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Regulated Effects of *Capsicum frutescens* Supplemented Diet (C.F.S.D) on Fasting Blood Glucose Level, Biochemical Parameters and Body Weight in Alloxan Induced Diabetic Wistar Rats

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Authors' contributions

This work was carried out in collaboration between all authors. Author OEA designed the study and wrote the first draft of the manuscript. Author ACE managed the literature searches; author EOL performed the statistical analysis and managed the analyses of the study. All authors read and approved the final manuscript. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aim of the Study: This study investigates the effects of *Capsicum frutescens* supplemented diet (C.F.S.D) on fasting blood glucose level, biochemical parameters and body weight in alloxan induced diabetic Wistar rats.
Experimental Design: 130 – 150g healthy forty male Wistar rats were divided into four groups as following; Group 1 served as a normal control and received normal feed-. Group 2 (Diabetic control) received normal feed-. Group 3 (Diabetic test 1) received normal feed + 1g Capsicum frutescens.-. Group 4 (Diabetic test 2) received normal feed + 2g Capsicum frutescens.
Place and Duration of Study: This study was carried out in the department of Physiology, Faculty of Basic Medical Sciences, Delta State University, Abraka and the

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feeding lasted for three weeks. At the end of the experiments, the animals were sacrificed, blood samples were collected and then the serum was further subjected to biochemical analysis using biochemical analyzer (Reflotron Plus).
Results: AST, ALT, ALP, GGT, Creatinine, Uric acid, total cholesterol and fasting blood sugar level in serum were increased however the high density lipoprotein cholesterol (HDL-c) of serum was decreased in diabetic control (group 2), compared with non-diabetic control (group 1). The administered *Capsicum frutescens* in the diet at 1g and 2g doses significantly reduced the fasting blood glucose level as well as the serum level of AST, ALT, ALP, GGT, Creatinine, Uric acid, total cholesterol, compared with diabetic control. Serum HDL was also significantly increased when compared with diabetic control $P<0.05$. Decrease in body weight in diabetic control group and increased in body weight of 1gand 2g Capsicum frutescens supplemented diet groups were also observed.
Conclusion: The observed improvement in the biochemical parameters, blood glucose levels and body weight of alloxan induced diabetic Wistar rats by 1g and 2g *Capsicum frutescens* supplemented diet suggests *Capsicum frutescens* to possess, cardio-protective and anti-diabetic properties.
Recommendation: The incorporation of *Capsicum frutescens* as spice in the diet of individuals who are diabetic, hypertensive and obese, is worthy of recommendation.

Keywords: Capsicum frutescens; fasting blood glucose; liver enzymes; capsaicin; thermogenesis.

1. INTRODUCTION

Diabetes mellitus (DM) has been described as a multifactorial disease that is characterized by hyperglycemia and lipoprotein disorders [1], increased basal metabolic rate [2], defect in reactive oxygen species scavenging enzymes, as well as altered metabolism of major food substances [2]. Diabetes is a major degenerative disease in the world today [3], affecting at least 15 million people and resulting in complications which include hypertension, atherosclerosis and microcirculatory disorders. Diabetes mellitus is a syndrome of impaired carbohydrate, fat and protein metabolism caused by either lack of insulin secretion or decreased sensitivity of the tissue to insulin.

At least 80% of Africans depend on plant medicine for their healthcare [4]. Today, medicinal plants are increasingly being used in most parts of the world as: hypolipidemic [5]; antihypertensive [6]; treatment for skin diseases [7] and hypoglycemic [8], agents.

For the past 25 years, epidemiological studies have revealed a diminished occurrence of chronic diseases in populations consuming diets fortified with fruits and vegetables, [9]. It has been suggested that antioxidants found in large quantities in fruits and vegetables may be responsible for this protective effect, [10]. In the past three decades, resulting from several studies, it has been documented that some common spices can also exert beneficial health effects, [11,12]. These beneficial health effects of spices in most instances have been reported to be as a result of their chemical composition; some of these beneficial health effects of spices documented are hypolipidemic and antioxidant properties [13].

One of such plant that produce spices is *Capsicum frutescens*; a short lived evergreen shrub that usually grows from 1 to 1.5m in height and 1 to 3cm in basal stem diameter. It is commonly recognized by its fruit, the large red, orange, or yellow chili peppers that the plant

produces. *Capsicum frutescens* fruits grow as long pods, and when ripe they develop their characteristic red coloring. This plant originated in south or Central America, then spread quickly throughout the subtropical regions and still grows wild today. The plant grows in tropical climates, because it needs a warm, humid climate to survive. It had been reportedly used in the treatment of various ailments such as diabetes, blood pressure [high/ low], bronchitis, burning feet, arthritis, etc [14].

Accumulating evidence has shown multiple pharmacological effects of Capsicum on a variety of physiological systems such as cardiovascular system, gastro-intestinal tract, metabolic rate, and pain relief, [15].

Previous research have shown the Chemo-Protective effect of spices among which are; *Turmeric*, *Capsicum frutescens*, *Cloves* and *Cardamom* in correcting iron overload-induced liver injury, oxidative stress and serum lipid profile in rat model. The incorporation of chili (*Capsicum frutescens*) in the diet at 2g significantly restored the enzyme activities of the liver AST, ALT, and ALP to normal level [16].

The chemical substance in *Capsicum frutescens* that gives it the hot and spicy flavor was identified as capsaicin, [15]. Red chili (*Capsicum frutescens)* is widely used as a spice for flavoring foods, particularly in South- East Asian and Latin-American countries. Several studies indicate that capsaicin (red pepper) is an appetite suppressant which can slightly increase metabolism. Spicing up one's foods with capsaicin-containing spices and using red pepper as a condiment can aid in increasing the rate of fat burning or thermogenesis. In an article published in the British Journal of Nutrition, Yoshioka et al. [17] concluded that the consumption of red pepper and caffeine can induce a considerable change in energy balance when individuals are given free access to foods. Pungent capsaicinoids (capsaicin, dihydrocapsaincin), antioxidant vitamins (ascorbic acid, vitamin E), carotenoids (β-carotene, β- cryptoxanthine) and several organic acids and minerals are the major active chemical substance found in *Capsicum frutescens,* [18]. Capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) is an irritant for mammals, including humans, and produces a sensation of burning on any tissue with which it comes into contact.The burning and painful sensations associated with capsaicin result from its chemical interaction with sensory neurons. Capsaicin, as a member of the vanilloid family, binds to a receptor called the vanilloid receptor subtype 1 (VR1), [19].

However, there are not enough scientific documentation on the effects of *Capsicum frutescens* supplemented diet on biochemical parameters in a diabetic state. The present study was designed depending on this background.

2. MATERIALS AND METHODS

2.1 Chemicals and Equipments

Some fresh fruits of red peper (*Capsicum frutescens*) Fig 1, was purchased from Abraka market in Ethiope East local government area, Delta State, and authenticated by Dr. (Mrs). N.E. Edema in the department of Botany, Faculty of Science, Delta State University, Abraka. It was then air-dried at room temperature (22±1ºC) for 14 days Fig 2, until a constant weight was attained and then blended with the aid of a grinding machine and stored in an airtight container for use in the experiment. Alloxan monohydrate (Sigma, alpha Aesar, 25g. A15324, CAS:2244-11-3. Cotton wool, Hand gloves, Dissecting kit, Centrifuge, Pipettes,

Growers mash, Beakers, Electronic weighing balance, Syringes and needles, Marker pen, Oncall Redii Glucometer with diagnostic glucose strips, and Reflotron plus kit.

Fig. 1. Fresh fruits of *Capsicum frutescens*

Fig. 2. Dried Fruits of *Capsicum frutescens*

2.2 Preparation of Pepper Suplemented Diet

1g and 2g *Capsicum frutescence* supplemented diet were prepared by weighing 1g and 2g of blended Capsicum frutescence and mixing them with 99g and 98g of animal feed (growers mash) respectively.

Composition of the grower's marsh:

Protein	-19.0%
Fat	-2.85%
Fibre	-6.00%
Calcium	-1.00%
Available phosphate	-0.45%
Energy	-2875 KGC

(Animal Care Services Konsult (NIG) LTD).

2.3 Handling of Experimental Animals

Forty (40) healthy Male Wistar rats weighing 130-150g were acquired from the International institute of tropical agriculture, (IITA), Ibadan Nigeria. They were acclimatized for 14 days before commencement of the experiment. The rats were kept in well ventilated wooden cages, in a room with optimal humidity and temperature, and fed growers marsh, with water *ad libitum*. Procedures followed in raising the experimental animals were in accordance with the ethical standards of the Institutional Animals Ethics Committee (IAEC). And permission for the use of animals and animal protocol was obtained from the Research Ethics Committee of Delta State University, Abraka.

2.4 Induction of Diabetes

Thirty (30) animals were fasted for 24 hours (but with free access to water) and then the diabetes was by injecting a single intraperitonial dose of alloxan monohydrate (150mg/kg) prepared in stock of 1500mg/50ml and a concentration of 30mg/ml. After three days, rats with fasting blood glucose concentration above 200mg/dl were considered diabetic and selected for the experiment.

2.5 Experimental Procedure

Diabetic rats were randomly divided into 3 different groups and rats the were not induced were grouped as normal control (Group 1) as following:

Group 1: Non diabetic rats received normal diet (non-diabetic control).
Group 2: Diabetic rats received normal diet (diabetic control).
Group 3: Diabetic rats received 1g *Capsicum frutescens* supplemented diet (test 1 group).
Group 4: diabetic rats received 2g *Capsicum frutescens* supplemented diet (test 2 group).

Each animal was fed a 5g meal formulated by mixing 1g and 2g *Capsicum frutescens* with 99g and 98g animal feed and treatment was done twice daily for twenty one days. Rats' initial body weight prior to commencement of treatment was recorded. Inclusion criteria in this study were non diabetic animals (which served as positive control), and animals with

evidence of diabetes. Exclusion criteria include those animals that died during induction of diabetes and the treatment period. Thus higher numbers of animals were allocated to groups 1, 2 and 3.

2.6 Blood Collection and Biochemical Assay

After twenty one days of treatment, the rats were anaesthetized using chloroform and then sacrificed. Blood samples was collected by cardiac puncture were delivered into lithium heparin bottles. The tubes were then centrifuged at 4000 rpm for ten minutes to obtain clear serum which were later subjected to biochemical evaluation for ALT, AST, ALP, GGT, URIC ACID, CREATININE, HDL, and TOTAL CHOLESTEROL using Reflotron plus kit.

Fasting blood glucose level was determined with the aid of glucose analyzer machine (Oncall- Redii glucometer) by collecting blood samples from tail veins of overnight fasted animals. Values were expressed in mg/dl.

2.7 Statistical Analysis

The result of this study were expressed as mean $\pm$ SEM, and were analyzed by one way analyses of variance (ANOVA) using statistical package for social science (SPSS, 16). Difference between the means were tested with post Hoc- Tukey's test for multiple comparison and significance was considered when $p< 0.05$. Student's dependent t-test was used to analyze the significant difference between body weight before treatment and after treatment.

3. RESULT AND DISCUSSION

The action of capsaicin is mediated by TPRV1 (vanilloid receptor), which belongs to an ion channel group. VR1 when activated permits cations to pass through the cell membrane and into the cell resulting in depolarization of the neuron stimulating it to signal the brain. By binding to the VR1 receptor, the capsaicin molecule produces the same sensation that excessive heat or abrasive damage would cause, explaining why the spiciness of capsaicin is described as a burning sensation. The inflammation resulting from exposure to Capsaicin is believed to be the result of the body's reaction to nerve excitement rather than just chemical burn or any direct tissue damage when chili peppers are the source of exposure. Capsaicin is the chemical in chili peppers that contributes to their spiciness; capsaicin stimulates a receptor found in sensory neurons, creating the heat sensation and subsequent reactions like redness and sweating.

Table 1. Effects of *Capsicum frutescens* supplemented diet on biochemical parameters of alloxan induced diabetic Wistar

	Group 1: Non-Diabetic control	Group 2: Diabetic control	Group 3: Diabetic +1g C.F.S.D	Group 4: Diabetic + 2g C.F.S.D.
Creatinine (IU/L)	0.42 ± 0.03	0.94 ± 0.17[a]	0.4 ± 0.3[b]	0.54 ± 0.07[b]
Uric acid (IU/L)	5.49 ± 0.2	7.87 ± 0.85[a]	5.03 ± 0.2[b]	6.3 ± 0.7
GGT (IU/L)	223.4 ± 7.5	275.0 ± 10.7[a]	221.8 ± 6.4[b]	224.8 ± 6.0[b]
AST (IU/L)	278.4 ± 19.6	325.2 ± 26.1	247.2 ± 10.8[b]	251.8 ± 12.3
ALP (IU/L)	251 ± 6.81*	316.4 ± 37.7*	327.6 ± 27.6*	243.8 ± 4.5 3*
ALT (IU/L)	61.7 ± 1.03*	128.2 ± 32.97*	98.98 ± 8.74*	87.86 ± 8 .54*
HDL (mg/dl)	47.98 ± 1.8 [ns]	43.1 ± 2.8	46.8 ± 1.6 [ns]	46.0 ± 1.4[ns]
T. Cholesterol (mg/dl)	85.6 ± 5.6	79.2 ± 4.4	101.6 ± 3.3[b]	61.5 ± 3.4[abc]
Initial blood glucose level (mg/dl)	88.8 ± 6.22	380.2 ± 16.6	363.8 ± 24.3 [d]	382.2 ± 14.7[d]
Final blood Glucose level (mg/dl)	94.8 ± 6.18 (6.8%)	370.0 ± 19.81[a] (-2.63%)	182.8 ± 16.82[abd] (-49.8%)	146.6 ± 14.8[bd] (-61.6%)

*Values are expressed as mean ± Standard error of mean (S.E.M), n=10 *P<0.05: Significant as determined by one way analysis of variance. Significant difference ([abc]P < 0.05): (a) compared to group 1, (b): to group 2, (c): to group 3.[d]P<0.05: Significant when initial and final fasting blood glucose level were compared in groups 3 and 4. Values in parenthesis depict the percentage change in FBGL when initial and final values were compared. Significant difference ([ns]P< 0.05) HDL, comparing groups 1, 3, 4 with group 2 .*

AST- (Aspartate Transaminase); ALT- (Alanine amino Transaminase); ALP- (Alkaline Phosphatase); GGT- (Gamma Glutamyl Transpeptidase). They are all liver enzymes (biomarkers) of liver damage.

In the study by Yoshioka et al. [17], 8.6g and 7.2g red pepper, added to lunch and dinner respectively and caffeine consumption significantly reduced the cumulative ad libitum energy intake and increased energy expenditure. Almost 1000 additional calories per day were burned by combining caffeine consumption with substances containing red pepper.

The New York Daily News published an article, “15 fat-burning foods” about the capsaicin and caffeine combination that simply states “men who consume coffee and red pepper-packed snacks and meal burned almost 1000 more calories a day then the control group”.

Yasser [22], found that capsaicin can create “heat” in a more direct manner by altering the activity of a muscle protein called SERCA. Normally, muscle contraction is initiated following the release of a wave of calcium ions from a compartment called the sarcoplasmic reticulum. SERCA then actively pumps the calcium back into the sarcoplasmic reticulum (using ATP energy), causing muscle relaxation and renewing the cycle. Capsaicin, however can attach to SERCA and “uncouple” this pumping activity, that is, the protein still burns ATP energy but does not use it to pump calcium. Instead, all the ATP energy is given off as heat. This uncoupling known as thermogenesis, is one important method of staying warm and is most often seen in hibernating animals. Yasser noted also that capsaicin is the first natural compound known to augment the thermogenesis process. The findings further explained how capsaicin intake can increase metabolism and body temperature. The study also noted that though relatively high amounts of capsaicin (probably more than someone could eat), was required to effectively achieve the desired result, but the structure of capsaicin could be used as a model to design more potent compounds that might have clinical use such as treating hypothermia.

Avraham et al. [23], in their study tittled, “Cannabinoids and capsaicin improve liver function following thioacetamide-induced acute injury in mice”, reported an improvement both in liver pathology and function.

In the present study, there was an observed decrease in body weight of the Wistar rats in the treated groups compared to the normal control group (Table 2). However, an increase in body weight was observed when the treated groups were compared to the diabetic control group. Though, *Capsicum frutescens* has been reported to aid the rate of fat burning [17], in a diabetic state it can actually reduce the rate of loss of the body’s protein (muscles). This is possibly achieved through the activities of the antioxidant vitamins such as ascorbic acids and vitamin E present in *Capsicum frutescens* [18], which helps to counteract the effect of the reactive oxygen species.

Table 2. Effects of *Capsicum frutescens* (C.F.) supplemented diet on body weight of alloxan induced diabetic rats

	Body weight before treatment Week 0 (g)	Body weight after treatment Week 3 (g)
Group 1 (Normal control)	131 ± 9.8	195 ± 17.2 (48.9%)
Group 2 (Diabetic control)	140 ± 9.6	120 ± 7.9 (-16.7%)
Group 3 (Diabetic, 1g C.F.S.D)	125 ± 6.7	134 ± 19.2 (7.2%)
Group 4 (Diabetic, 2g C.F.S.D)	140 ± 7.2	152 ± 16.9 (8.5%)

Values are expressed as mean ± Standard error of mean (SEM), n = five animals per group. C.F: Capsicum frutescence.

Significant reduction in FBGL in 1g (group 3) and 2g (group 4) C.F.S.D treated groups (Table 1), may be attributed to the presence of hypoglycemic agents in *Capsicum frutescens*. Studies had shown that *Capsicum frutescens* is used to treat diabetes mellitus by traditional healers in Jamaica, [24]. Pharmacokinetic and effect of Capsaicin in *Capsicum frutescens* on decreasing plasma glucose level in a crossover study of 12 healthy volunteers by performing the OGTT while receiving placebo or 5 grams of capsicum had been documented [25].

Impaired carbohydrate utilization in the diabetes also leads to accelerated lipolysis, which results in elevated plasma triglycerides levels (hyperlipidemia), [26]. The observed abnormalities of triglyceride and HDL metabolism are in accordance with reports on early manifestation of insulin resistance, the precursor to diabetes [27; 28]. In this study, treatment with 2g *Capsicum frutescens* resulted in a reduction in serum level of total cholesterol when compared to the control groups. Manjunatha and Srinivasan [13], in the study also reported the hypolipidemic and antioxidant potency of capsicum frutescens.

Individuals with type 2 diabetes had also been reported to have a higher incidence of liver function test abnormalities compared to non diabetic individuals. Mild chronic elevations of transaminases often reflect underlying insulin resistance. Diabetes mellitus can arise as a result of insulin insufficiency, which is associated with altered activity of various liver enzymes, [20]. Grossi, et al. [21] had also reported that values of serum ALP can be raised in diabetic patients. The liver releases alanine aminotransferase (ALT) and an elevation in serum levels are an indicator of liver damage, [28]. The levels of aspertate aminotransferase (AST), alanine amino transaminase (ALT) and alkaline phosphatase (ALP) had been reported to be increased in alloxan-induced diabetic rats, [29]. Increased in serum liver enzymes parameters in diabetic control group observed in the present study corroborates these findings. Reduction in liver enzyme levels in group 3 (1g, C.F.S.D.) and 4 (2g C.F.S.D.) clearly indicates the therapeutic potency of *Capsicum frutescens* against increased in serum liver enzyme parameters seen in alloxan induced diabetes (Table 1). In previous research, *Capsicum frutescens* had been documented to protect against iron overload liver injury by reducing plasma liver parameters levels to normal, [16].

There was a significant increase in serum creatinine level of group 2. An increase in plasma creatinine levels may be a sign of impaired renal function which is associated with diabetes. The elevation in the plasma creatinine concentration indirectly suggests kidney damage specifically the renal filtration mechanism, [30]. Significant reduction observed in the serum creatinine levels of the diabetic rats treated with 1g and 2g C.F.S.D in this study suggests protective effect by *Capsicum frutescens* against kidney disorders associated with diabetes mellitus (Table 1).

4. CONCLUSION

In this study, increase in serum liver enzymes (AST, ALT, ALP, GGT), increased in serum uric acid, creatinine, total cholesterol, fasting blood glucose level and reduced high density lipoprotein (HDL) cholesterol associated with alloxan induced diabetes mellitus were reversed after treatment with 1g and 2g *Capsicum frutescens* supplemented diet. Such remarkable changes observed in this study could be traced to the chemical substances [capsaicin, dihydrocapsaincin, antioxidant vitamins (ascorbic acid, vitamin E), carotenoids (β-carotene, β- cryptoxanthine) and several organic acids and minerals present in *Capsicum frutescens.*The thermogenic and protein sparing properties of *Capsicum frutescens* has been reported by several authors and results from this study also lends credence to this fact.

It's therefore recommended that *Capsicum frutescens* be added as spices to the food of obese individual as well as diabetic patients for its hypoglycemic properties, inducing of increase energy utilization as well as being cardio-protective by its effect on plasma lipids.

CONSENT

Not applicable.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee" of Delta State University, Abraka.

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki."

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Scoppola, A, Montecchi, FR, Mezinger, G, Lala, A. Urinary mevalonateexcretion rate in type 2 diabetes: role of metabolic control. Atherosclerosis. 2001;156:357-361.
2. Avesani, CM, Cuppari, L, Silva, AC., Sigulem, DM, Cendoroglo, M, Sesso, R. and Draibe, SA. Resting energy expenditure in predialysis diabetic patients. Nephrol. Dial. Transplant. 2001;16:556-560.
3. Ogbonnia SO, Odimegwu JI, Enwuru VN. Evaluation of Hypoglycemic and Hypolipidemic Effects of Aqueous Ethanolic Extract of *Treculia africana* Decne and *Bryophyllum Pinnatum* Lam and Their Mixture on Streptozotocin(STZ)-induced Diabetic Rats. Afr. J. Biotechnol. 2008;7(15):2535-2539.
4. Sofowora, A. Medicinal Plants and Traditional Medicine in Africa, 2nd Edition, Spectrum Books, Ibadan, Nigeria. 1993;26-100.
5. Ugochukwu, NH, Babady, NE, Cobourne, M Gasset, SR. The effect of Gangronema latifolium extracts on serum lipid profile and oxidative stress in hepatocytes of diabetic rats. Journal of Biosciences. 2003;28(1):1-5.
6. Ojewole, JAO, Adewole, SO. Hypoglycemic and hypotensive effects of Globimetula cupulata leaf extract in rats. Cardiovascular. J. S. Africa. 2007;18(1):9-15.
7. Ajose, FOA. Some Nigeria plants of dermatologic importance. Int. J. Dermatology. 2007;46(1):48-55.
8. Eddouks M, Jouad H, Maghrani M, Lemhadri A, Burcelin R. Inhibition of endogenous glucose production accounts for hypoglycemic effect of *Spergularia purpurea* in streptozotocin mice. Phytomedicine: International Journal of Phytotherapy andn Phytopharmacology. 2003;10(6-7):594-599.
9. Pryor W, Stahl W, Rock C. Beta carotene: Bio chemistry to clinical Trials. Nutr Rev. 2000;58:39-53.
10. Halliwell B. Antioxidants sense or speculation. Nutr Today. 1994;29:15-19.

11. Srinivasan MR, Chandrasekhara N. Comparative influence of vanillin and capsaicin on liver and blood lipids in the rat. Ind. J. Med. Res. 1992;96:133-135.
12. Srinivasan K. Role of spices beyond food flavouring: Nutraceuticals with multiple health effects. Food Reviews Int. 2005;21:167–188.
13. Manjunatha H, Srinivasan K. Hypolipidemic and antioxidant potency of heat processed turmeric and red pepper in experimental Rats. Afr. J. Food Sci. 2008;2:1-6.
14. Dewitt, DS, Melissa T, and Hunter, K. The Healing Powers of Hot Peppers. Three Rivers Press, NY. 1998;17-22.
15. Chaiyata P. Effect of chili pepper (Capsicum frutescens) ingestion on glucose response, metabolic rate, lipid profile, lipid peroxidation, thrombogenic and fibrinolytic activities in hyperlipidemic thai women. Doctoral dissertation. Bangkok: Research Unit Nutrition Faculty of Medicine Ramathibodi Hospital Mahidol University; 2003.
16. Eman AS, Fatma HA. The Chemo-Protective Effect of Turmeric, Chili, Cloves and Cardamom on Correcting Iron Overload-Induced Liver Injury, Oxidative Stress and Serum Lipid Profile in Rat Models. Journal of American Science. 2010;6(10):42- 47.
17. Yoshioka M, Doucet E, Dropeau V, Dionne I, Tremblay A. Combined Effect of Red Pepper and Caffeine Consumption on 24 Hour Energy Balance in Subjects Given Free Access to Foods. British Journal of Nutrition. 2010;85:203-211.
18. Antonious GF, Meyer J, Snyder JC. Toxicity and repellency of hot pepper extracts to spider mite, Tetranychus urticae Koch. J. Environ. Sci. Health. 2006;41:1383-1391.
19. Story GM, Crus-Orengo L. "Feel the burn". American Scientist .2007;95(4):326–333.
20. Siddiqui SA, Cheema AM, Waheed M. Study of serum insulin, liver profile and protein levels of insulin resistanttype-2 diabetics in Pakistan population. Pak J BiochemMol Biol. 2005;38(3-4):92-97.
21. Grossi SG, Genco RJ, Machtei E. Periodontal diseaseand diabetes mellitus: A two way relationship. J Ann Periodonta.1988;3:51-61.
22. Yasser Mahmoud. Capsaicin stimulates uncouple ATP hydrolysis by the sarcoplasmic reticulum calcium pump. Journal of Bio chem. 2008;283(31):214- 218.
23. Avraham Y, Zolofarev O, Grigoriadis NC, Poutahidis T, Magen I, Vorobiav I, et al. Cannabinoids and Capsaicin improve liver function following thioacetamide-induced acute injury in mice. Am J Gastroenterol. 2008;103(12):3047- 3056.
24. Tolan I, Ragoobirsingh D, Morrison EY. Isolation and purification of the hypoglycaemic principle present in *Capsicum frutescens*. Phytotherapy Research .2004;18(1):95-96.
25. Kamon C, Weerapan K, Supeecha W. Pharmacokinetic and The Effect of Capsaicin in *Capsicum frutescens* on Decreasing Plasma Glucose Level. J Med Assoc Thai. 2009;92(1):108-113
26. Granner DK, Mayes PA, Rodwell VW. Harper's Biochemistry, 24th ed, Connecticut, USA, Appleton and Lange. 1996;586-587.
27. Frederickson DS, Lee RS. A system for phenotyping hyperlipidemia. Circulation. 1965;31:321-327.
28. Lyons TJ. Lipoprotein glycation and its metabolic complications. Diabetes. 1992;41(2):67-73.
29. Claudia ENM, Julius EO, Dagobert T, Etienne D. Antidiabetic and Hypolipidemic effects of *Laportea ovalifolia (*URTICACEAE) in alloxan induced diabetic rats. Afr. J. Tradit., Complement. Altern. Med. 2006;3(1):36-43.
30. Akah PA, Alemji, JA, Salawu OA, Okoye TC, Offiah NV. Effects of *Vernonia amygdalina* on Biochemical and Hematological Parameters in Diabetic Rats. Asian Journal of Medical Sciences. 2009;1(3):108-113.
31. Wasan KM, Najafi S, Wong J, Kwong M. Assessing plasma lipid levels, body weight, and hepatic and renal toxicity following chronic oral administration of a water soluble phytostanol compound FMVP4, to gerbils. J. Pharm. Sci. 2001 4(3):228-234.

32. Lehninger, AL. Principles of Biochemistry. CBS Publishers and Distributors Pvt. Ltd, India 1998:531-535.

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