The Comparison of Total Fructose and Flavonoids Concentrations in Fresh Fruits with Different Glycemic Indexes

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Abstract: Obesity is the main risk factor of cardiovascular and diabetes mellitus diseases, leading to the highest premature death in the world. Fruits consumption is required to keep balance nutrition by providing macronutrients, vitamins, minerals and fibers. However, different kind of fruits have different sweet taste with variable fructose levels and bioactive chemical compounds. Therefore, this study aimed to analyze total fructose and flavonoids concentrations in some fresh fruits with different glycaemic indexes (GIs) to correlate between fructose and total flavonoids concentration. We choose 9 fresh fruits from local markets with low, moderate and high GIs. The Pearson test was used to analyze those correlation. We analyzed total fructose concentration using the *Nelson-Somogyi* method while flavonoids concentration used a UV-Vis spectrophotometer. The highest fructose and flavonoids concentrations of fruits in low, moderate and high GI grous were Fuji apple (9.88±0.12% and 16.18±0.19mg/100g), Golden banana (9.58±0.60%) and California papaya (34.38±0.09mg/100g) and ripe Ambon banana (10.69±0.04% and 9.74±0.27mg/100g) respectively. In conclusion, there is no difference total fructose concentration of fresh fruits among GI classification and there is differenceflavonoids concentration of fresh fruits among GI classification.

1 INTRODUCTION

Diabetes Mellitus (DM) has become the top 5 causes of death in the world (Andersson & Vasan, 2018). Based on data from Indonesian Health Research, the DM prevalence has increased by 4% in 2018 (Kemenkes RI, 2018b). Excess body weight or obesity is a major risk factor for DM disease (Scherer & Hill, 2016), which can be prevented by implementation of healthy diet and balanced nutrition (Brandhorst & Longo, 2019). The healthy diet consists of high consumption of non-starchy vegetables, fruits, whole grains, and legumes (Karageorgou et al., 2019). In general, whole fresh fruits have antioxidant and anti-inflammatory effects, which are suitable to overcome low grade inflammation in obesity (Nani et al., 2021). Moreover, total flavonoids in whole fresh fruits can improve endothelial function and glycemic metabolism through protecting β cells in the pancreas, increasing insulin sensitivity and reducing blood glucose levels (Pallazola et al., 2019); (Poolsup et al., 2019).

Indonesia is one of tropical countries that produces the highest number of tropical fruits in the world (Putri & Setiawati, 2015). However, the average of fruits consumption in Indonesian adults is lower than the recommended fruits consumption. According to the Central Statistics Agency, Indonesian people consume only 67g fruits/day, compared to the recommended fruits consumption from the Indonesian Ministry of Health (400g/day) (BPS, 2017; Kemenkes RI, 2018b). Therefore, it is not surprising that low fruits consumption has a strong association with high prevalence of non-communicable diseases (Xaba & Dlamini, 2020).

The main cause of low fruits consumption is due to the concerns of sweet taste and their impact to increase blood glucose levels (Davison & Temple, 2018). Basically, sweet taste of fruits is comes from

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fructose but not glucose, which does not affect blood glucose levels (Tappy, 2018; Yuliati & Kurniawati, 2017). A recent study showed that fresh fruits consumption with different GIs have similar effect on blood glucose levels in diabetes patients (Fitri, 2019). The fructose concentration in fruits ranges from 5 to 10% but they do not mention in detail related to the fruits type whether come from tropical countries or not (Tey et al., 2017). Therefore, the study aim to analyze total fructose and flavonoids concentrations in some fresh fruits with different GIs and to correlate between fructose and total flavonoids concentration.

2 MATERIALS AND METHODS

2.1 Sample Preparation

Nine fresh fruits, which were bought from a local market, Jebres, Surakarta city were used in this study. Fuji apple, Medan orange and red guava were classified as the fruits with low GI. The fruits with moderate GI were California papaya, honey pineapple and ripe golden banana while the fruits with high GI were melon, ripe Ambon banana and watermelon.

In brief, all fresh fruits were thoroughly washed and then were peeled off to get their flesh. After that, sliced fruits were crushed using a blender for several minutes. Finally, fruits juice was poured into a beaker glass and was ready to further analysis.

2.2 Determination of Fructose Concentration

To analyze fructose concentrations in each fruit juice, we used a standard method, the *Nelson-Somogyi* assay. One ml fruit juice was diluted into a 50ml final concentrations. One ml diluted fresh juice was mixed with 1ml *Nelson* solution and the mixed solution was heated for 30 minutes. Then, 1 ml arsenomolybdate and 7 ml distilled water solutions was added into the cooled solution. The absorbance of that suspension was spectrophotometrically measured at 540nm wavelength and then the fructose concentrations was calculated using a regression linear with various concentrations of standard fructose (Al-kayyis & Susanti, 2016).

2.3 Determination of Total Flavonoid Concentration

Total flavonoid concentration in fruit juice was determined using a colorimetric method. Briefly, 1-2g each fruit juice was added 10 ml of 96% ethanol to the test tube. After that, 1ml dilluted fruit juice was mixed with 5ml $FeCl_3$ solution until a red color formation. The red solution was then diluted with 96% ethanol to reach 10ml final concentration and was directly read in a spectrophotometer with 520nm wavelength.

2.4 Statistical Analysis

All data collected in this study were presented as means±standard deviasion (SD). The Shapiro wilk test was used to verify the data normality and the correlation of fructose concentrations with total flavonoids was analyzed using the Pearson correlation test. The significant value was <0.05.

3 RESULTS AND DISCUSSION

3.1 Different Fresh Fruits Have Different Fructose Concentrations

Table 1: Fructose concentrations in fresh fruits with different GIs.

GI Classification	Fruits	Mean±SD (w/w%)
Low	Fuji Apple	9.88±0.12
	Medan Orange	4.10±0.15
	Red Guava	3.51±0.02
Moderate	California Papaya	6.26±0.04
	Honey Pineapple	3.44±0.10
	Ripe Golden Banana	9.58±0.60
High	Melon	4.57±0.13
	Ripe Ambon Banana	10.69±0.04
	Watermelon	5.68±0.25

In this present study, we obtained fructose concentrations, which ranged from 3.44±0.10 to 10.69±0.04% (Table 1). From GI view point, there was no difference of fructose concentration in 9 fresh fruits. Red guava and honey pineapple had the lowest fructose concentration whereas golden banana, Fuji apple and ripe Ambon banana had the highest fructose concentration. The fructose concentration in other fresh fruits with different GIs varied between the lowest and the highest concentrations. In general, the fructose concentrations in mango fruits ranges from 5 to 10%. This study is in accordance with our results except red guava, honey pineapple, Medan

orange and melon of the fructose concentrations test carried out.

According to Stricker *et al* (2021), pure fructose has a lower GI than pure glucose so that our research findings are in line with the Stricker's study (Stricker et al., 2021). In addition, fructose concentration in fresh fruits is strongly related to the ripe stage. One recent study stated that fructose in kepok banana (*Musa paradisiaca L*) is reducing sugar that becomes a main substrate for respiration during fruit ripening process (Irfianti & Sunarharum, 2019; Putra et al., 2015). Ripe kepok banana has higher fructose concentration than unripe kepok banana. In our study, we used ripe fruits such as Ambon banana, golden banana and Fuji apple while California papaya, honey pineapple, red guava and melon were half ripe. In contrast, we used ripe watermelon and Medan orange, which had low fructose concentration because high water concentration in both fruit (Kemenkes RI, 2018a). Besides ripening process, Yuliati and Kurniawati (2017) reported that the different fructose concentration in each fruit is also influenced by growth factors, soil type, and nutrient availability (Yuliati & Kurniawati, 2017). The limitation of our study is we do not quantify soluble fiber and water content in fresh fruits, which also affect the fructose concentration.

3.2 Total Flavonoids in Fresh Fruits Concentrations

Table 2**:** Total flavonoid in fresh fruits with different GIs.

GI Classification	Fruits	Mean±SD (mg/100g)
Low	Fuji Apple	16.18±0.09
	Medan Orange	12.27±0.08
	Red Guava	13.98±0.07
Moderate	California Papaya	34.38±0.09
	Honey Pineapple	23.89±0.08
	Ripe Golden Banana	13.46±0.37
High	Melon	5.36±0.15
	Ripe Ambon Banana	9.74±0.27
	Watermelon	7.32±0.87

Flavonoids, a member of polyphenols are a bioactive chemical compound in plants and are also found in fresh fruits. These compounds generally have antioxidant activity (Calado et al., 2015). In this study, we analyzed total flavonoids in 9 different fresh fruit with low, moderate or high GI. Table 2 indicated that the highest total flavonoids were detected in the each GI group. Fuji apple, California papaya and ripe Ambon banana represented the highest total flavonoids in low, moderate and high GIs respectively. Moreover, Fuji apple and ripe Ambon banana had the highest concentration of fructose and total flavonoids. There were 3 fresh fruits (melon, watermelon and ripe Ambon banana), which had the lowest total flavonoids among other fresh fruits (<10%) but they had the highest GI. Overall, the highest total flavonoids were found in California papaya (34.48±0.09%) without GI consideration.

The results of our study are different from previous research studies conducted in Indonesia, Malaysia, and China. Fresh papaya had the lowest total flavonoids compared to fresh mangoes, bananas and apples (Khandaker et al., 2018). The second highest total flavonoids concentrations was honey pineapple with a total of 23.89%. Based on a research study carried out in Indonesia, total flavonoids in pineapple flesh extract was 0.73g QE/100g, higher than total flavonoids in pineapple peel extract (0.17g QE/100g) (Fidrianny et al., 2018). In addition, another study reported that 8 tropical fruits such as orange, guava, tamarind, strawberry, papaya, mango, Malang apple and avocado had higher total flavonoids than 9 tropical fruits in our study. The highest total flavonoids were observed in fresh avocado (0.94%) and fresh mango had the lowest total flavonoids (0.06%) (Febrianti & Sari, 2016). From a recent study, Fuji apple had 89.7mg/100g total flavonoids, higher than total flavonoid in our study (16.18mg/100g) (Li et al., 2020). As mentioned above, the different total flavonoids in fresh fruits can be influenced by several factors such as flavonoid solubility, variety, ripe fruit level, soil type and altitude (Sholekah, 2017).

3.3 Comparison Total Fructose and Flavonoids Concentration among GI Classification

Table 3: Comparison of Total Fructose and Flavonoids Concentrations among fresh fruits with different GIs.

GI Classification	Fructose (w/w%)	Flavonoids (mg/100g)
Low	5.83±3.51	14.14±1.96
Moderate	6.42±3.07	23.91±10.46
High	6.98±3.2	7.47±2.19
p	0.914	0.049*

*p-value one way anova

In general, 9 fresh fruits with low, moderate and high GIs had a different pattern of fructose and total

flavonoids concentrations (Table 3). The higher GI classification had the higher mean of fructose concentration but it was not significant difference (p=0.914) (Table 3). Theoretically, fructose concentration in fresh fruits does not affect the GI because the GI value is defined as the amount of carbohydrates in fresh fruits that are digested, absorbed, and metabolized in the human body so that it affects the increase in blood glucose levels (Augustin et al., 2015). Therefore, some health experts suggest that daily consumption of various fresh fruits help normalize blood glucose levels in people with type 2 diabetes (Cozma et al., 2012).

Based on Table 3, there are differences flavonoids concentration in fresh fruits among GI classfication (p=0,049). Perhaps, that differences in flavonoid concentrations can be influenced by different types of fruit and fruit pigments. Fruit pigments such as red and yellow tend to have higher concentrations of flavonoids (Wang et al., 2018). In addition to the type of fruit used, the concentration of flavonoids can be influenced by nutrients and where a plant grows (Vicente & Boscaiu, 2018).

3.4 Fructose Concentration Negatively Correlated with Total Flavonoids

Table 4: Correlations of Fructose Concentration with Total Flavonoids Concentration in fresh fruits with different GIs

Variable	r*	p**
Fructose	-0.09	0.80

*correlation coeficient, **p-value Pearson

Table 4 showed that fructose concentration negatively correlated with total flavonoids in fresh fruits with different GIs. However, the correlation was very weak and not statistically significant. From authors knowledge, we do not find yet any publication related to fructose and total flavonoids concentrations. The amount of fruit pigment also affects the concentration of total flavonoids. For example, a recent study has compared 16 different species of cherry fruits. The cherry fruits with red peel and flesh have the higher concentration of total flavonoids (Wang et al., 2018). In contrast to the Wang study, we did not examine the amount of fruit pigment in 9 fresh fruits. Therefore, we can not speculate that color pigment in 9 fresh fruits also affect the total flavonoids concentration.

4 CONCLUSIONS

Fuji apple (9.88±0.12%), Golden banana (9.58±0.60%) and ripe Ambon banana (10,69±0,04%) have similar fructose concentrations by which it does not correlate with GIs. However, California papaya with lower fructose concentration has the highest total flavonoids concentration (34.38±0.09mg/100g). There is no difference total fructose concentration of fresh fruits among GI classification and there is differenceflavonoids concentration of fresh fruits among GI classification. Further pharmacological analysis of fructose and total flavonoids in fresh fruits is required to understand their beneficial effects in the human body.

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