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# PURSE LIQUID SUGAR WITH IODINE FORTIFICATION

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## ABSTRACT

Sugar is one of the basic needs of society, especially its role as a sweetener whose needs are increasing. Therefore, alternatives to other sweeteners are needed as sugar substitutes, such as by developing glucose syrup (liquid sugar) from starch. Kimpul (*Xanthosoma sagittifolium*) as one type of root crop has a great opportunity to be developed because it has high carbohydrate content (34,2g/100g). Application of the use of kimpul liquid sugar as a sweetener requires testing of nutritional and health aspects. Therefore, it is necessary to test the nutritional, caloric value and glycemic index of purse liquid sugar. With the research of the process of making purse liquid sugar with iodine fortification, the benefits of sugar can be more efficient and effective.

This study aims to: (1) determine the process engineering to increase iodine levels through a fortification process and (2) determine the nutritional value, caloric value, glycemic index value, and iodine content of purse liquid sugar.

This study used a single factor randomized block design that is the concentration of Iodine ($KIO_3$), with 4 levels, namely : $K_1$ : 30 ppm; $K_2$ : 40 ppm; $K_3$ : 50 ppm; and $K_4$ : 60 ppm and repeated three times. The parameters tested were organoleptic tests of taste, color, and aroma, °Briks, water content, ash content, reducing sugar content, caloric value, glycemic index (GI), and iodine content.

The results showed that (1) Iodine fortification did not significantly affect the organoleptic properties of taste, color, and aroma. (2) Iodine fortification significantly affect the parameter of reducing sugar content and iodine content of kimpul liquid sugar. (3) The iodine fortification did not decrease the value of the glycemic index of the kimpul liquid sugar product.

**Keywords:** Liquid sugar, purse, fortification, iodine

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## INTRODUCTION

Kimpul (*Xanthosoma sagittifolium*) as one type of the root crop has a great opportunity to be developed because it has various benefits and can be easily cultivated. Kimpul can be developed as a potential producer of non-rice carbohydrates. Kimpul tubers contain high carbohydrates, namely 34.2g / 100g, so that potential for further processing into kimpul starch and subsequently into other processed products. The research results of (Puspitasari, Rahayuningsih, & Rejeki, 2015) stated that kimpul flour has the following chemical composition : water content 12,35%, carbohydrate content 82,05%, protein content 2,71%, Ca content 0,23%, ash content 2,70%, fat content 0,22%, amylose content 22,03%, amylopectin content 34,27%, starch content 56,26%, crude fiber content 3,43%, *gel strenght* 0,23N, gelatinization temperature 90,67$^0$C, and flour absorbability on water 7,95.

Iodine is a mineral material and including the essential nutritional elements although the amount is very little in the body. Iodine is needed in the synthesis of the thyroxine hormone secreted by the thyroid gland. Thyroxine hormone is very needed in the regulation of metabolism. Humans cannot make the iodine element in their body like they make protein or sugar. Humans obtain iodine from outside their bodies through the absorption of iodine contained in food and drinks consumed. Iodine is needed for the production of thyroid hormone which is important for brain growth and development (Zahrou et al., 2016) and (Pandav, Yadav, Srivastava, Pandav, & Karmarkar, 2013). Iodine deficiency is a result of iodine intake in food that is inadequate and as a consequence causes several side effects on growth and development especially at an early age (Tonacchera et al., 2013). Iodine deficiency (ID) in women of childbearing age is a concern for global public health, because it will have an impact on fetal nerve development and cognitive function (Bouga, Lean, & Combet, 2018). On an international scale fortification of iodine supplements for risk groups and vulnerable groups are considered the most successful micronutrient interventions (Abeshu & Geleta, 2016). Reduction on the program of iodized salt addition on foods resulting in iodine deficiency disease reappears globally (Winger, König, House, & Technology, 2008) and (Desta, Kulkarni, Abraha, Worku, & Sahle, 2019). Iodine intake should not be excessive, because exposure to high concentrations of iodine is likely to cause iodine-induced immune phenomena (Vithanage et al., 2016).

Fortification is a safe and effective way to increase micronutrient intake and restore the amount lost during processing by providing essential nutrients in food (Nagar, Popli, Gupta, & Research, 2018) .Food fortification provides opportunities to increase nutrient intake and has the potential to promote early age growth and development (Okeyo & Metabolism, 2018). Fortification in children's menus shows a significant effect on the increase in serum micronutrient concentrations (Das, Salam, Kumar, & Bhutta, 2013). Double fortification of salt with iodine and iron has good stability especially if stored in closed conditions (Helmyati, Narendra, Septi, Rochyana, & Endri, 2014).

Salt and flour fortification (as well as several other foods) with iodine and iron are priorities for improving health in developing countries (Horton, Mannar, & Wesley, 2008). National iodine fortification policy in India can improve basic numeracy and literacy skills by 2,67 - 5,83% (Tafesse, 2018). Iodine fortification needs to be developed in materials other than salt so that humans do not consume too much salt which will adversely affect blood vessels. (Mirmiran et al., 2013). Fortification of staple foods other than salt with iodine (or with other vitamins and minerals) is related to population health. Careful processing, packaging, and storage of fortified salts remain stable for a period of six months sufficient for distribution and consumption (Diosady, Alberti, Ramcharan, Mannar, & Bulletin, 2002).

This study aims to (1) develop an iodine fortification model that has been implemented in salt, which will be developed in sugar, and (2) developing purse liquid sugar products/produk gula cair kimpul into iodized sugar so that it gives added value to the purse/kimpul commodity.

Research Methods

Research on purse liquid sugar with iodine fortification was carried out in the Agricultural Industrial Technology laboratory, Faculty of Engineering, University of Wijaya Kusuma Surabaya. Kimpul material is obtained from the agricultural market in Malang Regency which produces kimpul/purse, NaCO3, α-amylase enzyme and glucosidase enzyme, NaOH 1%, and $KIO_3$.

The experimental process of processing the purse liquid sugar with iodine fortification with iodine concentration ($KIO_3$) treatment consisted of :$J_0$ : 0 ppm; $J_1$ : 30 ppm; $J_2$ : 40 ppm; $J_3$ : 50 ppm; and $J_4$ : 60 ppm. The treatment was repeated three times. The experimental unit is the process of making 1 liter of purse liquid sugar with iodine according to the treatment.

The making of kimpul/purse starch conducted with the stages (1) peeling the purse tuber, (2) washing and cutting the purse tuber, (3) Soak the purse pieces in 5% salt solution for 10 minutes, (4) wash clean then drained, (5) grind the purse/kimpul until smooth and extract in a ratio of 4: 1 (water: taro tubers) then squeezed using a filter cloth, (6) Add water to the taro dregs of purse in a ratio of 4: 1 (water: taro dregs) then extract again. (7) Precipitate starch milk for 8 hours, then dry the starch which formed at 60$^o$C temperature for 6 hours, then grind and sift the starch with a 100 mesh sieve.

The making of purse liquid sugar with the addition of iodine conducted with the stages (1) weigh 300 g of purse starch, (2) Add distilled water/aquades to a volume of 1,000 ml, (3) starch suspension is heated at 95$^o$C temperature until gelatinized, (4) conducted the Iodine solution addition according to the treatment namely for treatment J0: not given, J1: 0,03 cc $KIO_3$, J2: 0,04 cc $KIO_3$ , J3: 0,05 cc $KIO_3$, J4: 0,06 cc $KIO_3$, (5) α-amylase enzyme addition of 3 ml and hydrolyzed at 100°C temperature for 60 minutes, (6) The result of liquidation is then saccharified with the enzyme of amiloglucosidase and heated at 60$^o$C temperature for 72 hours with stirring every 12 hours.

Research variables include $^o$Briks, water content, ash content, reducing sugar content, iodine content and organoleptic test on taste, color and aroma/flavor. The selected process then will be calculated the calorie value and the Glycemic Index (GI)

Organoleptic test data processing which is ordinal data using the Friedman Test. While the chemical test data processing is done by analysis of variance, if there are any differences conducted the Duncan test with a confidence level of 95%.

An alternative selection was made to determine the best treatment in the process of making the purse liquid sugar with enzymatic hydrolysis. The concept of the expected value decision is to choose a decision that has a maximum pay-off (profit or use) or a minimum cost (loss or sacrifice). For kimpul/purse liquid sugar products, quality parameters used for the selection of the best alternative processes are aroma/flavor, color, taste, reducing sugar, iodine, calories, and GI.

**Research Result**

1 Organoleptic Test

a. Taste

Based on the results of the Frequency Analysis, the percentage score acquisition for the taste parameters is shown in Figure 1. Friedman Test Results for score acquisition of the purse liquid sugar taste showed that there was no significant difference among treatments, with the $F_{calculate}$ amounted to 1,646. Panelist test results on taste showed that the differences in sweetness in the purse liquid sugar which produced due to iodine fortification treatment did not affect the panelists' preferences.

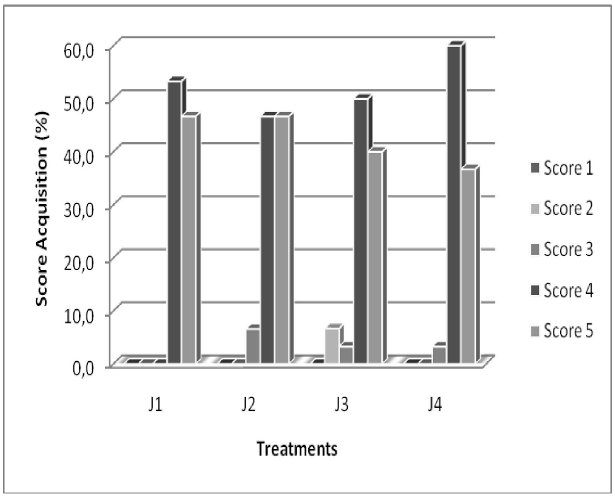


**Figure 1**. Diagram of the Percentage Data for the Acquisition of Purse Liquid Sugar Taste Parameters Score with Iodine Fortification

b. Aroma/Flavor

Based on the results of the Frequency Analysis, the percentage score acquisition for the flavor parameters is shown in Figure 2. Friedman Test Results for score acquisition of the purse liquid sugar flavor showed that there was no significant difference among treatments, with the $F_{calculate}$ amounted to 1,228.

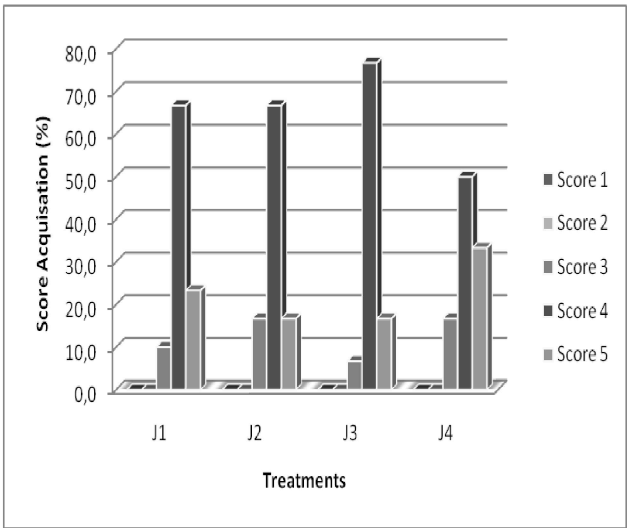


**Figure 2.** Diagram of the Percentage Data for the Acquisition of Purse Liquid Sugar Flavor Parameters Score with Iodine Fortification

c. Color
Based on the results of the Frequency Analysis, the percentage score acquisition for the color parameters is shown in Figure 3. Friedman Test Results for score acquisition of the purse liquid sugar color showed that there was no significant difference among treatments, with the $F_{calculate}$ amounted to 0,421.

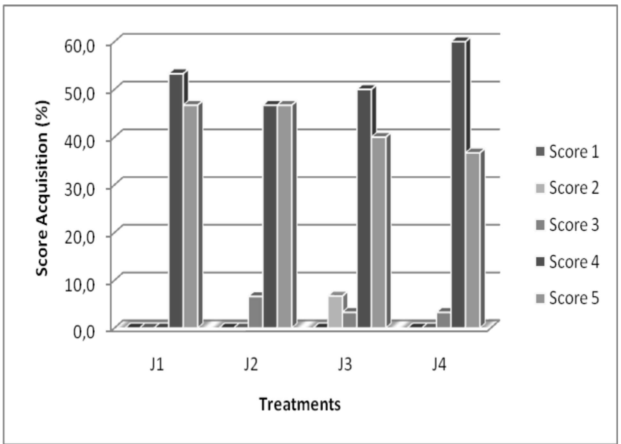


**Figure 3.** Diagram of the Percentage Data for the Acquisition of Purse Liquid Sugar Color Parameters Score with Iodine Fortification

2. Chemical Test
a. Briks Degrees
$^{0}$Brix measurements were performed to determine the degree of sweetness of purse liquid sugar with iodine fortification at different concentrations. Data and graphs of $^{0}$Brix of Purse Liquid Sugar with iodine fortification can be seen in Figure 4.

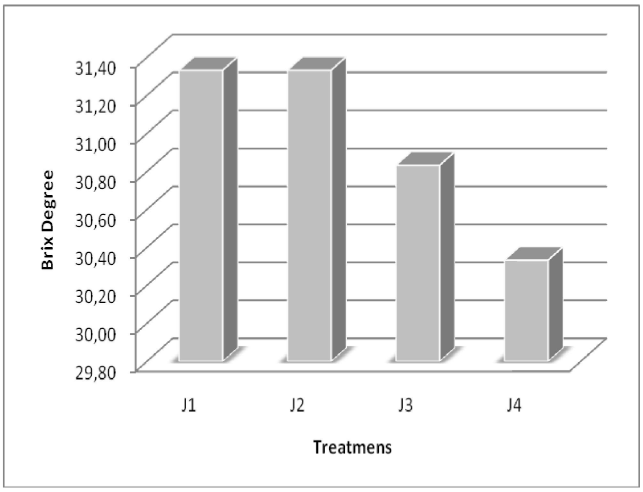


**Figure 4.** Data Diagram for Briks Degrees of Purse Liquid Sugar with Iodine Fortification

The results of the variance analysis showed that there was no significant difference in the treatment of iodine concentrations of $^{0}$Briks of purse liquid sugar produced, although the higher levels of added iodine would tend to cause the lower $^{0}$Briks produced. This is probably due to the addition of iodine will not cause a decrease in enzyme activity.

b. Ash Content
Measurement of ash content was carried out to determine the water content of purse liquid sugar with iodine fortification at different concentrations. The measurement results of the ash content of the purse liquid sugar can be seen in Figure 5. The results of statistical analysis show that there is no significant difference among the treatments. This is likely due to the addition of iodine added only to very small amounts, with a concentration range of 30 to 60 ppm, so it hasn't caused a significant increase in ash content.

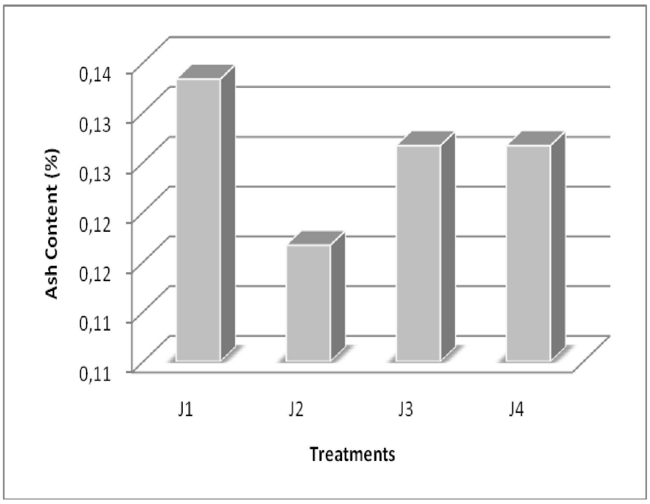


**Figure 5.** Diagram of Ash Content (%) of Kimpul/Purse Liquid Sugar with Iodine Fortification

c. The Reducing Sugar Content
The measurement of reducing sugar content is carried out to determine the reducing sugar content of purse

liquid sugar with iodine fortification at different concentrations. The measurement results of the reducing sugar content of purse liquid sugar can be seen in Figure 6. The results of the statistical analysis show that there is no significant difference in the reducing sugar content of purse liquid sugar.

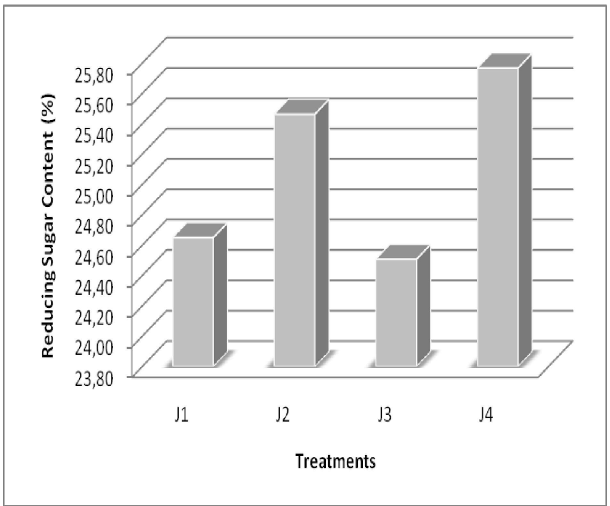


**Figure 6.** Diagram of the Reducing Sugar Content (%) of Purse Liquid Sugar with Iodine Fortification

d. Calorie

The results of statistical calculations show that there is no significant difference among the treatments on the calorie value of the purse liquid sugar produced. This is probably due to the addition of iodine at low concentrations does not cause changes in pH and because iodine is not included in the heavy metal group, then it does not inhibit the work of enzymes.

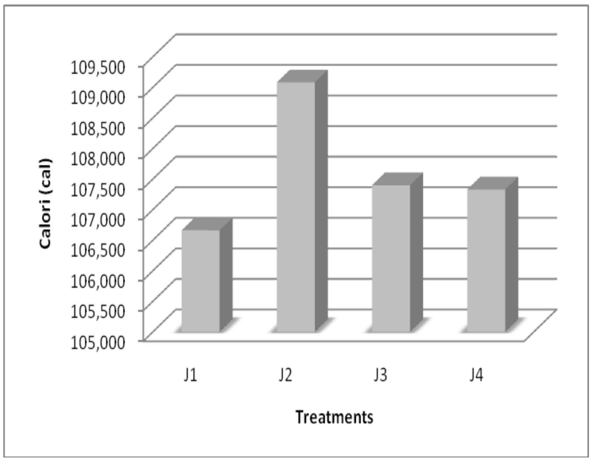


**Figure 7.** Diagram of the Amount of Purse Liquid Sugar Calories with Iodine Fortification

e. Iodine Content

The results of the statistical analysis showed that there were significant differences in the treatment of the iodine content of purse liquid sugar produced. The higher the concentration of iodine added, the higher the content of iodine in the purse liquid sugar produced. The iodine content found in the purse liquid sugar ranges from 10,0667 ppm to 17,667 ppm, which is still in the range allowed for food products.

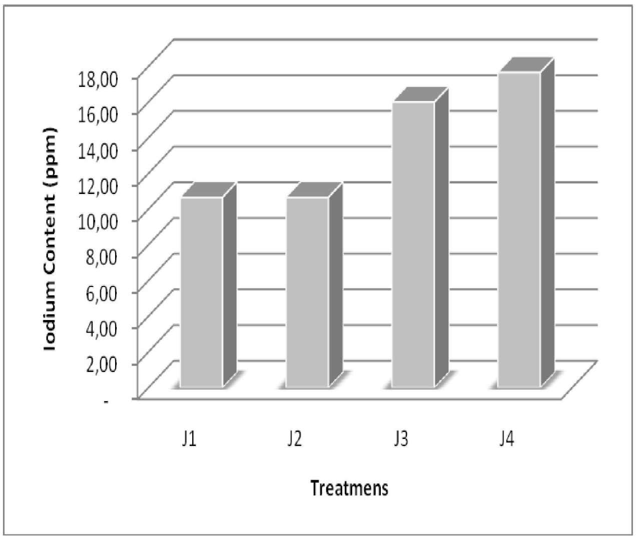


**Figure 8.** Diagram of Iodine Content (ppm) of Purse Liquid Sugar with Iodine Fortification.

**Table 1.** Average content of iodine in purse liquid sugar with the addition of iodine in the making process (ppm)

| Treatment | Iodine Content |
|---|---|
| J0 = 0 ppm | 0,0000 c |
| J1 = 30 ppm | 10,0667 b |
| J2 = 40 ppm | 10,0667 b |
| J3 = 50 ppm | 16,0000 a |
| J4 = 60 ppm | 17,6667 a |

Information : the average value followed by the same letter is not significantly different based on the Duncan test of 5%

f. Glycemic Index (GI)

Calculation of the glycemic index (GI) value/score is based on the increase in blood sugar of experimental animals (mice) during observation. Observation of blood sugar content was carried out at 0, 15, 30, 60, and 90 minutes after giving samples of purse liquid sugar products to animals. The observation results of an increase in blood sugar content of mice for the test of purse liquid sugar with iodine fortification can be seen in Figure 9.

**Table 2.** An Increase in Blood Sugar Content of Mice after given the purse liquid sugar with iodine fortification

| time (minutes after treatment) | Glucose | Control ( 0 ppm) | J1 (30 ppm) | J2 (40 ppm) | J3 (50 ppm) | J4 (60 ppm) |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 280 | 280 | 169 | 235 | 245 | 219 |
| 30 | 343 | 346 | 313 | 316 | 309 | 248 |
| 60 | 311 | 195 | 257 | 201 | 195 | 190 |
| 90 | 160 | 62 | 65 | 72 | 63 | 82 |

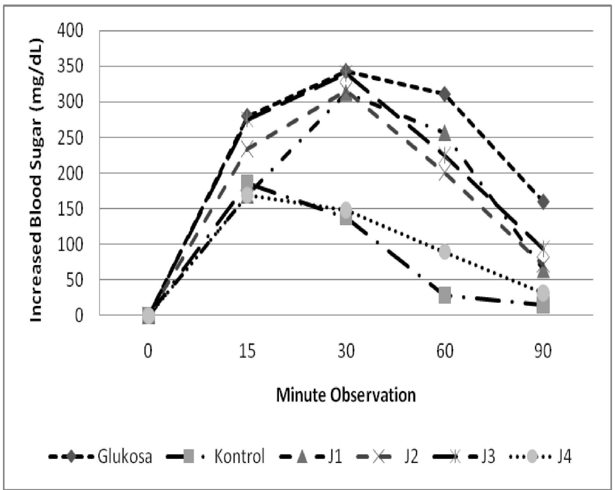


**Figure 9.** Graph of an Increase in Mice Blood Sugar Level/Content (Liquid Sugar with Iodine Fortification)

Based on observations of an increase in blood sugar levels at 0, 15, 30, 60, and 90 minutes then made a quadratic regression curve. The quadratic regression equation is then integrated into finding the area under the curve. To calculate the GI value, the area under the curve is compared to the area under the curve for glucose as standard. Glucose GI value is 100. From the calculation results obtained, that the glucose GI value is 100, the smallest IG value of J4 process is 67,81. Based on the calculation of the GI value, then the resulting purse liquid sugar is still included in the high GI group (GI> 55).

**Table 3.** GI (Glycemic Index) Value of Liquid Sugar with Iodine Fortification

| Treatment | Area | GI Value |
|---|---|---|
| Glucose | 25315,83 | 100,00 |
| Control | 20712,42 | 81,82 |
| J1 = 30 ppm | 19821,06 | 78,30 |
| J2 = 40 ppm | 19452,24 | 76,84 |
| J3 = 50 ppm | 19261,35 | 76,08 |
| J4 = 60 ppm | 17167,14 | 67,81 |

3. Alternative Selection

The alternative selection is done in order to choose the best alternative treatment. The selection criteria to be taken into consideration are the aroma/flavor, color, taste, reducing sugar, iodine, calories, and GI. Determination of the weight of the importance of each selection criteria is conducted by using the AHP (*Analitycal Hierarchy Process*). Weight determination is done to determine the weight or size of the parameters in each selection criteria considered. Whereas the determination of the best alternative uses the Expectation Value method.

The alternative process chosen for processing of purse liquid sugar with iodine fortification is J4 treatment (addition of iodine with a concentration of 60 ppm) with a total expectation value of 5,26, and with the composition as presented in Table 4.

**Table 4.** Quality and Value of the Calorie of Selected Processed Liquid Sugar Products

| No. | Parameter | J4 |
|---|---|---|
| 1. | Reducing sugar content (%) | 25,770 |
| 2. | Water content (%) | 73,060 |
| 3. | Ash content (%) | 0,130 |
| 4. | Protein content (%) | 0,012 |
| 5. | Fat content (%) | 0,012 |
| 6. | Carbohydrate Content (%) | 26,793 |
| 7. | Iodine Content (ppm) | 17,670 |
| 8. | Calorie Value (kal) | 107,327 |
| 9. | Glycemic Index Value | 67,810 |

DISCUSSION

The treatment of KIO3 concentration did not cause differences in organoleptic variables which included the taste, aroma/flavor and color of purse liquid sugar. Research by (Kaushik & Arora, 2017) concluded that yogurt fortification showed no different sensory and physicochemical properties compared to unfortified yogurt (control). Development of low-fat buffalo milk products with 0.5% b-glucan fortification, causing more attractive colors (Bhaskar et al., 2017). Research by (Ghadge, Prasad, Kadam, & chemistry, 2008) showed that superior sensory quality yogurt was obtained by fortification of 10% apple pulp and 5 percent honey concentration. (Gaur, Waller, & Andrade, 2019) states that the addition of micronutrients to yogurt will not affect on the sensory format of consumption. Research by (Roncolini et al., 2019) concluded that fortification of bread protein with mealworm powder (MP) significantly affected the texture and level of consumer preferences related to bread appearance, and crust color. In line with the statement of (Clifton et al., 2013) that fortification of bread with iodized salt only affects on the iodine content, does not affect on the appearance of bread. Various types of food used for fortification include cereals and cereal-based products, milk and milk products, tea, fats and oils, beverages and seasonings such as salt, sugar and soy sauce (Nagar et al., 2018) .Milk, iodine, cornmeal, and vegetable oil as an introduction to fortification in order to provide complementary foods for breast milk. Fortification has a significant impact on children's growth and cognitive abilities (Okeyo & Metabolism, 2018). Some micronutrient fortifications show insignificant effects on height and weight (Das et al., 2013)

Treatment of KIO3 concentration did not cause differences in the chemical properties of purse liquid sugar, including Briks degrees, ash content, reducing sugars, and calorie value. In line with the research results of (Kaushik & Arora, 2017) which concluded that the fortification on yogurt does not affect on the physiochemical and texture properties. Research by (Ozturkoglu-Budak, Akal, & Yetisemiyen, 2016) concluded that fortified yogurt has higher protein and lower solid content. According to Gaur et al, 2018 fortification has no effect on the physico-chemical properties of yogurt. According to the research by (Malahayati, Muhammad, Bakar, Karim, & Volume) Steamed rice noodles are recommended for fortification purposes because they produce better rice noodles in terms of chemical properties, quality of ripeness and texture and retention of vitamin A, folic acid and iron. The research by (Rebellato, Klein, Wagner, Pallone, & technology, 2018) concluded that the form of iron compounds used in fortification of flour affected on the quality and / or stability parameters of the samples studied.

The iodine content in the purse liquid sugar is significantly different among the treatments, the more KIO3 given the higher the iodine content. In line with the statement by (Clifton et al., 2013) that fortified bread with iodized salt increases iodine intake. (Charlton, Probst, & Kiene, 2016) stated that the results of the evaluation of the iodized salt fortification program in bread in Australia in 2009 showed an association between fortified bread intake and an adequacy of iodine intake.

## CONCLUSION

The treatment of iodine concentration did not cause differences in organoleptic variables including taste, aroma/flavor and color. The iodine content in purse liquid sugar is significantly different among the treatments, the more KIO3 given the higher the iodine content, and for variable of Briks degrees, ash content, reducing sugars, calorie values and iodine content did not differ.

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