Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Israel MO, J Nutr Food Sci 2015, S11:001
DOI: 10.4172/2155-9600.1000S11001
Review Article Open Access

Shea Butter: An Opposite Replacement for Trans Fat in Margarine

Malachi Oluwaseyi Israel*

Biochemistry Department, Afe Babalola University, Ado-Ekiti, Nigeria

***Corresponding author:** Malachi Oluwaseyi Israel, Biochemistry Department, Afe Babalola University, Ado-Ekiti, Nigeria, Tel: 2348068846518; E-mail: malachiseyi@gmail.com

Rec date: May 06, 2015; **Acc date:** June 11, 2015; **Pub date:** June 15, 2015

Abstract

Shea butter is the edible fat extracted from the nut of African Shea tree (*Vitellaria paradoxa*). Consequence of having half of its fatty acids saturated, Shea butter melts at a very high temperature and will be a suitable raw material for margarine production. Margarine is a butter mimicry that is produced from vegetable oils and water. The production of margarine requires a solid fat. Hence hydrogenation is employed to "harden" the vegetable oil. However, hydrogenation generates trans unsaturated fatty acids which are more detrimental to cardiovascular health than the highly denunciated saturated fatty acids. Since Shea butter is a stable solid at room temperature and has its saturated fatty acid fraction predominated by stearic acid, the use of Shea butter as a raw material for margarine will not only eliminate trans unsaturated fatty acids from the product but also make use of the least deleterious saturated fatty acid because stearic acid has been reported as the healthiest saturated fatty acid as regards cardiovascular health. Also, the unsaponifiables of Shea butter have been credited for their anti-hypercholesterolemic effects in experimental animals. This increases the healthfulness of dietary Shea butter, and of course, the margarine end product.

Keywords: Margarine; Shea butter; Cardiovascular disease; Saturated fatty acid; Stearic acid

Introduction

Shea butter is an off-white or ivory-colored fat extracted from the nut of Shea tree (*Vitellaria paradoxa* formerly *Butryspermum paradoxum*, *B. parkii* and *B. paradoxa*) [1]. Shea tree is native to the dry savanna belt of West Africa, where it grows wild across a 5000 km wide belt of savanna [2,3]; inhabiting West African countries of Senegal, Burkina Faso, Côte d'Ivoire, Mali, Ghana, Togo, Benin, Nigeria, Cameroon, Niger, and further east into Sudan, Uganda and Ethiopia [4,5]. The West African trees are classified as the subspecies "*paradoxa*" and the East African one as "*nilotica*" [6-8].

Shea butter is solid at room temperature with a good buttery consistency. It is edible and is used in food preparation in Africa [9,10] and as a substitute for cocoa butter in chocolate industry [3], although the taste is noticeably different [11]. Shea butter is also renowned for its use as a component of cosmetic formulations [9,12]. There are no reports of allergic reaction owing to consumption of Shea butter or its produce [13,14].

Margarine is a butter mimicry used for spreading, baking and cooking [15]. While butter is made from butterfat of milk, margarine is made principally from vegetable oil and water, and may also contain milk. Like butter, margarine, consists of a water-in-fat emulsion, with tiny droplets of water dispersed uniformly throughout a fat phase which is in a stable crystalline form [16]. Margarine has a minimum fat content of 80%, the same as butter, but unlike butter, reduced-fat varieties of margarine can also be labeled as margarine.

Margarine was formulated in the 19th century as a replacement for butter because of inability of the low class to afford dairy butter [17]. Although the raw material for the original margarine formulation was beef fat, shortages in beef fat supply combined with advances in the hydrogenation of plant materials led to its replacement with hydrogenated vegetable oils [18].

In recent decades, the composition of margarine has changed significantly in efforts to increase its healthfulness; notably in relation to cardiovascular disease. Hydrogenation of vegetable oils has consequently been severely discouraged as it leads to the generation of trans-unsaturated fatty acids which increase levels of LDL, lower levels of HDL and therefore increases the risk of coronary heart disease [19], the leading cause of death [20]. The use of tropical vegetable oils including palm oil, palm kernel oil and coconut oil, which are rich in saturated fatty acid, is progressively reducing hydrogenation in margarine production. Shea butter is a stable solid at room temperature, even in the warm tropics unlike other tropical oils, and will therefore require no hydrogenation for production of margarine. This work therefore presents Shea butter as a more suitable raw material for margarine production than other tropical oils.

Dietary Lipid and Cardiovascular Health

Cardiovascular diseases are the leading cause of global death [20], and are projected to remain the single leading cause of death till 2030 [21]. Cardiovascular diseases are multi-factorial and several risk factors have been identified. These risk factors include: gender, age, physical inactivity, unhealthy diet, family history of cardiovascular disease, tobacco use, excessive alcohol consumption, obesity, raised blood pressure (hypertension), raised blood cholesterol (hyperlipidemia), raised blood sugar (diabetes mellitus), psychosocial factors, poverty and low educational status and air pollution [22-25]. While some of these risk factors such as age, gender or family history are immutable; many important cardiovascular risk factors are modifiable by social change, lifestyle change, drug treatment and prevention of hyperlipidemia, hypertension, and diabetes.

Of the risk factors that can be modified to improve cardiovascular health is healthy dietary lipid [26]. It has become clear that it is the composition and not the total amount of fat intake that affects cardiovascular health [27,28]. While it is evident that the dynamics of cholesterol homeostasis and development of cardiovascular disease are extremely complex and multifactorial [29], researchers maintain that cholesterol intake increases the risks of cardiovascular diseases [29-31]. Also, dietary saturated fatty as well as trans-unsaturated fatty acids increases the risks of cardiovascular diseases as they both raise levels of LDL cholesterol and lower levels of HDL cholesterol [26,27,32-34].

It is also clear that different type of saturated fatty acids contribute differently to cardiovascular disease [35]. An isotope labeling study in humans [36] concluded that the fraction of dietary stearic acid (18:0) that oxidatively desaturates to oleic acid (18:1) is 2.4 times higher than the fraction of palmitic acid (16:0) analogously converted to palmitoleic acid (16:1). This demonstrates that dietary palmitic acid (16:0) contributes to progression of cardiovascular disease than stearic acid (18:0). Also, in a systemic review of clinical and epidemiological studies [37], dietary Stearic acid (18:0) was found to be associated with lower LDL and directionally lower total cholesterol/HDL cholesterol ratio compared to any other saturated fatty acid. Substitution of Stearic acid (18:0) for trans-unsaturated fatty acid also decreased LDL cholesterol, increased HDL cholesterol and decreased the total cholesterol/HDL cholesterol ratio. However, when compared with unsaturated fatty acids, Stearic acid raised LDL cholesterol, lowered HDL cholesterol, and increased the total cholesterol/HDL cholesterol ratio. It was thus concluded that Stearic acid (18:0) is a reasonable substitute for trans-unsaturated fatty acids and cholesterol-raising saturated fatty acids for solid fat applications.

Composition and Properties of Shea Butter

In addition to a stearic and oleic acids rich saponifiable fraction, Shea butter contains an unsaponifiable fraction composed of bioactive substances that are responsible for its medicinal properties [38]. These bioactive compounds are majorly triterpene alcohols, with some hydrocarbons, sterols, and other minor components such as vitamin E [39-42]. The saponifiable triglyceride fraction of Shea butter constitutes about 90% by mass of the butter [39-43] and is composed primarily of stearic and oleic acids with lesser amounts of palmitic, linoleic and arachidic acids [44]. While Shea butter has about 50% of its fatty acid saturated, about 83% of the saturated fatty acid is made up of stearic acid [44], the least deleterious of the saturated fatty acids [37] (Table 1).

Component		**Quantity**
Saponifiables (%)		90
Unsaponifiables (%)		10
Fatty acids (% of saponifiable)	Palmitic	4
	Stearic	42
	Oleic	45
	Linoleic	6
Unsaponifiables (% of total unsaponifiable fraction)	Triterpene alcohols	65
	Hydrocarbons	27
	Sterols	8
	Tocopherols	0.805

Table 1: Chemical composition of Shea butter; Source: [41,45,46].

Shea butter has a relatively high melting point compared to other vegetable oils. When contrasted with highly unsaturated vegetable oils like grape seed oil, olive oil, canola oil and soybean oil that have saturated fatty acid fraction less than 20% [47-50], the elevated melting point of Shea butter can be attributed to its high saturation [51]. However, Shea butter melts between 51°C and 56°C; a temperature much higher than the melting points of highly saturated tropical vegetable oils like palm oil (35°C), palm kernel oil (24°C) and Coconut oil (24°C). This is because the saturated fatty acid fraction of Shea butter is majorly constituted by stearic acid while that of palm kernel oil, palm oil and coconut oil is majorly constituted by lauric, palmitic and lauric acids respectively [49]. Lauric and palmitic acids are of shorter carbon chains, hence have lower melting points, than stearic acid [52,53].

The high melting point of Shea butter can also be in part due to its high content of unsaponifiables which make up 8-10% of Shea butter [38]. These unsaponifiables are majorly triterpene alcohols and sterols [39-42], which have high melting points [54].

Margarine and its Ingredients

Margarine is basically a water-in-fat emulsion [16] made from vegetable oil or animal fat, mixed with skim milk, salt, and emulsifiers like lecithin [55,56]. The vegetable oils are hydrogenated by passing hydrogen through the oil in the presence of a nickel or palladium catalyst, under controlled conditions [57]. The hydrogenation process increases the melting point of ("*Harden*") the oil by reducing the unsaturated bonds (alkenic double C=C bonds) to saturated C-C bonds [58]. While the Soft vegetable fat spreads and Margarines in bottle can circumvent hydrogenation by making use of tropical oils like palm oil, coconut oil and palm kernel oil that are naturally rich in saturated fatty acids and are semi-solid at room temperature, hard margarines, used for cooking and baking, unavoidably requires hardening to increase its melting point [59].

Shea Butter versus Other Tropical Oils as Raw Material for Margarine

While the manufacture of margarine requires a vegetable fat that is solid at room temperature, most vegetable oils are liquid at room temperature. Increasing the melting point of such oils through partial hydrogenation leads to the generation of trans unsaturated fatty acids which increases the risk of cardiovascular diseases [19]. To reduce hydrogenation in margarine production, tropical oils like palm oil and palm kernel oil, with high melting points are increasingly gaining application in margarine production [60]. However, while this tropical oils which are semi solid at room temperature, are saturated enough to eliminate the need for hydrogenation in the production of softer tub margarines, the production of solid block margarines that are required for cooking and baking, requires further saturation [59]. Hence hydrogenation is unavoidable even with the use of such oils.

Shea butter, by contrast, is a stable solid at room temperature and will remain a solid even at a temperature as high as 50°C [61]. The use for Shea butter for the production of margarine will therefore require no further hardening. Hence no generation of trans unsaturated fatty acids. This will consequently eliminate the risk of cardiovascular disease associated with the consumption of trans unsaturated fatty acids in margarine. Albeit, the mechanisms through which trans unsaturated fatty acids contribute to cardiovascular disease are still poorly understood, research has shown that trans unsaturated fatty acids are more deleterious to cardiovascular health than the highly denounced saturated fatty acids [37,62,63].

Also, stearic acid, which constitutes the saturated fraction of Shea butter [49], is considered the least deleterious of the saturated fatty acids [36,37]. Therefore, the use of Shea butter for the manufacture of margarine will not only eliminate trans unsaturated fatty acids from the product but will also make use of the healthiest saturated fatty acid as a source of "hardening" in the product. Another edge Shea butter has over other tropical vegetable oil with regards to cardiovascular health is that it is exceptionally high in unsaponifiables and these unsaponifiables have been credited for anti-hypercholesterolemic activities in experimental animals [64,65].

Finally, looking from the manufacturers' point of view, Shea butter as a raw material for margarine production will reduce cost of production as it does not require hardening. The cost of hydrogenation will thus be eliminated (Table 2).

	Shea Butter	**Other Tropical Oil**
Melting point	-A stable solid at room temperature and will remain a solid till 51°C.	-A semi solid at room temperature.
	-Will not require hydrogenation for the production of solid margarine	-Melts at temperatures higher than 35°C.
		-Will require hydrogenation for the production of solid margarine
Saponifiable Composition	Saturated fatty acid is chiefly stearic acid, which is the least deleterious saturated fatty acid to cardiovascular health.	Palmitic and Lauric acids are the predominant saturated fatty acids and are more deleterious to cardiovascular health than stearic acid.
Unsaponifiable Composition	Incredibly high in unsaponifiables that have been shown to contribute to cardiovascular health	Unsaponifiable fractions are not as much as that of Shea butter
Cost of Production	Since hydrogenation is eliminated, the cost of production will be reduced.	Hydrogenation will increase the cost of production.

Table 2: Shea butter versus other tropical oils as raw material for margarine.

Conclusion

Due to its high stearic acid concentration and high melting point, Shea butter as a raw material for margarine production is healthier, as regards to cardiovascular health, than other vegetable oils because it eradicate the presence of the much criticized trans unsaturated fatty acids from the product while it making use of the least deleterious saturated fatty acid. The unsaponifiable fraction of Shea butter also contributes to cardiovascular health. The exclusion of hydrogenation process, which is otherwise used for "hardening" vegetable oils, will reduce the cost of production of margarine from Shea butter.

Acknowledgement

A huge thank you goes to Pastor David Adebayo his encouragement and kindness. The guidance of Professor OB. Ajayi is highly appreciated.

References

1. Alfred T (2002) "Fats and Fatty Oils". Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH.
2. Maranz S, Wiesman Z (2003) Evidence for Indigenous Selection and Distribution of the Shea Tree, Vitellaria paradoxa, and its potential significance to prevailing parkland savanna tree patterns in sub-Saharan Africa north of the equator. J Biogeogr 30: 1505-1516.
3. Masters ET, Yidana JA, Lovett PN (2004) Reinforcing Sound Management through Trade: Shea Tree Products in Africa. Unasylva. 210: 46-52.
4. Goreja WG (2004) Shea Butter: The Nourishing Properties of Africa's Best-Kept Natural Beauty. Amazing Herbs Press. New York, NY.
5. Chalfin B (2004) Shea Butter Republic. Routledge. New York.
6. Ferris RSB, Collinsom C, Wanda K, Jagwe J, Wright P (2001) Evaluating the Market Opportunities for Shea Nut and Shea Nut Processed Products in Uganda. Submitted to USAID, The United States Agency for International Development.
7. Di Vincenzo D, Maranz S, Serraiocco A, Vito R, Wiesman Z, et al. (2005) Regional variation in shea butter lipid and triterpene composition in four African countries. J Agric Food Chem 53: 7473-7479.
8. Mbaiguinam M, Mbayhoudel K, Djekota C (2007) Physical and Chemical Characteristics of Fruits, Pulps, Kernels and Butter of Shea Butyrospermum parkii (Sapotaceae) from Mandoul, Southern Chad. Asian J. Biochem. 2: 101-110.
9. Abbiw DK (1990) "Useful plants of Ghana, West Africa. Uses of wildand cultivated plants". Intermediate technology publication and the royal botanic gardens, Kew, London, pp. 66-67.
10. National Research Council (2006) Lost Crops of Africa: Volume II: Vegetables. ISBN 978-0-309-10333-6.
11. Fold N (2000) 'A matter of good taste? Quality and the construction of standards for chocolate in the European Union. Cahiersd' Economieet Sociologie Rurales, 55,56: 92-110.
12. Akihisa T, Kojima N, Katoh N, Ichimura Y, Suzuki H, et al. (2010) Triterpene alcohol and fatty acid composition of shea nuts from seven African countries. J Oleo Sci 59: 351-360.
13. Kanwaljit KC, Ramon B, Rosalia A, Galina G, Anna NW (2010) Shea butter contains no IgE-binding soluble proteins. J Allergy Clin Immunol. 127: 680-682.
14. Essengue SB, Stechschulte D, Olson N (2009) The use of Shea butter as an Emollient for Eczema. Journal of Allergy and Clinical Immunology. 123: 145-148.
15. Freeman IP (2005) "Margarines and Shortenings." Ullmann's Encyclopedia of Industrial Chemistry. (Wiley-VCH, Weinheim).
16. Rajah K (2005) "Spread thickly with innovation: with the basic concept of spreads unchanged for decades, producers have to be increasingly innovative in their product development and marketing. Kanes Rajah

outlines some successful strategies." Al Business website. The Gale Group, Inc.

17. Science Power (2006) Atlantic Edition, McGraw-Hill Ryerson Limited.
18. Clark P (1983) "The marketing of margarine". Paper presented to a seminar on Marketing and Advertising in the 20th Century at Central London Polytechnic. Emeral Backfiles. p 54.
19. Food and nutrition board, institute of medicine of the national academies (2005). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients). National Academies Press. p. 504.
20. Holt JB, Huston SL, Heidari K, Schwartz R, Gollmar CW, et al. (2015) Indicators for chronic disease surveillance - United States, 2013. MMWR Recomm Rep 64: 1-246.
21. Mathers CD, Loncar D (2006) Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 3: e442.
22. World Health Organization. Cardiovascular diseases (CVDs). Media centre.
23. Finks SW, Airee A, Chow SL, Macaulay TE, Moranville MP, et al. (2012) Key articles of dietary interventions that influence cardiovascular mortality. Pharmacotherapy 32: e54-87.
24. Howard BV, Wylie-Rosett J (2002) "Sugar and cardiovascular disease: A statement for healthcare professionals from the Committee on Nutrition of the Council on Nutrition, Physical Activity, and Metabolism of the American Heart Association." Circulation; 106: 523-7.
25. Micha R, Michas G, Mozaffarian D (2012) "Unprocessed red and processed meats and risk of coronary artery disease and type 2 diabetes- an updated review of the evidence." Current atherosclerosis reports, 14: 515-524.
26. Ramsden CE, Zamora D, Leelarthaepin B, Majchrzak-Hong SF, Faurot KR, et al. (2013) "Use of dietary linoleic acid for secondary prevention of coronary heart disease and death: evaluation of recovered data from the Sydney Diet Heart Study and updated meta-analysis." BMJ, 346: e8707.
27. Willett WC (2012) Dietary fats and coronary heart disease. J Intern Med 272: 13-24.
28. "Fats and fatty acids in human nutrition Report of an expert consultation". World Health Organization. WHO/FAO.
29. Jones PJ (2009) Dietary cholesterol and the risk of cardiovascular disease in patients: a review of the Harvard Egg Study and other data. Int J Clin Pract Suppl : 1-8, 28-36.
30. Goodrow EF, Wilson TA, Houde SC, Vishwanathan R, Scollin PA, et al. (2006) Consumption of one egg per day increases serum lutein and zeaxanthin concentrations in older adults without altering serum lipid and lipoprotein cholesterol concentrations. J Nutr. 136: 2519-2524.
31. Shrapnel WS, Calvert GD, Nestel PJ, Truswell AS (1992) Diet and coronary heart disease. The National Heart Foundation of Australia. Med J Aust 156 Suppl: S9-16.
32. "Trans- fat: Avoid this cholesterol double whammy". Mayo Foundation for Medical Education and Research (MFMER).
33. Mozaffarian D, Micha R, Wallace S (2010) "Effects on Coronary Heart Disease of Increasing Polyunsaturated Fat in Place of Saturated Fat: A Systematic Review and Meta-Analysis of Randomized Controlled Trials". PLoS Medicine 7: 1-10.
34. Chowdhury R, Warnakula S, Kunutsor S, Crowe F, Ward HA, et al. (2014) Association of dietary, circulating, and supplement fatty acids with coronary risk: a systematic review and meta-analysis. Ann Intern Med 160: 398-406.
35. Malachi OI (2015) Palm Oil: An Over - Acclaimed Cooking Oil in Nigeria. Annual Research & Review in Biology. Sciencedomain International. In Press.
36. Emken EA (1994) Metabolism of dietary stearic acid relative to other fatty acids in human subjects. Am J Clin Nutr 60: 1023S-1028S.
37. Hunter JE, Zhang J, Kris-Etherton PM (2009) "Cardiovascular disease risk of dietary stearic acid compared with trans, other saturated, and unsaturated fatty acids: A systematic review". Amer J Clin Nutr; 91: 46-63.
38. Esuoso KO, Lutz H, Bayer E, Kutubuddin M (2000) Unsaponifiable lipid constituents of some underutilized tropical seed oils. J Agric Food Chem 48: 231-234.
39. Alander J (2004) Shea Butter- a Multi-Functional Ingredient for Food and Cosmetics. Lipid Technol. 16: 202-205.
40. Ito T, Tamura T, Matsumoto T (1974) Sterols, methylsterols, and triterpene alcohols in three Theaceae and some other vegetable oils. Lipids 9: 173-184.
41. Lipp M, Anklam E (1998) Review of Cocoa Butter and Alternative Fats for Use in Chocolate-Part A. Compositional Data. Food Chem 62: 73-97.
42. Peers KE (1977) The Non-Glyceride Saponifiables of Shea Butter. J Sci Fd Agric. 28: 1000-1009.
43. Hamilton RJ, Rossell JB (1986) Analysis of Oils and Fats. Elsevier Applied Science. New York. NY.
44. Davrieux F, Allal F, Piombo G, Kelly B, Okulo JB, et al. (2010) Near infrared spectroscopy for high-throughput characterization of Shea tree (Vitellaria paradoxa) nut fat profiles. J Agric Food Chem 58: 7811-7819.
45. Maranz S, Wiesman Z (2004) Influence of climate on the tocopherol content of shea butter. J Agric Food Chem 52: 2934-2937.
46. Maranz S, Wiesman Z, Bisgaard J, Bianchi G (2004) Germplasm resources of Vitellaria paradoxa based of variations in fat composition across the species distribution range. Agroforestry systems (in cooperation with ICRAF). 60: 71.
47. Baydar NG, Ozkan G, Cetin ES (2007) Characterization of Grape Seed and Pomace Oil Extracts. Grasas Aceites. 58: 29-33.
48. Damodaran S, Parkin KL, Fennema OR (2008) Fennema's Food Chemistry. 4th edn. CRC Press. Boca Raton, FL.
49. USDA (2007) National Nutrient Database for Standard Reference. National Agricultural Library.
50. Samman S, Chow JWY, Foster MJ, Ahmad ZI, Phuyal JL, et al. (2008) Fatty Acid Composition of Edible Oils Derived from Certified Organic and Conventional Agricultural Methods. Food Chem. 109: 670-674.
51. Malachi OI (2014) Effects of topical and dietary use of Shea butter on animals. American Journal of Life Sciences; 2: 303-307.
52. Lide DR (2009) CRC Handbook of Chemistry and Physics (90th edn). Boca Raton, Florida: CRC press. ISBN: 978-1-4200-9084-0.
53. Beare-Rogers J, Dieffenbacher A, Holm JV (2001) "Lexicon of lipid nutrition (IUPAC Technical Report)". Pure and Applied Chemistry 73: 685-744.
54. Oja V, Chen X, Hajaligol MR, Chan WG (2009) "Sublimation Thermodynamic Parameters for Cholesterol, Ergosterol, ß-Sitosterol, and Stigmasterol". Journal of Chemical & Engineering Data 54: 730-734.
55. "Imace - How margarine is made". Imace. Available at:
56. Baker CGJ, Ranken HD, Kill RC (1997) Food industries manual. (24thedn). Springer. pp. 285-289.
57. Babaeu Z, Nikoopour H, Safafar H (2007) A comparison of commercial nickel catalysts effects on hydrogenation of soybean oil. World Applied Sciences Journal 2: 621-626.
58. Claek J "The Hydrogenation of Alkenes: Margarine Manufacture". Chemguide: Helping you to understand Chemistry.
59. "Margarine". Butter through the ages.
60. Shurtleff W, Akiko A (2007) "History of sot oil margarine". Soyinfo Center.
61. Asuquo JE, Anusiem CI, Etim EE (2010) Extraction and characterization of Shea butter oil. World journal of applied science and technology; 2: 282-288.
62. de Roos N, Schouten E, Katan M (2001) Consumption of a solid fat rich in lauric acid results in a more favorable serum lipid profile in healthy men and women than consumption of a solid fat rich in trans-fatty acids. J Nutr 131: 242-245.
63. Sundram K, French MA, Clandinin MT (2003) Exchanging partially hydrogenated fat for palmitic acid in the diet increases LDL-cholesterol and endogenous cholesterol synthesis in normocholesterolemic women. Eur J Nutr 42: 188-194.

64. Malachi OI, Ajayi OB, Akomolafe SF (2014) Effects of Shea Butter Based Diet on Hepatic and Renal Enzymes and Plasma Lipid Profile in Albino Rats. Advances in Biochemistry. 2: 80-84.

65. Akinwale A, Modu S, Maisartu MA, Zainab MA, Bilkisu UMA (2012) Effect of Feeding Various Concentrations of Shea oil on Some Biochemical Parameters in Normal Albino Rat. Bulletin of Environment, Pharmacology & Life Sciences. 1: 14 -17.

This article was originally published in a special issue, entitled: **"Effects of Obsession or ignorance of Nutrtion",** Edited by Weiqun George Wang