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RESEARCH ARTICLE

# Effect of Cross-flow Velocity and Temperature in Microfiltration of Wax Apple (*Syzygium samarangense*) Juice

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## Abstract

Wax apple (*Syzygium samarangense*) fruit has a good source phenolics, flavonoids and antioxidant constituents with great potential benefits for human health. Its pulp is crisp and watery, slightly acid flavor to a full and fruity apple flavour. Microfiltration is an emerging technology, a good alternative for the fruit juice processing with a significant interaction to sensory and nutritional attributes. Purpose of our research verified the feasibility of different variables of cross-flow velocity (3.2, 4.0, 4.8, 5.6, 6.4 m/s) and temperature (22, 26, 30, 34, 38°C) in microfiltration using hollow fibre membrane to permeate flux (L/m²h), total phenolic (mg GAE/g) and flavonoid (mg GE/g) in wax apple juice. Our results revealed that the microfiltration should be performed at cross-flow velocity 4.8 m/s at temperature 34°C to get the highest permeate flux, total phenolic and flavonoid.

***Keywords:*** *Wax apple juice, Microfiltration, Cross-flow velocity, Temperature, Permeate flux, Total phenolic, Flavonoid.*

## Introduction

Vegetable and fruit juices are commonly treated by thermal processing for stability in preservation. People require safe and minimally processed products having high-quality properties with a minimum of changes. Non-thermal technologies become an alternative approach to meet customer's requirements in maintaining nutritional components, color, flavor and overall acceptance [1, 3]. Microfiltration is one of non-thermal technologies widely applied for fruit juice and beverage production. It has been extensively applied as an efficient strategy for clarification and microbial elimination, as well as to preserve high nutritional and organoleptic attribute of foodstuffs [4].

Microfiltration operates on symmetric and asymmetric filters having pore size in the range 0.05-10 µm. Micro porous membranes of various materials can be utilized. The feeding solution is injected to the membrane surface, and pressure is the main driving force [5].In watermelon juice, the lycopene concentration and antioxidant capacity were improved by 402.8% and 416.3%, respectively [6]. In pineapple juice, phytochemical properties and soluble components were retained in the juice after microfiltration. Moreover, microbial proliferation was not detected after 6 months of preservation at 4, 27, and 37° C [7]. Significant enhancements in the organoleptic attributes of clarified products have been noticed on carrot [8], kiwifruit [9], orange [10, 11], and pomegranate [12] juices. Microfiltration could decrease antioxidant activity, betacyanins, betaxanthins, and total phenolic compounds in red beet juice [13]. Wax apple (*Syzygium samarangense*) is non-climacteric tropical fruit. It has a thin, slightly acid flavor to a full and fruity apple flavour [14]. It is a rich source of phenolics, flavonoids and antioxidant compounds [15, 16].

It has been utilized to treat high blood pressure and several inflammatory conditions, including sore throat, and can also be used as an antimicrobial, antiscorbutic, carminative, diuretic, and astringent [17]. Microfiltration was efficient in eliminating solids causing turbidity, creating clear juice free from pulp and suspended particles [18]. Purpose of our study focused on the effect of cross-flow velocity and temperature to permeate flux, total phenolic and flavonoid in wax apple juice.

# Material and Method

## Material

Wax apple fruits were collected from Can Tho city, Vietnam. After collecting, they must be kept in dry cool box and quickly conveyed to laboratory for experiments. They were washed in portable water having 20 ppm peracetic acid for sanitation. Juice was extracted by squeezing fresh wax apple fruits, filtered by a sieve of 400 mesh, kept at 4°C in sealed container before microfiltration.

## Researching Method

The microfiltration using hollow fibre membrane was conducted for wax apple juice at different tangential cross-flow velocity (3.2, 4.0, 4.8, 5.6, 6.4 m/s) and in different temperature (22, 26, 30, 34, 38°C). Cross-flow velocity (m/s) was measured with the flow meter. Permeate flux ($L/m^2h$) was determined by time weighing the permeate solution with the analytical balance. Total phenolic content (mg GAE/g) was evaluated using Folin-Ciocalteu assay [19]. Total flavonoid content (mg GE/g) was a valuated by the aluminum calorimetric method [20]. The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Stat graphics Centurion XVI.

# Result & Discussion

## Effect of Tangential Cross-flow Velocity on the Permeate Flux, Total Phenolic and Flavonoid Content

The cross-flow velocity affects the shear stress at the membrane surface, reduces the concentration polarisation and accumulation of retained solutes by increasing the mass transfer coefficient [21]. High tangential velocity tends to prevent fouling and facilitate the subsequent membrane cleaning process. The increase in the tangential velocity requires more energy [22].

In our research, wax apple juice was treated by microfiltration using hollow fiber membrane at different tangential cross-flow velocity (3.2, 4.0, 4.8, 5.6, 6.4 m/s) in the same temperature 22°C. Our results were elaborated in Table 1. It's obviously noticed that cross-flow velocity 4.8 m/s was suitable for juice microfiltration. In another report, orange juice was clarified by cross flow microfiltration at feed flow rate (v=0.77-1.25 m/s).

The maximum permeate flux was achieved at v = 1.25 m/s [11]. The clarification of tomato juice was done through microfiltration at cross-flow velocity (300, 1500 and 2500 Reynolds). An increase in the cross-flow velocity reduces the concentration polarisation and deposition of particles on the membrane surface [23].

**Table 1: Effect of cross-flow velocity on the permeate flux, total phenolic and flavonoid content**

| Cross-flow velocity (m/s) | 3.2 | 4.0 | 4.8 | 5.6 | 6.4 |
|---|---|---|---|---|---|
| Permeate flux ($L/m^2h$) | 20.15±0.01$^c$ | 27.41±0.02$^b$ | 30.04±0.03$^a$ | 30.09±0.01$^a$ | 28.61±0.00$^{ab}$ |
| Total phenolic (mg GAE/g) | 39.08±0.03$^c$ | 43.74±0.01$^b$ | 44.25±0.00$^a$ | 44.01±0.02$^{ab}$ | 43.95±0.03$^{ab}$ |
| Total flavonoid (mg GE/g) | 8.99±0.00$^c$ | 9.32±0.03$^{bc}$ | 10.29±0.02$^a$ | 10.02±0.00$^{ab}$ | 9.73±0.01$^b$ |

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

## Effect of Temperature on the Permeate Flux, Total Phenolic and Flavonoid Content

Higher temperature leads to higher permeate flux because the viscosity will be lower and the diffusion coefficient of macromolecules higher mass transfer rate enhances and increase in the permeation rate [23]. The temperature affects the mobility of the polymeric chains of the membrane, making the polymeric material more flexible, allowing larger species to permeate the membrane [24, 25]. In our research, wax apple juice was treated by microfiltration using hollow fibre membrane at tangential cross-flow velocity 4.8 m/s in different temperature (22, 26, 30, 34, 38°C). Our results were elaborated in table 2. It's obviously noticed that 34°C was appropriate for juice microfiltration. The clarification of tomato juice was done through microfiltration at temperature (30, 40 and 50°C). Temperature should be as high as possible to improve the clarification performance [23].

 

**Table 2: Effect of temperature on the permeate flux, total phenolic and flavonoid content**

| Temperature (°C) | 22 | 26 | 30 | 34 | 38 |
|---|---|---|---|---|---|
| Permeate flux (L/m²h) | 30.04±0.03[c] | 35.79±0.01[b] | 37.63±0.00[ab] | 39.57±0.02[a] | 39.64±0.01[a] |
| Total phenolic (mg GAE/g) | 44.25±0.00[d] | 46.17±0.03[c] | 47.53±0.02[b] | 49.16±0.00[a] | 46.92±0.03[bc] |
| Total flavonoid (mg GE/g) | 10.29±0.02[d] | 12.57±0.00[c] | 13.79±0.01[b] | 15.82±0.03[a] | 13.04±0.02[bc] |

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

## Conclusion

Fruit juice has a huge demand by its nutritional, phytochemical constituents like vitamins, ascorbic acids, fibers, antioxidants. Wax apple (*S. samarangense)* fruit is crispy, juicy and tasty with apple aroma. Fruit flesh contains spongy tissue. It represents potential benefits for human health because they are rich source of polyphenolic antioxidants. This fruit is also highly perishable. Microfiltration is a green technology preserving fruit juice with high quality, natural taste, and free of additives. It operates in simple continous production with low energy consumption. In order to accelerate the added value of wax apple fruit, we attempted to produce wax apple fruit juice via microfiltration. In this research, we have successfully examined the effect of cross-flow velocity and temperature to permeate flux, total phenolic and flavonoid in wax apple juice during microfiltration using hollow fibre membrane.

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