic membrane was used for microfiltration (MF) on 0.7–3.2 bar transmembrane pressure difference range. The clarified juice was concentrated with a Millipore spiral wound reverse osmosis (RO1) module on 9–30 bar transmembrane pressure difference range. The raw juice (without clarification) was concentrated once with a flat sheet Trisep nanofiltration (NF) membrane on 9–32 bar transmembrane pressure difference range and in the other case with a flat sheet Filmtec DOW reverse osmosis (RO2) membrane on 22–48 bar transmembrane pressure difference range.

About 30 °C temperature was used in all cases because the juice is very sensitive (vitamin content).

Fig. 1 shows the flow chart of the experimental set-up, which was used for the measurements.

The juice was fed into the tank (1) and the pump (2) pressed the liquid to the membrane (4). The pressure was measured by the manometers (3) and controlled with the valve (5). The permeate was drained continuously from the membrane during the measurements. The retentate was recycled back to the tank through a rotameter (6) until the end of the experiments. In the case of MF the flow rate was changed with bypass, at nanofiltration and reverse osmosis it was changed by setting the speed of the engine of the pump.

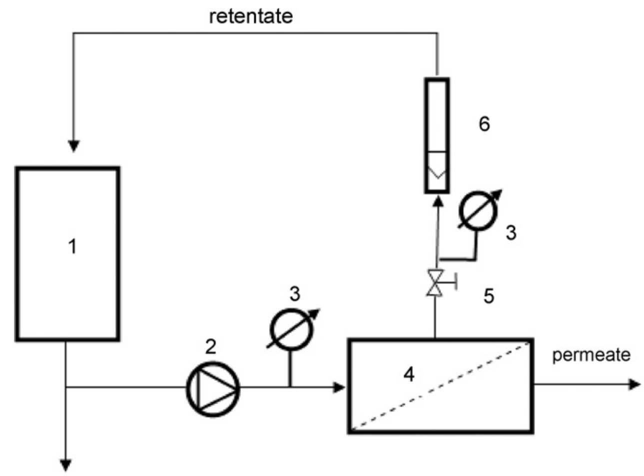


Fig. 1. Flow chart of the equipments: (1) tank; (2) pump; (3) manometers; (4) membrane; (5) valve; (6) rotameter.

The technical parameters of the equipments can be seen in Table 1.

Eight litres of juice were used to run all the experiments. At microfiltration (MF) 5 L permeate were drained. The maximal capacity of the tank of the reverse osmosis (RO) equipment was 3 and 1.8 L permeate was drained. At nanofiltration (NF) 2.6 L permeate was drained from the 8 L. At reverse osmosis (without clarification) 3 L permeate was drained. The applied pressures was 3 bar at MF, 30 bar at RO1, 30 bar at NF and 48 bar at RO2, without clarification.

The antioxidant activity, the Vitamin C—and total solid content of the juice was measured. The Benzie and Strain modified method was used to determined the total antioxidant activity [12]. It was determined with spectrofotometer at 593 nm wavelength with ascorbic acid calibration diagram. The results were given in mMAA/L (millimol ascorbic acid per litre) dimension.

The ascorbic acid content was determined using the MSZ ISO 6557-2 method. The Vitamin C was extracted from the sample with oxalic acid, after that it was titrated with dichloro-phenol-indophenol colouring solvent until it reached salamon colour. The results were given in m/m% dimension [13].

The total solid content of the juice were measured with refractometer. The results were given in ref% dimension.

The water fluxes were determined before and after the measurements and after the cleaning procedure. The cleaning procedure was carried out in the following way at all of the membranes: rinsing with tap water, washing with 0.2% (w/w) NaOH—and $HNO_3$ solutions for 1 h, and – between the chemicals – rinsing with deionized water for half an hour. After

Table 1
Parameters of the used equipments

| | Membrane type/material | Producer | Area of the membrane ($m^2$) | Max. flow rate (L/h) | Max. pressure (bar) |
|---|---|---|---|---|---|
| MF | Ceramic/$Al_2O_3$ | Millipore | 0.125 | 500 | 6 |
| RO1 | Spiral wound/polyamide | Millipore | 0.3 | 250 | 40 |
| NF | Sheet/polyamide | Trisep | 0.036 | 800 | 40 |
| RO2 | Sheet/polyamide | Filmtec DOW | 0.072 | 800 | 70 |