eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE07

Clarification of Guava Juice Through Membrane-Based Process

J.M. Omar[1] and M.Z.M. Nor[1,*],
Department of Process and Food Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
*Corresponding author. Tel.: +603-97694303, Email: zuhair@upm.edu.my

Abstract
This study was aimed to explore the potential of using membrane-based process for the clarification of fresh guava juice. The study was done to determine the effect of the process on the permeate flux behavior as well as the guava juice quality attributes such as pH, turbidity and total soluble solids (TSS). The clarification of guava juice was performed using 100 kDa polymeric membrane in a dead-end module. The clarification process exhibited high productivities in terms of permeate flux (12.72 -60.94kg/m²/hr) at a processing pressure of 1 bar. The process has also resulted a high reduction of turbidity (95%) in the permeate with 5.67% reduction of TSS. No significant change was observed in terms of the pH of the feed, permeate and retentate. The findings indicate that ultrafiltration can be successfully used in guava juice clarification.

Keywords: Clarification, Guava, Membrane-based process, Ultrafiltration, Processing pressure, Fruit juice

Introduction

Guava (*Psidium guajava* L.) is a very popular fruit in many tropical and subtropical countries. It has been cultivated and distributed by man and bird where the place of origin is uncertain but it is believed to be an area extending from Southern Mexico into or through Central America. Guava is usually consumed fresh where it contains high vitamin C and lycopene as compared to orange fruit (Sciences, Akesowan, and Choonhahirun 2013). Besides, it is rich in vitamin A, omega-3 and -6 polyunsaturated fatty acids, dietary fibre, potassium, magnesium and antioxidant pigments such as carotenoid and polyphenols (Sciences, Akesowan, and Choonhahirun 2013).

Guava is also being processed and preserved into puree, canned slices in syrup and juice. Due to its high nutritional values, guava has high potentials to be promoted as a healthy fruit juice. However, similarly to other typical fruit juices, guava juice contains high concentration of pectin and other carbohydrates such as cellulose, hemicellulose and etc. resulting the juice to be high in turbidity and viscosity. This characteristic may affect the consumers acceptance as they prefer pleasant flavour, texture and colour of fruit juices. Besides, normal fruit juice processing undergoes pasteurization and concentration process by thermal treatment that cause colour changes and loss of nutritional values. Hence, a suitable processing approach is needed in order to improve the juice characteristics while maintaining its nutritional substances.

Membrane-based process offers an alternative to the conventional juice processing since it has many advantages such as the absence of phase transition, mild operating conditions and easy scaling up (Castro-mu, Fíla, and Barrag 2017). Membrane-based process is a method which selectively separate materials via pores and/or minute gaps in the molecular arrangement of continuous structure. It is classified by pore size and separation driving force which includes microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO) and nanofiltration (NF).

Membrane-based process, especially ultrafiltration (UF) has been widely used in many industrial applications such as recovery and concentration of protein from cheese whey for dairy application, recovery of electrodeposition paints in chemical and mechanical industries and also in the fruit juice industry (Jonsson and Tragbirdh 1990). There are many reports on the successfullness of using UF to clarify pear, kiwifruit and alfalfa juice (Rai, Majumdar, and Gupta 2007). The advantages of using membrane-based process is that it consumes lower energy which is able to reduce the operating cost while allows significant improvement on the process efficiency and juice quality attributes such as colour, turbidity and preservation of its natural bio-active compounds.

By considering its advantges, UF has a big potential in the guava juice processing. However, guava fruit has been minimally processed at industrial trial and up to date there is lack of information on the processing of guava juice by membrane technology. Hence, this study was aimed to explore the potential of applying the membrane-based process using ultrafiltration (UF) for guava juice clarification by observing its effect on the permeate flux behaviour and guava juice quality attributes.

Materials and methods

Material

Ripe seeded guavas (*Psidium guajava* L.) with 80-90% maturity and free from visual blemishes and bruises were purchased from a local market in Seri Kembangan, Malaysia.

Method

1) *Guava juice preparation*

Ripe guavas were washed with tap water, peeled off the skin and cut into small pieces. The peeled guavas were then processed using a juice extractor. The guava puree was filtered through a cheese cloth prior to centrifugation at 9000 rpm for 15 minutes in a centrifuge (Hettich Benchtop centrifuge Universal

320, Germany). The obtained supernatant was used as a feed for the ultrafiltration (UF) process.

2) Experimental set-up and procedures

This process was carried out using a laboratory scale membrane stirred cell unit (Milipore, USA) attached with a compressed air tank. The system was equipped with a polyethersulfon dead end disc membrane with a molecular weight cut-off (MWCO) of 100 kDa, which had been reported to be suitable for clarification of natural juices and agro-food by-products. Each UF experiment performed was executed with a capacity of 250 ml of juice at 1.0 bar processing pressure. The specifications of the membrane used for guava juice clarification are shown in Table 1.

Table 1: The specifications of the membrane-based process for the guava juice clarification

Membrane	Ultrafiltration (UF)
Manufacturer	EMD Millipore Corporation
MWCO (Da)	100,000
Filter diameter (mm)	63.5
Membrane material	Polyethersulfon (PES)
Configuration	Dead end
Processing pressure (bar)	1.0

Performance of the UF process was measured in terms of the permeate flux (*J*) and permeate recovery (PR) as described below:

$$J = \frac{1}{A_m} x \frac{\Delta W}{\Delta t} \quad (1)$$

$$PR(\%) = \frac{V_p}{V_f} x100 \quad (2)$$

where A_m is the effective membrane area (m^2) and ($\Delta W/\Delta t$) is the permeate weight ΔW collected over time Δt ($kg.h^{-1}$). While V_f and V_p are the volume (g) of the feed and permeate, respectively.

3) *Physicochemical properties*

The properties of the feed, permeate and retentate were analyzed in terms of pH, total soluble solids (TSS), and turbidity.

i) pH

The pH was determined using pH meter (PB-11, Sartorius, USA). It was calibrated with buffer solution of pH 4 and 7.

ii) Total soluble solid (TSS)

The TSS was measured in terms of ˚Brix using a handheld refractometer (PAL-3, Atago Co., Tokyo, Japan) with a scale of 0-50 ˚Brix.

iii) Turbidity

Turbidity in the samples was determined using microprocessor turbidity-meter (TN-100, Eutech Instrument, Singapore) and was calibrated with patron solution 0-1000 NTU.

Results and discussion

Permeate flux behaviour

Figure 1 shows the behavior of permeate flux as a function of time at the processing pressure of 1.0 bar. There are three obvious states to represent the flux behavior, where the first state was identified as an extreme reduction in permeate flux during the first 18 minutes. Then, the second state at time between 18-105 minutes was identified as a minor flux reduction, while the third state was identified after the 105 minutes which is known as steady-state that represents non-variation of permeate flux as a function of time.

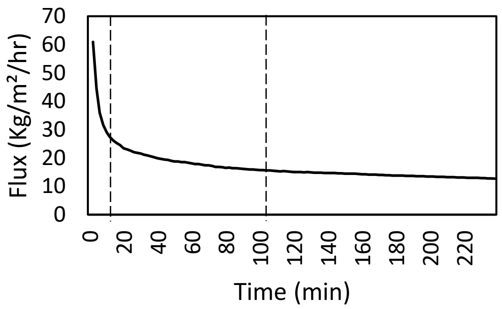

Figure 1: Permeate flux vs time

The initial productivity of the membrane in terms of permeate flux was 60.94 kg/m²/hr and a continuous decreasing trend was observed up to a final permeate flux of 12.72 kg/m²/hr. The result shows that the decreasing trend in permeate flux may be due to the fouling and polarization-concentration phenomena (Castro-mu, Fíla, and Barrag 2017). During the first state, it can be clearly seen that there was a drastic decrease in permeate flux and it started to decrease slowly in the second and third state. This is due to the gel polarization phenomenon where the feed pass through the membrane and the separation of suspended solid from the guava juice occurs. When the rejected particles (suspended solids) start to deposit on the membrane surfaces, the rate of flux decreases (Castro-mu, Fíla, and Barrag 2017).

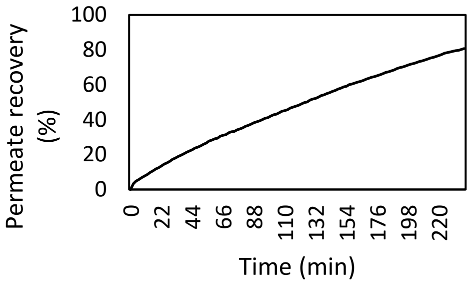

Figure 2: Permeate recovery (PR) vs time

Figure 2 shows the permeate recovery (PR) as a function of time. The clarification process was completed at 80% PR. At the end of the process, 160 g of permeate was recovered as clarified juice from 200 g of feed, with 40 g remaining as retentate in the system. The performance of the pressure-driven membrane process depends on many factors such as MWCO, configuration, membrane material, fouling phenomena and etc. Besides, operating conditions such as feed flow rate, processing pressure and temperature also play important roles in the separation process.

Effect of the membrane process on guava juice properties

Table 2 shows the properties of feed, permeate and retentate from the UF process. The original pH of the crude guava juice was 3.81, indicating the presence of organic acids such as ascorbic, malic and citric acid (Castro-mu, Fíla, and Barrag 2017) in the feed. The filtration process did not affect the pH of the sample since no obvious change of the value can be observed in the permeate and retentate compared to its initial value after the UF process was completed. This claim can be supported by similar research done by Castro-mu, Fíla, and Barrag (2017) where the findings have shown that there was a minimal changes in pH values observed in the fresh, clarified and retained juice.

Table 2: Physicochemical properties of guava juice during membrane separation process

	Feed	Permeate	Retentate
pH	3.81	3.78	3.79
Turbidity (NTU)	20.01	1.00	33.32
TSS (˚Brix)	5.29	4.99	5.20

Meanwhile, the turbidity value was greatly reduced from 20.01 NTU to only 1.00 NTU when the guava juice was filtered through UF membrane. This indicates a 95% reduction in turbidity in the clarified guava juice (permeate) through the UF process. Hence, the UF process is proven to be an effective mean to clarify the juice. Furthermore, in an observation-based study by Cassano, Donato, and Drioli (2007), the finding have found that the suspended solids in fresh kiwi fruit juice was fully removed by UF that cause the turbidity of clarified juice was negligible. The finding is further supported by the reduction of TSS from 5.29 ˚Brix in the feed, to only 4.99 ˚Brix in the permeate sample. According to Castro-mu, Fíla, and Barrag (2017), turbidity and TSS are related to each other. High turbidity indicates the presence of many soluble solids content in the sample such as fibers, suspended solids, high molecular weight compounds such as sugars (sucrose, glucose and fructose), mineral salts and organic acids. The membrane removed about 5.67% of TSS and therefore resulting a clear filtered guava juice in the permeate.

Conclusion

The clarification of guava juice was performed via ultrafiltration with a 100kDa PES membrane at 1.0 bar. 80% of the initial juice was recovered in the permeate as clarified juice. Permeate flux values ranging 12.72-60.94kg/m²/hr, reflecting a good filtration efficiency. The UF process managed to reduce the turbidity of the juice by 95%, 5.67% reduction of TSS and a stable pH, indicating the successfulness of the clarification process. The findings in this study show potential application of UF to clarify guava juice.

References

Cassano, A, L Donato, and E Drioli. 2007. "Ultrafiltration of Kiwifruit Juice : Operating Parameters , Juice Quality and Membrane Fouling." 79: 613–21.

Castro-mu, Roberto, Vlastimil Fíla, and Blanca E Barrag. 2017. "Processing of Xoconostle Fruit (Opuntia Joconostle) Juice for Improving Its Commercialization Using Membrane Filtration" : 1–9.

Jonsson, Ann-sofi, and G U N Tragbirdh. 1990. "Ultrafiltration Applications." 77: 135–79.

Rai, P, G C Majumdar, and S Das Gupta. 2007. "Effect of Various Pretreatment Methods on Permeate Flux and Quality during Ultrafiltration of Mosambi Juice." 78: 561–68.

Sciences, Plant, A Akesowan, and A Choonhahirun. 2013. "Effect of Enzyme Treatment on Guava Juice Production Using Response Surface Methodology." 23(1): 114–20.