Polyphenolic Retention During UF-Membrane Clarification - pH

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ABSTRACT

The optimum liquor temperature for clarification of tea products by ultra-filtration (UF) membrane was determined in an earlier study (SEN-TN-0013). The present study was conducted to determine the optimum pH of tea liquor passing through UF membrane at optimum temperature (12-14°C) as a series of UF membrane optimization since temperature and pH are the most important factors for polyphenolic retention during clarification process. Polyphenolic compounds were significantly better retained at low pH (3), however the efficiency of UF membrane became significantly decreased at low pH.

INTRODUCTION

Temperature and pH significantly affect the solubility of the compounds responsible for the tea creaming phenomenon as well as other tea phytochemicals. By using the optimized treatment, one can obtain a concentrate with optimal polyphenolic and antioxidant content while reducing the creaming effect. This study is 2nd study of three UF membrane related studies. From the results of the first study, the current temperature for UF membrane (12-14°C) is the optimal temperature for polyphenolic retention and resultant color intensity. Based on this defined temperature, this study was focusing on optimal pH for highest polyphenolic retention and resultant color intensity. Based on defined temperature, this study was focusing on optimal pH for highest polyphenolic retention and resultant color intensity.

MATERIALS AND METHODS

Material: Raw tea material (80:20 = Indonesian black tea: Vietnamese black tea) was obtained from UF membrane processing. The pH of tea liquors was adjusted to pH 3, natural (no pH adjustment), and pH 7 prior to UF membrane clarification.

Methods:

pH of tea liquors was measured using Accumet AB15 pH meter (Fisher Scientific, Pittsburgh, PA) at fixed temperature with constant stirring.

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°Brix was measured using AR200 digital hand-held refractometer at room temperature.

Turbidity of each infusion (diluted 5x) was determined using a 2100P turbidimeter (Hach Company).

Total Phenolics (TP) (also known as total soluble Phenolics): TP was determined using Folin-Ciocalteau assay as early described by Swain and Hillis (1959) and expressed as gallic acid equivalent.

Total liquor color was measured using a spectrometric method. Properly diluted tea samples (5X) was transferred to cuvette and measured at 460nm using Genesis 6 spectometer (Thermo Inc.). The absorbance of each tea infusion was recorded and the color value was calculated.

Individual black tea polyphenolics including theaflavin, theaflavin 3-gallate, theaflavin 3'-gallate, and theaflavin 3-digallate were determined using Agilent 1200 HPLC analysis. The identifications of black tea polyphenolics were determined against genuine standards of theaflavin, theaflavin 3-gallate, and theaflavin 3-digallate based on retention time and similarity of each compound's characteristic spectrum.

RESULTS AND DISCUSSION

Table 1 displays pH, Turbidity, °Brix, and total color of tea liquors from UF membrane. The pH of lowered pH liquor and natural pH liquor did not significantly change during UF membrane clarification; however, the pH of raised pH liquor (pH 7) was lowered to ≈pH 5 during processing. No remarkable difference was observed in °Brix level. The most important observation here is turbidity. While no significant difference was observed between natural and pH 7 liquors, lowered pH liquors showed dramatically higher turbidity by 365%. This result indicates that when low pH is applied to UF membrane system, the clarification process is not working with 100% efficiency. Even though significantly higher amount of polyphenolics was observed at pH 3 liquor (discussed later), lowering pH is not a desirable method for high clarity products. The highest total color value was also observed in pH 3 liquor.

Figure 2 illustrates total phenolic contents and total theaflavin in three different pH liquors from UF membrane. Both total phenolic content and total theaflavin were significantly higher in pH 3 liquor.

Table 3 shows the flavor profiles in three different pH liquors. As observed in total phenolic content and total theaflavin, higher concentration of flavor compounds was observed.

When pH was lowered to 3, the UF membrane was not 100% efficient even though pH 3 tea liquor contains highest amount of polyphenolics.

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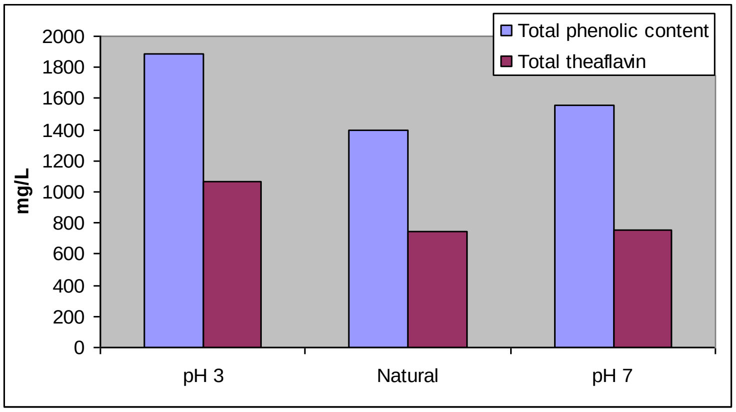

Figure 1. Total phenolic content and total theaflavins in pH 3, natural, pH 3 tea liquors.

Table 1. pH, Turbidity, °Brix, and total color of tea liquors from UF membrane.

	1. pH 3	2. Natural	3. pH 7
pH (after UF membrane)	3.33	5.27	5.03
Turbidity	957.33	2.62	3.09
°Brix	2.15	1.45	1.5
Total color	2.35	1.43	1.67

Table 2. Flavor profiles of three different pH liquors. The values represent the relative amount of flavor compounds compared to natural pH liquor.

Peak #	Compound	pH=3	pH=7
1	Propanal, 2-methyl-	58	98
2	Ethyl Acetate	2032	150
3	Butanal, 3-methyl-	46	109
4	Butanal, 2-methyl-	48	112
5	Pentanal	74	123
6	Furan, 2-ethyl-	174	227
7	Hexanal	56	160
8	2-Hexenal	124	198
9	Heptanal	55	200
10	Benzeneacetaldehyde	122	149
11	Benzene, substituted (MW=134)	245	146
12	1,6-Octadien-3-ol, 3,7-dimethyl-	303	232
13	Nonanal	161	201
14	Benzene, substituted (MW=134)	125	91
15	1-Butanamine	85	82
16	1-Pentanone, 1-(4-methylphenyl)-	115	97
17	Naphthalene	78	95
18	Estragole	153	170
19	2-Octanone	71	49

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20	Naphthalene, 1-methyl-	73	98
21	1-Butanamine1	92	81
22	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	83	59
23	3-Buten-2-one, 4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-	90	63
24	Phenol, 2,4-bis(1,1-dimethylethyl)-	40	92
	Average	188	128

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