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Full Length Research Paper

Weight reduction with improvement of serum lipid profile and ratios of S*esamum radiatum* leaves diet in a non-obese Sprague Dawley rats

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Development of **novel natural dietary adjunct/agent with significant therapeutic effects on metabolic disease conditions such as obesity and heart disease raises concern in recent times. We studied chronic toxicity of the combined active ingredients present in the sesame leaves and their interaction on the fasting serum lipid profiles with their ratios in thirty adult male non-obese Sprague Dawley (SD) rats. Such that, both treated groups received 14.0 and 28.0 mg/kg body weight doses of aqueous leaves extract of *Sesamum radiatum* respectively on a daily basis via gastric gavage, while, the control received equal volume of normal saline daily for six weeks. Significant ($P < 0.05$) weight loss observed in the treated groups was associated with significant ($P < 0.05$) reductions in both serum cholesterol and triglycerides (TG). The effect on the serum lipoprotein cholesterol components and ratios were significant in a dose related manner, such that increase in HDL accompanied a corresponding decrease in both LDL and LDL/HDL ratio. In addition, to increased in TG/HDL ratio. However, no significant differences in the relative reduction level of VLDL and triglycerides in the treated groups were found compared to control. Thus, LDL/HDL ratio is significantly a better indicator than the TG/HDL ratio in assessing the impact of sesame treatment with evidence of weight loss and hypolipidaemia especially in hypertensive heart diseases.**

Key words: Aqueous extract, GC/MS, hypolipidaemia, rats, weight loss.

INTRODUCTION

The development of new dietary adjuncts and novel natural anti-obesity agents with a reducing effect on the long-term complications associated with metabolic syndrome, thereby helping to reinstate a normal metabolic environment in the body have been expressed in recent times. Today, obesity has attained a pandemic health-needs concern status affecting all age groups worldwide and recognized since ancient times to be a clinical syn-

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drome with multiple aetiology. However, it is a chronic complex metabolic syndrome with genetic determinants and associated with serious long term morbidity and mortality worldwide (Arner, 2000; Nanchanda et al., 2005). Also, recognized by World Health organization to be among the top 10 global health problem, such that over 1 billion adults are overweight and more than 300 billions are obese, worldwide with a rising incidence from country to country (Marx, 2003). This was corroborated with data from US National Health and Examination Survey in 2003 - 2004, which revealed that 67% of adults are overweight or obese, with 17% of children and adolescents overweight (Ogden et al., 2006).

We know that as our body mass index (BMI) increases, the total and LDL-cholesterol increases while, the HDL-cholesterol decreases. Thus, it is not surprising that coronary heart disease (CHD) is the leading cause of death worldwide and is strongly linked to overweight and obesity in adolescent. As obtained from report of the 1998 National Health Survey (NHS) in England, where excess body weight alone accounted for 47% of the CHD found in these high-risk men (United States Renal Data System, 1998).

Adipose tissue is now known to play a vital role in body metabolism (carbohydrates, proteins, and lipids) through the exclusive secretion of arrays of proteins such as adiponectin (also called Acrp30 or adipoQ in mice) (Scherer et al., 1995; Maeda et al., 2001). Other studies have shown that plasma concentrations of adiponectin are lower in high fatty diet, obesity and type 2 diabetes (Hotta et al., 2000; Weyer et al., 2001) and that adipose tissue Acrp30/adiponectin mRNA expression is equally reduced in obese *ob/ob* mice and obese humans (Hu et al., 1996). However, its impact on dietary fat or vice versa is unknown. Although, one potential pathway is the activation of nuclear receptor peroxisome proliferator-activated receptor-γ (PPAR-γ), involved in peroxisomal β oxidation of fatty acids. Such that, PPAR-γ can also be activated by fatty acids in itself (Green, 1995) and that pharmacologic activation with PPAR-γ agonists including hypolipidaemic agents has led to increased plasma adiponectin concentrations (Maeda et al., 2001; Miyazaki et al., 2004). However, increase in level of sesamin (phytoestrogenic-lignans) consumption in diets has been found to progressively increase the mitochondrial and peroxisomal fatty acid oxidation activity rate in rats (Jeng and Hou, 2005).

Study also showed that hyperlipidaemic treatment would reduce 25 - 30% of CHD risks in patients and that free fatty acids are associated with rise in myocardial oxygen consumption (Nasiruddin and Ahmed, 2006). It is now known that certain nutritional factors present in our natural diets through certain mechanisms can reduce serum cholesterol level, these substances include dietary soluble fiber (Saltzman et al., 2001), plant sterols (Jones, 1999; Meguro et al., 2001; Maki et al., 2001) and phytoestrogens-lignans (Potter et al., 1998; Baum et al., 1998). More so, serum lignan concentrations has an inverse relationship with the risk of acute coronary heart disease as shown in a recent population based study (Vanharanta et al., 1999).

Fujiyama-fujiwara et al. (1995) in a similar study showed that sesamin (0.5%, w/w) synergistically increases the liver weight and phospholipids contents in liver of rats fed with γ -linolenic acid-rich (GLA) diet or α-linolenic acid-rich (ALA) diet (found abundantly in sesame plant - leaves) for 4 weeks. Thus, the hypocholesterolemic effect of sesame plant could also be attributed to its α-linolenic acid (ALA) and fiber mucilage components (Chen and Anderson, 1986; Brown et al., 1999). However, feeding of α-linolenic acid-rich diet to rats lowers their serum cholesterol levels more effectively than a linoleic acid rich diet (Garg et al., 1989; Steinberger et al., 1995). Their mechanisms may be related to their effects on platelet functions as provided in a recent clinical trial (Renaud, 1990).

Sesame is an annual herbaceous plant, which belongs to the family- Pedaliaceae and genus-Sesamum (Purseglove, 1974). Sesame is reputed in folk medicine in Africa and Asia. Sesame plant especially the seed, oil and leaves are consumed locally as a staple food by subsistence farmers in South-West and Middle Belt areas of Nigeria (Akpan-Iwo et al., 2006) and this may account for the high fecundity among the adult male population in these areas (Shittu, 2006). Phytochemical study has shown that the sesame plant is rich in phenolic compounds (phenols, lignans and flavonoids), non-protein amino acids, cyanogenics glycosides, alkaloids, polyunsaturated fats and lipids, mucilage, phospholipids, vitamins B1, B2 and E, trace elements and minerals such as calcium, iron, magnesium, copper and phosphorus (Shittu, 2006; Shittu et al., 2006).

The high incidence of obesity, its mutifactorial nature and the scarcity of adequate therapeutics have fuelled the increase in anti-obesity drug related research in recent times. However, because of paucity of knowledge on the chronic toxicity effects of aqueous crude leaves extracts of *Sesame radiatum* on the lipids profile in a non-obese adult male Sprague Dawley rats, this study test the serum lipid response and dietary adaptation to recommended daily inclusion of sesame leaves in an otherwise regular diet and to give its possible mechanism of action.

MATERIALS AND METHODS

Collection of plant materials

Sesame plants (*S. radiatum*, Schum and Thonn - Pedaliacaea family) were bought from a vendor in Agege market. The plant was authenticated by the herbarium section of Forestry Institute of Research (FRIN) with FHI # 107513 on the 5th of August, 2005 (Shittu, 2006). Voucher specimens were deposited in Botany Departments of University of Ibadan and Lagos State University, Nigeria.

Preparation of aqueous extraction of sesame leaves

The leaves of the plants were air dried for 2 weeks and powdered. 100 g of the powdered leaves was added to 1.0 litre of distilled water at a ratio of 1:10 in a beaker. This was allowed to boil to boiling temperature after intermittent stirring on a hotplate for one hour. The decoction was filtered into another clean beaker using a white sieve clothing material and the filtrate evaporated at 50°C to dryness in a desiccator to produce a black shinning crystal residue form with a yield of 83% w/w of the extract. The crude extract was kept in the refrigerator (4°C) before being reconstituted and used for the *in vivo* study (Nanchanda et al., 2005).

Ether-extracts preparation of sesame leaves for phytochemical assay

The leaves were air-dried and 100 g of the powdered leaves were extracted with 500 ml of 40% diethyl ether for 72 h with Soxhlet equipment as previously described in our study (Shittu et al., 2006).

Phytochemical screening using gas chromatography-mass spectral

Gas chromatography of crude ether extract of sesame leaves was performed using a Hewlett Packard GCD system (model 6890), equipped with a flame ionization detector and injector MS transfer line temperature maintained at 230°C respectively as described in our previous studies (Shittu et al., 2006; Bankole et al., 2007). Compound identification was accomplished by comparing the GC relative retention times and mass spectra to those of authentic substances analyzed under the same conditions, by their retention indices (RI) and by comparison to reference compounds and library searches (Shittu et al., 2006).

Animal

Thirty mature and healthy adult male Sprague Dawley rats weighing 120 to 216 g were procured from Lagos State University, College of Medicine, Ikeja, and housed in well-ventilated wire-wooden cages in the departmental animal house. They were maintained under controlled light schedule (12 h light : 12 h dark) at room temperature (28°C) and constant humidity of 40 - 50%. The animals were allowed to acclimatize for a period of 7 days before treatment. During this period, they were fed with standard rat chows/pellets supplied by Pfizer Nigeria Limited and water *ad libitum*. Individual identification of the animal was made by ear tags.

Experimental procedure

The rats were randomly divided into three groups (A to C) comprising of ten rats each. The group A served as the control while B and C constituted the treated groups. The animals in group A received equal volume of 0.9% (w/v) normal saline daily while group B (high dose) received aqueous extract of sesame leaves at 28.0 mg/kg body weight /day, the animals in group C (low dose) were given aqueous extract of sesame at 14.0 mg/kg body weight /day (half group B dose). All the doses were given via gastric gavage (oro-gastric intubation) daily for a period of 6 weeks.

All animals were observed for clinical signs of plant-induced toxicity (such as tremors, weakness, lethargy, refusal of feeds, weight loss, hair-loss, coma and death) throughout the duration of the experiment.

All procedures involving animals in this study conformed to the guiding principles for research involving animals as recommended by the Declaration of Helsinki and the Guiding Principles in the Care and Use of Animals (American Physiological Society, 2002) and were approved by the Departmental Committee on the Use and Care of Animals.

Animal sacrifice

The rats were anaesthetized at the time of sacrifice by being placed in sealed cotton wool soaked chloroform inhalation jar between 0900 and 1100 h done the following day after the termination of the experiment after post over night fasting of the animals. The weights of the animals were taken weekly and before the sacrifice.

Blood collection and serum preparation

Blood was collected via cardiac puncture from each animal as described in our previous study (Shittu, 2006). The blood were collected into sterile bottles and centrifuged at 4000 × g for 10 min using a MSE tabletop centrifuge machine (Minor Gallenkamp). The extracted serum of each rat was stored in the freezer at -20°C for biochemical assay.

Determination of biochemical lipid parameters

The concentration of serum total cholesterol and triglyceride concentrations were measured enzymatically by using kits and standards supplied by (Sigma Diagnostics, St. Louis, MO). HDL cholesterol was measured by using an EZ HDL-Cholesterol Kit as previously described (Burstein et al., 1970). LDL-Cholesterol was calculated by using the formula of Friedewald et al. (1972). However, we calculate the non- HDL-Cholesterol concentration by subtracting HDL-Cholesterol from total cholesterol. The intra assay CVs were 2.2, 2.6 and 1.7% for total cholesterol, HDL Cholesterol and triglycerides, respectively.

Statistical analysis

The weight data were expressed in Mean ± S.D (standard deviation) while other data were expressed as Mean ± S.E.M (standard error of mean). Statistical analyses were done by using the student t-test and ANOVA as the case may be with input into SPSS 12 software Microsoft computer (SPSS, Chicago, Illinois). Statistical significance was considered at $P \leq 0.05$.

RESULTS

No obvious signs of toxicity (such as tremors, weakness and lethargy, refusal of feeds, weight loss, hair-loss, coma and death) were observed in any of the animals throughout the duration of our observation. The GC/MS showed the presence of essential oils mainly the carboxylic phenolic groups such as (sesamol, sesamin) and other compounds such as thiazole, pyrroles, disulphide and aldehyde. Also, confirmed the presence of trace elements/minerals, vitamins and steroid such as adrostenedione among others. Significant ($P < 0.05$) evidence of weight gain was seen in all the treated animals. However, about 78% and 57% relative weight loss were found in the high and low dose groups respectively when

Table 1. Average weekly body weight of animal.

Weight	A (Control)	B (High dose)	C (Low dose)
Initial (Pre-experiment) (g)	127.3 ± 5.55	206.2 ± 6.45	186.3 ± 1.99
Final (Post- experiment) (g)	185.2 ± 11.05	248.2 ± 14.40*	219.8 ± 4.47*
Weight gain (g)	58.5 ± 5.50*	42.0 ± 7.95*	33.4 ± 2. 48*
% Relative weight (compared to control)	100	28.2	42.9

*P < 0.05, significant statistically.

Table 2. Lipids and lipoproteins profiles of sesame-treated animals.

Parameters	A (Control)	B (High dose)	C (Low dose)
Serum total cholesterol (CHOL.)	116.0 ± 2.20	91.8 ± 10.30*	70.3 ± 7.60*
HDL-CHOL.	76.8 ± 1.93	62.5 ± 4.27*	39.8 ± 0.70*
LDL-CHOL.	38.4 ± 0.42	2.40 ±0.12*	7.10 ± 1.84*
VLDL-CHOL.	16.4 ± 0.32	14.9± 0.54*	14.3 ± 0.61*
Serum total triglycerides (TG)	105.0±12.3	74.4± 2.06*	74.2 ± 3.90*
LDL-C/HDL-C ratio	0.5 ± 0.01	0.04 ± 0.004*	0.18 ± 0.04*
TG/HDL-C ratio	1.37 ± 0.15	1.20 ± 0.06*	1.88 ± 0.13*

*P < 0.05 was considered significant statistically.

compared to the control group in the adjusted weight as shown in Table 1. Also, the weight loss in low dose was increased by 27% over the high dose group as seen in Table 1.

About 21 and 39% significant (P < 0.05) reduction in total cholesterol when compared to control for both high and low dose were observed respectively. Such that, cholesterol level in high dose was reduced by 47% over the low dose group as shown in Table 2. LDL reduces significantly (P < 0.05) by 94 and 82% in high and low dose respectively when compared to the control. Thus, the high dose is decreased by 13% over the low dose group as shown in Table 2. HDL significantly (P < 0.05) reduced by 19 and 48% in both high and low dose groups respectively, when compared to the control. However, the high dose increased by 60% over the low dose as shown in Table 2. VLDL significantly (P < 0.05) reduced by 9 and 13% for both high and low dose respectively when compared to the control. However, high dose mildly decreased by 31% over the low dose group as shown in Table 2. There were significant reduction in TG level about 2% in the treated than the control, but no significant difference exists between the low dose and high dose groups as shown in Table 2.

DISCUSSION

To our knowledge after extensive literature searches, this study appear to be the first that looked at the chronic toxicity of aqueous sesame leaves extract on the serum lipids profile and ratios in non-obese rats. The benefits derived from high intake of any fruits and vegetables on the various metabolic disease conditions such as diabetes mellitus, obesity, heart diseases and cancer might not always be due to the impact of their well characterized antioxidants (such as, beta-carotene, vitamins C and E only). But rather related to the presence of other antioxidants or non-antioxidant phytochemicals or by an additive action of the different compounds present in foods themselves such as alpha-linolenic acid (poly unsaturated fatty acids), various phenolic compounds (sesamin, sesamol) and fibres, which are also present in sesame leaves for example.

All the animals used in this study, irrespective of their initial aggressive nature, exhibited some degree of calmness (non-aggressive state) during treatment. More so, there was a general state of well-being observed among all the animals during the whole experimental period. This may reflect the positive effect of some of the active ingredients/agents present in the sesame plant on the neurophysiological pathway of the animals.

In this study, there was evidence of significant (P < 0.05) weight gain observed in all the animals. But, when adjustment was made for their relative weight, a significant (P < 0.05) weight reduction difference was observed in the treated groups when compared to the control and was dose dependent, such that the weight loss in the high dose was more than in the low dose group as shown in Table 1.

Findings in this study also showed evidence of decrease in the total cholesterol and the LDL-C when compared to control, which reflects the beneficial effect of sesame leaves. However, this effect is dose dependent

and is much lower in the high dose than the low dose. Hence, in a way has favoured a significant lower LDL/HDL ratio in this group of animals as observed in Table 2. These findings are due to the fact that Apo A-1, the major HDL proteins inhibits LDL oxidation (Ohta et al., 1989). Other study by Gosh et al. (2006) show that low HDL-C levels with low ApoA-1 will increase LDL oxidation and hence, decrease the ratio of LDL-C: HDL-C, which is a better indicator of lipid perioxidation as seen in this study. It is now recognized that dietary LA also favours oxidative modification of LDL cholesterol (Abbey et al., 1993) and increases platelet response to aggregation (Renaud, 1990). However, HDL-C also has preventive role in CHD, by reducing endothelial incorporation of lysophosphatidy choline (Nasiruddin and Ahmed, 2006).

The effect of sesame lignans in this study was similar to that obtained with other types of lignans found in Flaxseed supplementation diet with a significantly lowered serum total cholesterol and non-HDL-cholesterol and Soy-based meal, which was effective in losing weight and reducing LDL-C beyond the expected level (Gregory, 2006). Diesters of arylnapthalene lignans (synthetic lignans) have been shown to be also effective in lowering serum total cholesterol and LDL cholesterol while increasing HDL cholesterol (Kuroda et al., 1997). Study has shown that LDL, which is a major component of total cholesterol is directly related to coronary artery disease (CHD) as a major atherogenic lipoprotein and hence, appears to be the main target of any lipid lowering agents including sesame leaves as reflected in this study.

Sesame leaves significantly ($P < 0.05$) lowered both the TG and VLDL, although, found to be within the same range for both the high and low dose. No doubt, the arteriosclerosis index (AI) for the animals will be reduced because of the higher HDL- cholesterol level in the high dose compared to the low dose; which can also be of beneficial importance to heart disease management. This significant reduction in TG levels may be attributed to an increasing lipid peroxidation activity (LPL), which will lead to an increase in the degredation of TG and/or reduction in VLDL which is usually produced in the liver and aids in lipolytic removal of TG- rich lipoproteins from the circulation (Wang et al., 2003; Megalli et al., 2006). Studies have shown that elevated VLDL-C is associated with a high TG, since VLDL-C carries the highest amount of TG in the body (Ghosh et al., 2006) as observed in this study.

Similar to our findings, Sirato-Yasumoto et al. (2001) observed that serum triacylglycerol concentrations were lower in rats fed with high dose sesame-lignans rich diets than Masekin (low dose) diet or control. They concluded that consumption of sesame rich in lignans diet have more profound physiological effects on hepatic fatty acid oxidation and serum triacylglycerol levels. Other study has also suggested that sesamolin and its metabolites-sesamol and sesamolinol in the vivo system will strongly inhibit lipid peroxidation, hence preventing oxidative DNA stress damage and contribute to the antioxidative properties of sesame lignans (Kang et al., 1998). Studies in both humans and animals have suggested that the primary mechanism through which dietary soluble fiber present in sesame plant lowers cholesterol is through enhanced synthesis of bile acids and their fecal excretion. Such that the enhanced elimination of bile acids also results in increased hepatic cholesterol synthesis. However, in this study, the low cholesterol may be due to impairment of cholesterol synthesis or rapid eliminations by bile salt from the system.

Conclusion

This study has demonstrated that sesame-treated rats significantly showed evidence of weight loss and hypolipidaemia in a dose related manner via the combined effects of all the active ingredients mainly the rich lignans (sesamin, sesamolin and sesamol) and fatty acids (especially the oleic, linoleic, linolenic and palmitic acids) among others present in the plant leaves. Further study is aimed to isolate these already characterized active agents and evaluation of their individual effects on lipid profiles as whole.

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REFERENCES

Abbey M, Belling GB, Noakes M, Hirata F, Nestle PJ (1993). Oxidation of low-density lipoproteins: intraindividual variability and the effect of dietary linoleate supplementation. Am. J. Clin. Nutr. 57: 391-398.

Akpan-Iwo G, Idowu AA, Misari SM (2006). Collection and evaluation of sesame (*Sesamum* spp.) germplasm in Nigeria. IGPR/FAO. 142: 59-62.

American Physiological Society. (2002). Guiding principles for research involving animals and human beings. Am. J. Physiol. Regul. Integr. Comp. Physiol, 283: 281-283.

Arner P (2000). Obesity a genetic disease of adipose tissue? Br. J. Nutr. 83: S9-S16.

Bankole MA, Shittu LAJ, Ahmed TA, Bankole MN, Shittu RK, Ashiru OA (2007). Synergistic Antimicrobial Activities Of Phytoestrogens In Crude In Crude Extracts Of Two Sesame Species Against Some Common Pathogenic Microorganism. Afr. J. Tradit, Comp. Altern. Med., 4(4): 427-433.

Baum JA, Teng H, Erdman JW, Weigel RM, Klein BP, Persky VW, Freels S, Surya P, Bakhit RM, Ramos E, Shay NF, Potter SM (1998). Long-term intake of soy protein improves blood lipid profiles and increases mononuclear cell low density lipoprotein receptor messenger RNA in hypercholesterolemic, postmenopausal women. Am. J. Clin. Nutr. 68: 545–551.

Brown L, Rosner B, Willett WW, Sacks FM (1999). Cholesterol-lowering effects of dietary fiber: a meta-analysis. Am. J. Clin. Nutr. 69: 30-32.

Burstein M, Scholnick H, Morfin R (1970). Rapid method for the isola-

tion of lipoproteins from human serum by precipitation with polyanions. J. Lipid Res. 11: 583-95.
Chen WJL, Anderson JW (1986). Hypocholesterolemic effects of soluble fibers. In: Kritchevsky D, Yahouny GV, eds. Dietary fiber: basic and clinical aspects. New York: Plenum Press. pp. 275–289.
Excerpts from the United States Renal Data System, (1998). Annual Data Report. VI. Causes of death. Am. J. Kidney Dis. 32: s81–s88.
Friedewald W, Levy R, Fredrickson D (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin. Chem. 18: 499-502.
Fujiyama-Fujiwara Y, Umeda-Sawada R, Kuzuyama M, Igarashi OJ (1995). Effects of sesamin on the fatty acid composition of the liver of rats fed N-6 and N-3 fatty acid-rich diet. Nutr. Sci. Vitaminol. 41: 217.
Garg ML, Wierzbicki AA, Thomson ABR, Clandinin MT/ (1989). Dietary saturated fat level alters the competition between -linolenic and linoleic acid. Lipids. 24: 334–339
Ghosh J, Mishra TK, Rao YN, Aggarwal SK (2006). Oxidised LD, HDL Cholesterol, LDL Cholesterol levels in Patients of Coronary Artery Diseae. Ind. J. Clin. Biochem. 21: 181-184.
Green S (1995). Mutation Research, 333:101. In Jeng KCG, Hou RCW. (2005). Sesamin and Sesamolin: Nature`s therapeutic lignans. Curr. Enzym. Inhib. 1: 11-20
Gregory LP (2006). Weight loss diets with soy protein improve blood lipids profiles. AgroFood industry hi-tech, 5: 1-3.
Hotta K, Funahashi T, Arita Y, Takahashi M, Matsuda M, Okamoto Y (2000). Plasma concentrations of a novel, adipose-specific protein, adiponectin in type 2 diabetic patients. Arterioscler Thromb Vasc Biol. 20: 1595-1599.
Hu E, Liang P, Spiegelman BM (1996). AdipoQ is a novel adipose-specific gene dysregulated in obesity. J. Biol. Chem. 271: 10697-10703.
Jeng KCG, Hou RCW (2005). Sesamin and Sesamolin: Nature`s therapeutic lignans. Curr. Enzym. Inhib. 1: 11-20.
Jones PJ (1999). Cholesterol-lowering action of plant sterols. Curr Atheroscler Rep. 1: 230-235.
Kang M-H, Naito M, Tsujihara N, Osawa T (1998). Sesamolin Inhibits Lipid Peroxidation in Rat Liver and Kidney. J. Nutr. 128(6): 1018-1022.
Kuroda T, Kondo K, Iwasaki T, Ohtani A, Takashima K (1997). Synthesis and hypolipidemic activity of diesters of arylnaphthalene lignan and their heteroaromatic analogs. Chem. Pharm. Bull. (Tokyo). 45: 678–684.
Maeda N, Takahashi M, Funahashi T, Kihara S, Nishizawa H, Kishida K (2001). PPAR ligands increase expression and plasma concentrations of adiponectin, an adipose-derived protein. Diabetes. 50: 2094-2099.
Maki KC, Davidson MH, Umporowicz DM, Schaefer EJ, Dicklin MR, Ingram KA, Chen S, McNamara JR, Gebhart BW, Ribaya-Mercado JD, Perrone G, Robins SJ, Franke WC (2001). Lipid responses to plant-sterol-enriched reduced-fat spreads incorporated into a National Cholesterol Education Program Step I diet. Am. J. Clin. Nutr. 74: 33-43.
Marx J (2003). Cellular warriors at the battle of the bulge. Science. 299: 846-849.
Megalli S, Davies NM, Basil DR (2006). Anti-hyperlipidemic and hypogllycaemic effects of Gynostemma pentaphyllum in Zucker fatty Rat. J. Pharm Pharmaceut. Sci. 9: 281-291.
Meguro S, Higashi K, Hase T, Honda Y, Otsuka A, Tokimitsu I, Itakura H (2001). Solubilization of phytosterols in diacylglycerol *vs.* triacylglycerol improves the serum cholesterol-lowering effect. Eur. J. Clin. Nutr. 55: 513–517.
Miyazaki Y, Mahankali A, Wajcberg E, Bajaj M, Mandarino LJ, DeFronzo RA (2004). Effect of pioglitazone on circulating adipocytokine levels and insulin sensitivity in type 2 diabetic patients. J. Clin. Endocrinol. Metab. 89: 4312-4319.
Nanchanda K, Morris JN, Sullivan LM, Wilson PW (2005). Coronary heart disease risk in men and the epidermic of overweight and obesity. Int. J. Obes. (Lond). 29: 317-23.
Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM (2006). Production of overweight and obesity in the united States, 1999-2004, JAMA. 295: 1549-55.
Nasiruddin TM, Ahmed N (2006). Effects of an unani formulation on lipid profile in rats, Indian J. Pharmacol. 25: 56-57.
Ohta T, Takata K, Horiuchis W (1989). Protective effect of lipoproteins containing apoproteins A_1 on Cu 2+ catalysed oxidation of human low density lipoprotein. Febs. Lett. 257: 435-438.
Potter SM, Baum JA, Teng H, Stillman RJ, Shay NF, Erdman JW (1998). Soy protein and isoflavones: their effects on blood lipids and bone density in postmenopausal women. Am. J. Clin. Nutr. 68: 1375S–1379S.
Purseglove JW (1974). Tropical Crops: Dicotyledons. Longman Group, London, UK. pp. 430-435.
Renaud S (1990). Linoleic acid, platelet aggregation and myocardial infarction. Atherosclerosis 80: 255-256.
Saltzman E, Das SK, Lichtenstein A, Dallal GE. Corrales A, Schaefer EJ, Greenberg AS, Roberts SB (2001). An oat-containing hypocaloric diet reduces systolic blood pressure and improves lipid profile beyond effects of weight loss in men and women. J. Nutr. 131: 1465–1470.
Scherer PE, Williams S, Fogliano M, Baldini G, Lodish HF (1995). A novel serum protein similar to C1q, produced exclusively in adipocytes. J. Biol. Chem. 270: 26746-26749.
Sirato-Yasumoto S, Katsuta M, Okuyama Y, Takahashi Y, Ide T (2001). Effect of Sesame Seeds Rich in Sesamin and Sesamolin on Fatty Acid Oxidation in Rat Liver. J. Agric. Food Chem. 49(5): 2647 -2651.
Shittu LAJ (2006). The effect of the aqueous crude leaves extract of *Sesamum radiatum* compared to Mesterolone (proviron) on the adult male Sprague Dawley rats testis and epididymis. MSc Dissertation, Department of Anatomy, Lagos State University, College of Medicine, School of Post-graduate Studies, Ikeja, Nigeria.
Shittu LAJ, Bankole MA, Ahmed T, Aile K, Akinsanya MA, Bankole MN, Shittu RK, Ashiru OA (2006). Differential antimicrobial activity of the various crude leaves extracts of *Sesame radiatum* against some common pathogenic micro-organisms. Sci. Res. Essay. 1(3): 108-111.
Steinberger J, Moorehead C, Katch V, Rocchini AP (1995). Relationship between insulin resistance and abnormal lipid profile in obese adolescents. J. Pediatr. 127: 1009.
Vanharanta M, Voutilainen S, Lakka TA, van der Lee M, Adlercreutz H, Salonen JT (1999). Risk of acute coronary events according to serum concentrations of eneterolactone: a prospective population-based case-control study. Lancet. 354: 2112–2115.
Wang Y, Jones P, Pischel I, Fairow C (2003). Effects of policosanols and phytosterol on lipid levels and cholesterol biosynthsisi in namster. Lipids. 38: 165-170.
Weyer C, Funahashi T, Tanaka S, Hotta K, Matsuzawa Y, Pratley RE (2001). Hypoadiponectinemia in obesity and type 2 diabetes: close association with insulin resistance and hyperinsulinemia. J. Clin. Endocrinol. Metab. 86: 1930-1935.