

# Chemical composition and sensory analysis of fresh pineapple juice and deacidified pineapple juice using electrodialysis

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## Abstract

Electrodialysis with monopolar ion exchange membranes was used to reduce the acid content of pineapple juice. It is an electrochemical membrane separation process in which electrically charged membranes and an electrical potential difference are used to separate ionic species in the pineapple juice from other uncharged components. Several physico-chemical (pH, titratable acidity and soluble solids) and chemical (elemental contents) characteristics and sensory attributes (sweetness, tartness, colour, odour and acceptability) of fresh pineapple juice and deacidified pineapple juice were studied. Electrodialysis of pineapple juice resulted in the reduction of titratable acidity. However there was a pH reduction in the diluting stream. The transfer of the acids salts through the membrane along with the weak acids disturbed the buffer action and resulting in the reduction of pH along with reduction in acidity. The soluble solids content was unchanged. Result from elemental analysis showed that the major mineral components in pineapple juice (magnesium, phosphorus and potassium) were reduced in the diluting stream compared to fresh juice. The result of sensory analysis of the deacidified pineapple juice showed considerable increased in sweetness and reduction in the tartness. No significant changes were observed in odour and colour.

*Keywords:* pineapple juice; electrodialysis; deacidification; chemical composition; sensory analysis

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## 1. Introduction

### 1.1. Pineapple

Pineapple (*Ananas comosus*) is sometimes called the 'King of Fruit'<sup>1</sup>. Pineapple is grown extensively in Hawaii, Philippines, Caribbean area, Malaysia, Taiwan, Thailand, Australia, Mexico, Kenya and South Africa. Pineapple has long been one of the most popular of the non-citrus tropical and subtropical fruits, largely because of its attractive flavour and refreshing sugar-acid balance<sup>2</sup>. It is available fresh, canned and as juice<sup>1</sup>. 100 g pineapple contain 47-52 calories, 85.3-87.0 g water, 0.4-0.7 g protein, 0.2-0.3 g fat, 11.6-13.7 g total carbohydrate, 0.4-0.5 g fibre, 0.3-0.4 g ash, 17-18 mg calcium, 8-12 mg phosphorus, 0.5 mg iron, 1-2 mg sodium and 125-

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146 mg potassium<sup>3</sup>. Pineapple also contains 12-15 % sugars of which two-third is in the form of sucrose and the rest are glucose and fructose. 0.6-1.2 % of pineapple is acid of which 87 % is citric acid and 13 % is malic acid<sup>4,5</sup>. The pH of pineapple is acidic, which is 3.71 and the acidity percentage is 53.5 %. The composition of the juice varies with geographical, cultural and seasonal harvesting and processing.

About 10-25 % pineapple juice obtained from canning industry is not suitable for production of single strength or concentrate juice, due to the high acidity<sup>5</sup>. Several methods have been attempted in order to reduce the sourness by adding sweetening agents, simple neutralization by alkali or partially remove it by ion-exchange techniques<sup>6</sup>. There is an increasing demand for fruit juices with the original characteristics of the fresh fruits and free from chemical additives. This results in the search of new technologies that are able to improve the sensorial, nutritional and microbiological quality of the fruit juices<sup>7</sup>. Since thermal processes largely affect the characteristics of fruit juices, electrodialysis can be used as alternative to fruit juice preservation and conservation, because it does not involve the use of heat treatment. As such the nutritional quality and the sensorial attributes of the products are retained.

Hence a study is warranted to produce pineapple juices with acceptable acidity level using an electrodialyzer system.

### *1.2. Electrodialysis and Ion Exchange Membrane*

Electrodialysis is an electrochemical separation process by which ionic (electrically charged) species are transported from one solution to another by crossing one or more selective permeability membranes, under the influence of a direct electrical current<sup>8</sup>. It also can be used to separate ionic species from uncharged components. Electrodialysis is one of a group of membrane based separation technologies that are finding increasing use in the agri-food industries. The applications vary from demineralisation of cane sugar, desalination of cheese whey, deacidification of fruit juices, wines stabilization, production of acids and bases from a salt stream and for the recovery of concentrated acids.

The ion exchange membranes become the key element to electrodialysis process. It is made of polymer matrix material with fixed charged groups covalently bonded to the polymer matrix<sup>9</sup>. A membrane containing fixed negative charges is called a cation exchange membrane; meanwhile a membrane with fixed positive charges is referred as anion exchange membrane<sup>10</sup>.

## 2. Materials and methods

### 2.1. Preparation of pineapple juice

Fresh pineapple (*Ananas comosus*) was procured locally. The crown and stem portions were removed and the skin was peeled using knife. After that, the fruit was sliced and the fruit slices were pressed in a fruit juicer for one to two minutes<sup>11</sup> to get the pineapple juice. The pineapple juice was kept in a cold room at 4 °C.

### 2.2. Electrodialysis of pineapple juice

The volume of pineapple juice used was 1000 ml in each bottle solution. The experimental set-up for deacidification of pineapple juice using electrodialysis is shown in Figure 1. In the experiment, AFN and CMX membranes, which were supplied by Tokuyama Soda Corp., Japan were used. The current density throughout the system was maintained at 2.60 mA/cm<sup>2</sup>. In the electrode compartments, a 500 ml of 5.0 % (w/v) sodium sulphate (Na<sub>2</sub>SO<sub>4</sub>) solution (Merck, analytical grade) was used. The flow rate in the diluate and concentrate compartments was maintained at 500 ml/min. This study was carried out at room temperature.

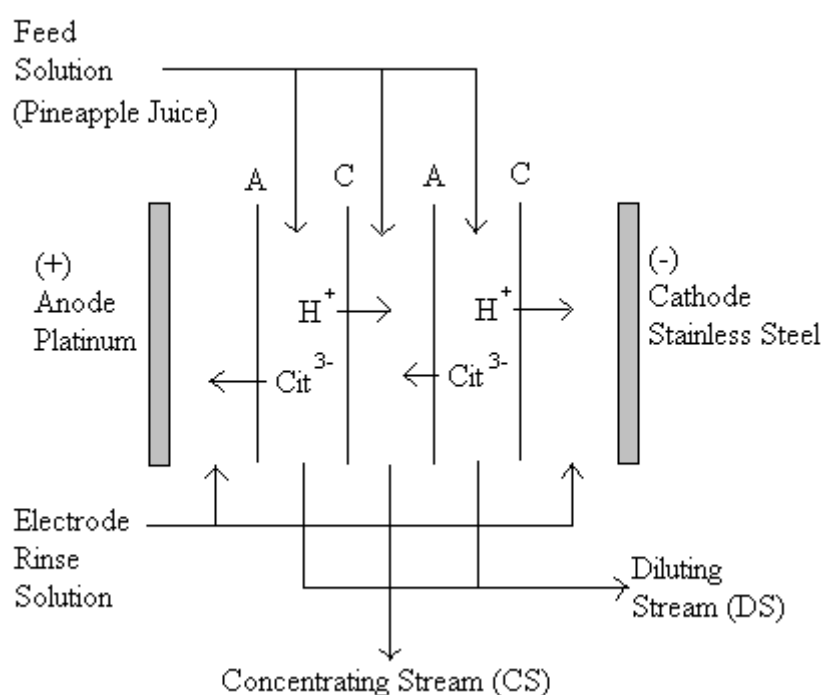


Figure 1: The schematic diagram of membranes arrangement in the five-compartment electrodialysis cell

During the electrodialysis processing, the pH of pineapple juice in the diluate compartments was noted. Samples of pineapple juice from diluting stream and concentrating stream were taken at 60 minutes interval for the determination of titratable acidity and total soluble solids. For the determination of pineapple juice

elemental components, samples from diluting stream and concentrating stream were collected after two hours of processing.

### *2.3. Analytical procedures*

Analytical procedures carried out in this study were the analysis of titratable acidity by titration method, pH, total soluble solids and elemental components by ICP-MS.

### *2.4. Titratable Acidity of pineapple juice*

The pineapple juice contains a number of organic acids such as malic acid and citric acid, which are readily neutralized by strong bases and can be titrated against standard bases such as sodium hydroxide.

A 10 g sample of pineapple juice was weighed. Then, the sample was transferred to a 500 ml Erlenmeyer flask. The sample was diluted to 250 ml with deionised water. Using a standard solution of 0.1 N sodium hydroxide (Hanns, analytical grade), the sample was titrated to the end point. The end point was determined using pH meter and phenolphthalein indicator. 1 ml of phenolphthalein indicator was added to the sample and titrated to faint pink end point. The volume of 0.1 N sodium hydroxide used was recorded. The total acidity can be calculated using equation (1)<sup>12</sup> and expressed as concentration of citric acid (g/l). The measurement was repeated at least three times.

$$\% \text{ Acid (as anhydrous citric acid)} = \text{Volume of 0.1 N NaOH (ml)} \times 0.64 / 10 \quad (1)$$

### *2.5. pH of pineapple juice*

pH of pineapple juice samples was evaluated by pH meter Cyberscan 1000 (Eutech Cybernetics, Singapore). The measurement was carried out at least in triplicates.

### *2.6. Total soluble solids in pineapple juice*

Brix % is generally used as indicator for soluble solid content %. The total soluble solids of pineapple juice samples were evaluated using digital refractometers Palette Series (Atago Co. Ltd., Japan).

### *2.7. Analysis of elemental components in pineapple juice by ICP-MS*

The elemental compositions in pineapple juice were determined using Elan 6100 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) (Perkin Elmer, USA) method and Multi Element Calibration Standard.

### *2.8. Organisation of sensory evaluation test*

A typical taste panel room is provided with a space between taste panels, so that they do not influence one another with conversation or facial expressions. The samples are coded with random letters. Then, the tasters are given an evaluation form.

They are asked to taste one sample at a time, and record their responses. Allow time between samples so that tasters can record their opinions.

In this test, a 10-trained-members panel were selected to evaluate the quality of fresh and processed pineapple juice. A 1 to 5 structured scale was used for sweetness, tartness or sourness, colour and overall acceptability of pineapple juice. Meanwhile, a 1 to 3 structured scale was used for odour. For sweetness, 1: no, 2: low, 3: fair, 4: strong, 5: very strong; tartness, 1: no, 2: low, 3: fair, 4: strong, 5: very strong; colour, 1: brown, 2: brownish yellow, 3: slightly brownish yellow, 4: pale yellow, 5: bright yellow; odour, 1: off-odours, 2: slightly characteristic, 3: characteristic; overall acceptability, 1: dislikes, 2: dislikes slightly, 3: accepts, 4: likes slightly, 5: likes very much.

### 3. Results and discussion

#### 3.1. Effect of electrodialysis on titratable acidity

Titratable acidity was evaluated to determine the total acidity in pineapple juice. Total acidity is expressed as anhydrous citric acid. Electrodialysis of pineapple juice resulted in the reduction of titratable acidity in the diluting stream and increment of titratable acidity in concentrating stream, after two hours of processing. The data for titratable acidity is tabulated in Table 1.

Table 1  
Data for Titratable Acidity

	Fresh Pineapple Juice	Processed Juice (Using Electrodialysis)	
		Diluting Stream	Concentrating Stream
Volume of 0.1 N NaOH (ml)	10.5	9.3	11.3
% Acid (as anhydrous citric acid)	0.67	0.60	0.72

#### 3.2. Effect of electrodialysis on pH of pineapple juice

Electrodialysis of pineapple juice surprisingly decreased the pH value (the processed juice become more acidic). The pH value reduced from 4.01 to 3.75. It was expected that the pH value to increase as the conductivity value of pineapple juice decreased. The conductivity value presented hydrogen ions concentration as well as citrate ions. In a solution, hydrogen ions determined the degree of acidity. As the concentration of hydrogen ions were reduced, so it was expected pH value to increase.

This decrease in pH with removal of acidity for the pineapple juice during electrodialysis was attributed to buffer salts, their ionisation and removal during the process. Pineapple juice contained weak acids like citric acid and malic acid and sodium, potassium and calcium salts. The presence of these acids and salts formed a buffer. During electrodialysis, salts of these acids were transported through the

membranes along with weak acids. This disturbed the buffer action resulting in reduction of pH along with some removal of acidity<sup>5</sup>.

If other salts or ions are present in solution besides the conjugate acid-base pair, the  $pK'$  of the weak acid and hence the pH of the solution will not only depend on the concentration of conjugate acid-base pair, but also on the concentrations of all other ions present in solution. Furthermore, divalent ions (e.g.  $Ca^{2+}$ ) will have a stronger buffer effect than monovalent ions (e.g.  $Na^+$ )<sup>13</sup>.

### *3.3. Effect of electro dialysis on sugar contents*

No significant differences in % Brix value were observed on the electro dialysed pineapple juice sample. The values in concentrating stream were slightly higher than in diluting stream. The % Brix varies from 10.17 to 10.50. For fresh juice, the value was 10.50. After two hours of processing, % Brix in diluting stream was 10.17 and 10.30 in concentrating stream. As a conclusion, electro dialysis process did not significantly effect the % Brix value.

Since Brix is a measure of soluble solids (primarily sugars and acids), it should be expected that Brix in high acid juices should decrease as acid was removed. But very little of the Brix reading was from acids. Thus, Brix values were essentially unchanged as the small amount of acid was removed<sup>14</sup>.

### *3.4. Effect of electro dialysis on elemental components in pineapple juice*

The major elemental components present in pineapple juice are magnesium, phosphorus and potassium. The other elemental components are present in trace amount. From pineapple juice elemental analysis, it can be seen that the compositions of magnesium, phosphorus and potassium were decreased in the diluting stream and increased in the concentrating stream.

Magnesium ( $Mg^{2+}$ ), phosphorus ( $P^{6+}$ ) and potassium ( $K^+$ ) were positive charged ions. During electro dialysis, the positive charged ions were transported from the diluting stream to the concentrating stream through cation exchange membranes towards cathode. As a result the amount of cations in diluting stream was reduced. Table 2 shows the minerals presents in pineapple juice and their value after electro dialysis.

Table 2

The compositions of fresh pineapple juice and processed pineapple juice using electro dialysis

Minerals	Compositions (mg/100 ml)		
	Fresh Pineapple Juice	Processed Pineapple Juice (Using Electro dialysis)	
		Diluting Stream	Concentrating Stream
Zinc (Zn)	0.538	0.864	0.586
Arsenic (As)	0.060	0.090	0.092
Iron (Fe)	0.748	1.238	0.982
Magnesium (Mg)	12.004	11.538	13.478
Sodium (Na)	0.898	2.836	3.402
Phosphorus (P)	9.250	9.070	9.756
Potassium (K)	128.076	111.538	159.722
Aluminium (Al)	0.890	1.320	0.866

Sensorial Analyses of Pineapple Juice

When it comes to consumer quality acceptance, there is still no substitute for sensory evaluation. The sensory evaluation test was done to determine the quality and consumer acceptance of the treated pineapple juice using electro dialysis. The scales and categories test was used. The results of the sensory evaluation test are tabulated in Table 3.

Table 3

Sensory Evaluation Test Results

Pineapple Characteristics	Average Score		Percentage (%)	
	Sample M	Sample S	Sample M	Sample S
Sweetness	2.5	3.1	50.0	62.0
Tartness	4.1	2.9	82.0	58.0
Colour	4.5	4.2	90.0	84.0
Odour	2.6	2.5	86.7	83.3
Overall Acceptability	2.8	3.3	56.0	66.0

Sample M: Fresh pineapple juice

Sample S: Processed pineapple juice (deacidification using electro dialysis)

The average score by the taste panellists showed a low to fair sweetness in fresh juice and a fair sweetness in processed juice. They also found out strong tartness in fresh juice and nearly fair tartness in processed juice. For colour, no significant differences were noticed as the colour of the two samples was in the range of pale yellow to bright yellow. A slightly characteristic to characteristic, was found in odour analysis of both samples. On the whole, the taste panellists accept the electro dialysed juice better.

#### 4. Conclusion

The results from chemical composition and sensory analysis of deacidified pineapple juice shows a more acceptable level compared to fresh pineapple juice.

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