Preliminary study: the use of sugarcane juice to replace white sugar in an effort to overcome diabetes mellitus

R A Ayuningtyas, C Wijayanti, N R P Hapsari, B F P Sari and Subandi

Chemistry Department of Mathematics and Science Faculty, State University of Malang, Malang, Indonesia

E-mail: subandi.fmipa@um.ac.id

Abstract. The prevalence of diabetes mellitus, especially type 2 diabetes mellitus, continues to increase. One of the characteristic type 2 diabetes mellitus is insulin resistance, which caused by lack of trivalent chromium. This occurred because the habits of the people, who consume white sugar more than brown sugar or sugarcane juice. Refining process will eliminate the mineral content in white sugar. Mineral content in white sugar is assumed to be lower than brown sugar or sugarcane juice. Consuming sugarcane juice as a substitute for white sugar is also thought to be able to increase the level of chromium in the body's cells. It will be publicly accepted in organoleptic. The purpose of this study are to compare the levels of chromium in sugar and sugarcane juice, to know level of chromium in the blood and urine of healthy and diabetes mellitus patients before and after consuming sugarcane juice and to know the level of consumers’ preference to the flavour of white sugar compared to sugarcane juice. Samples of sugarcane juice and white sugar products were obtained from a sugar factory in Java. Determination of chromium content was carried out by dry destruction using Atomic Absorption Spectrophotometer. Organoleptic test was performed using a preference test of 30 untrained respondents. The results had shown that the chromium levels in sugarcane juice were 35 times higher than in white sugar has; sugarcane juice consumption for one month apparently can increase the levels of chromium (both in the blood and in the urine of people) but increased level in diabetes mellitus patients higher than healthy people; and in the terms of the taste, the average respondents' preferences for sugarcane juice and white sugar is the same. This preliminary study showed that sugarcane juice is potential to overcome diabetes mellitus type 2.

1. Introduction
Diabetes Mellitus (DM) is a global problem with the prevalence of 425 million people worldwide in 2017, where prevalence is increasing, both type 1 and type 2 [1]. If this is not handled quickly and responsibly, the prevalence of sufferers will increase to 629 millions in 2045 [1]. The prevalence of DM in Indonesia was 10.3 million in 2007 and in 2030 will increase to reaching 21.3 million [2]. DM can damage blood vessel tissue and chronic diabetes can cause kidney failure and blindness [3].

High blood sugar levels or known as hyperglycemia is one of the characteristics of DM, due to glucose cannot or difficult to enter the cell. In DM type 1, high blood sugar levels are caused by the inability of the pancreas to produce adequate amounts of insulin. DM type 2 is caused by abnormal insulin receptors on the surface of cells that are not sensitive or resistant to insulin [4]. If diabetes type 1 mostly caused by hereditary factors, then diabetes type 2 is generally caused by lifestyle and eating...
patterns, including the low intake of chromium(III) [5]. The insulin receptor is only active if it binds to chromium (III) chromodulin, so chromium is an important component in Glucose Tolerance Factor [6].

Chromium (III) in the diet is usually known as organic chromium, which can later act as glucose tolerance factor. Organic chromium is a complex form between dinitocin acid glutathione complex or chromium picolinate and vitamin B3 or niacin [7]. The daily needs of organic chromium in healthy people are around 50 to 200 μg per day, depending on their age. Patients with diabetes mellitus type 2 need 200 to 1000 μg per day. Consuming chromium over 1000 μg per day is not recommended for health [8].

DM type 2 can cause by insulin resistance, due to a lack of trivalent chromium. This allegedly happened because of people’s habits, who consume white sugar more than brown sugar or sugarcane juice. Refining process will eliminate the mineral content in white sugar and it is thought contain lower mineral than brown sugar or sugarcane juice. The purification process of white sugar increases the level of sucrose, but removes other substances such as chromium in sugarcane juice. Therefore, it should be suspected that the high prevalence of diabetes type 2 is caused by this faulty sugar consumption pattern.

Although chromium chloride or chromium picolinate supplements have been used to overcome the deficiency of organic chromium micro elements in DM patients, but it is still relatively expensive and has to be imported [9]. In addition, these supplements cannot replace sugar as a sweetener. Therefore, it is suspected that consuming sugarcane juice as a substitute for white sugar will be able to increase the level of chromium in the body’s cells, and it will be accepted by the public organoleptically.

The purpose of this study were to compare the levels of chromium in sugar and sugarcane juice, to compare the level of chromium in the blood and urine of healthy and DM patients before and after consuming sugarcane juice twice 200 ml a day for a month, and to know the level of consumers’ preference to the taste and flavour of sugarcane juice compared to white sugar.

2. Materials and Method
2.1. Materials
Samples of sugarcane juice and white sugar were obtained from a sugar factory in Java Island, and as a sample of DM patient was selected a person with a fasting glucose level of 375 mg/dL. This research used descriptive and laboratory experiments design and consisted of several steps.

2.2. Chromium trivalent analysis
First, sugarcane juice and white sugar samples were analysed in the laboratory of Politeknik Negeri Malang by a dissolution of dry destruction result of samples using HNO₃ and HCl, and then measuring chromium content with Atomic Absorption Spectrophotometer using a standard curve of chromium. Second, determined the levels of chromium in the blood and urine of healthy people and DM patients before and after consuming the sugarcane juice for a month, 200 mL every morning and evening. This method is modified from the previous research [10].

2.3. Organoleptic test
The taste and flavor of the sugarcane juice and white sugar samples by 30 untrained respondents. The results of preference test in the form of a score which shows the average level of respondents preference, namely score of 5 (very like), of 4 (likes), of 3 (rather like), of 2 (less like), of 1 (dislike).

3. Results and Discussion
There are three results of this study, (1) comparison of the chromium content in sugarcane juice and white sugar, (2) comparison of chromium content in the urine and blood of healthy people and DM patients, before and after consuming sugarcane juice, and (3) preference test for the taste and flavor of sugarcane juice compared to white sugar.
3.1. Comparison of chromium content in sugarcane juice and white sugar

The AAS results indicate that chromium content in sugarcane juice is much higher than those in white sugar, which is about 35 times. Chromium content in sugarcane juice is 0.4758 ppm while white sugar is 0.0135 ppm. The low chromium content in white sugar is understandable. The purification process of making white sugar is removing useful substances, including the mineral content. Therefore, white sugar becomes only sucrose.

Although the measurement of chromium content using AAS in this study, was calculated as total chromium, the content of chromium in organic samples, however, is thought to be almost entirely in the form of trivalent chromium and not in the form of hexavalent chromium, which is toxic. This is due to the instability of chromium hexavalent [11,12]. Based on the research of Hernandez et al. [13], it was also proven that there was no chromium hexavalent in processed milk and cereals. Therefore, the sugarcane juice is relatively safe because the presence chromium in the form of trivalent chromium and presumed at low rates. In addition, low doses of chromium hexavalent in the body of organism undergoes bioreduction to chromium triavalent and can be excreted in the urine [14].

Trivalent chromium in chromodulin is identified as an active component in glucose tolerance factor which can alleviate impaired glucose tolerance. The occurrence of chromium in our body is beneficial because it can stabilize blood sugar and normalize extreme insulin responses. Therefore, it helps in the treatment of type 2 DM and hypoglycaemia [15]. The effect of chromodulin on insulin is on the functions related to the capacity of blood glucose uptake by cells.

Food is generally only able to meet the daily needs of chromium (50-200 micrograms), less than 60% [14]. Based on the results above, a healthy person, if only using sugarcane juice to fulfill all his/her daily chromium needs, he/she has to consuming 105.3 grams or about 7 tablespoons of sugarcane juice, but if he/she consuming white sugar, he/she has to consume 3.846 kg of white sugar, a number that can actually trigger DM.

3.2. The comparison of chromium content in healthy and diabetes mellitus type 2 patients

Based on the data in Table 1, it can be seen that the chromium content in the blood of healthy people are higher than DM patients. This result is in accordance with previous research [10] that chromium levels in healthy people are higher than in DM patient. The results in Table 1 also showed that consumption of sugarcane juice 200 ml twice a day, can increase the levels of chromium in the blood and urine, both in healthy people and DM patients. However, increased levels of chromium in DM patients is higher than in healthy people.

| Sample           | Before Sugarcane juice Consumption Chromium Content (ppm) | After Sugarcane juice Consumption Chromium Content (ppm) | Increase of chromium (%), Before to After Sugarcane juice Consumption |
|------------------|----------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------|
|                  | Blood          | Urine         | Blood          | Urine         | Blood | Urine |
| Healthy person   | 0.030          | 0.019         | 0.032          | 0.021         | 6.67  | 15.78 |
| DM Patient       | 0.017          | 0.014         | 0.020          | 0.018         | 17.64 | 28.57 |

The presence of trivalent chromium in the blood is related to transfer in protein and transported with iron [16]. Trivalence chromium acts as an insulin cofactor on the cytoplasmic side of cell membrane, through the formation of a complex between insulin receptors on the cell membrane [17]. Chromium forms a complex called chromodulin inside the cytoplasm side of the membran cell. Chromodulin works to stimulate insulin activity by strengthening insulin affinity with insulin receptors, thereby facilitating
glutathione mediated to increase blood glucose flow entering the cells through the plasma membrane [14,15, 18, 19].

In general, DM diseases occurs due to an imbalance of blood glucose levels, which increases from the normal limit (lesser than 200 mg/dL) [20]. By increasing levels of chromium in the blood, it is hoped that the formation of cromodulins is not inhibited, which in turn can increase the sensitivity of cells to insulin. It would be able to entry blood glucose into cells, so that blood glucose levels decrease. Glucose that enters the cell will be converted into energy by cells.

3.3. The result of preference test for the taste and flavor of sugarcane juice compared to white sugar

The organoleptic test results on sugarcane juice (Table 2) showed an average of total score of respondents' preference level is 3.45, indicating that the average panelist tended to like the taste and flavor of sugarcane juice. The score is relatively not different from the white sugar score, which is 3.95.

| No. | Sample         | Score of respondents preference level | Mean  |
|-----|----------------|---------------------------------------|-------|
|     |                | Male (18)                             | Female (12) |       |
| 1.  | White sugar    | 3.8                                   | 4.1    | 3.95  |
| 2.  | Sugarcane juice| 3.7                                   | 3.2    | 3.45  |

The level of preference for sugarcane juice is still slightly lower than that of white sugar, probably because people rarely consuming sugarcane juice compared to white sugar. The results of this preliminary study have shown that the use of sugarcane juice as a substitute for white sugar to cope with diabetes mellitus seems reasonable. In addition, consuming sugarcane juice as habits to replace white sugar in the community, is expected to not only to change people's mindsets and behavior to consume local sugarcane juice as a healthy sugar, but it also increase the added value of the local sugarcane juice. If this happens, then to sugarcane farmers will benefit more, because they are no longer dependent on white sugar factories.

4. Conclusions

The chromium content in sugarcane juice was 35 times higher than in white sugar has; sugarcane juice consumption 200 ml twice a day for one month, apparently can increase the levels of chromium the blood and urine, but the increment level in a DM patient was higher than in a healthy people, and in the terms of the taste and flavor, the average respondents' preference for sugarcane juice and white sugar are the same. This preliminary study has shown that sugarcane juice is potential to substitute white sugar in an effort to overcome diabetes mellitus.

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