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A Study on the Effect of Aspartame and Glucose on Post-Prandial Blood Glucose and Cognition

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Abstract

Sugar substitutes play a big role in the lifestyle changes made by many individuals in an effort to control their blood sugar levels. One of the most popular substitute is Aspartame. The question this study seeks to resolve is, does Aspartame really work to produce a lower postprandial blood glucose level hence making it useful for glucose control in diabetes? And does Aspartame affect the mood, memory and concentration of a person differently than 'table sugar'? A randomized control trial was conducted from August-September 2019 in a private medical college in Malaysia. Socio-demographic data, medical background, and mood scores were collected using a questionnaire. Blood glucose levels, before and after test sample consumptions, were measured using a glucometer. Participants also performed 3 computerized tests to assess their memory and concentration abilities. Mean, mean difference, various t-test (paired and unpaired) and p-values were calculated in the statistical analysis of the collected data. From a population of 300 students, we derived a sample size of 30 for which we received 40 volunteers – allowing for a 25% drop out rate. The results of our study were non-significant but indicate that consuming the intervention sample (Aspartame) resulted in a greater decrease in blood glucose levels than the control (Sucrose) sample. There was no significant difference in mood, memory and concentration either. The trend of our findings are coherent with the hypotheses of the study. All findings point to the effect use of Aspartame as a sugar substitute with no significant effects on mood, memory and concentration.

Keywords

Aspartame, Sucrose, Post-prandial, Sugar Substitutes

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1. Introduction

"You are what you eat"; In today's modern world, countless interventions have been created to tackle the various nutritional issues faced by the developing world. [1] Among such interventions are artificial sweeteners (also known as sugar substitutes). The list of common FDA approved artificial sweeteners are Aspartame (sweetener of choice in this study), Acesulfame potassium (ace-K), Advantame, Sucralose, Saccharin, Neotame, Stevia and Siratia grosvenorii extract (which is the extract of a fruit commonly used in traditional chinese medicine (Luo Han Guo)) [2].

Sugar substitutes have been instituted as the intervention of choice to counter increasing incidence of Metabolic disorders such as Diabetes Mellitus. [3] They are beneficial as they provide an equal/more intense sweetness but have less calories when compared per gram of conventional sweeteners. Because substitutes are virtually calorie free and are not carbohydrates, they reduce weight gain and generally do not increase blood glucose levels. [2, 16]

Although the use of Aspartame is in decline, it still remains one of the most commonly consumed sugar substitutes

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among the general population. [4] Aspartame is commercially available under the trademark brands of Equal and Canderal and can be found globally in approximately 6000 consumer food products such as soft drinks, baked goods, candy, jams and dairy products. [18]

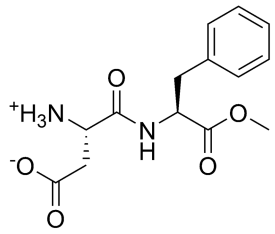

Figure 1. Aspartame 2D Chemical Structure [5].

Aspartame is a non-carbohydrate, artificial sugar substitute. Its chemical name is L-aspartyl-L-phenylalanine methyl ester and it has a molecular formula of C14H18N2O5. [5] Aspartame is 200 times sweeter than sucrose and each gram of Equal has 4kcal. [6] The FDA has established an acceptable daily intake (AD) of 50mg/kg/day of Aspartame (whilst the EFSA has proposed a slightly lower value of 40mg/kg/day). [7, 8] ADI is defined as "the maximum amount of a chemical that can be ingested daily over a lifetime with no appreciable health risk, and is based on the highest intake that does not give rise to observable adverse effects" [9]

Aspartame is metabolized in the body into phenylalanine and aspartic acid, [10] phenylalanine cannot be metabolized in individuals affected by phenylketonuria (an autosomal recessive disorder) - failure to metabolize phenylalanine may lead to its build up in the brain leading to irreversible brain damage. [12] Aspartic acid, its other metabolite, belongs to a group of chemicals called Excitotoxins. Excitotoxins are known to be neurotoxic to areas of the brain unprotected by the Blood-Brain-Barrier. [13] It is shown in a study that the use of aspartame in male Swiss mice a significant dose-related increased incidence of hepatocellular carcinoma ($p<0.01$) and alveolar/bronchiolar carcinoma ($p<0.05$) at the ADI of humans. [14] Due to its potential toxicity, aspartame is considered highly controversial as a sugar substitute. However, it retains its GRAS status with the FDA as it has been proven that doses of 2-100mg/kg produced no dose related effects on behavioural or cognitive performance in humans. Possible adverse effects with consumption of Aspartame include headache, dry mouth, dizziness, mood changes, nausea & vomiting, reduced seizure threshold and thrombocytopenia. [11]

Despite being low in calories, a previous study showed that satiety levels were not affected in both individuals who consumed aspartame or sucrose. The participant did not express any difference in hunger ratings in the immediate period following the consumption of both preloads, however, individuals who consumed Aspartame reported increased hunger after 2 hours. [15] Studies also show that Aspartame has a controversial effect on blood glucose levels. A systematic review on the topic, revealed that only 2 out of 14 similar postprandial studies resulted in lower blood glucose levels. [16] In one such study, it has been shown to cause a significantly smaller rise in postprandial blood glucose levels at 20min compared to Sucrose; but no difference at the 30min mark. However it was observed that consumption of a sucrose preload in that study led to a lower 2 hour postprandial blood glucose level than aspartame. [15]

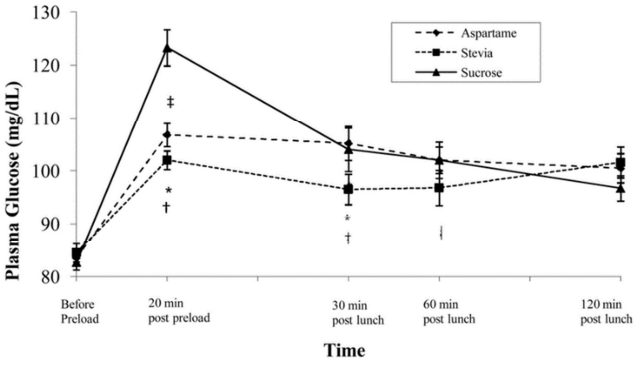

Figure 2. Post Prandial Blood Glucose Comparison Graph [15].

The question this study seeks to resolve is, does Aspartame really work to produce a lower postprandial blood glucose level hence making it useful for glucose control in diabetes? And does Aspartame affect the mood, memory and concentration of a person any differently than 'table sugar' would? To study this, one must first understand what exactly 'table sugar' is.

Simple sugars such as Glucose, Fructose and Galactose are examples of monosaccharides. Disaccharides is formed when 2 monosaccharide combined together and are found in the well-known forms of sucrose, lactose and maltose. [17] Sucrose, also known as "table sugar", is a disaccharide consisting of one molecule of glucose and fructose and has a molecular formula of C12H12O11. [19] It is found naturally in plants are usually extracted for commercial purposes from sugar cane or sugar beet. [20]

Consumption of sucrose causes blood sugar levels in the human body to rise leading to hyperglycaemia which is proven to cause complications such as Diabetes Mellitus and Obesity. [21] As many studies have shown, the overuse of this highly addictive substance is directly correlated to the rising prevalence of metabolic disorders globally. [22, 23] The objectives of this study are to determine and compare the effects of Aspartame versus Sucrose on postprandial blood glucose levels, changes in mood, memory and concentration.

1.1. Research Question

1. Is there a difference in the effect of Aspartame and

Sucrose on post-prandial blood glucose in healthy undergraduate medical students?

2. How does the consumption of Aspartame and Sucrose affect mood in healthy undergraduate medical students?
3. What is the difference in the effect of Aspartame and Sucrose on memory in healthy undergraduate medical students?
4. What is the difference in the effect of Aspartame and Sucrose on concentration in healthy undergraduate medical students?

1.2. Research Objectives

1. To compare the effect of Aspartame versus Sucrose given in equal quantity on post prandial blood glucose levels in healthy undergraduate medical students after 2 hours.
2. To determine and compare any mood changes in healthy undergraduate medical students when given an equal amount of Aspartame and Sucrose.
3. To study the difference in memory levels of healthy undergraduate medical students when given an equal amount of Aspartame and Sucrose.
4. To study the difference in concentration levels of healthy undergraduate medical students when given equal amount of Aspartame and Sucrose.

1.3. Research Hypothesis

1. Aspartame when given in equal amount as sucrose will result in lower post prandial blood glucose level in healthy undergraduate medical students.
2. There is a difference of mood, memory and concentration in healthy undergraduate medical students when consumed Sucrose and Aspartame.

2. Methodology

2.1. Study Design

A randomized controlled trial parallel design was conducted in order to compare the effects of consuming Aspartame (a substitute sugar) versus Sucrose (a table sugar) on blood glucose level, concentration level, mood and short term memory (verbal and number) among students of Melaka Manipal Medical College (MMMC), Muar Campus, Johor, Malaysia.

2.2. Study Setting and Study Population

The study was conducted in MMMC Muar Campus, Johor, Malaysia which has a student population of approximately 300 students from 2 different batches (Batch 38 and Batch 39) studying in their 4th year of Bachelor of Medicine and Surgery (MBBS). The study was held from August to September 2019.

2.3. Sample Size

The sample size was calculated based on the values of previous research entitled, "Effect of Artificial Sweeteners on Blood Glucose Concentrations" (2018) by Toora BD, Seema S, Manju M, Mishra S at Journal of Medical Academics.

Table 1. Data for calculation of Sample Size.

Sample allocation ratio:	**50%/50% (1:1)**
μ_o:	80.42
μ_1:	74.42
Difference in mean:	6
Standard deviation:	5.62
Alpha (α):	0.05
Power	0.8000
Total sample size (N_o+N_1):	30 (15+15)

Based on the results obtained, 15 participants were needed for each group (intervention group and control group). After allowing for a 10% attrition rate, we approximated that 17 participants would be needed for each group. However, for the purpose of this study we selected 40 eligible students who were randomized into 2 groups of 20 - intervention (aspartame) and control (sucrose).

2.4. Sampling and Randomization

Purposive sampling, a form of non-probability sampling, was used in this study in order to obtain the sample from our study population. We requested for 40 volunteers from the 146 students of Batch 39 to join the study. 20 participants were randomized to control group and the 20 participants to the intervention group making use of the software - Research Randomizer (https://www.randomizer.org). The randomization method used was block randomization, block size is 2, to ensure a balance between the intervention and control group. The randomization results are shown in Table 1. The guide for the selection of participants is listed in the Inclusion Criteria displayed in Table 2.

Table 2. Block randomization scheme (Sampling result obtained from https://www.randomizer.org).

Set 1	2,1	Set 11	1,2
Set 2	1,2	Set 12	2,1
Set 3	2,1	Set 13	1,2
Set 4	1,2	Set 14	2,1
Set 5	2,1	Set 15	1,2
Set 6	2,1	Set 16	2,1
Set 7	2,1	Set 17	2,1
Set 8	2,1	Set 18	1,2
Set 9	1,2	Set 19	2,1
Set 10	2,1	Set 20	2,1

Table 3. Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
Student of MMMC willing to voluntarily participate in the study	Known pre-diabetic or diabetic
Age >18 years old	Having a known medical illness
Normal BMI (18.5-24.9)	Random blood glucose equal to or more than 11.1 mmol/L or fasting blood glucose >7.0 mmol/L
Non-diabetic	Hypersensitivity to aspartame
Free from any underlying medical conditions	Consumption of alcohol prior to studies
May or may not consume caffeine regularly prior to the study	On any medication that can alter concentration, mood or memory (For example, anti-depressive, anti-convulsive, et cetera)
Smoker	Having fever, headache, stomach ache or any discomfort/pain during the study that might affect their mood and concentration level

As mentioned before, the subjects for this study were selected based on an inclusion and exclusion criteria. Upon agreement to volunteer for this study, participants were made to give written consent by completing an Informed Consent form. Height and weight measurements were taken during subject selection and BMI was calculated. Random blood glucose also was taken as screening measure to ensure that all subjects are free from diabetic background to ensure the results from the study is more reliable. Previous studies have utilized similar inclusion criteria to design their study. A past study engaged a sample size of 30 healthy individuals age between 18-25 years old with normal BMI range (18.5-25 kg/m^2) and without pre-existing medical illness in order to study the effects of substitute sugar on blood glucose level. However, in this study we will study the effect of substitute sugar and sucrose not only on blood glucose level but additionally on mood, concentration, and short term memory.

2.5. Data Collection

2.5.1. Study Procedure

In this study, the independent variable was the consumption of aspartame and sucrose in equal amounts. While the dependent variables were the blood glucose change score, mood change score, memory and concentration scores. The students were divided into two groups - intervention and control group. Participants who received aspartame were placed in the intervention group and participants who received sucrose were placed in the active control group. Single blinding was applied in this study where all participants were not informed if they were receiving aspartame (intervention) or sucrose (control). All eligible students were given informed consent form at the beginning of the study. As the study required the cooperation and availability of the participants for follow up, they were fully informed about the study procedure and the side effects of the substances used in the study.

Both groups, underwent pre-study screening (BMI, Random Blood Glucose testing). Participants in the intervention group were asked about their mood levels and received 20g of aspartame dissolved with 100mL of water after their random blood sugar sample was taken. After 2 hours, post-prandial blood sugar was taken from the participants and the participants' mood scores were reassessed. Tests for concentration, number and verbal memory were also done. The same procedure was repeated for the active control group except that the participants were given 20g of sucrose with 100mL of water in order to differentiate its effects on postprandial blood glucose level, concentration level, mood, and short-term memory.

2.5.2. Data Collection Instruments

Blood sampling

The blood glucose level of both intervention and control groups' were taken prior to the test sample consumption and 2 hour afterwards. The blood glucose levels were measured by taking capillary blood using an Accu-Check Glucometer Active Series 1 in accordance to the manufacturer's protocol. This method was chosen as it was appropriate in our study set up and more preferable than venous blood.

Concentration level

The concentration levels' of the participants were measured by using the continuous concentration tool from testmybrain.org. The tool has been validated by the Committee on the Use of Human Subjects in Research at Harvard University. The subjects were asked to pay pictures projected on their computer screen and make an appropriate response using a keyboard/touchscreen. As they performed this task, the website recorded all key presses, mouse movements, clicks, and/or interactions with the touchscreen. Each participant' response was analyzed reported.

Mood

The mood of the participants were assessed by using a Mood Scale by Alex Nite, which required the subjects to rate their mood on a scale of 1 (Low mood) to 10 (High mood). The mood scale can be accessed on https://codepen.io/alexnite/details/pRJWjN.

Short-term Memory

Short-term memory ability of the participants was assessed

by using 2 tests from https://www.humanbenchmark.com. Subjects were required to do a 'Verbal Memory' test which measured the number of words he/she could remember. Each participant was made to decide if they had 'seen' the projected word or if it was a 'new' word. The test ends once a participant makes 3 mistakes. The second task was to perform the 'Number Memory' test. Participants were made to remember a sequence of numbers which expanded as they provided the valid response. Getting any one number wrong would result in the test concluding.

2.6. Data Processing and Data Analysis

Data collected in the questionnaire and the study (before and after intervention) for both control and intervention group were input into Microsoft Excel. Epi Info™ version 7 from the Centres for Disease Control and Prevention (CDC) website was used in reviewing and analysing all the data collected. The mean and standard deviation of blood glucose level and mood change score, were compared between control and intervention group. However, comparisons for concentration and short-term memory was done only between intervention and control group as chronological change was not assessed. Mean and standard deviation has been reported and tabulated in the results section of this article. T-test were used as the inferential statistical test of choice. Relative Risk (RR) was calculated as a measure of association and interpretation of the results are based on the mean difference, t value, 95% confidence and level of significance. The table below enumerates the various statistical tests used for each parameter in the study.

Table 4. Statistical Tests.

Independent variable	Dependent variable	Statistical test
Intervention (Aspartame) group vs Control (Sucrose) group	Change score (before – after) of blood glucose level	Unpaired T-test
	Change score (before – after) of mood score	Unpaired T-test
	Concentration	Unpaired T-test
	Short-term memory (total score)	Unpaired T-test
Before vs after in intervention (Aspartame) group	Difference in blood glucose level	Paired T-test
	Difference in mood score	Paired T-test
Before vs after in control (Sucrose) group	Difference in blood glucose level	Paired T-test
	Difference in mood score	Paired T-test

2.7. Ethics

All subjects were brief about the study objectives, procedures and risks. An informed written consent was obtained from all subjects. Participation was voluntary. Subjects were allowed to withdraw from the study at any time of the study without the need of providing any reasons. Subjects were not given any monetary benefits for participating in the study. Approval for conducting the study was obtained from the Department of Community Medicine, Melaka Manipal Medical College and the ethical committee before proceeding with the study.

3. Results

There was a 12.5% drop out rate from our sample pool. The following responses were given by 35 out of 40 initial participants. The respective 5 participants failed to report for follow up.

Table 5. Sociodemographic characteristics of participants between intervention (Aspartame) group (n=17) and control (sucrose) group (n=18).

Variables		Intervention; Aspartame (n=17) n (%)	Control; Sucrose (n=18) n (%)	Total n (%)
Age (years)[a]		22.06 (0.97)	22.50 (0.86)	22.29 (0.93)
Gender	Male	7 (41.18%)	10 (55.56%)	17 (48.57%)
	Female	10 (58.82%)	8 (44.44%)	18 (51.43%)
BMI (kg/m^2)[a]		21.46 (1.73)	21.78 (2.19)	21.62 (1.96)
Mood (before intervention)[a]		6.29 (2.05)	6.89 (1.71)	6.60 (1.88)
Blood glucose level (before intervention)[a]		5.63 (0.89)	5.11 (0.73)	

[a] Mean (SD).

Interpretation:

A total of 35 students participated in this study and were randomized into two group, which was the Aspartame intervention group (n=17) and Sucrose control group (n=18). Table 1 shows baseline characteristics between the intervention group (Aspartame) and control group (Sucrose). The mean age of participants in the intervention group was 22.06 (SD=0.97), while in the control group, the mean age was 22.5 (SD=0.86). For gender, female participants were the majority (58.82%) in the intervention group, however males were the majority (55.56%) in the control group.

The mean BMI in the intervention group (21.46) was very

similar to that of the control group (21.78), with the total mean of 21.62kg/m2. For mood before any intervention was introduced, the mean score was 6.29 in the Aspartame group and 6.89 in the Sucrose group. The mean baseline blood glucose levels in the intervention group (Aspartame) was 5.63 while in the control group (Sucrose), it was 5.11.

Table 6. Comparison in blood glucose level, mood, concentration and memory between the intervention (aspartame) group (n=17) and control (sucrose) group (n=18).

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Intervention; Aspartame (n=17) n (%)	Control; Sucrose (n=18) n (%)			
Blood glucose level change score (before-after)	0.94 (1.11)	0.53 (0.72)	0.41 (-0.23 to 1.05)	1.30 (33)	0.204
Mood change score (before-after)	-0.18 (2.27)	0.00 (1.24)	-0.18 (-1.42 to 1.07)	-0.29 (33)	0.775
Concentration	90.11 (10.57)	82.64 (14.31)	7.48 (-1.22 to 16.17)	1.75 (33)	0.089
Short-term memory (total score)	69.35 (31.01)	59.83 (30.99)	9.52 (-11.81 to 30.85)	0.91 (33)	0.371

Interpretation:

Table 2 shows the comparison of blood glucose level, mood, concentration and memory (n=35) between the intervention (aspartame) group and control (sucrose) group. The mean of the participants' blood glucose levels in the intervention group (aspartame) was 0.94 with standard deviation of 1.11 while in the control group (sucrose) the mean was 0.53 with standard deviation of 0.72. The mean difference (95% CI) and t-statistics of the blood glucose level difference between the intervention and control group were 0.41 (-0.23 to 1.05) and 1.30 respectively. The p-value obtained for blood glucose level difference was 0.204. Hence, there is no significant difference between the two groups in blood glucose level difference before and after the consumption of test samples.

The mean score difference of the participants' mood in the intervention group (aspartame) was -0.18 with standard deviation of 2.27 while in the control group (sucrose) the mean score difference was 0.00 with standard deviation of 1.24. The mean difference (95% CI) and t-statistics of the mood difference between the intervention and control group were -0.18 (-1.42 to 1.07) and -0.29 respectively. The p-value obtained for mood difference was 0.775. Hence, there is no significant difference in the change of mood for both control and interventional groups after consuming the test samples.

The P-values for other measure parameters such as memory (0.371) and concentration (0.089) revealed no significant difference between the intervention and control groups.

Table 7. Short-term memory score of verbal memory and number memory in intervention (Aspartame) group (n=17) and control (sucrose) group (n=18).

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Intervention; Aspartame (n=17) n (%)	Control; Sucrose (n=18) n (%)			
Verbal memory	59.53 (30.38)	50.11 (30.24)	9.42 (-11.43 to 30.27)	0.92 (33)	0.365
Number memory	9.82 (1.59)	9.72 (1.64)	0.10 (-1.01 to 1.21)	0.19 (33)	0.854

Interpretation:

Table 3 shows the breakdown for short term memory scores in both the intervention (Aspartame) and control (Sucrose) groups. The mean verbal memory score for the intervention group was 59.53 (SD=30.38) while the control group score was 50.11 (SD=30.24). The mean difference was 9.42 with 95% CI from -11.43 to 30.27 and the P-value was 0.365. This suggests that there is no significant difference in the mean verbal memory score of both intervention and control groups.

For number memory, the mean score of the intervention group was 9.82 (SD=1.59) while the control group had a mean score of 9.72 (SD=1.64). The mean difference was 0.10 with 95% CI from -1.01 to 1.21 and the P-value was 0.854. This suggests that there is no significant difference in the mean number memory score for both intervention and control groups.

Table 8. Comparison of blood glucose level and mood score before and after in intervention (Aspartame) group (n=17).

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Before (n=17) n (%)	After (n=17) n (%)			
Blood glucose level	5.63 (0.89)	4.69 (0.43)	0.94 (0.36 to 1.51)	3.47 (16)	0.003
Mood score	6.29 (2.05)	6.47 (1.97)	-0.18 (-1.34 to 0.99)	0.32 (16)	0.753

Interpretation:

Table 4 shows the comparison of blood glucose levels and mood score before and after the test samples were consumed in the intervention (Aspartame) group.

The mean blood glucose levels before taking the Aspartame was 5.63 (SD=0.89) which then dropped to 4.69 (SD=0.43) in the 2 hours following the sample consumption. The mean difference was 0.94 with 95% CI 0.35 to 1.51 and P-value of 0.003, hence there was a significant difference in pre and post sample blood glucose levels.

The mean mood score before consuming the Aspartame was 6.29 (SD=2.05), which became 6.47 (SD=1.97) in the 2 hours following the consumption of intervention sample. The mean difference was -0.18 with 95% CI -1.34 to 0.99 and P-value 0.753, hence there was no significant difference in pre and post sample mood scores.

Table 9. Comparison of blood glucose level and mood score before and after in control (Sucrose) group (n=18).

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Before (n=18) n (%)	After (n=18) n (%)			
Blood glucose level	5.11 (0.73)	4.58 (0.69)	0.53 (0.17 to 0.89)	3.12 (17)	0.006
Mood score	6.89 (1.71)	6.89 (1.78)	0.00 (-0.61 to 0.61)	0.00 (17)	1.000

Interpretation:

Table 5 shows the comparison of blood glucose levels and mood score before and after the test samples were consumed in the control (Sucrose) group.

The mean blood glucose levels in participants before consuming the Sucrose was 5.11 (SD=0.73) which then dropped to 4.58 (SD=0.69) in the 2 hours following the sample consumption. The mean difference was 0.53 with 95% CI 0.17 to 0.89 and P-value of 0.006, hence there was a significant difference in pre and post sample blood glucose levels of the control group.

The mean mood score in participants before consuming the Sucrose was 6.89 (SD=1.71), which remained at 6.89 (SD=1.78) in the 2 hours following the consumption of intervention sample. The mean difference was 0.00 with 95% CI -0.61 to 0.61 and P-value was 1.000, hence there was no significant difference in pre and post sample mood scores of the control group.

Table 10. Adverse reactions among the intervention (Aspartame) group (n=17) and control (Sucrose) group (n=18).

Adverse reaction	Aspartame (%)	Sucrose (%)
Headache	0 (0)	2 (11.11)
Dizziness	1 (5.88)	2 (11.11)
Nausea	1 (5.88)	3 (16.67)
Vomiting	0 (0)	0 (0)
Abdominal pain	0 (0)	0 (0)

Interpretation:

Table 6 shows the incidence of adverse effects among participants in the intervention group who consumed Aspartame and in the control group who consumed Sucrose. Only 1 participant reported of dizziness and nausea in Aspartame group while 3 participants experience various adverse reactions among Sucrose group such as headache, dizziness and nausea.

4. Discussion

The study conducted was a randomized control trial done among students of Melaka Manipal Medical College in Malaysia. The objectives of this study were to determine and compare the effects of Aspartame versus Sucrose on postprandial blood glucose levels as well as changes in mood, memory and concentration.

The results of our study were not significant but indicated that consuming the intervention sample (Aspartame) resulted in a greater decrease in blood glucose levels than the control (Sucrose) group. In previous studies, it was proven that consumption of an Aspartame preload reduced postprandial glucose levels more than Sucrose at two hours following the consumption of the preload. Previous studies have also shown that because artificial sweeteners are non-saccharides, unlike sucrose, they generally do not raise glucose levels in the blood. [15] Hence, our results concur with our initial hypothesis that "Aspartame when given in equal amount as sucrose will result in lower post prandial blood glucose level in healthy normal weight adults."

According to previous studies, both aspartame and sucrose consumption have been known to affect certain aspects of neurobehavioral performance (such as mood). One study revealed that consuming normal doses of Aspartame and Sucrose produced no difference in mood between them. Furthermore, high doses of aspartame were reported to cause increased irritability and depression. Another study revealed non-conclusive results on the effect of sucrose on mood. In fact, it was observed that "mood was worst after the sucrose drink, the drink with the highest amount of carbohydrates, which can be attributed to the low score on pleasantness of the sucrose drink." [24] Hence, the results of our study seemingly concur with such findings as the measured change score for mood was positively higher in the intervention group compared with the control. However, this difference was not significant. As a matter of fact, the control group (Sucrose) didn't show any mood changes before and after the intervention.

The mean score for concentration after the test samples were consumed was much higher in the intervention (Aspartame) group when compared to the control (Sucrose) group. However, this difference was not significant. Past studies have been done on the effect of glucose and sucrose on cognitive performance and mood in elderly people. In that particular study, attention and information processing speed were proven to be significantly improved following sucrose consumption. However, its effects on episodic memory, working memory and executive function were non-

substantial [26] The mean score for short term memory after the intervention, is higher in the intervention group (Aspartame) when compared to the control group (Sucrose), however this difference is not significant. Furthermore, each individual component of memory (verbal and numerical) showed similar trends as the mean short term memory with a higher score in the intervention group but with no significant difference. These trends in the test results for mood, memory and concentration do not concur with our initial hypotheses that "fluctuations in blood glucose levels when sucrose is given has a greater effect on altering mood, memory and concentration in healthy normal weight adults when compared to Aspartame".

It can be noted that the blood glucose levels before and after the test samples were consumed in both intervention (Aspartame) and control (Sucrose) groups dropped with a significant difference in pre and post consumption samples.

There were reports of adverse effects (headache, light dizziness and nausea) by a few participants. This finding agrees with previous studies, as consumption of artificial sweeteners has been known to produce adverse effects such as headaches or migraines, weight gain, depression, muscle dysfunction and skin eruptions. [11]

The main strength of our study was a response rate of 87.5% by the participants. We also managed to eliminate selection bias by using block randomization techniques. Furthermore, we minimized information bias by standardizing the conditions for each participant between each data collection (ie before and after consumption of test samples). To reduce confounding bias, we ensured that participants belonged to similar age groups and had a normal BMI. However, including individuals who were smokers may have a confounding effect on the results of this study. Our main limitation was the small size of our sample due to limitations in manpower, time and finance. We could only get participants from a single batch as other batches were unavailable at the time of data collection. Hence, we were unable to confidently answer our research question for the greater population.

Future studies should make use of a larger sample in order to get a more significant results. It is also recommended that future research assesses both pre and post-test sample scores for short term memory and concentration. New researchers, can also explore the use of other sugar substitutes other than aspartame in an attempt to ascertain their effects to a greater detail.

5. Conclusion

In conclusion, although there is no significant difference between the glycaemic response of Sucrose and Aspartame, the study indicated that consuming the intervention sample (Aspartame) resulted in a greater decrease in post-prandial blood glucose levels than the control (Sucrose) group. Hence, it can be an effective tool to control blood glucose level in individuals who would otherwise consume sucrose. Although the difference in change scores for mood, concentration and short-term memory in the control and intervention group were not significant, there is a positive increment in change of score for mood, concentration and short-term memory for the intervention group. Therefore, these results suggest that consuming the intervention (Aspartame) can produce a positive impact on the behaviour and mental ability of a person.

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