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The Effects of *Moringa Oleifera* Intake on Plasma Glucose and Serum Lipid Concentrations in Apparently Healthy Students of College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria.

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Abstract: **The World Health Organization (WHO) has undertaken scientific researches on *Moringa* plant, and has come to the conclusion that it is extremely nutritional and medicinal. This study investigated the effect of oral administration of *Moringa oleifera tea* on serum Total cholesterol (TC), Triglycerides (TG), High density lipoprotein-cholesterol (HDL-C), Low density lipoprotein-cholesterol (LDL-C) and glucose concentrations in young apparently healthy male and female subjects. A total of 40 subjects (20 males and 20 females) were recruited to serve as both the test and control groups. Base line samples were collected from both males and females at day 0 as control samples and levels of glucose and lipid profile were evaluated. Subsequently, in addition to their normal healthy diet, each of the subjects received a sachet of *Moringa oleifera* leaf daily for 21days. After overnight fasting, post research (test 1st& 2nd) samples (fasting blood sample) were collected on days 11 and 22 respectively and the levels of glucose and lipid profile were re-evaluated. The subjects consumed the *Moringa* tea prior to their breakfast daily. Blood glucose and lipid concentrations were determined using standard methods. There was a significant decrease in the mean plasma glucose value 11 days following *Moringa* intake (post-test-1) when compared to the baseline level (4.19±0.76 Vs 4.56±0.42; p<0.05). There was however, significant increase in the mean serum TG value 11 days following *Moringa* intake (post-test-1) when compared to the baseline levels (0.83±0.31 Vs 0.66±0.30; p<0.05). There was also, significant increase in the mean serum TG value 21 days following *Moringa* intake (post-test-2) when compared to the baseline levels (0.81±0.36 Vs 0.66±0.30; p<0.05). There was significant increase in the mean serum VLDL value 11 days following *Moringa* intake (post-test-1) when compared to the baseline levels (0.38±0.14 Vs 0.298±0.14; p<0.05). Also, there was significant increase in the mean serum VLDL value 21 days following *Moringa* intake (post-test-2) when compared to the baseline levels (0.37±0.17 Vs 0.298±0.14; p<0.05). TC, HDL and LDL-C remained unchanged. Interestingly, intake of *Moringa* seemed to reduce the blood glucose concentration and increase the HDL on the short term administration however, it also increased VLDL and TG after the long term administration. From these studies, taking *Moringa* can be beneficial to health.**

Keywords: **High Density Lipoprotein, Low Density Lipoprotein, Very Low Density Lipoprotein and Triglyceride, Total Cholesterol, World Health Organization (WHO).**

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1. INTRODUCTION

The use of herbs as medicines has played an important role in nearly every culture on earth, including Asia, Africa, Europe and the Americas. Herbal medicine is based on the premise that plants contain natural substances that can promote health and alleviate illness. Several herbs can help to reduce high blood cholesterol concentrations (Aattar, 2006). *Moringa oleifera*, locally known as shajna, belongs to the monogeneric family *Moringaceae*, native to India, Africa, Arabia, Southeast Asia, South America and the pacific and Caribbean Island (Iqbal, *2006*)and is widely distributed in the Indo-Bangla subcontinent and cultivated throughout the tropical belt (Nikkon *et al*., 2003). It has been reported that there are thirteen species of *Moringa* trees in the family *Moringaceae* (Kristin, 2000). The *Moringa* tree was introduced to Africa from India at about twentieth century where it was used as health supplements (Bosch, 2004). This rapidly-growing tree also known as horseradish tree or drumstick tree was utilized by the ancient Romans, Greeks and Egyptians. The other names for *Moringa oleifera* include the benzolive tree (Haiti), Saguna/Sainjna(India), Zogale, Bagaruwar Maka (Hausa) Ewe Ile, IgiIyaanu (Yoruba) and Okweoyeibe (Igbo) (Farooq *et al*., 2007). The leaves of *Moringa oleifera* can be eaten fresh, cooked or stored as dried powder for many months and reportedly, without any loss of its nutritional value (Arabshahi *et al*., 2007). *Moringa* leaf has been purported to be a good source of nutrition and naturally organic health supplement that can be used in many therapeutic way (Fahey, 2005). The leaves are considered as rich source of mineral (Gupta *et al*., 1989), polyphenol (Bennette *et al.,* 2003), flavonoids (Lako *et al.,* 2007), alkaloid and protein (Soliva *et al.,* 2005). These essential nutrients can help to combat many chronic diseases. The leaves are also rich in biologically active antioxidant α carotene, querectin, Isoquercetine, kaempfrerol, zeatin, rutin. (Siddhuraju and Becker, 2003; Yang *et al*., 2006). Vitamin C has health promoting potential to maintain a balance diet and preventing free radicals damage that can initiate much illness (Smolin *et al*., 2007). Epidemiology studies have indicated that *Moringa* leaves are a good source of nutrition and anti tumor anti-inflammatory, anti ulcer, anti atherosclerotic, anti convalescent activities. (Churmark *et al.,* 2008).Different parts of this plant are used in the indigenous systems of human medicine for the treatment of a variety of human ailments. The leaves of *Moringa oleifera* are reported to be used as a hypocholesterolemic agent, and hypoglycemic agent (Siddiqui and khan, 1968; Ghasi, *et al*., 2000; Dangi, *et al*., 2002).

Lipid profile is a panel of blood tests that serves as an initial broad medical screening tool for abnormalities in lipids (Sidhu and Naugler, 2012). It is well known that the lipid fraction of plasma particularly total cholesterol and LDL intervene in the process of arteriosclerosis; the clinical manifestation of which is cardiovascular disease, high levels of LDL and total cholesterol are risk factors for cardiovascular disease. The role of lipids in the etiology and management of cardiovascular disease has been of concern for decades (Kris-Etherton *et al*., 1999). This study have investigated the effect of oral administration of *Moringa oleifera tea* on serum lipid profile (Total cholesterol, Triglycerides, HDL cholesterol and LDL cholesterol) and glucose levels in young apparently healthy male and female subjects prior and after the administration, and to compare the difference between the effect of this leaf extract on blood glucose and lipid profile levels in both sexes.

2. MATERIALS AND METHODS

Study Area:

Nnamdi Azikiwe University, Okofia-Otolo, Nnewi campus comprises the college of Health Sciences having the faculties of Basic Medical Sciences, Health Sciences and Technology and Medicine. It is located in the suburb of Nnewi - a popular town in Anambra State Nigeria. The environment is poorly developed and lacking basic amenities such as housing, road, communication, electricity and potable water compared to campuses located in urban areas.

Study Design:

A total of 40 subjects (apparently healthy young male and female students those are not obese, diabetic within the age range of 18-35 years) were recruited to serve as both the test and control group. 5mls of whole blood was collected from the subjects using the standard venepuncture technique, after overnight (12 hours) fast. The blood samples (3ml)and 2mls were dispensed into plain and fluoride oxalate sample containers respectively for the estimation of biochemical parameters. Base line samples were collected from both the males and females at day 0 as control sample and levels of glucose and lipid profile (TC, TG, HDL, LDL) were evaluated using standard methods as described by Bergmeyer and Bernt (1974), Roeschlau *et al.* (1974); Tietz *et al.* (1995); Burstein *et al.* (1980); Assman *et al.* (1984) respectively.

Subsequently, in addition to their normal healthy diet, each of the subjects received a sachet of *Moringa oleifera* leaf daily for 21days. Post research (test 1st& 2nd) samples were collected on days 11 and 22 respectively and the levels of glucose and lipid profile were re-evaluated. The subjects consumed the *Moringa* tea prior to their breakfast daily. Arterial blood pressure was measured using a sphygmomanometer by auscultatory method while the weight was measured with a weighing balance and height measured to the nearest centimetre by a measuring tape. Questionnaires were used to obtain some information such as age and feeding habits of the subjects.

Ethical Consideration:

Ethical approval was obtained from the Faculty of Health Sciences and Technology ethical committee, NnamdiAzikiwe University, Nnewi campus, Anambra State, Nigeria for sample collection.

Statistical analysis:

Statistical package for social science (SPSS) version 20 was employed in the analysis of the result and the results were presented as mean± standard deviation. Student t-test was used to and compare the pre andpost-tests and result were considered significant when($p<0.05$).

3. RESULTS

There was significant difference in the mean SBP of males when compared to females (114.00±15.01 Vs 104.50+8.87; $p<0.05$), while there was no significant difference in the mean Age, DBP, and BMI of the male and female participants (Table 1). There was no significant difference in the mean plasma glucose value of male when compared to female ($p>0.05$). There was no significant difference in the mean serum TC, TG, LDL, VLDL values of male when compared to female ($p>0.05$). There was significant decrease in the mean serum HDL value of male when compared to female (0.97±0.29 Vs 1.24+0.27; $p<0.05$) (Table 2).There was a significant decrease in the mean plasma glucose value 11 days following Moringa intake (post-test-1) when compared to the baseline level (4.19±0.76 Vs 4.56±0.42; $p<0.05$). However, there was no significant difference in the mean plasma glucose value 21 days following Moringa intake (post-test-2) when compared to the baseline levels and also between post-test-2 and post-test-1($p>0.05$). More so, there was no significant difference in the mean serum cholesterol value 11days following Moringa intake (post-test-1) when compared to the baseline level, 21days following Moringa intake (post-test-2) when compared to the baseline levels and also between post-test-2 and post-test-1 ($p>0.05$). However, there was significant increase in the mean serum triglyceride value 11 days following Moringa intake (post-test-1) when compared to the baseline levels (0.83±0.31 Vs 0.66±0.30; $p<0.05$). Also, there wassignificant increase in the mean serum triglyceride value 21 days following Moringa intake (post-test-2) when compared to the baseline levels (0.81±0.36 Vs 0.66±0.30; $p<0.05$)**.** There was no significant difference in the mean serum triglyceride value between post-test-2 and post-test-1 ($p>0.05$). There was no significant difference in the mean serum HDL value 11 days following *Moringa* intake (post-test-1) when compared to the baseline levels, 21 days following *Moringa* intake (post-test-2) when compared to the baseline levels and also between post-test-2 and post-test-1($p>0.05$). There was no significant difference in the mean serum LDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to the baseline levelsand between post-test-2 and post-test-1($p>0.05$). There was significant increase in the mean serum VLDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels (0.38±0.14 Vs 0.298±0.14; $p<0.05$). Also, there was significant increase in the mean serum VLDL value 21 days following Moringa intake (post-test-2) when compared to the baseline levels (0.37±0.17 Vs 0.298±0.14; $p<0.05$)**.** There was no significant difference in the mean serum VLDL value between post-test-2 and post-test-1 ($p>0.05$) (Table 3). There was no significant difference in the mean plasma glucose value 11 days following intake of Moringa (post-test-1) when compared to the baseline levels, 21 days following *Moringa* intake (post-test-2) when compared to baseline levels and between post-test-2 and post-test-1 ($p>0.05$). There was no significant difference in the mean serum TC value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to baseline levels and between post-test-2 and post-test-1 ($p>0.05$). There was no significant difference in the mean serum TG value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following intake of Moringa (post-test-2) when compared to baseline levels and between post-test-2 and post-test-1 ($p>0.05$). There was no significant difference in the mean serum HDL value 11 days following Moringa intake (post-test-1) when compared to baseline

levels, post-test-2 when compared to baseline levels and between post-test-2 and post-test-1 (p>0.05). There was no significant difference in the mean serum LDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following intake of Moringa (post-test-2) when compared to baseline levels and between post-test-2 and post-test-1 (p>0.05).There was no significant difference in the mean serum VLDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to baseline levels and between post-test-2 and post-test-1 (p>0.05) (Table 4). There was a significant decrease in the mean plasma glucose value 11 days following Moringa intake (post-test-1) when compared to the baseline levels (4.05±0.47 Vs 4.61±0.37; p<0.05). There was no significant difference in the mean plasma glucose value 21 days following Moringa intake (post-test-2) when compared to the baseline levels (p>0.05). Also, there was significant increase in the mean plasma glucose value between post-test-2 and post-test-1 (4.57 ± 0.33 Vs 4.05±0.47; p<0.05). More so, there was no significant difference in the mean serum TC value 11 days following intake of Moringa (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to the baseline levels and between posttest-2 and post-test-1(p>0.05). However, there was no significant difference in the mean serum TG value 11 days following Moringa intake (post-test-1) when compared to the baseline levels and also between post-test-2and post-test-1 (p>0.05). Also, there was significant increase in the mean serum TG value 21 days following Moringa intake (post-test-2) when compared to the baseline levels (0.75 ± 0.35 Vs0.55±0.20;p<0.05)**.** There was no significant difference in the mean serum HDL value 11 days following intake of Moringa (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to the baseline levels and between post-test-2 and post-test-1 levels (p>0.05). There was no significant difference in the mean serum LDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, 21 days following Moringa intake (post-test-2) when compared to the baseline levels (p>0.05). There was significant increase in the mean serum LDL value between post-test-2 and post-test-1 (2.86±0.78 Vs 2.49±0.56; p<0.05). There was no significant increase in the mean serum VLDL value 11 days following Moringa intake (post-test-1) when compared to the baseline levels, between post-test-2 and post-test-1 (p>0.05). Also, there was significant increase in the mean serum VLDL value 21 days following Moringa intake (post-test-2) when compared to the baseline levels (0.34 ± 0.16 Vs 0.25 ± 0.09; p<0.05) (Table 5)**.**

There was no significant difference in the mean plasma glucose value of males when compared to that of females (p>0.05). There was no significant difference in the mean serum TC, TG, LDL, VLDL values of males when compared to females (p>0.05). There was significant decrease in the mean serum HDL value of males when compared to females (1.01±0.24 Vs 1.24±0.29; p<0.05) (Table 6). There was no significant difference in the mean plasma glucose value of males when compared to females (p>0.05).There was no significant difference in the mean serum TC, TG, HDL, LDL, VLDL values of males when compared to females (p>0.05) (Table 7).

Table 1:The Age, Systolic Blood Pressure, Diastolic Blood Pressure, and Body Mass Index of Male and Female Subjects Before Intake of Moringa oleifera (Mean ± SD) .

Parameters	Male(n=20)	Female (n=20)	T - value	P-value
Age (Years)	23.55 ± 3.20	22.55 ± 1.93	1.195	0.239
SBP (mmHg)	114.00 ± 15.01	104.50 ± 8.87	2.437	0.020*
DBP (mmHg)	75.90 ± 10.35	71.00 ± 9.12	1.588	0.120
BMI(kg/m^3)	23.98 ± 3.71	26.75 ± 7.01	1.556	0.128

*** Significant p<0.05**

Table 2: Serum Levels of the Parameters in the Male and Female Subjects at Baseline (Mean ± SD).

Parameters	Male (n=20)	Female (n=20)	T - value	P-value
Plasma Glucose (mmol/l)	4.53 ± 0.49	4.57 ± 0.39	0.249	0.805
Serum TC(mmol/l)	3.96 ± 0.92	4.38 ± 0.88	1.452	0.155
Serum TG(mmol/l)	0.74 ± 0.30	0.61 ± 0.20	1.634	0.110
Serum HDL (mmol/l)	0.97 ± 0.29	1.24 ± 0.27	2.982	0.005*
Serum LDL (mmol/l)	2.65 ± 0.75	2.85 ± 0.76	0.855	0.398
Serum VLDL (mmol/l)	0.34 ± 0.14	0.27 ± 0.09	1.619	0.114

***significant p<0.05**

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Table 3: ***Effect of Moringa oleifera Intake on Glucose and Serum Lipid Levels*** **(Mean ± SD).**

Parameters	Baseline n = 28	Post-test 1 (11th day) n = 28	Post-test 2 (22nd day) n = 28	T-value/P-value (B & Pt-1)	T-value/P-value (B & Pt-2)	T-value/P-value (Pt-1 & Pt-2)
Plasma Glucose (mmol/l)	4.56±0.42	4.19±0.76	4.53±0.53	2.11/0.045*	0.30/0.76	1.85/0.07
Serum TC (mmol/l)	4.12±0.90	4.04±0.68	4.14±0.86	0.47/0.64	0.13/0.90	0.67/0.51
Serum TG (mmol/l)	0.66±0.30	0.83±0.31	0.81±0.36	2.45/0.02*	2.45/0.02*	0.32/0.75
Serum HDL (mmol/l)	1.07±0.29	1.12±0.28	1.02±0.30	1.06/0.30	1.32/0.20	2.21/0.36
Serum LDL (mmol/l)	2.75±0.79	2.54±0.63	2.75±0.80	1.46/0.16	0.03/0.98	1.68/0.10
Serum VLDL (mmol/l)	0.298±0.14	0.38±0.14	0.37±0.17	2.44/0.02*	2.54/0.02*	0.29/0.78

***significant p<0.05**

Table 4: Effect of Moringa oleifera on Glucose and Lipid Levels Before and After Administration on Male Subjects (Mean ± SD; N=15).

Parameters	Baseline mean± SD	Post-test - 1 (11th day)	Post-test - 2 (22nd day)	T-value/P-value (B & Pt-1)	T-value/P-value (B & Pt-2)	T-value/P-value (Pt-1 & Pt-2)
Plasma Glucose (mmol/l)	4.52 ± 0.47	4.30 ± 0.94	4.48 ± 0.67	0.74/0.47	0.15/0.88	0.59/0.57
Serum TC (mmol/l)	4.04 ± 0.99	3.99 ± 0.73	3.96 ± 0.94	0.17/0.87	0.39/0.70	0.14/0.89
Serum TG (mmol/l)	0.75 ± 0.35	0.89 ± 0.22	0.85 ± 0.38	1.54/0.15	1.18/0.26	0.38/0.71
Serum HDL (mmol/l)	0.98 ± 0.30	1.01 ± 0.24	0.92 ± 0.30	0.46/0.66	0.98/0.34	1.67/0.12
Serum LDL (mmol/l)	2.72 ± 0.83	2.58 ± 0.71	2.65 ± 0.82	0.61/0.55	0.44/0.67	0.35/0.73
Serum VLDL (mmol/l)	0.34 ± 0.16	0.41 ± 0.10	0.39 ± 0.17	1.54/0.15	1.27/0.23	0.33/0.74

***significant p<0.05 ; B = base line; Pt-1 = post-test 1; Pt-2 = post-test 2.**

Table 5: Effect of Moringa oleifera on Glucose and Lipids Levels Before and After Administration on Female Subjects (Mean ± SD; N=13).

Parameters	Baseline	Post-test - 1 (11th day)	Post-test - 2 (22nd day)	T-value/P-value (B & Pt-1)	T-value/P-value (B & Pt-2)	T-value/P-value (Pt-1 & Pt-2)
Plasma Glucose (mmol/l)	4.61 ± 0.37	4.05 ± 0.47	4.57 ± 0.33	3.12/0.01*	0.40/0.70	3.42/0.01*
Serum TC (mmol/l)	4.21 ± 0.83	4.08 ± 0.64	4.34 ± 0.74	0.62/0.55	0.70/0.50	1.44/0.18

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Serum TG (mmol/l)	0.55 ± 0.20	0.76 ± 0.38	0.75 ± 0.35	1.87/0.09	2.35/0.04*	0.08/0.94
Serum HDL (mmol/l)	1.18 ± 0.23	1.24 ± 0.29	1.13 ± 0.26	1.05/0.32	0.86/0.41	1.45/0.17
Serum LDL (mmol/l)	2.78 ± 0.78	2.49 ± 0.56	2.86 ± 0.78	1.73/0.11	0.61/0.55	2.72/0.02*
Serum VLDL (mmol/l)	0.25 ± 0.09	0.35 ± 0.17	0.34 ± 0.16	1.86/0.09	2.37/0.04*	0.08/0.94

***significant p<0.05; B = base line; Pt-1 = post-test 1; Pt-2 = post-test 2.**

Table 6: Serum Levels of Parameters for Male and Female Subjects at Post-test – 1.

Parameters	Male (n=15)	Female (n=13)	T - value	P-value
Plasma Glucose (mmol/l)	4.30 ± 0.94	4.05 ± 0.47	0.907	0.371
Serum TC (mmol/l)	3.99 ± 0.73	4.08 ± 0.64	1.466	0.152
Serum TG (mmol/l)	0.89 ± 0.22	0.76 ± 0.38	0.902	0.373
Serum HDL (mmol/l)	1.01 ± 0.24	1.24 ± 0.29	2.253	0.031*
Serum LDL (mmol/l)	2.58 ± 0.71	2.49 ± 0.56	0.737	0.466
Serum VLDL (mmol/l)	0.41 ± 0.10	0.35 ± 0.17	0.893	0.378

***significant p<0.05**

Table 7: Serum Levels of Parameters for Male and Female Subjects at Post-test – 2.

Parameters	Male (n=15)	Female (n=13)	T - value	P-value
Plasma Glucose (mmol/l)	4.48 ± 0.67	4.57 ± 0.33	0.234	0.817
Serum TC (mmol/l)	3.96 ± 0.94	4.34 ± 0.74	0.726	0.474
Serum TG (mmol/l)	0.85 ± 0.38	0.75 ± 0.35	1.018	0.317
Serum HDL (mmol/l)	0.92 ± 0.30	1.13 ± 0.26	1.629	0.115
Serum LDL (mmol/l)	2.65 ± 0.82	2.86 ± 0.78	0.424	0.675
Serum VLDL (mmol/l)	0.39 ± 0.17	0.34 ± 0.16	1.040	0.307

***significant p<0.05**

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4. DISCUSSION

In this study, the mean systolic blood pressure was higher, whereas the mean diastolic blood pressure was similar in males than in females prior to *Moringa* consumption. Previous studies, have indeed reported gender associated differences in blood pressure, and androgens such as testosterone are implicated in the association (Bachmann, *et al*., 1987 and Harshfield, *et al*., 1994). It was reported that after the onset of puberty, boys have higher blood pressure than their age-matched girls (Bachmann, *et al*., 1987 and Harshfield, *et al*., 1994). At ages 13 to 15 years, systolic blood pressure was approximately 4 mm Hg higher in boys than girls, and at ages 16 to 18 years, boys had higher systolic blood pressures than girls by 10 to 14 mm Hg (Harshfield, *et al*., 1994).In this study, the male subjects had a higher systolic blood pressure compared to the females. These data clearly show that in adolescence and puberty, when androgen levels are increasing, blood pressure increases in boys than in girls.

On the other hand, the mean serum high density lipoprotein cholesterol (HDL-C) concentration was significantly lower in males than in females before *Moringa* intake, 11 days following daily *Moringa* intake. In previous studies it was observed that women have higher HDL cholesterol levels than men and hence one of the reasons women have a lower incidence of coronary disease (Gordon *et al*., 1989). Moreover, the magnitude of this difference is greatly influenced by genetic differences, environmental factors such as cigarette smoking, alcohol consumption, body mass, and exogenous hormone use. However, the observed difference in HDL-C 11 days following *Moringa* intake was not as a result of *Moringa* intake, as there was no difference in HDL-C concentration prior and following *Moringa* intake in males and females. Therefore the difference between males and females was the initial difference prior to *Moringa* intake. Interestingly, there was no significant difference and *Moringa* intake effect on serum total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C).

The overall effect of *Moringa* consumption on male and female subjects (total studied population), showed a significant decrease in the mean values of plasma glucose concentration 11days following daily consumption of *Moringa* (post-test-1) compared to baseline (prior to *Moringa* intake). This was in line with the previous study in rats, which showed lowered blood glucose concentration in rats administered the aqueous leaf extract of *Moringa oleifera* (Oyewo *et al*., 2012b). This observation was attributed to the levels of alkaloids and polyphenols in the extract (Oyewo *et al*., 2012b). However, the mean glucose level on the 22nd day showed no significant reduction rather it returned to the concentration prior to *Moringa* intake. This may be attributed to factors such as complaints by subjects, which ranged from increased appetite, to travels by some of the subjects. Some of the subjects resorted to eating more than usual and some may have evaded *Moringa* intake which the researcher is unaware of. The compliance was very good up to the 11th day of intake of the *Moringa* extract by subjects. The probable mechanism of the reduction in blood glucose level could be through the prevention of absorption of glucose in the gut and/ or increased insulin secretion by pancreatic stimulation (Borhanduddlin *et al*., 1994). However, the reported levels of alkaloids, saponins and flavonoids (Oyewo *et al*., 2012b) in *Moringa* might have prevented the absorption of dietary glucose in the gastrointestinal tract (Khanna *et al*., 2002) and (Oyewo*et al*., 2012a) reported that saponins in diets interferes with the absorption of glucose in the small intestine. Thus, the high content of saponins in the leaf extract (Oyewo *et al*., 2012b) could have permeabilized the plasma membranes of the small intestine, thereby causing disruption of the plasma membrane and hence marked reduction in the absorption of dietary glucose in the gastrointestinal tract due to 'autointoxication' or "leaky gut' (Choi *et al*., 2001; Evers, 2008).

In addition, it was also reported IL-6 mediates the absorption of dietary glucose in the gastrointestinal tract by enhancing or inhibiting the intake of glucose by GLUT-2. Serum IL-6 concentration mediates glucose absorption in the small intestine, thereby regulating the exocytosis of insulin by the pancreas and the oxidation and uptake/storage of glucose at the muscles by GLUT-4 (Hardardottir *et al*., 1994). The probable explanation for the trend obtained in the blood glucose levels is the prevention of the absorption of glucose in the gastrointestinal tract by the reported levels of alkaloids, saponins and flavonoids in the aqueous leaf extract (Oyewo *et al*., 2012b). In line with this, the reduction in the blood glucose concentrations in apparently healthy humans administered with the aqueous leaf extract supported the reported immune modulating activities of the aqueous leaf extract of *Moringa oleifera* (Oyewo *et al*., 2012b), as some immune modulating regimes are reported to possess blood glucose reducing or maintenance properties (Spleman *et al*., 2006; Oyewo and Akanji, 2011; 2012a). Volk *et al*., 1993 also reported that increase in blood glucose levels reduced the phagocytic index of macrophage and neutrophils by 75%. In addition, Langley- Evans and Carrington, 2006, reported that increased concentrations of glucose in the blood proportionally reduce the ability of cell-mediated immune cells to

capture bacteria and increased the incidence of degenerative diseases (cancer). Therefore, the trend obtained in the blood glucose levels in apparently healthy individuals administered the aqueous leaf extract of *Moringa oleifera* could be recommended in clinical conditions where the reduction/maintenance of blood glucose level is required. Furthermore, there was significant decrease in the mean values of plasma glucose post-test-1 compared to baseline of females and increase in post-test-2 compared to post-test-1. This corresponded with previous research which reported that females have a higher percentage of body fat and tend to accumulate more subcutaneous fat than males, whereas males have a lower percentage of body fat and accumulate more visceral fat (YazminMacotela, 2009). Despite the higher level of body fat, female humans and rodents are more insulin sensitive than males. Thus, women have improved glucose tolerance and increased insulin sensitivity compared with men (Boyns *et al*., 1969; Yki-Jarvinen, 1984).

The intake of *Moringa* caused a significant increase in the mean values of TG throughout the duration of the study. Similarly, serum VLDL also increased, which is a reflection of the fact that VLDL transport endogenous TG. This result however, contradicted that of previous studies, which reported a significant decrease in TG (Kumara, 2010). Their study on type 2 diabetic patients given 8 g *Moringa oleifera* leaf for 40 days showed a decreasing trend in plasma triglycerides (Kumari, 2010). Other previous study demonstrated that *Moringaoleifera* possesses a hypolipidaemic effect (Mehta *et al.*, 2003). However, the concentrations of TC and LDL on the 11th day following Moringa intake were reduced though not significant.

In females, mean concentrations of serum TG and VLDL equally increased post *Moringa* intake. There was also significant increase in the mean value of LDL post Moringa intake. This was in contrast with previous study which showed decreased serum TG and LDL levels, which are likely associated with the alkaloid, saponin, flavonoids contents of *Moringa* (Oyewo *et al*., 2012b). These contrary findings may be due to the difference in duration of the research. Some studies therefore concluded that the leaves of *Moringa oleifera* have definite hypocholesterolaemic activity (Ghasi *et al*., 2000). Women tend to have a greater number of alpha receptors in the hip and thigh regions (Blaak, 2001). The differences in the type and number of cell receptors may be one of the mechanisms contributing to the differences in fat distribution between men and women (Blaak, 2001). Another mechanism contributing to the differences in fat distribution between men and women is the concentration of lipoprotein lipase (LPL) in various tissues. Women have a higher LPL concentration and activity in the hip and thigh region compared to the abdominal region (Pollock & Wilmore, 1990). There are several proposed mechanisms for this increase in fat mobilization. First estrogen has been found to inhibit the hormone LPL (Ashley *et al*., 2000). LPL is responsible for the breakdown of TG in the blood stream for storage in adipose tissue or fuel for active tissues. Secondly, estrogen has been shown to enhance epinephrine production. A higher concentration of epinephrine would increase the activity of HSL, the hormone responsible for adipose tissue lipolysis. Another factor that could promote a higher fat metabolism in women is an increase in blood flow to adipose tissue, especially during exercise (Braun and Horton, 2001).

5. CONCLUSION

The intake of Moringa seemed to have reducing effect on blood glucose levels, increases high density lipoprotein. However, it also increases very low density lipoprotein and triglycerides. These observed effects of Moringa were more pronounced in females than males. While the changes in the parameters were not significant in males, in female intake of Moringa caused significant decrease in blood glucose concentration and an increase in both TG and VLDL.

6. RECOMMENDATION

Adequate nutritional and health education strategies should be adopted to enlighten the general public on the beneficial effects of Moringa. Therefore, more and long term studies are needed to fully understand the full benefit of Moringa consumption.

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