Optimization of Membrane Separation Process for Comparative Study of Clarification Process of Enzyme Treated and Untreated Lemon Juice

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Abstract—The efficiency of microfiltration (MF) process on enzyme treated and untreated lemon juice for clarification in terms of juice quality has been evaluated. The scope of work also aimed to evaluate microfiltration membranes on the basis of flux as a function of time. Lemon juice squeezed from fresh fruit was given enzyme pretreatment to reduce fouling. Enzyme treated juice shows improved clarity and reduced turbidity and reduced viscosity as compared to untreated lemon juice. The microfiltration experiments were performed with total recycling on enzyme treated and untreated lemon juice. It has been noted that permeate flux for enzyme treated lemon juice is more than untreated lemon juice. The result shows that the MF clarified enzyme treated lemon juice permeate has considerable titrable acidity, pH, vitamin C and 0Brix values as compared to untreated lemon juice.

Index Terms—lemon juice; microfiltration; enzyme treatment; permeate flux; turbidity; 0Brix

I. INTRODUCTION

Citrus fruits are commonly available in large quantity in India. Among citrus fruits lemon fruits are seasonal and therefore appropriate processing of the juice is essential so that it can be available throughout the year. Traditionally lemon juice was concentrated using multi stage vacuum evaporation resulting in loss of fresh juice flavors, degradation of colour and a cooked taste due to thermal evaporation. With the application of membrane separation technology juice can be concentrated at room temperature which facilitates retention of natural flavour in juice. The use of membrane processes, such as microfiltration (MF) and ultra-filtration (UF) in the clarification of citrus juices and reverse osmosis (RO) for concentration of juices are becoming popular and gaining more importance over some conventional treatments including diatomaceous earth, paper filters, bentonite, etc. [1-2]. However, the major disadvantage of membrane separation process for fruit juice clarification is a rapid decrease of flux due to membrane fouling [3-7]. Yin N.T. et al. [8] showed the decline in permeate flux is due to membrane fouling and high osmotic pressure of fruit juices and juice compositions in which especially pectin plays an important role in the fouling of the membrane. During clarification of juice membrane fouling leads to decline in the membrane permeability, deposition of gel layer and its subsequent growth with time result into additional resistance to the solvent flux, leading to reduction of the system productivity was reported by Rai P. et al [9]. Therefore in present work emphasis is given on pretreatment of lemon juice to increase clarity and reduce viscosity. The widespread and more efficient use of microbial enzymes in the preparation of wines and fruit juices started in 1960s, therefore pectinases today are among the leading enzymes used in the commercial fruit juice processing industry [10]. These enzymes are found to be responsible for the degradation of pectins [11]. It has been studied that by using pectinase enzymes, the pectin-coating surrounding the protein particles is broken down and this allows the particles to aggregate and accumulate as sediment in the bottom of the tank [12]. Pectins can cause problems in the food industry by increasing turbidity and viscosity during the extraction, filtration and clarification of fruit juices was investigated by Fernandez-Gonzalez M. et al., [13]. The presence of pectic substances in fruit juices causes a considerable increase in their viscosity, thus improving filtration and further concentration processes [14]. Treatment of the mashed fruit with macerating enzymes further causes breaks down of the fruit pulp, resulting in increased juice yields and reduced viscosity and finally improved run-off [15]. The dose, time and temperature should be determined in trials depending on the degree of maceration required and the type of fruit used [16]. The development of turbidity during cold storage is haze formation in the juice [17].

II. MATERIALS AND METHODS

A. Lemons

The major raw materials required were lemon fruit. Lemon was procured from the local market of Amravati. Lemon was medium size, roundish, with yellow, soft flesh, sour, pleasant flavour, very few seeds.
B. Enzymes

Amylase AG XXL from Novozymes A/S, Denmark having Product specifications as Colour -Brown, Physical form - Liquid, Approximate density - 1.15g/ml, Stabilizers - Sucrose/Glucose, Preservatives -Potassium sorbate, Sodium benzoate, Odour- Slight fermentation odour, Solubility- Active component is readily soluble in water at all concentrations. Pectinex Ultra SP-L From Novozymes A/S, Denmark had Product Characteristics as follows, Colour- Brown, Physical form -Liquid, Approximate Density - 1.16 g/ml, Stabilizers -Glycerol Potassium chloride, No preservatives added, Odour - Slight fermentation odour, Solubility- Active component is readily soluble in water at all concentrations .

III. EXPERIMENTAL SETUP

A. Enzyme Pretreatment to Lemon Juice

Lemon juice was extracted from locally purchased fresh lemon fruits using household squeezer and was stored in refrigerator till use. Both depectinization and destarching are essential for juice processing, hence depectinization with Pectinase and destarching treatment with amylase is therefore needed in lemon juice to achieve high flux in membrane clarification processes. Four pretreatments were given to lemon juice with different concentration of enzyme Pectinase and amylase 40°C for 50 minutes of incubation time. After the enzymatic liquefaction the juice was passed through crossflow micro filtration unit for filtration. Pretreated juice with this four treatments was evaluated for permeate flux by MF process.

B. Clarification of Lemon Juice by Cross Flow Microfiltration unit

Experimental set up as shown in fig. 1 is used for clarification experimentations of lemon juice both treated and untreated by microfiltration process with polyolefin as membrane material, 0.2 micron membrane pore size, plate and frame membrane module, 0.1 m² membrane area, 2 bar transmembrane pressure, 27°C operating temperature and 60 minutes operating period.

IV. RESULTS AND DISCUSSION

A. Enzyme Treatment on Lemon Juice

Fig. 2 shows the effect of various pretreatments (at 40°C for 50 minutes) on Permeate flux of Microfiltration Process of lemon juice Where, T₁ represents 500 ppm Pectinase + 1000 ppm Amylase T₂ represents 750 ppm Pectinase + 1000 ppm Amylase T₃ represents 1000 ppm Pectinase + 1000 ppm Amylase T₄ represents 1250 ppm Pectinase + 1000 ppm Amylase Thus from the fig. 2 T₂ pretreatment i.e.750 ppm Pectinase + 1000 ppm Amylase was finalized for further experimental work as it was giving higher permeate flux during microfiltration process.

As T₂ treatment was finalized at 40°C for 50 minutes of incubation time. Hence 40°C temperature, amylase concentration as 1000 ppm, Pectinase concentration as 750 ppm, incubation time as 50 minutes was finalized for further study by microfiltration unit.

B. Comparative study of actual fruit juice i.e untreated and enzyme treated juice Parameter Actual Untreated Lemon Juice

It can be depicted from table 1 that after enzyme treatment lemon juice shows the ascorbic acid value as 43.4 mg/100g from 46 mg/100g of actual untreated fresh lemon juice which shows reduction in ascorbic acid after enzyme treatment to the lemon juice. A similar report by Yusof S. et al, [18] indicated that the enzyme treatment did not seem to increase the Clarity increased from 30.6% to 91.2% for enzyme treated lemon juice as compared to actual untreated fresh lemon juice. Viscosity reduced from 18.12 cps to 7.51 cps for enzyme treated lemon juice as compared to actual untreated fresh lemon juice which shows 58.55% reduction in viscosity of juice after enzyme treatment. Turbidity decreased significantly from 810.11 NTU to 42.28 NTU for enzyme treated lemon juice as compared to actual untreated fresh lemon juice which shows 94.7% reduction in turbidity of juice after enzyme treatment. Similar results were obtained by Kareem S.O.et al., [19] i.e. reduction in viscosity and turbidity for orange juice.

The pH value of lemon juice decreased from 2.52 to 2.41 after enzyme treatment. Kareem S.O.et al., [19] reported for orange juice that the pH decreases from 3.8 in untreated juice to 3.54 in juice treated with 2.0% enzyme concentration. The pH of the juice decreases with increasing levels of enzyme concentration. Total soluble solids increases from 7.5 to 7.52
TABLE I
COMPARISON OF ACTUAL UNTREATED LEMON JUICE AND ENZYME TREATED LEMON JUICE (T2-750 ppm PECTINASE +1000 ppm AMYLASE)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ACTUAL UNTREATED LEMON JUICE</th>
<th>ENZYME TREATED LEMON JUICE (T2-750 ppm Pectinase +1000 ppm Amylase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.52</td>
<td>2.41</td>
</tr>
<tr>
<td>Total soluble sugar (°Brix)</td>
<td>7.5</td>
<td>7.52</td>
</tr>
<tr>
<td>Acidity as citric acid (gm/100ml)</td>
<td>6.04</td>
<td>6.12</td>
</tr>
<tr>
<td>Clarity (%T at 670 nm)</td>
<td>30.6</td>
<td>91.2</td>
</tr>
<tr>
<td>Viscosity (cps)</td>
<td>18.12</td>
<td>7.51</td>
</tr>
<tr>
<td>Ascorbic acid (mg/100ml)</td>
<td>46</td>
<td>43.4</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>810.11</td>
<td>42.28</td>
</tr>
<tr>
<td>Pectin (% Calcium pectate)</td>
<td>2.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

°Brix and total titrable acidity increases from 6.04 to 6.12 mg/100g of lemon juice after enzyme treatment.

The appearance characteristic such as color was the first judgment of a clarified juice quality. A dark product indicates deterioration of juice which was usually less appealing to the consumers was reported by Abdullah A.G.L.et al., [20], but lemon juice was not showing dark colour but the colour was more appealing after enzyme treatment.

C. Effect on Permeate Flux (L/m²/hr) with respect to time (minutes) for MF of Untreated and Enzyme treated Lemon Juice

From the fig.3 it is observed that during comparative study of microfiltration process of treated and untreated lemon juice permeate flux decreases in initial period of time then it becomes stable. Permeate flux of enzyme treated juice is 73.17% higher than permeate flux of untreated juice. Thus permeate flux of microfiltration process of enzyme treated lemon juice was more than permeate flux of microfiltration process of untreated lemon juice. Therefore enzyme treatment to the lemon juice had increased the efficiency of microfiltration process.

D. Effect on Permeate Flux (L/m²/hr) with respect to TMP (bar) for MF of Untreated and Enzyme treated Lemon Juice

From fig. 4 it can be observed that during comparative study of microfiltration process of treated and untreated lemon juice as feed, permeate flux behaviour with respect to transmembrane pressure shows that it increases for both treated and untreated juice but it is maximum for treated lemon juice. Increase in permeate flux with respect to transmembrane pressure is 63.55% higher for enzyme treated lemon juice as compared to untreated lemon juice. Thus enzyme treatment to the lemon juice had increased the efficiency of microfiltration process.

V. CONCLUSION

1. Enzymes pectinase and amylase were used for enzymatic pretreatment of lemon juice for removing turbidity, reducing viscosity and increasing clarity of juice so as to reduce membrane fouling.
2. Significantly higher yields of clarified juice were obtained using 750 ppm Pectinase enzyme with 1000 ppm amylase enzyme concentrations i.e. T₂ pretreatment for incubation time of 50 minutes at 40°C.
3. Enzymatic process makes the juice clear by reducing viscosity and turbidity and as a result juice becomes free flowing.
4. Higher clarification (% T₆₇₀=91.2) of lemon juice was achieved by using enzymes pectinase and amylase i.e. T₂ pretreatment for incubation time of 50 minutes at 40°C.
5. During study of effect of various pretreatments on the
efficiency of microfiltration process, T₂ pretreatment (i.e. 750 ppm Pectinase with 1000 ppm Amylase) for incubation time of 50 minutes at 40°C resulted in higher permeate flux as compared to other pretreatments during microfiltration process. Therefore T₂ pretreatment was finalized for further experimental study.

6. Comparative composition study of enzyme treated and untreated lemon juice showed that due to pretreatment of juice with enzyme before microfiltration had improved the clarity of the juice and reduced the viscosity and turbidity of the treated juice which had possibly reduced the problem of membrane fouling.

7. For study of effect of enzyme treatment on efficiency of microfiltration process, comparative study of microfiltration process of treated and untreated lemon juice was studied which shows that permeate flux of microfiltration process of enzyme treated lemon juice was more than permeate flux of microfiltration process of untreated lemon juice and thus increased the efficiency of microfiltration process.

8. Comparative study of microfiltration process of treated and untreated lemon juice showed that permeate of enzyme pretreated lemon juice microfiltration process was better than permeate of untreated lemon juice microfiltration process with respect to clarity, viscosity and turbidity. Therefore pretreatment had increased the efficiency of microfiltration process by reducing the problem of membrane fouling.

REFERENCES


