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Issue **Article**

Faizah Hamzah
unemployed
Researcher

Nirvana Hamzah
unemployed
Researcher

MINERALIZATION AND CONCENTRATION OF SODIUM CHLORIDE DIHYDRATE IN THE PROCESS OF SEPARATION OF GLUCOSE USING METHANOL SOLVENT FROM MOLASSES

***Abstract**: Mineralization and concentration of sodium chloride dihydrate on the separation process of glucose from molasses were investigated, and the experiment was conducted ar guajava sugar factory Bogor from January-December 2023. Mineralization affects glucose recovery, glucose, reduced-sugar total and soluble ash. The amount of methanol added also affects separation factor, soluble ash, glucose recovery and reduced sugar total, while concentration of sodium chloride dihydrate affects separation factor, glucose recovery, glucose and reduced-sugar total. The best result was obtained by combination treatment of mineralizations using 1.0 part of methanol without addition of sodium chloride and soluble ash content obtained by this combination was 1.0603; 83.68% and – 26.41%, repectively.*

***Key words**: Mineralization, sodium calcium chloride dihydrate, methanol and molasses.*

***Language**: English*

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Introduction

Sugar in Indonesia has recently experienced rapid development. The development of sugar was followed by an increase in the amount of molasses production as an increasingly abundant by-product. Using advanced technology, molasses can be used as raw material for industries, one of which is the high fructose liquid sugar industry. This is possible because the sugar content in molasses is still quite high, namely around 75 percent and the price is relatively cheap (Oltsch, 2023)

The process of extracting sugar from drops can be carried out using various methods such as chromatography methods and membrane technology (Hulland, 2023). The sugar produced is a mixture of glucose, fructose and sucrose. To get syrup with high fructose, it is necessary to separate the sugar.

The separation process can be carried out using the chromatography method and another alternative that can be used is the extraction method with mixed solvents based on the differences in solubility properties of the two monosaccharide isomers where the solubility of glucose in the mixed solvent methanol water can be increased by adding sodium chloride dihydrate salt. This process is based on the formation of a glucose sodium chloride cyhydrate complex which at a methanol concentration of around 75% will precipitate.

The research aims to obtain mineralization, the amount of methanol added and the concentration of sodium chloride dihydrate in the process of separating glucose from molasses raw materials and to obtain separation factors, total recovery of reducing sugar and good changes in dissolved ash.

MATERIALS AND METHODS

This research was carried out at the Gondang Baru sugar factory, Yogyakarta, from January to December

2023. The material used was sugar cane molasses obtained from the Gondang Baru sugar factory, Yogyakarta, for a period of 1 year starting from January to December 2023 with a liquid concentration of 79. 0 oBrix. The dry matter content is 80 percent, the dissolved ash content is 10.96 percent, the sucrose content is 36.40 percent and the reducing sugar content is 25.35 percent. The invertase enzyme was obtained by PT UHT Laksamana Yogyakarta, while the chemicals were obtained from the BP3G Bogor Side Products Technology Laboratory. The equipment used is ultra thinner and vacuum evaporator equipment, cooling chamber, electric stirrer and glass equipment. The measuring instruments used are spectrophotometers, densitometers, balances and so on.

The treatment levels of the separation process were observed using several parameters, namely separation factor, glucose recovery, glucose recovery, total reducing sugar recovery and changes in dissolved ash.

Purification of drops is carried out by ultra filtration and partial mineralization, followed by separation of sugar which is carried out by adding solvent and sodium chloride dihydrate salt, and followed by precipitation, separation and evaporation of the solvent. Systematic sample preparation can be seen in Figure 1.

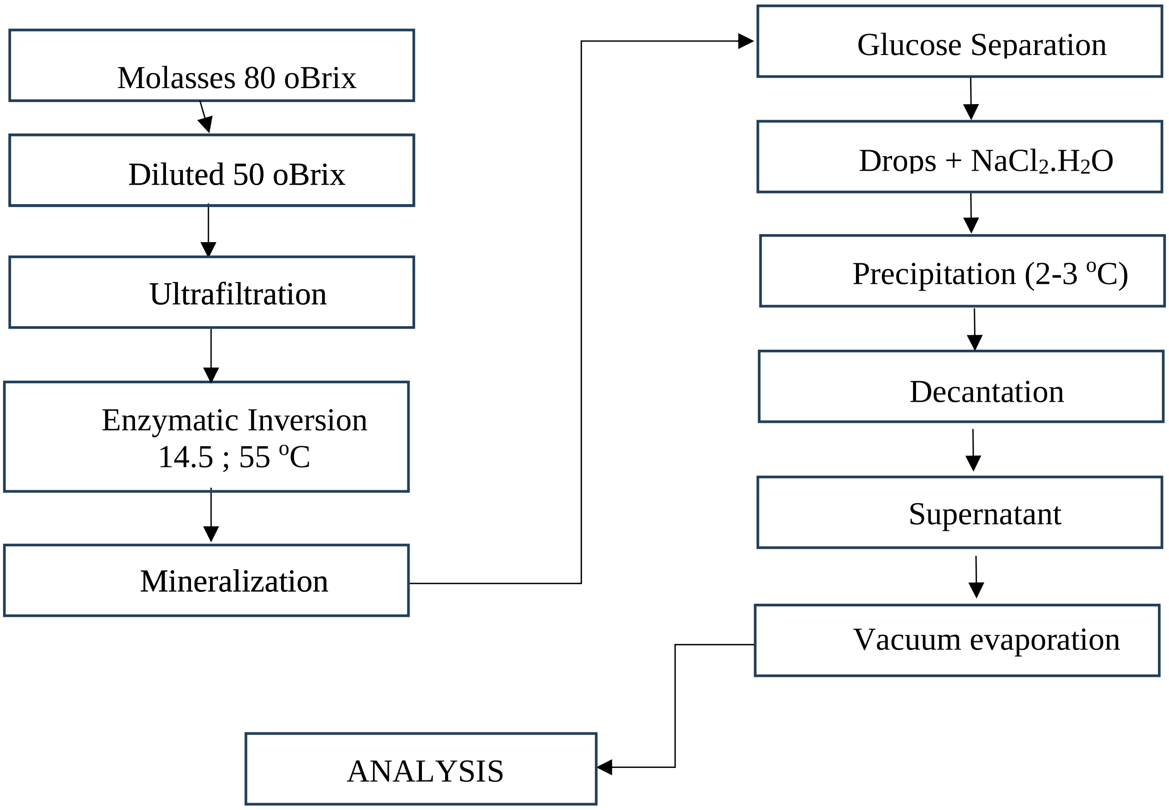

Figure 1. Separation Process Diagram

The experimental design used was a completely randomized design with a factorial experiment of three treatments and two replications. Data were analyzed using variance and the average value was tested using Duncan's distance test. The level of treatment used is:

1. Drops without mineralization and mineralization.
2. The amount of methanol added is 1 part, 2 parts, 3 parts and 4 parts.
3. The sodium chloride concentration is seen as 0; 2%; 4%; 6%, and 8%.

Observations and Calculations:

Analysis carried out on the filtrate resulting from the separation and initial drops includes:

1. Glucose levels using the cysteine carbazole method (Freund, 2023) in the book Dische and Borenfreund, 2023)
2. Dissolved ash content using the conductometric method (Lia sandra, 2023) in the book Gandana and Ananta, 2023)
3. Total sugar reduction using the dinitrosalicylic acid method (Frankast, 2023) in Miller's book, 2023)
4. Sugar composition using the thin layer chromatography method (Djoko Soedarmo, 2023).

Parameter Calculation:

1 Separation Factor $= \dfrac{\text{Fructose recovery}}{\text{Glucose recovery}}$

2 Glucose Factor $= \dfrac{\text{Glucose filtrate}}{\text{Original glucose drops}} \times 100\%$

3 Glucose Recovery $= \dfrac{\text{Filtrate glucose}}{\text{Original glucose drops}} \times 100\%$

4 Total Sugar Reduction Recovery $= \dfrac{\text{Filtrate reducing sugar}}{\text{Dula original drop reduction}} \times 100\%$

5 Changes in Dissolved Ash $= \dfrac{\text{Filtrate dissolved ash}}{\text{Dissolved ash drops of origin}} \times 100\%$

RESULTS AND DISCUSSION

Effects of Mineralization

Mineralization had a significant effect ($p > 0.05$) on glucose recovery, while glucose recovery, total reducing sugar and changes in dissolved ash had a very significant effect ($p < 0.01$). The data in Table 1 shows the average values for the mineralization treatment. These results show that sugar recovery can be increased by mineralization treatment. This change is caused by mineral drops which have a "salting out" effect on the dissolved sugars (Sony, 2023)

Dissolved ash content increased as a result of the P<0.05 mineralization treatment because the amount of minerals that precipitated together with the methanol-insoluble drop components decreased. This occurs because the reduction in certain ions in the drop solution causes no mineral deposits to form.

Table 1. Average Value of Separation Factor, Recovery of Fructose, Glucose and Total Sugar, Reduction and Changes in Dissolved Ash in Mineralization Treatment

Parameter	Mineralization	
	No Mineralization	Mineralization
Fructose Recovery	74.77 b	70.50 c
Recover Glucose	87.25 b	92.44 a
Separation Factor	0.88 a	0.830 b
Total Sugar Reduction Recovery	80.24 b	83.74 c
Changes in Dissolved Ash	06.25 b	0.954 b

Note: Values with the same letter symbol on the same row are not significantly different (P<0.25)

Effect of Amount of Methanol Addition

The amount of methanol added had a significant effect ($p<0.05$) on the separation factor, while the change in soluble ash, fructose recovery and total reducing sugar had a very significant effect ($p<0.01$). Table 2 shows the average value for the treatment with the amount of methanol added. Changes in the separation factor occur because the solubility balance of fructose and glucose is disturbed due to an increase in the concentration of mhethanol acid in the solution system. This balance change occurs due to differences in the concentration of fructose and glucose in the solution and the influence of the solvent concentration. Also the composition of the sugar mixture affects the separation factor (Chang, 2023).

The solubility of fructose decreases with increasing amount of methanol addition. This is in accordance with the opinion (McDonald, 2023) that the solubility of fructose and glucose will decrease with increasing methanol solvent in the mixed solvent system, while glucose does not exceed the solubility threshold.

The decrease in total recovery of reducing sugar due to the increase in the amount of methanol added is due to the influence of this solubility, it is also thought that the sugar binds to the molasses component which is not soluble in methanol, so it also precipitates.

Table 2. Average Value of Separation Factor, Fructose Recovery, Total Reducing Sugar and Changes in Dissolved Ash in the Treatment of Amount of Methanol Addition

Parameter	Methanol (part)			
	2	4	6	8
Fructose Recovery	79.25 a	74.95 b	75.38 b	73.38 b
Recover Glucose	90.40 a	90.92 a	88.25 a	89.64 a
Separation Factor	0.58 a	0.820 b	0.860 ab	0.827 a
Total Sugar Reduction Recovery	85.45 a	82.05 b	81.05 BC	80.60 c
Changes in Dissolved Ash	09.78 a	80.83 b	0.038 b	0.149 b

Note: Values with the same letter in the same row are not significantly different (P<0.05)

Dissolved ash decreases with increasing amount of methanol addition, because more and more droplet components precipitate.

Effect of Sodium Chloride Dihydrate Concentration

The concentration of sodium chloride dihydrate had a very significant effect (p<0.01) on the separation factor. Recovery of fructose, glucose, total reducing sugars and changes in dissolved ash. The average value for the sodium chloride dihydrate concentration treatment is shown in Table 3. The change in the separation factor occurs due to the reaction forming a complex of fructose with sodium chloride dihydrate and at an additional concentration of 4 percent an equilibrium occurs, so that the solubility of fructose is quite high, in addition to reacting with fructose.

Natrium chloride dihydrate also forms a complex with molasses minerals which causes a decrease in the separation factor at additions of 2 and 6 percent but due to tight formation with minerals causes the recovery of reducing sugars to increase because the solubility of glucose increases.

Increasing the concentration of sodium chloride dihydrate causes an increase in glucose recovery and total reducing sugar which occurs due to the reduction in the "Salting Out" effect of mineral drops and the mutarotation of glucose due to the presence of salt which can increase its solubility. The presence of salt causes glucose mutarotation (McDonald, 2023). Increasing the concentration of sodium chloride dihydrate causes increased changes in dissolved ash because sodium chloride dihydrate is very soluble in methanol.

Table 3. Average Value of Separation Factor, Recovery of Fructose, Glucose, Total Reducing Sugar and Changes in Dissolved Ash in the Sodium Chloride Dihydrate Concentration Treatment.

Parameter	Methanol (part)			
	0	2	4	6
Fructose Recovery	77.05 a	73.10 b	77.25 a	75.25 a
Recover Glucose	85.50 c	90.25 b	88.43 b	94.58 a
Separation Factor	0.087 a	0.79 a	0.885 a	0.795 b
Total Sugar Reduction Recovery	80.85 c	81.05 BC	82.25 b	83.85 a
Changes in Dissolved Ash	47.05 d	14.13 c	18.25 b	50.45 a

Note: Values with the same letter in the same row are not significantly different (P<0.05)

Interaction Effect of Demineralization with the Amount of Methanol Added

This interaction had a very significant effect (p<0.01) on separation factors, recovery of fructose, glucose, total reducing sugars and changes in dissolved ash. Table 4 shows the average value of the mineralization treatment interaction, the highest separation factor was obtained at the amount of methanol addition of 1 part, while in drops without mineralization the neutralization was not different at all amounts of ethanol addition. This change is caused by the mineral content of the drops and the methanol concentration affecting the solubility of the sugar.

Table 4. Average Separation Factor, Recovery of Fructose, Glucose, Total Reducing Sugar and Changes in Dissolved Ash on the Interaction of Mineralization Treatment and the Amount of Methanol Added

Parameter	Mineralization	Methanol (part)			
		0	2	4	6
Fructose Recovery	No mineralization	76.04 bc	72.48 c	74.89 BC	75.13 bc
	Mineralization	82.34 a	77.49 b	75.89 BC	71.60 c
Recover Glucose	No mineralization	92.28 a	87.48 a	83.58 ca	82.25 bc
	Mineralization	88.58 b	94.30 a	92.88 a	93.95 a
Separation Factor	No mineralization	8.84 bcd	0.83 bcd	0.91 ab	0.75 abc
	Mineralization	0.93 a	0.82 cd	0.82 cd	0.83 d
Total Sugar Reduction Recovery	No mineralization	83.50 a	79.20 c	78.89 c	79.92 c
	Mineralization	85.19 a	84.99 a	83.35 a	81.89 b
Changes in Dissolved Ash	No mineralization	03.05 c	09.38 d	08.89 d	09.85 d
	Mineralization	16.90 a	07.38 b	06.05 b	06.90 a

Note: Values with the same letter symbol on the same row are not significantly different (p<0.05)

The amount of methanol added to 1 part of a drop of mineralization results in high fructose recovery, because of this interaction the solubility of fructose is optimum, while the amount of glucose recovery increases due to the increase in the amount of methanol added and mineralization. The total recovery of reducing sugars in the mineralization treatment showed a decrease with increasing amounts of methanol addition. Likewise with mineralization drops. Dissolved ash in the filtrate decreased with increasing amounts of methanol addition. Meanwhile, mineralization treatment gave the opposite reaction results.

CONCLUSION

Mineralization affects the recovery of fructose, glucose and total reducing sugars, as well as changes in dissolved ash. The amount of methanol added influences the separation factor, change in dissolved ash, recovery of fructose and total reducing sugar, while the concentration of sodium chloride dihydrate influences the separation factor, change in dissolved ash, recovery of fructose, glucose and total reducing sugar.

Changes in the separation factor and sugar recovery are caused by changes in the solubility of the sugar in the separation system. Increasing the concentration of sodium chloride dihydrate and mineralization can increase sugar recovery, but is not accompanied by changes in the good separation factor, while increasing the amount of methanol added causes a decrease in total recovery of reducing sugar and changes in dissolved ash.

Good separation results were obtained in the combination of mineralization drop treatment, the amount of methanol added was one part methanol and the concentration of sodium chloride dihydrate was zero.

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