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Effect of Tropical Vegetable Oil Consumption on Lipid Profile and Glycaemic Control in Type 2 Diabetics

[1,2]*Dorice Akosua Berkoh*, [1]*Emmanuel Timmy Donkoh*, [1]*Akwasi Asamoah*, [1]*Raji Abdul Sakibu*, [2]*William Kwame Boakye Ansah Owiredu and* [2]*Robert Amadu Ngala*

[1]*Department of Medical Laboratory Science, University of Energy and Natural Resources, P.O. Box 214, Sunyani, Ghana*

[2]*Department of Molecular Medicine, School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology, Kumasi Ghana*

ABSTRACT

Background and objective: Divergent relationships with several inconsistencies have been established on the effect of vegetable oils consumption on blood glucose and lipid profiles in type 2 diabetes. The study sought to determine the effect of consuming some tropical vegetable oils on glycaemic and lipid control in type 2 diabetes patients in the middle belt of Ghana and evaluate the relationship between lipid profile and FBG. **Materials and Methods:** In an open-labelled 4-arm parallel prospective dietary cohort study, 62 type 2 diabetic out-patients on metformin medication, consumed meals supplemented with red palm oil (n = 17), groundnut oil (n = 16) or coconut oil (n = 21) as the only source of fat for 4 weeks except control (n = 8) whose diets were not supplemented with vegetable oil or any other oil. A twelve hour fasting venous blood samples were collected at baseline and week 4 (W4), FBG and lipid profile were then determined. **Results:** There were no significant metabolic changes in the fasting blood glucose and lipid profile generally in the diabetics after the consumption of the vegetable oils. No statistically significant ($p>0.05$) changes were observed in blood glucose levels across all groups from baseline to W4. Although, serum triglycerides (TG) was significantly increased ($p = 0.020$) among groundnut oil-treated group from baseline to W4, there were no significant correlations observed between FBG and lipid profile indices across all groups. **Conclusion:** The consumption of different tropical oils; red palm oil, coconut oil and groundnut oil did not impair glycaemic control or induce dyslipidaemia in type 2 patients.

KEYWORDS

Type 2 diabetes, fasting blood glucose, lipid profile, palm oil, groundnut oil, coconut oil

INTRODUCTION

Type 2 diabetes (T2D) has become a major public health problem affecting 425 million people worldwide and is currently described by the International Diabetes Federation (IDF) as an "emerging medical emergency of the 21st century" due to the alarming rate of increase in the number of diagnosed diabetics over the past decade[1,2]. Decades ago the incidence of diabetes in sub-Saharan Africa was less than 2%[3].

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In Ghana the prevalence of diabetes is about 6%[4]. This percentage is believed to be worsening as the country acquires a middle-income status with corresponding changes to increased sedentary lifestyle and the consumption of energy dense diets high in fat but low in carbohydrates[5]. These lifestyle dietary changes have resulted in an increase in the incidence of diabetes mellitus and other diet-related diseases, including, obesity, hypertension cardiovascular disease and stroke in developing countries[6].

Somes studies have related, high fat intake, particularly, rich in saturated fatty acids to reduced insulin sensitivity and secretion[7,8] and the aetiology of type 2 diabetes[9]. Insulin sensitivity has been proven to be decreased by fats and oils[10].

The quality of fat in the diet is relevant to the health status of the diabetics and hence it is argued that substituting foods high in saturated and trans fats for those rich in mono and polyunsaturated fatty acids may reduce the risk of CVD and improve glucose metabolism[11,12]. The World Health Organisation (WHO) in a bid to enforce the consumption of healthy fats introduced the REPLACE action package policy as a strategy to eliminate the consumption of trans fatty acids by 2023[13]. Furthermore, contrasting views from various research findings have been established between fasting blood sugar (FBG) and lipid profile parameters in type 2 diabetes[14,15]. Studies have shown in a Chinese population, that the consumption of certain fats and oils were associated with an increased risk of type 2 diabetes[16]. Many clinicians have therefore discouraged patients of type 2 diabetes from consuming fats and oils or at least limit their consumption.

However certain oils including vegetable oils have been shown to have positive effect on diabetes management. Indeed fish oil supplementation has been proven to improve insulin sensitivity in rat study[17]. Olive oil is a vegetable oil that has also been scientifically proven to have least dyslipidaemic and atherogenic effect[18].

In Ghana, particularly in rural and peri-urban settings, red palm oil, coconut oil and groundnut oil are commonly used for cooking due to their availability and the prohibitive cost of imported or refined oils[19]. It is believed that prudent consumption of these indigenous oils to supplement a balanced diet may be cost-effective and reduce the risk of CVD for diabetic patients living on low income in sub-Saharan Africa[20]. Ngala *et al*.[21] have shown in animal studies, that rodent chow, supplemented with 10% by weight red palm oil, coconut oil and groundnut oil significantly reduced fasting blood glucose with no dyslipidaemia. Despite the positive effect of these vegetable oils in the rodent study, little is known about the effect of this vegetable oil consumption on FBG and the lipid profile of Ghanaian type 2 diabetes patients and the healthy population. This study therefore investigates the effects of the consumption of three tropical vegetable oils, amist the belief that fats and oils consumption negatively impact glycaemic and lipid control in type 2 diabetes patients.

MATERIALS AND METHODS

Study design and setting: This was an open-labelled, 4-arm parallel prospective dietary cohort study in which 62 diabetic out-patients of both sexes between the ages of 30-75 attending Sunyani and Duayaw Nkwanta Hospitals-Ghana, who had volunteered and given written and/oral consent were recruited between June to December, 2022. Patients consuminmg alcohol or smoking and those with existing malignancies or autoimmune diseases were excluded. All patients were on metformin prescription. A standardised questionnaire was used to collect demographic and clinical data. Patients were administered daily intake of one of the three vegetable oils which were added to their regular meals for four weeks exclusively on their preference. Red palm oil, extract from African oil palm, *Elaeis guineensis,* groundnut oil extracted from the nuts of *Arachis hypogaea*) and coconut oil (extracted from the kennel of *Cocos nucifera*). The quantity of oil administered was based on each individual's BMI, was calculated and converted into handy measures equivalent to 20-30 g of oil/day/person.

Ethical approval: Ethical approval was obtained from the Kintampo Health Research Centre (KHRC) Institutional Ethics Committee (KHRCIEC/2018-22) with additional permission from the Regional Health Directorate of the Ghana Health Service, Bono Region. Study participants were adequately informed of the purpose, nature, procedures, risks and hazards of the study and signed informed consent forms according to the recommendations of the local ethics review committees that were approved. All work was conducted in accordance with the declaration of Helsinki[22].

Blood sample collection and analyses: As 12 hrs fasting venous blood samples were collected into serum separator tubes at baseline and week 4 for lipid profile assessment. Serum samples were separated by centrifuging at 3000 rpm for 10 min from the respective tubes and stored at -20°C until analysis. Fasting blood glucose was measured with a (OneTouch Select Plus Simple®) glucometer while serum concentrations of total cholesterol (TC), High-Density Lipoprotein Cholesterol (HDL-C) and triglycerides (TG) were assayed with standardized enzymatic methods using commercial kits (Medsource Ozone Biomedicals Pvt. Ltd., India). Low-Density Lipoprotein Cholesterol (LDL-C) was calculated using the Friedewald equation:

$$\text{LDL - C (mmol / L)} = \frac{\text{TC - HDL - TG}}{2.2}$$

The LDL-C is low density lipoproteins, TC is total cholesterol, HDL is high density lipoprotein and TG is triglycerides.

Statistical analysis: The results obtained from the FBG and lipid profile analyses were presented as Mean±SEM. A paired t-test was used to compare the mean FBG and lipid profile parameters with a one-way ANOVA to compare the differences among treatment groups. A $p<0.05$ was considered statistically significant. A multivariate logistic regression (Pearson-Correlation coefficient) was used to assess the correlation between the FBG and lipid profile indices of treatment groups at week 4. The p-values of <0.05 and <0.01 (two-tailed) were considered statistically significant.

RESULTS

Relationship between FBG and lipid profile parameters at W4: Out of the 62 patients recruited (mean age 61±8.5 years), 19 (30.6%) were male while 43 (69.4%) were female. As 18 (28.7%), 33 (53.5%) and 11(17.9%) attended clinics at the Sunyani Regional Hospital, Municipal Hospital and the St. John of God Hospital, Dua-Yaw Nkwanta, respectively. All other demographic data for the level of education, marital status, presence of- and type of comorbidity, religion and family history of diabetes and presence of family support in addition to health insurance cover were presented in Table 1.

The distributions across treatment groups based on patients' preference for oil are as follows: 8 (12.9%) patients were allocated to the control group while 17 (27.4%), 16 (25.8%) and 21 (33.9%) were assigned to comsume palm coconut and groundnut oils, respectively (Table 2).

There were no significant changes in the plasma glucose level in all the oil treatment in the diabetes patients (Table 3).

There was no significant difference in the absolute glucose values between the control and all the treatment groups (Table 4).

Lipid profile results of respondents from baseline to week 4: There were no significant changes in lipid profile across all groups, total cholesterol (TC) increased among the control, palm oil-treated and groundnut oil-treated groups from baseline to W4 but slightly decreased among the coconut oil-treated group. The HDL, LDL and TC were not significantly changed in all the treatment groups compared to the control.

Table 1: Demographics of study participants

Parameter	Frequency	Percentage
Total	62	100
Age Mean±SD (Years)	61±8.5	
Hospital		
Regional Hospital	18	28.7
Municipal Hospital	33	53.4
Duayaw Nkwanta Hospital	11	17.9
Gender		
Male	19	30.6
Female	43	69.4
Marital status		
Single	5	7.5
Married	33	53.9
Separated/widowed	24	38.6
Educational level		
Non-formal	16	26.5
Basic	19	30.3
Secondary/vocational	21	34.6
Tertiary	5	8.6
Employment status		
Unemployed	17	26.8
Employed	4	7
Self-employed	24	39.4
Pensioner	17	26.8
Religion		
Christian	55	89
Muslim	7	11
Presence of family support		
Yes	42	67.7
No	20	32.3
Family history of diabetes		
Yes	38	61.9
No	24	38.1
Presence of comorbidity		
Yes	45	72.6
No	17	27.4
Comorbidities		
Hypertension	39	62.9
Ulcer	6	9.6
Insurance cover		
None	0	0
NHIS	62	100

Table 2: Distributions of dietary intervention groups

Variable	Frequency (%)
Treatment group	
Control	8 (12.9)
Palm oil	17 (27.4)
Coconut oil	16 (25.8)
Groundnut oil	21 (33.9)
Total	62 (100)

Table 3: Fasting blood glucose among treatment groups from baseline to W4

	Mean FBG (mmol/L)				
Treatment group	Baseline	Week 4	t-value	Df	p-value
Control	9.9±2.8	8.3±2.6	1.13	5	0.310
Palm oil	10.0±3.7	10.6±3.1	-0.40	11	0.697
Groundnut oil	10.8±4.9	10.3±2.6	0.24	13	0.817
Coconut oil	10.8±4.6	11.8±3.1	-0.92	18	0.371

Effect of vegetable oils on plasma glucose of diabetes patients. Mean values are expressed as ±SEM. N: 8, 17, 16 and 21 for the control, palm, groundnut and coconut oil groups, respectively, $p<0.05$, indicate a significant difference between the group and the control

Table 4: ANOVA comparison of the absolute differences between the week 4 and baseline FBG among treatment groups against the control group

Treatment group	Mean (W4-B_FBG)	Standard deviation	Mean difference (I-J)	Standard error	p-value	95% confidence lower bound	95% confidence upper bound
Palm oil	1.93	1.56	-1.06	1.27	0.91	0.93	2.92
Groundnut oil	3.64	3.08	0.65	1.24	0.47	1.86	5.41
Coconut oil	2.51	2.57	-0.48	1.19	0.82	1.27	3.74

Table 5: Effect of vegetable oil consumption on plasma lipid profile in type 2 diabetes patients after 4 weeks treatment

	Treatment	Baseline	Week 4	t-value	df	p-value
CHOL	Control	4.19±0.59	5.17±0.32	-2.006	6	0.092
	Palm oil	4.91±0.27	5.18±0.21	-1.341	13	0.203
	Groundnut oil	4.89±0.24	5.11±0.42	-0.393	13	0.701
	Coconut oil	5.40±0.28	5.35±0.23	0.254	18	0.802
TRIG	Control	1.39±0.24	1.75±0.15	-1.439	6	0.200
	Palm oil	1.69±0.23	1.67±0.20	0.112	13	0.913
	Groundnut oil	1.56±0.10	2.06±0.26	-2.662	13	0.020*
	Coconut oil	1.87±0.22	1.97±0.16	-0.611	18	0.549
HDL	Control	1.43±0.26	1.3±0.35	0.473	6	0.653
	Palm oil	1.51±0.26	1.16±0.16	1.482	13	0.162
	Groundnut oil	1.14±0.16	1.37±0.18	-0.888	13	0.391
	Coconut oil	1.42±0.14	1.44±0.22	-0.034	18	0.974
LDL	Control	2.13±0.43	3.08±0.54	-1.475	6	0.191
	Palm oil	2.65±0.22	3.04±0.33	-1.184	14	0.256
	Groundnut oil	3.04±0.25	2.80±0.49	0.377	13	0.712
	Coconut oil	2.97±0.28	2.93±0.24	0.139	18	0.891
LDL/HDL ratio	Control	1.79±1.08	3.53±2.46	-1.737	6	0.133
	Palm oil	2.39±1.51	3.39±2.06	-1.840	14	0.087
	Groundnut oil	3.21±1.51	2.73±2.35	0.617	13	0.548
	Coconut oil	2.70±1.89	3.28±2.52	-0.851	18	0.405

Effect of vegetable oils on the plasma lipids of diabetes patients. Mean values are expressed as Mean±SEM in each group. TC: Total cholesterol, LDL: Low density lipoprotein, HDL: High density lipoprotein, TG: Triglycerides and compared to controls, $p<0.05$, indicates a significant difference

There were also no significant changes in the cardiovascular risk indiex across all groups for all the oils (LDL/HDL).

Only triglyceride was significantly ($p = 0.020$) increased in the groundnut oil-treated group but not above the physiological upper reference range (Table 5).

The TC, TG and LDL were positively correlated with FBG while HDL negatively (-0.643) correlated with FBG among the control group though not significant. For the palm oil-treated group, all lipid profile parameters were non significantly negatively correlated with FBG while for the groundnut oil-treated group, there was a positive correlation between FBG and TG but a negative correlation was found between TC, LDL, HDL and FBG. There was a positive correlation between FBG and TC, TG and HDL with a negative correlation between LDL and FBG for the coconut oil-treated groups. Although, some of these findings are consistent with other research findings, none were considered to be statistically significant (Table 6).

DISCUSSION

Insulin is the major hormone controlling plasma glucose homeostasis. However this effect is impaired in type 2 diabetes patients, whose predicaments are a result of insulin resistance, hence medication including insulin secretegoques (sulfonylureas and glinides) and insulin sensitizers (metformin, pioglitazone), are administered to achieve a glycaemic control[23].

The Ghana Health Service treatment guideline for type 2 diabetes requires metformin as the first line therapy[24], therefore all the subjects were on metformin prescription. The antidiabetic effect of metformin

Table 6: Correlation between W4-FBS and lipids

		W4-FBG	
Treatment group	Lipids	Pearson correlation value	p-value
Control	W4-CHO	0.365	0.477
	W4-TG	0.260	0.618
	W4-TG/2.2	0.260	0.618
	W4-HDL	-0.643	0.168
	W4-LDL	0.553	0.255
Palm oil	W4-CHO	-0.571	0.085
	W4-TG	-0.111	0.760
	W4-TG/2.2	-0.111	0.760
	W4-HDL	-0.035	0.923
	W4-LDL	-0.347	0.326
Groundnut oil	W4-CHO	-0.079	0.789
	W4-TG	0.131	0.656
	W4-TG/2.2	0.131	0.656
	W4-HDL	-0.179	0.539
	W4-LDL	-0.072	0.806
Coconut oil	W4-CHO	0.171	0.484
	W4-TG	0.190	0.435
	W4-TG/2.2	0.267	0.270
	W4-HDL	0.303	0.207
	W4-LDL	-0.181	0.457

on glycaemic control is due to the inhibition gluconeogenesis, reduction of intestinal glucose absorption and improve peripheral glucose uptake and insulin sensitivity[25]. The activity of metformin is not known to be negatively affected by plasma lipids. Clinical studies have demonstrated that metformin positively modifies lipids metabolism[26,27] by altering fatty acid de novo synthesis and the mitochondrial β-oxidation of fatty acids[28]. However, lipids have been proven to impair insulin sensitivity[29], whilst other studies have shown that sesame oil has a synergistic effect with anti-diabetic medication in patients with type 2 diabetes mellitus[30].

The consumption of the local vegetable oils; coconut, groundnut and red palm oils for four weeks did not significantly alter the blood glucose levels compared to the base line (Table 3). Metformin administration alone (control) did not reduce the blood glucose of the diabetics to the physiological range. Indeed, base line blood glucose levels in all the subjects were higher than the normal reference range (3.4-6.4 mmol/L). Comparison of the absolute differences in the blood glucose levels (Table 4) in the subjects were also not significantly changed.

There are various multifactorial and complex reasons given for poor glycaemic control in T2D[31] that are patient- and disease-related or psychosocial. These include factors such as age, physical activity, educational level, lack of knowledge of diabetes and glycaemic targets, smoking, poor or inadequate Self-Monitoring of Blood Glucose (SMBG), duration of diabetes, presence of comorbidities, missing scheduled hospital appointments, poor adherence of medication and diet, anxiety and depression, false beliefs about treatments and availability of family and/or social support[32,33] (Table 1).

According to Afaya *et al.*[34] persons aged below 50 years constitute a larger proportion of patients with poor glycaemic control. While some studies report young age to be associated with poor glycaemic control, other studies report no statistically significant relationship between age and glycaemic control[35]. Again, it is believed that elderly people are more likely to comply with diabetes management regimens and hence have better glycaemic control than young individuals[36]. Yet, advancement in age can lead to the development of comorbidities and also cause a decline in beta-cell function in diabetic patients[31]. Both of these theories could account for the poor glycaemic control observed among the study participants since the average age recorded in this study was 61 years and all patients had at least one comorbidity (Table 1). Furthermore, it is reported that patients with one or more comorbidities such as hypertension or cardiovascular diseases have increased odds of having poorer glycaemic control due to an increased burden of medication from combined drug therapy and hence increases the probability of non-compliance[30] (Table 1). The recorded baseline high glucose level, may also imply either a poor compliance with prescribed medication or not following dietary guidelines. Medication adherence is significantly associated with glycaemic control and targets for good glycq1aemic control can be achieved by adhering to appropriate medications[37,38]. There is evidence to suggest that the practice of following dietary and lifestyle interventions with medication is not completely adhered to worldwide, which could be due to the giving of pharmacotherapy before diet and lifestyle interventions[39]. It can therefore be inferred that the consumption of these vegetable oils per se did not worsen the glycaemic control as has been observed in the consumption of some oils in a some studies by Zhuang *et al.*[16] and Okuyama *et al.*[40]. However, in a similar animal study, lipids-induced improved glycaemic control was observed[21].

Studies have long shown that, saturated fatty acids and cholesterol raise the plasma cholesterol high plasma lipid levels havebeen shown to induce insulin resistance in various body organs, including the liver, the adipose tissue, the hypothalamus, the skeletal muscle, the pancreas and the intestines by different mechanisms[41]. Although, these mechanisms are not fully understood, at the cellular level, the insulin signaling effect from its receptor to its final action is impaired. However, the phosphorylation of insulin receptors at the serine or threonine positions, may exacerbate the breakdown of the phosphorylated protein and therefore impair insulin signaling[41,42] level and are a cardiovascular risk, whereas Polyunsaturated Fatty Acids (PUFA) lowers it and have reduced cardiovascular and diabetic risk because of the LDL lowering effect. In addition, soluble fiber and vegetarian diets favorably affect plasma lipid levels[43]. The administration of the vegetable oils to diabetic patients did not result in dyslipidemic effect (Table 5). The consumption of vegetable oils in the four week period did not induce cadiovascular risk. Indeed the cardiovascular risks calculated 1.79±1.08, 2.39±1.51, 3.21±1.51 and 2.70±1.89 for the controls, palm, groundnut and coconut oils respectively, were within the physiological range of 0-7 (Table 5).

Although, there was a significant increase in triglycerides after the intake of groundnut oil, the triglyceride concentration of 2.06 mmo/L was within the physiological reference range of up to 2.26 mmol/L set up by the laboratory. All the other lipid parameters were not significantly changed compared to the control and not significantly above the upper reference ranges.

The vegetable oils in this study consisted of a mixture of various fatty acids depending on the oil source. The groundnut oil consists of 46 and 32% of Monounsaturated Fatty Acids (MUFA) and Polyunsaturated Fatty Acids (PUFA), respectively. The palm oil contains an almost equal amounts of saturated and unsaturated fatty acids[44] and coconut oil though a saturated fat mainly consists of medium-chain fatty acids[45,46].

It is therefore not surprising that the oils when consumed at the appropriate amount did not have any dyslipidaemic effect because all the oils were not fully saturated, the unsaturated portion may have had a counter effect on the metabolic activity of the saturated part.

The metabolism of glucose and lipids are interrelated, Randle *et al.*[47] proposed a “glucose-fatty acid cycle” that describes the selectionof fuel by tissues. The cycle explains the inhibition of glucose oxidation by fatty acids. This principle has been investigated by other researchers and new theories explaining the utilization of glucose and fatty acids, including that the changes in lipids and glucose levels which are interconnected through coordinated metabolic pathways and acetyl-CoA formation in which the changes of one pathway can affect the other[48].

Hence, blood lipids must be well-controlled in T2D patients to slow down or limit complications and/or mortality rates[49]. In the diabetic control group of this study, FBG positively correlated with TC, TG and LDL (0.365, 0.260, 0.530) but negatively with HDL (-0.079) (Table 6) which establishes the already existing evidence of the relationship between blood glucose and lipid profile parameters in diabetes. Although, these findings were statistically non-significant but showed the trend of lipid glucose relation. A similar relationship was established between HbA1c and lipid profile where LDL, TC, TG, LDL/HDL ratio, TG/HDL ratio and TC/HDL ratio were positively associated with HbA1c while HDL was negatively associated[50]. In another study in India, FBG positively correlated with TG, HDL, LDL, VLDL and TC in a diabetic population when compared with healthy population in which FBG positively correlated with TG, VLDL and TC but negatively correlated with HDL and LDL[51]. These findings are suggestive of the complex and variable nature of lipid and glucose metabolism in both diabetic and non-diabetic populations. The disparities in observations made from these studies could be due to the heterogeneity of study populations, differences in research designs, differences in variable definitions or inadequate adjustment for medical confounders[10].

Nutritional or dietary interventions have a significant impact on FBG and lipid profiles49. In the current study, FBG was negatively associated with lipid profile in the palm oil intervention group; while for the groundnut oil-treated group, there was a positive correlation between FBG and TG (0.313, p = 0.020) but a negative correlation was found between TC, LDL and HDL (-0.079, -0.179, -0.072) and FBG. In the coconut oil intervention group, FBG positively correlated with TC, TG and HDL (0.171, 0.190, 0.303) but negatively correlated (-0.181) with LDL. There was no statistically significant relationship between FBG and the lipid profile of all intervention groups compared to the control. This is similar to findings from a study done in India in which, no significant relationship was established between FBG and lipid profile among sedentary individuals consuming a non-vegetarian diet even though high levels of FBG and HbA1c were recorded[52].

Even though the vegetable oil intervention did not significantly ameliorate the glycaemic and lipid control as was observed by Ngala *et al.*[21] in the animal study, the oil intervention did not also induce dyslipidamia or hyperglycaemia. The plasma lipid values observed were not significantly higher than the upper reference ranges of the physiological ranges in our Clinical Laboratory setting (TC: 3.9-5.2, Trg: 0.5-2.6, HDL 0.9-2.2 and LDL 0.0-3.8 mmol/L). It therefore implies the Ghanaian tropical vegetable oils do not impair glycaemic and lipid control in type 2 diabetics contrary to other findings elsewhere[10,53]. These oils may therefore not be contraindicated in the management of type 2 diabetes. The study was conducted using Ghanaian subjects and locally extracted oils, further studies may be required to acertain the effect in other populations.

CONCLUSION

The consumption of tropical vegetable oils (palm, coconut and groundnut oils) did not negatively impact on blood glucose levels of type 2 diabetes patients.The consumption of the vegetable oils did not also induce dyslipidaemia or impair glyceamic control effect of metformin in the management of type 2 diabetes. This finding therefore provides guide to clinicians monitoring diatary regulations in diabetes patients.

SIGNIFICANCE STATEMENT

High plasma lipids have been shown in several studies to impair glucose metabolism in diabetic patients.

Some clinicians therefore prescribe olive oil (believed to be the least atherogenic inducing oil) or reduced fat intake by diabetic patients to make it easy to maintain a glucose homoeostasis. However, lipids are essential in several metabolic processes including energy production, cell membrane synthesis and the biosynthesis of other biomolecules and therefore their consumption cannot be compromised with. Animal studies have shown that the consumption of some tropical vegetable oils rather improve glucose homeostasis and did not induce dyslipidemia in diabetic mice and these oils are cheaper in cost compared to olive. The study therefore investigates the effect of supplementation of some tropical vegetable oils In the diets of type 2 diabetic patients: palm, coconut and groundnut oil on glucose homeostasis. It is hoped that these oils may have similar effect as was observed in the animal study and may therefore go a long way in reducing the cost of management of type 2 diabetes.

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