



## Acceptance of Stevia as A Sugar Substitute and its Determinants among Health Educated Individuals

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### Abstract

**Introduction:** Stevia is a safe, zero calorie, low glycaemic, natural sweetener and is suitable for pre-diabetic and diabetic patients. This study investigated the perceived effect of a stevia product on taste, satiety, appetite and carbohydrate craving, and its acceptance as a sugar substitute.

**Methodology:** An exploratory study was conducted among the randomly selected group of 73 medical students and eight lecturers. The participants consumed commercially available stevia, replacing sugar, with their morning drink for a week. Data was collected by face to face interview using a standardized questionnaire pre and post stevia challenge.

**Results:** The Majority (66.7%) of respondents from student group liked the taste of stevia, 74.1% experienced after taste and 65.4% reported taste change of the drink with stevia. During the challenge week, 34.6% experienced early satiety, 8.6% had increased appetite and 16.0% noted carbohydrate craving. The majority of respondents were willing to continue with stevia for their health benefits and 95.1% wanted to recommend it for diabetic patients. In contrary, 66.7% of participants from lecturer group did not like the taste of stevia. Significant association was found between the amount of stevia used and liking the taste of stevia ( $p < 0.05$ ). Taste liking is positively ( $p < 0.001$ ) and perceived taste change of the drink is negatively correlated to its acceptance ( $p < 0.05$ ).

**Conclusion:** The majority of respondents demonstrated good acceptance of commercially available stevia product. Liking sweet taste of stevia and perceived taste change of their drink determined the acceptance of stevia product among health educated individuals. Future research should focus on effectiveness of natural sweeteners in reducing calorie intake to fight against obesity to provide public health policy makers with more evidence based information on use of non-caloric sweeteners.



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## Introduction

Epidemic of type 2 diabetes and obesity continued to increase in developing countries in all population and ethnic groups. It has been proved that use of sucrose is strongly linked with weight gain and increased body fat mass when compared with artificial sweeteners.<sup>1</sup> Overconsumption of fructose is also associated with dyslipidemia and lipid deposition in healthy subjects.<sup>2</sup> It is also related with visceral fat deposition and insulin resistance in overweight individuals.<sup>3</sup> Consumption of sugar-sweetened foods and beverages significantly influence the glycemic index of each meal, as well as the diet as a whole.<sup>4</sup> Moreover, excessive intake of high calorie, high glycemic food can result in exaggerated postprandial glucose and insulin levels, and potentially lead to metabolic and hormonal changes that stimulate hunger levels and promote fat deposition.<sup>5</sup> The consumption of foods and beverages containing artificial sweeteners has shockingly increased over the past few years, and approximately 15% of the U.S. population are estimated to consume artificial sweeteners.<sup>6</sup> According to Malaysian clinical practice guidelines, sugar sweetened beverage should be limited to less than two servings in a day.<sup>7</sup>

## Stevia

The plant product sweetener, stevia, contains no calorie and low glycemic index. Therefore, it is suitable for pre-diabetic and diabetic and hypertensive patients, and also for health conscious individuals. Stevia is also a source of protein, ash and crude which are essential for good health.<sup>8</sup> High-purity stevia extracts which contains 95% or more of *steviol glycoside* are approved by major regulatory agencies, including the Joint Food and Agriculture Organization/WHO Expert Committee on Food Additives.<sup>9</sup> An acceptable daily intake (ADI) for *steviol glycosides* was established as 4 mg/kg bw/day.<sup>10</sup> Japan was the first country in Asia to market stevioside as a sweetener in the food and drug industry. Since then, cultivation has expanded to China, Malaysia, Singapore, South Korea, Taiwan, and Thailand.<sup>11</sup> In the United States, high-purity stevia glycosides are considered safe and allowable as ingredients in food products sold in 2017.<sup>12</sup>

Heat stable and PH range resistant stevia has advantages over other artificial sweeteners because there is no colour change after the cooking, therefore,

it can easily mix with juice or milk products.<sup>13</sup> After extensive review of the literature, Panghal and Vikas summarized numerous health benefits of Stevia such as anti-hyperglycemic, anti-cancer, hepato-protective, antihypertensive, anti-caries, antioxidant, and antimicrobial.<sup>14</sup> The availability of stevia-based products in the Malaysian markets could possibly increase consumer awareness of sugar alternatives, however, Malaysians have not whole heartedly accepted such healthy alternative. Information on the current situation of acceptance on stevia and its consumption in Malaysia is limited.<sup>11</sup>

## Effects of stevia on Taste and After Taste

Although stevia is incredibly sweet, at high concentrations, it elicits liquorice-like aromas and a bitter aftertaste. Chemical compounds found in the stevia plant interact with both the sweet and bitter receptors and the structure of glycoside molecules plays a key role in determining sweetness or bitterness in stevia.<sup>15</sup> Compare to rebaudioside A, rebaudioside M has a clean sweet taste with slight bitter or liquorice aftertaste therefore has many beneficial properties and abundant potential as a sweetener in beverage and food products.<sup>16</sup>

## Effects of Stevia on Satiety and Carbohydrate Craving

In comparison to Stevia, other artificial sweeteners (aspartame and sucralose), were associated with increase postprandial hyperglycaemia and postprandial insulin level indicating the possible association of metabolic abnormalities.<sup>17</sup> It was reported that *steviol glycosides* does not have effect on satiety but significantly decreased the daily energy intake.<sup>17,18</sup> Artificial sweeteners decreases sugar consumption leading to less weight gain among healthy school age children.<sup>19</sup> However there is limited information related to stevia's effect on carbohydrate craving.

## Acceptance of Stevia

The result of a survey involving various nationalities with a wide age range, indicated that stevia awareness ranged from 8% to 35%, positive impression of stevia (57% -87%) and acceptance of stevia as "natural" product (48% - 86%) across countries. There appeared to be a relation between overall impression of stevia and the belief that stevia is natural.<sup>20</sup>

Role of artificial sweeteners has evolved from sugar substitutes to health substitutes and are being marketed to the public looking for substitution of sugar. At the same time, we need to look into the user's acceptance of any alternative health product. Although the effect of stevia on blood glucose level appears promising, its acceptance has never been confirmed by in this region.

#### **The Need for Sugar Substitutes Malaysia**

In Malaysia the prevalence of overweight and obesity among adults were 30.0% and 17.7% respectively in 2015 compared to 16.6% and 4.4% respectively in 1996 and the childhood obesity rate was 11.9% in 2015. Decreased productive years in both genders that is directly linked to obesity and its related diseases, costs the government high economically. Again, in 2015, the prevalence of hypertension, diabetes and hypercholesterolemia among men and women aged above 18 were 30.3%, 17.5% and 47.7% respectively.<sup>21</sup>

High calorie food consumption is one of the main causes of high obesity rate in Malaysia. The Malaysian adult nutrition survey 2014 highlighted that the rates of daily rice consumption (86.9%), sugar consumption (55.9%) and sweetened condensed milk consumption (29.3%) are still high among urban and rural adults though the rates became slightly lower than a decade ago.<sup>22</sup> A recently published data suggested the high prevalence of sugar-sweetened drinks consumption among Malaysian school-aged adolescents with the mean daily consumption amount more than 1000 ml, equivalent to four servings per day.<sup>23</sup>

Therefore zero calorie sweeteners can be an alternative to reduce the consumption of sugar or condensed milk consumption. While the majority of the respondents were willing to use Stevia-based products as a sugar substitute, health benefits, promotion, availability, and price were found to be the most influential factors toward acceptance by Malaysian consumers.<sup>11</sup>

According to a study that evaluate the consumer' preference of artificial or natural sweeteners when used in protein blends, the label-conscious segment of consumers preferred beverages sweetened with

natural blends and the flavour-driven segment of consumers conceptually preferred naturally sweetened beverages but preferred sucralose-sweetened beverages when primed. Therefore, the taste of natural sweeteners either stevia or monk fruit can be of one of the determining factor for the consumer acceptance.<sup>24</sup>

Thus, the present study was designed to assess the user's perspective of stevia among health educated individuals and health care professionals after experiencing it by themselves who can be a consumer as well as a prescriber of it.

Therefore this study was conducted with the aim of investigating the effects of stevia on taste, satiety, appetite and carbohydrate craving, and its acceptance as sugar substitute among medical students and medical lecturers in UniKL RCMP. We also determined the factors associated with acceptance of stevia product.

#### **Materials And Methods**

An exploratory study was conducted among the medical students and medical lecturers of University Kuala Lumpur Royal College of Medicine Perak (UniKL RCMP) during the period between 18<sup>th</sup> March 2019 and 12<sup>th</sup> April 2019 with the approval from Medical Research Ethics Committee of University Kuala Lumpur Royal College of Medicine (UniKL RCMP/MREC/2018/SRP-034).

The sample size for this study was estimated 81 assuming that 50% of the subjects would have good acceptance of stevia as a sugar substitute after having experience the taste of stevia and change in taste of food or drink with a precision of 10% for 95% confident level based on previous study findings of positive impression of stevia among the respondents who did not take the challenge.<sup>20</sup> In this study, the lecturers and the students were to give their impression on stevia after one week of stevia challenge therefore we assumed 50% of them would have positive response. During the study period, there were 69 medical lecturers and 571 medical students from five year medical program. Thus, 73 medical students and 8 lecturers were selected by systematic random sampling to be able to get the right student-lecturer ratio.

Inclusion criteria were medical students or medical lecturers from UniKL RCMP, age between 19 and 70 years, who regularly takes breakfast with self-prepared drinks with normal sugar. When the selected student or lecturer refused to participate in this study or did not fulfil the criteria, the next person from the name list was again approached. Participation in this study was made voluntary and written consent was obtained from each respondent after explaining details of the purposes of study and the steps involved. All identities and respondents' responses are being kept confidential from any public domain.

For the stevia challenge, we used commercialized stevia products ( such as EQUALS) which comes in 2 g sachets which contains active ingredients: *steviol glycoside*, 0.83%, *Erythritol* and natural flavorings. In one sachet amount of active ingredient of *steviol glycoside* is only 16.6 mg. Each sachet per

contains 0 g of protein, fat, sugars, dietary fiber and sodium while it contains 1.1 g of carbohydrate per 100 g. Therefore it provides 0 kcal. The safe amount of *steviol glycoside* as approved by the governing bodies of food and drug safety is 4 mg/ kg of body weight/day.

According to the specification, one sachet provides the same level of the sweetness from two teaspoonful of sugar. We provided participants with the amount they need for the sweetening of their morning drinks but it should be lower than the safety level. Even for the participants who use sugar much more than ordinary amount, it will be much lower than the recommended quantity of safety. Stevia sachets were supplied to each participant according to their requirement for one week of the challenge to prepare the drink with stevia replacing the sugar. They can continue with other meals as usual.

**Table 1: Socio-demographic background of respondents and information about the morning drink preparation (n=81)**

Variable	Students (n=73) n (%)	Lecturer (n=8) n (%)
<b>Gender</b>		
Male	25 (34.2)	5 (62.5)
Female	48 (65.8)	3 (37.5)
<b>Academic Year</b>		<b>Educational Level</b>
Year 1	19 (26.0)	Degree 2 (25)
Year 2	12 (16.4)	Masters 4 (50)
Year 3	12 (16.4)	Ph D 2 (25)
Year 4	20 (27.4)	
Year 5	10 (13.7)	
<b>Ethnicity</b>		
Malay	66 (90.4)	2 (25.0)
Chinese	1 (1.4)	0 (0)
Indian	3 (4.1)	3 (37.5)
Others	3 (4.1)	3 (37.5)
<b>Type Of Drinks Taken During Breakfast</b>		
Coffee	30 (41.1)	3 (37.5)
Tea	33 (45.2)	5 (62.5)
Others	10 (13.7)	0 (0)
<b>Amount Of Sugar Used Per Drink</b>		
1-2 tsp+	53 (72.6)	8 (100.0)
3-4 tsp+	17 (23.3)	0 (0)
5-6 tsp+	3 (4.1)	0 (0)

+tsp-teaspoonful

The data was collected using a standardized questionnaire by interviewing method. The questionnaire consists of two parts, Part I (pre-stevia challenge) for demographic data and some information about breakfast preparation and eating interval and frequency and Part II (post-stevia challenge) which consists three parts, Part A on taste, after taste and change in taste Part B about satiety, eating interval in response to hunger and carbohydrate craving and part C about acceptance of stevia.

Data was collected and analyzed according to participants' response on taste, satiety, meal interval, carbohydrate craving and the perception of stevia consumption. Data analysis was done by using the Statistical Package for Social Sciences (SPSS 21).

### Results

A total 73 students and eight lecturers participated in stevia challenge and all signed the informed consent form. The mean age of respondents from student group was  $22.0 \pm 1.1$  years. The majority were female and from Malay ethnicity. The largest proportion of respondents was from Year 4. For their breakfast 45.2% drink tea and 41.1% drink coffee. The majority used 1-2 teaspoonful of sugar per serving. The mean age of lecturer was  $49.5 \pm 1.1$  years and the majority were males. Most respondents from lecturer group preferred tea as their morning drink and all of them took 1-2 teaspoonful of sugar per serving.

Our analysis showed no significant correlation between demographic variables; age, gender, academic year, and either type of drinks taken during breakfast or amount of sugar usually used per drink. ( $p > 0.05$ )

During the challenge week, 7% of the respondents used half sachet of stevia to prepare their drink, 60% used one sachet, 3% needed one and half sachets and 30% preferred two sachets to achieve the sweetness level of their liking.

Among respondents, 66.7% like the taste of the stevia and 68.5% reported that they liked it because of the sweet taste. Among those who dislike the taste

of stevia, 40.7% reported that it was because of liquorice taste. While 74.1% reported the aftertaste, 68.3% had sweet aftertaste and 18.3% had bitter aftertaste. When the drink was prepared with stevia, change in taste of the drink was noted by 65.4% of the respondents.

Only 22.2% of respondents reported that the taste of food is different or changed after drinking with coffee or tea with stevia and 33.3% stated it was due to an aftertaste. Overall, 34.6% of the respondents experienced early satiety, while only 8.6% have reported change in their appetite. The minority (16%) had increased carbohydrate craving during stevia challenge. (Table-2)

The statement "Stevia can be used as a sugar substitute in everyday consumption" was agreed by 71.6% of the respondents and the most common reason given by 56.1% is "health benefits". The majority (80.2%) considered continuing stevia for their health benefits and 95.1% would like to recommend stevia for patients with diabetes. (Table -3)

Result of our analysis for the correlation between amount of stevia used and its effect on taste, aftertaste, change in taste of the drink, satiety and carbohydrate craving is shown in table 4. The only significant association is between liking the taste of stevia, and amount of stevia used ( $p < 0.05$ ). The respondents who used half or two sachets of stevia are more likely to like the taste of stevia.

The significant association was found between acceptance of stevia and liking the taste ( $p < 0.001$ ) or taste change of the drink when prepared with stevia ( $p < 0.05$ ). The larger proportion of respondents who like the taste of stevia demonstrate good acceptance and the majority of the respondents who perceived taste change with stevia exhibit poor acceptance. (Table 5)

### Discussions

In this study, we explored the user's perspective of stevia and determined the factors related to its acceptance as a sugar substitute.

**Table 2: Taste of stevia product and its effect on the taste of drink or food, satiety, appetite and carbohydrate craving (n=81)**

Variable	n (%)	Reason	n (%)
<b>Taste of the stevia</b>			
like	54(66.7)	Sweet	37 (68.5)
		Aromatic	11 (20.4)
		Others:	
		-Different taste	3 (5.5)
		-Sweeter than sugar	2 (3.7)
		-Same taste as sugar	1(1.9)
		Bitter	5 (18.5)
dislike	27 (33.3)	Metallic	2 (7.4)
		Liquorice-like taste	11 (40.8)
		Others:	
		-Too sweet	2 (7.4)
		-Sweet aftertaste	2 (7.4)
		-Taste different from normal sugar	5 (18.5)
<b>Experience after taste of stevia</b>			
Yes	60 (74.1)	Bitter	11(18.3)
		Sweet	41(68.3)
		Others	8(13.4)
No	21 (25.9)		
<b>Experience taste change of the drink with stevia</b>			
Yes	53 (65.4)		
No	28 (34.6)		
<b>Experience taste change of the food after having a drink with stevia</b>			
Yes	18 (22.2)	After taste	6 (33.3)
		Sweeter than with sugar	5 (27.8)
		Different type of sweetness	2 (11.1)
		Weird taste	2 (11,1)
		Aromatic	2 (11.1)
		Less tasty	1 (5.6)
No	63 (77.8)		
<b>Experience early satiety</b>			
Yes	28 (34.6)		
No	53 (65.4)		
<b>Experience appetite change</b>			
		Increased	7 (8.6)
Yes	14 (17.3)	Less	7 (8.6)
No	67 (82.7)		
<b>Experience carbohydrate craving</b>			
Increased	13 (16)		
No change	68 (84)		

**Table 3: Acceptance of stevia product as a sugar substitute(n=81)**

Variables	n (%)	Reason	n (%)
Do you agree that stevia can substitute sugar in everyday consumption?			
Agree	58 (71.6)	1.Health benefits	33 (56.1)
		2. Sweeter than sugar	11 (19)
		3. Same taste as sugar	11 (19)
		4.Cost	1 (1.7)
		5.Minimal after taste	1 (1.7)
		6.Approved clinically	1 (1.7)
Neutral	15 (18.5)	1.Different taste from sugar	5 (33.3)
		2.Depends on the individual who consume it	4 (26.7)
		3.Taste same as sugar	3 (20.0)
		4.Too sweet	2 (13.3)
		5.Good health benefits	1 (6.7)
Disagree	8 (9.9)	1.Different taste from sugar	3 (37.5)
		2.Prefer normal sugar instead of stevia	2 (25.0)
		3.Doubt that it is healthier	2 (25.0)
		4.Tasteless	1 (12.5)
Do you consider continuing stevia for your health benefits?			
Yes	65 (80.2)		
No	16 (19.8)		
Would you like to recommend stevia for a diabetic patient?			
Yes	77 (95.1)		
No	4 (4.9)		

**Table 4: Correlation between amount of Stevia used and its effect on taste, after taste, taste different, satiety and carbohydrate craving (n=81)**

Variable		Half‡ n(%)	One‡ n(%)	One and a half‡ n(%)	Two‡ n(%)	P-Value
Liking of taste	Yes	5 (83.3)	28 (57.1)	0	21 (87.5)	<b>0.010*</b>
	No	1 (16.7)	21 (42.9)	2 (100)	3 (12.5)	
After taste	Yes	4 (66.7)	36 (73.5)	1 (50.0)	19 (79.2)	<b>0.775</b>
	No	2 (33.3)	13 (26.5)	1 (50.0)	5 (20.8)	
Perceived taste change of the drink with stevia	Yes	5 (83.3%)	30 (61.2)	2 (100.0)	16 (66.7)	<b>0.511</b>
	No	1 (16.7)	19 (38.8)			
Early satiety	Yes	3 (50)	17 (34.7)	0 (0)	8 (33.3)	<b>0.636</b>
	No	3 (50)	32 (65.3)	2 (100)	16 (66.7)	
Carbohydrate craving	Yes	1 (16.7)	8 (16.3)	1 (50)	3 (12.5)	<b>0.585</b>
	No	5 (83.3)	41 (83.7)	1 (50.0)	21 (87.5)	

‡Sachets

Among our respondents, the majority of them like the taste of stevia and reported sweet aftertaste. This finding is similar to that reported by Bartolotto<sup>25</sup> and different from the findings of Sontrunnarudrungsri & Tejo,<sup>26</sup> in which the majority of the respondents have an aftertaste of bitter or astringent and undesirable.

The different finding might be the result of different preparation of stevia used in our research, which is a commercialized product and is mixed with other substance whereas in the previous study a pure extract from stevia leaves was used.

**Table 5: Correlation between perception of liking of taste, after taste, taste change, satiety and carbohydrate craving, and acceptance (n=81)**

Variable		Poor acceptance n (%)	Good acceptance n (%)	P-Value
Liking of taste	Yes	12 (40.0)	42 (82.4)	<b>0.000***</b>
	No	18 (60.0)	9 (17.6)	
After taste	Yes	23 (76.7)	37 (72.5)	<b>0.683</b>
	No	7 (23.3)	14 (27.5)	
Perceived taste change of the drink with stevia	Yes	24 (80.0)	29 (56.9)	<b>0.034*</b>
	No	6 (20.0)	22 (43.1)	
Early satiety	Yes	9 (30.0)	19 (37.3)	<b>0.507</b>
	No	21 (70.0)	32 (62.7)	
Carbohydrate craving	Yes	6 (20.0)	7 (13.7)	<b>0.458</b>
	No	24 (80.0)	44 (86.3)	

More than half of our respondents reported no change in satiety during stevia consumption, that is similar to the findings of a previous study.<sup>27</sup> In a previous study, most of the respondents consume less food after taking the stevia but our participants reported same level of appetite during the challenge week.<sup>27</sup> We can assume that the appetite may be reduced if the stevia is given in all three set course meals consisting of breakfast, lunch and dinner as in the previous research. At the same time, we have to acknowledge the shortcoming of our data collection method in which we only record the appetite change at the end of the one-week stevia challenge which is different from previous research which recorded the appetite or hunger by using visual analogue scale before and after each meal daily.

The majority of our respondents reported no change in carbohydrate craving. This finding is adding the evidences from previous studies which revealed stevia does not increase or help in reducing carbohydrate craving among consumers.<sup>25,28,29</sup> No report of decrease in carbohydrate craving among

our respondents, was also an expected finding as this effect can be seen after two weeks up to a month after consuming the stevia. The participants who reported carbohydrate craving must be compensating the amount of calories that they lost during the breakfast as reported that low calories sweetener, providing sweetness without energy, confuse the body's regulatory mechanisms.<sup>30</sup>

In this modern era, consumers around the world have increasing awareness about potential health goodness by reducing calories and sugar intake causing a shift in consumer preferences for healthier low calorie and less sugar food and beverages. There is limited research data on consumer and health care professional perception and attitudes towards low or no calories sugars. In our study, it shows that 71.6% of respondents agree that stevia could substitute sugar in everyday consumption. This result is very similar to a study done in Malaysia, which shows that the majority of their respondents willing to use stevia-based products as a sugar substitute.<sup>11</sup> Their study findings also indicate a significant correlation

between consumer's education level and their willingness to change to stevia-based products. However, in our study as majority of our respondents are well health educated, MBBS degree students and lecturers who hold Ph D and Master degrees therefore we could not determine this association.

According to a study from California, most participants stopped craving of sugar after six days of sugar challenge by cutting all added sugars and artificial sweeteners for two weeks.<sup>25</sup> However, the practicality of stopping sugar consumption without using sweeteners are not supported by the evidence provided by Li, Lopetcharat & Drake which indicates the chocolate milk sweetened with monk fruit and stevia leaf extract is more favoured by the young adults than less sweetened skimmed chocolate milk.<sup>31</sup>

Health benefits, promotion, availability, and price were found to be the most influential factors toward acceptance of Stevia-based products by consumers.<sup>13</sup> In our study, we differentiate poor acceptance and good acceptance based on the composite score calculated from the positive or negative response to three strong statement questions listed in table 3, one of which is related to health benefits. In our study, liking the taste of stevia has strong influence on acceptance.

Again, the after taste may play a role in accepting any sugar substitute. It has been proved that a bitter aftertaste was predominated with 20% or higher level of rebaudioside A and it influence the user's acceptance.<sup>32</sup> However, the results of our analysis did not support their finding of the relation of aftertaste and consumer's acceptance. The strong point behind it, is that we used the product which contains flavourings and the majority of our participants had sweet aftertaste which might be quite acceptable for them. However, among our participants, taste change of the drink while prepared with stevia was negatively linked to the acceptance.

Based on the results, we agreed with the suggestion made by Verruma-Bernardi *et al* to look into optimization of sucrose levels to increase acceptance while minimizing added calories as their study findings indicate that chocolate milk which used

stevia alone was least preferred and that which used of stevia and small amounts of sucrose was most preferred among school age children. The latter preparation saved 40 calories per serving and increased taste acceptance of chocolate milk.<sup>33</sup>

Actually, while global community is fighting against obesity epidemic, zero calorie natural sweeteners become popular as a good substitution of sugar or sugared products. A recent polish survey showed nearly 40% of respondents reported to use sweeteners and nearly half of them are regular users. Among natural and artificial sweeteners, stevia and xylitol are most commonly used and the usage is strongly linked with university education, big city residency and good financial situation.<sup>34</sup>

While stevia use is in rising trend, we need to look at benefits and risks of long term use including the safety of its use in pregnancy. A recent review summarized anti-inflammatory, anti-carcinogenesis, anti-atherosclerotic, anti-diabetic and anti-hypertensive potential of stevia and a growing scientific evidence of anticarcinogenic effect of Stevia rebaudiana Bertoni by inhibition of DNA replication in human cancer cell growth *in vitro*.<sup>35</sup>

Natural sweetener Stevia could also be a good alternative to sugar for pregnant women with diabetes as FDA rated as GRAS (generally recognized as safe) based on the favourable results from animals studies,<sup>36</sup> while *in-utero* exposure of artificial sweeteners could lead to potential to congenital structural malformations and atypical mammary gland structure as demonstrated in mice.<sup>37</sup>

Therefore our health care professionals must be well updated with the evidence based knowledge about the benefits and risks of the use of natural sweeteners that penetrating to the international market and at the same time should be ready to explore more with observational research and clinical trials based on human subjects. With the support of Government and active participation of health care professionals in promoting use of non-caloric sweeteners in food production, there will be voluminous change in public food consumption pattern and high chance of winning in fight of rising trend in obesity.

**Limitations**

The main limitation of our research was the time constraint as we conducted this study as a student research project which allowed only one month to complete. Therefore, we could not perform the stevia challenge more than one week. Furthermore, we did our our stevia challenge only for the breakfast therefore the findings are more accurate for investigating the taste, after taste, change in taste and satiety but not for carbohydrate craving. Besides, we did not explore some possible factors related to its acceptance such as cost, availability, previous knowledge and promotion because our sampling frame is in health educated environment.

**Conclusion and Recommendations**

The majority of our respondents liked the taste of stevia and demonstrated good acceptance of commercially available stevia product. Most of them would recommend it to diabetic patients. Liking sweet taste of stevia and perceived taste change of the drink, determined the acceptance of stevia product among health educated individuals. Future

research should focus on effectiveness of natural sweeteners in reducing calorie intake to fight against obesity to provide public health policy makers with more evidence based information on use of non-caloric sweeteners.

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**Conflict of interest**

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