Clarification of sugar palm sap usinga pilot scale microfiltration

Tapanee Ritthipairote*, Wirote Youravong*, Mutita Meenun*, Pikul Wanichapichart**

Membrane Science And Technology Research Center, Department Of Food Technology Faculty Of Agro-Industry, Department Of Physic** Facultry Of Science, Prince Of Songkla University, Hatyai, Songkhla, 90112, Thailand*

Abstract

It is known that microfiltration can be used for clarification and cold sterilization of beverage and drink products. In this study the sugar palm sap was clarified using a pilot scale of crossflow microfiltration system. The membrane used was tubular ceramic membrane (ZrO_2-TiO_2) with pore size 0.1 and 0.2 μm. The experiments were carried out with batch mode at constant crossflow velocity 3.5 $m.s^{-1}$ and 50 °C. It was found that the turbidity and number of microorganism in the permeate for both membrane pore size were reduced greatly while total soluble solid did not significantly decreased. The permeate flux behavior and fouling were also investigated. The permeate flux decreased greatly with processing time due to membrane fouling. The irreversible fouling of both membrane pore size also increased greatly indicating that the irreversible fouling was a major cause of fouling.

Keyword : fouling/ microfiltration/ sugar palm sap/ clarification/ cold sterilization

---

1. Introduction

The sugar palm tree (Borassus flabellifer) is a source of material for producing a variety of product. The most important product of sugar palm is the sap or juice. It can be produced about 5-6 months each year, mainly in the dry season (Borin Khieu, 1996). Crossflow microfiltration (CFMF) technique is one of the most recent developments in membrane technology. It is replacing a number of traditional clarification and sterilisation processes in a wide variety of industries since the consumers demand the fresh like products. Microfiltration (MF) therefore, can be considered as a non thermal process. The advantage of this process is that the product has the original characteristics or fresh- like products and free from chemical additives since the temperature used is low compared those used in conventional thermal processing. In general, the propose of using microfiltration in fruit juice production are (1) to clarified the product by removing substance such as starch, colour compound and suspended soluble matters (2) to reduce a number of microorganism, in some to produce free microorganism product, called "cold sterilization".

The main problem in MF processing, however is flux decline due to concentration polarization and fouling. Fouling can be found on the membrane surface or with in the

---

Correspondence : ywirote@ratree.psu.ac.th

pore. It causes a reduction in process efficiency and increasing the cost of cleaning. Fouling by fruit juice is attributed to the accumulation of macromolecular or colloidal (such as pectic materials, proteins and fiber). Foulant deposition increases with time and can also change membrane selectivity. (Palacios, et al., 2002).

The aim of this work was to study the possibility of using microfiltration to clarify sugar palm sap and to investigate the flux behavior, fouling and membrane selectivity.

2. Materials and methods

2.1. Sugar palm sap

Sugar palm sap was collected from the local farmer and storaged in icebox giving temperature about 4 °C until use. Prior to MF, the sugar palm sap was prefiled by cheesecloth and heated to 50 °C.

2.2. Experimental condition

A pilot-scale MF unit, Kerasep membrane (Rhodia Orelis, France) with pore size 0.1 and 0.2 µm, respectively, and made of ZrO_2-TiO_2. The tubes had an inner diameter of 3.5 mm, length of 1.20 m giving a surface area of 0.245 m^2. The experiment were carried out in batch mode at constant TMP 100 kPa , crossflow rate 3.5 m/s and temperature 50 °C. The permeate flux was measure with a digital balance. Samples were collected sample for physical and chemical analysis.

All experiments were stopped when the volumetric concentration factor was equal to 2. At the end of each run, cleaning-in-place was employed.

2.3. Determination of fouling index

Total hydraulic resistances of membrane process can be expressed as the following equation (1)

$$R_t = R_m + R_{rf} + R_{if} \qquad (1)$$

Where R_t is the total resistance, R_m is the membrane resistance, R_{rf} is the reversible fouling, R_{if} is the irreversible fouling,

The fouling index (FI) can be used to indicate the extent of fouling after the fouled membrane was flush with water. It can be calculated from the following equation (2).

$$FI = 1 - \frac{R_m}{(R_m + R_{if})} \qquad (2)$$

Thus when FI = 0 then no fouling is detected and if FI = 1 it indicated that the membrane was completely fouled and could not removed by flushing with water. (Youravong, et al., 2002was)

2.4. Apparent rejection (R_j)

Protein rejection was determined using (3)

$$R_j = 1 - \frac{C_p}{C_r} \times 100 \qquad (3)$$

where C_p and C_r are solute concentrations in the permeate and retentate, respectively.

3. Results and discussion

3.1. Feed, Retentate and permeate characteristic

The physical, chemical and microbiological characteristics of sugar palm sap in feed, permeate and retentate are shown in Table 1.

TABLE 1
Average physical, chemical and microbiological characteristics of feed, permeate and retentate sugar palm sap during of microfiltration processes

Analytical	0.1 µm			0.2 µm		
	Feed	Permeate	Retentate	Feed	Permeate	Retentate
%T	68.0* ± 0.37	99.02 ± 0.37	28.35 ± 1.63	28.35 ± 0.63	98.10 ± 0.52	26.82 ± 2.07
Total soluble solid (^{o}Bx)	10.07 ± 0.23	9.67 ± 0.50	10.00 ± 0.20	10.00 ± 0.20	9.80 ± 0.20	9.87 ± 0.12
pH	5.01 ± 0.35	5.01 ± 0.30	4.99 ± 0.21	4.99 ± 0.21	5.45 ± 0.16	5.45 ± 0.16
Total solid (%)	12.59 ± 0.97	11.93 ± 0.78	12.41± 0.75	12.41 ± 0.75	12.42± 0.13	12.85 ± 0.12
Protein content (g/100ml)	0.23 ± 0.09	0.22 ± 0.11	0.24 ± 0.23	0.26 ± 0.25	0.25 ± 0.30	0.30 ± 0.30
Total micro. (logCFU/ml)	8.19	2.52	6.99	7.79	1.95	6.63

* ± SD : three replications

3.2. Permeate flux behaviour

Permeate flux behavior was presented in Fig.1. It can be seen that the permeate flux decline with processing time. Flux of 0.2 µm membrane was lower than that of 0.2 µm 0.1 µm membrane about 3 times. The major factor to permeate flux decline are the concentration polarization, the pore blocking and particles in feed solute accumulated on the membrane surface.

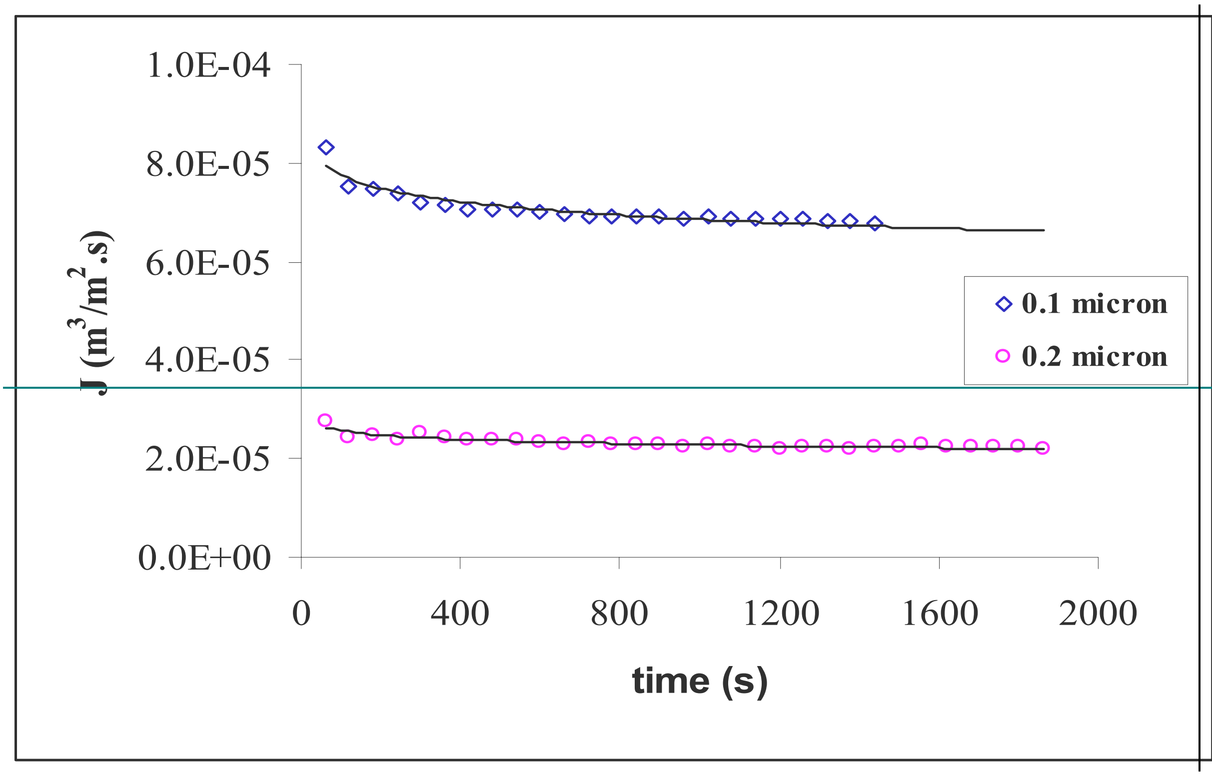

FIGURE 1 Permeate flux during a microfiltration process of sugar palm sap (crossflow velocity 3.5 m.s^{-1}, TMP 100 kPa, temp. 50±2 °C)

3.3. Fouling resistance and fouling index

The R_m, R_{if} and FI for both membrane pore size are shown in Table 2. The FI of fouled membrane were considerable high (>0.50).

TABLE 2
Membrane resistance (R_m),irreversible fouling resistance (R_{if}) and fouling indexes (FI) of fouled membrane after sugar palm sap wash water microfiltration

Pore size (μm)	R_m (m^{-1})	R_{if} (m^{-1})	FI
0.2	1.76* ± 0.55 x 10^{12}	4.41 ± 1.09 x 10^{12}	0.58 ± 0.15
0.1	1.43 ± 0.77x10^{12}	6.56 ± 0.61x10^{12}	0.77 ± 0.14

* ± SD : three replications

4. Conclusions

MF reduces the turbidity and microorganism greatly. Therefore it is possible to use MF for clarification sugar palm sap. Fouling index of fouled membrane was high and played a major role in determination of the membrane performance. Techniques used for reducing this fouling much be considered.

Acknowledgement

The author would like to thanks membrane science and technology research center and the faculty of Agro-Industry, Prince of Songkla University, Thailand for their financial support.

References

[1] Borin, K. 1996. The sugar palm tree as the basis of integrated farming systems in Cambodia. Contribution to Second FAO Electronic Conference on Tropicol Feeds. Livestock Feed Resources within Integrated Farming System.

[2] Carneiro, L., Iralla dos Santos, S., Flávia dos Santos, G., Matta, V.M. and Cabral, L.M..C. 2002. Cold sterilization and clarification of pineapple juice by tangential microfiltration. Desalination. 148: 93-98.

[3] Fukumoto, L.R., Delaquis, P. and Girard, B.1998. Microfiltration and Ultrafiltration Ceramic Membranes for Apple Juice Clarification. J. of Food Sci. 63: 845-850.

[4] Palacios, V.M., Caro, I. and Pérez, L. 2002. Comparative study of crossflow microfiltration with conventional filtration of sherry wines. J. of Food Eng. 54: 95-102.

[5] Youravong, W., Giandison, A.S. and Lewis, M. 2002. Effect of hydrodynamic and physicochemical changes on critical flux of milk protein suspension. J. Dairy Research. 69: 443-455.