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Okoi Nta Obono
MBBS, Department of Family Medicine, University of Calabar Teaching Hospital, Calabar, Nigeria

Etim John John
B.PH, Department of Public Health, Faculty of Allied Medical Sciences, College of Medical Sciences, University of Calabar, Calabar, Nigeria

Correspondence
Okoi Nta Obono
MBBS, FWCP Department of Family Medicine, University of Calabar Teaching Hospital, Calabar, Nigeria

Nutritional and therapeutic importance of lycopene: a strong antioxidant present in red tomatoes for effective reduction of plasma lipid profile (hyperlipidemia) and prevention of cardiovascular diseases in humans

Okoi Nta Obono and Etim John John

Abstract
The nutritional and therapeutic importance of fruits and vegetables cannot be over emphasized. This was the case of what the researchers found out of lycopen in red tomatoes especially in the prevention and management of hyperlipidemia. The study was to investigate the comparative effect of lycopene in raw tomatoes, tomato juice and cooked tomatoes on the lipid profile in male rats induced with hyperlipidemic diets. Forty (40) male Wister rats were used for the studies which were fed for 30 different days with hyperlipidemic diets. Data was collected and analyzed using SPSS version 15. ANOVA and T-test was used to test for associations and results were presented in tables. The study showed that lycopene present in red tomatoes can be used in the prevention and management of hyperlipidemic which is a risk factor for cardiovascular risks. The assessment of the effect of the three preparations of tomatoes showed that the cooked tomatoes have the greatest effect of reducing the activity of the enzyme lipase. This is because lycopene present in the cooked tomatoes was more readily absorbed in the intestine and thus has a higher concentration in the blood. The higher the concentration of lycopene in the blood, the more effective it is on serum lipid metabolism. This can be used as weight reducing agent since it lowers the intestinal fat absorption and increases faecal fat content.

Keywords: Lycopene, hyperlipidemia, red tomatoes, cardiovascular diseases, diet

Introduction

Dietary intake of fats strongly influences the risk of cardiovascular diseases such as coronary disease and stroke through effect on blood lipid thrombosis and inflammation (Byers, 1997) [2]. Fats are important nutrient in our diet. They provide a concentrated form of energy of about 9 calories per gram and help to give our foods high satiety value. Fats also help to give foods its pleasing taste. It carries the fats soluble vitamins A, D, E and K. without fats, these vitamins would quickly pass through the body. Fats insulate our bodies to help us retain heat during cold weather.

Every type of dietary fat is made up of a combination of three forms: saturated, mono-unsaturated and poly-unsaturated based on the chemical and the number of double bonds present in the composition. Saturated fats including those found in animal sources and in vegetable oils to which hydrogen has been added, becoming trans-fatty acids is responsible for the deposition of cholesterol on the walls of the heart and arteries. A high blood level of cholesterol has been found to be a risk factor for the development of cardiovascular diseases. Cholesterol is important in all animals' tissue and is manufactured by our bodies from carbohydrates and fats. Therefore, cholesterol in the blood and tissue is derived from two sources: the exogenous synthesis. The dietary fats, mostly of animal origin, include whole milk, shellfish, animal fats and egg yolks that contain saturated fats.

The second half of the 20th century has witnessed a major shift in the pattern of diseases which is characterized by profound changes in diet and lifestyle. In developing countries like ours, the effect of the nutrition transition and the mismatch between healthcare needs and resources and the already scarce resources will be stretched further more. The association of dietary fats with heart attack and stroke has by no means resolved and this diet-heart disease was the basis of this research. Recently, the role of antioxidant use in the prevention of cardiovascular diseases and cancer has received much attention and β-carotene began in 1920s (Grossman, Lohr & Im, 2004) [5] and lycopene found in red tomatoes in 1980s (Rao & Agarwal, 1998) [8]. The rationale for the use of lycopene in the treatment of cardiovascular diseases was seen in people that are diet rich in red tomatoes to have a lower risk of heart diseases (Draz, 1997) [3].

A study carried out using men and women with moderate ischaemic heart disease found that the consumption of red tomatoes has a significant reduction in cardiovascular symptoms (Weisburger, 1998) [9]. Another study conducted by Gerster (1997) [4] found that the consumption of red tomatoes lowers the risk of developing degenerative diseases of which arteriosclerosis is one of them. The health benefit of dietary red tomatoes was attributed to lycopene as a strong antioxidant with many antiproliferative actions. Consequently, lycopene prevents lipid oxidation which causes damage to normal fat molecules that lead to tissue inflammation and lipid deposition to the heart muscles and arteries. However, the results of this study may suggest the best type of tomato preparation that is most effective in the reduction of plasma lipid profile and prevention of cardiovascular diseases in humans.

Statement of the Problem

Hyperlipidemia and free radical build up, secondary to Hypertension, Diabetes mellitus, and hyper cholesterol has contributed to increase in cardiovascular diseases. The strong antioxidant activity of lycopene in red tomato makes lycopene a potent agent for reduction and prevention of cardiovascular disease. Lycopene dietary intake in humans has been reported to reduce the risk of heart diseases and contributed in the reduction of plasma total cholesterol, low density lipoprotein and C-reaction protein. Controversy still abounds on the form of dietary lycopene which is most potent in the reduction of plasma lipid profile. There is paucity of data or studies of which type of lycopene preparation is most effective in the reduction of plasma lipid profile of hyperlipidemic rats in the study area. This has necessitated this study. Therefore, it was justified to carry out this study to show the effect of different red tomatoes preparation on the lipid profile in male rats induced with hyperlipidemic diets.

Aim and Objectives of the Study

The aim of the study was to investigate the comparative effect of lycopene in raw tomatoes, tomato juice and cooked tomatoes on the lipid profile in male rats induced with hyperlipidemic diets. Specifically, the study sought to achieve the following objectives:

1. To determine weight changes in male rats induced with hyperlipidemic diets.
2. To determine the weight of the fat content present in the faeces.
3. To determine the effect of the three different preparations of red tomatoes on the lipid profile in male rats.

Literature Review

Over the years, Non-Communicable Diseases (NCDs) were found to be prevalent in developed countries but this is becoming alarming in developing countries like Nigeria. Recently, obesity and sedentary lifestyle was thought to account largely for the increase in cardiovascular diseases among young Nigerians. This increase is two times higher, about 10% in urban dwellers than in rural Nigerian dwellers. A number of research have taken a quantitative approach to the evaluation of the causes of cardiovascular diseases but the risk factors could not fully explain the reason for the increase in cardiovascular diseases among young Nigerians. Some studies have suggested that hyper triglycerides, low level of HDL, central obesity, high levels of LDL and low levels of antioxidants may have contributed to the increase in cardiovascular diseases among young Nigerians.

A new concept has been proposed that tries to explain the high incidence of cardiovascular diseases among Nigerians. This is due to oxidative stress. Oxidative stress is a change in the pro-oxidant and antioxidant balance which leads to biological tissue damage. This oxidative stress lowers the antioxidant effect present in the body and increases the production of free radicals that causes wide spread organ damage and lipid oxidation which initiates the genesis of atheriosclerosis among young Nigerians. Oxidative stress is now a well-established major factor in the etiology of numerous chronic degenerative diseases like: arteriosclerosis, diabetes mellitus, asthma, arthritis and in some cases the antioxidant intervention has been shown to be effective in the prevention and treatment of these degenerative diseases. Some studies have shown that lycopene supplementation has reduced the risk of cardiovascular diseases by 30%-40%. The conclusion was that oxidative stress plays an important role both in the onset of arteriosclerosis and in its associated complications (Basu, 2007) [1].

Lycopene is a symmetrical molecule assembled from eight double bond units. It is a member of the carotenoid family of compound and consists entirely of carbon and hydrogen ($C_{40}H_{56}$). It was first isolated in 1910 and the structure of the molecule was determined in 1931. In its natural form, it is a long and straight molecule interrupted with eleven conjugated double bond. Each double bond has reduced energy required for electrons to move to the next higher energy level. These properties allow the molecule to be a powerful antioxidant. Lycopene is insoluble in water and can be dissolved only in an organic solvent and oils. It is stable between the temperature of 172-173ºC, so it is not easily destroyed by heat or cooking. They are responsible for the bright colours of fruits and vegetables. After the ingestion of cooked tomatoes, lycopene is incorporated into lipid micelles in the small intestine. These micelles are formed from dietary fat and bile acids which helps to solubilize the hydrophobic nature of lycopene and allow it to permeate the intestinal walls by a passive transport mechanism (Mozos, Stoian, Caraba, Malainer, Horbanczuk & Atanasov, 2018) [7].

Lycopene is one of the major carotenoids in the diet of most countries including Nigeria, North America and Europe. Momordia Cochinchinensis has the highest content of lycopene of any known fruits or vegetables up to seventy times (70x) more than tomatoes, but due to its scarcity outside its natural region of South East Asia, tomatoes and tomato-based sauces and juices accounts for more than 85% of the dietary intake of lycopene for most people in Nigeria. The lycopene content of tomatoes depends on the species and increases as the fruit ripens. Other sources of lycopene include apricot, guava, watermelon, papaya and pink grape fruits.

Tomatoes, unlike other fruits and vegetables where nutritional contents such as vitamin C are diminished upon cooking, the cooking of tomatoes increases the absorption of lycopene. Lycopene in tomato paste is four times more bio-available than in fresh tomatoes. For this reason, tomato sauce is a preferable source as opposed to raw tomatoes. Consequently, processed tomato products such as pasteurized tomato juice, soup or cooked contains the highest concentration of bio-available lycopene from tomato-based sources. Cooking and crushing tomatoes and serving in oil-rich dishes greatly increases assimilation from the digestive tract into the blood stream. Lycopene is fat-soluble, so the oil is to aid absorption of lycopene from the intestinal tract.

Table 1: Dietary sources and wet weight of tomato

Dietary sources	Wet weight (mg/g)
Raw tomato	8.8 – 42.0
Tomato juice	86 – 100
Tomato sauce	63 – 131
Tomato pink	20 – 54
Tomato puree	<0.1 – 7.8

Table 2: Distribution of Lycopene in body tissues

Tissues	Wet weight (mul/g)
Liver	1.28 – 5.72
Kidney	0.15 – 0.62
Adrenal gland	1.90 – 21.40
Ovary	0.25 – 0.28
Adipose tissue	0.20 – 1.30
Lung	0.31
Colon	0.75
Breast	0.78
Skin	0.42

Tomato, just like every fruit and vegetables provide important nutrients including anti-oxidants such as vitamins C, vitamin E, Bete-carotene and lycopene. Anti-oxidants have diseases-fighting properties that protect cells from damage by free radicals. Anti-oxidants work by neutralizing the free radicals generated when the body cells use oxygen for energy production in the body. Anti-oxidants may also help to keep the immune system healthy and reduce the risk of cancer and other chronic degenerative diseases.

There have been many studies into the use of lycopene as anti-oxidants to fight diseases. A heart study gave lycopene to 1,374 men for a period of one month and the result showed a reduction in the risk of heart diseases and some cancers (Basu, 2007) [1]. In a six years study of 47,000 male health professionals in Harvard Medical School found that eating a diet rich in tomato product more than twice a week was associated with reduction in heart diseases and some cancer incidence (Basu, 2007) [1]. Epidemiological studies have shown that the consumption of tomato-based product lowers the risk of degenerative diseases. A study by Gerster (1997) [4] showed that tomatoes, even the yellow varieties without lycopene have stronger anti-oxidant effects on rats. The procedure showed that, rats with mild oxidative stress caused by low vitamin E were fed with placebo, yellow tomato extract, red tomato extract and lycopene supplement. All the different tomato diets had no effect on plasma cholesterol but only the red tomato extract diet reduced the triglycerides. Rats fed with yellow tomato extract diet showed lower levels of thiobarbituric reactive species which is in bio-marker for cardiovascular diseases than those fed with placebo or lycopene supplement (Gerster, 1997) [4].

Other studies have also come to the conclusion that not only lycopene, but also other components present in the tomato extract may natural therapeutic potential as an anti-oxidant but not as hypolipidemic agents in hypertension and consumption of tomato juice for two weeks by human volunteer showed that lycopene present in the tomato juice reduced the plasma cholesterol and C-reactive proteins (Khan, Afaq & Mukhtar, 2008) [6]. Similarly, a study on adult human asthmatic patients showed that the intake of tomato juice or a daily intake of 45mg of lycopene supplement was good enough to reverse the unfavourable effect of a low anti-oxidant effect on eight (8) asthmatic patients airway obstruction due to inflammatory reaction (Rao & Agarwal, 1998) [8].

Materials and Method

The similarity with respect to metabolism of tomatoes between rats and humans suggests that the male rat is a good model for studying the effect of lycopene contained in red tomatoes on the lipid profile in humans. It is also known that the findings in rats are often been extrapolated to humans with a fair degree of accuracy in most cases. In this research, the effect of lycopene on the lipid profile in male rats was studied using the three different preparations of tomatoes, namely: raw tomatoes, tomato juice and cooked tomatoes. Consequently, laboratory male rats were used as animal model in this study. The scope narrowed to the use of male rats instead of humans for easy compliance which were fed with home based diets prepared for humans.

Fresh red tomatoes, eggs, dried fish, maggi, palm oil, cassava, yams, cocoyams and garri used in preparing the basal home meals were purchased taken to the laboratory where the study was conducted as all different meals prepared were weighed using the triple balance (Ohan's 2610gm capacity USA). Forty male rats of one month old were purchased. The rats were fed of the diet in the interval of eight hours daily to acclimatize with it for four weeks. The researchers had groups: A, B, C, and D where A was control group while B, C and D were intervention groups. The reference test diet of hyperlipidemia was induced by feeding high lipid diets of 1gm cholesterol, 0.5gm of bile salt and 10gm of egg yolk and 100gm of basal home diet.

Stage one: The forty male rats were weighed and group mean weight was recorded. The male rats were allowed to acclimatize with the basal home diet for four weeks, which their group mean weight were determined.

Stage two: Group A continued with the basal home diet while groups B, C, and D were fed with high lipid diet. One gram of cholesterol, 0.5gm of bile salt and 10gm of egg yolk and 100gm of basal home diet. The male rats, both in the control and intervention groups were fed for another four weeks after which their mean weight and serum cholesterol levels were determined and recorded. At the end of the four weeks, blood samples were obtained from randomly selected five male rats from each group for serum lipid profile. The blood samples collected were sent to the chemical pathology laboratory for the total serum cholesterol (TC), low density lipoprotein (LDL), high density lipoprotein (HDL), and very low-density lipoprotein estimation.

Stage three: group B continued with the basal home diet and mixed with the grinded raw fresh red tomatoes; group C continued with the basal home diet and mixed with tomato juice; group D continued with the basal home diet and mixed with cooked tomatoes. This process continued for another four weeks. At the end of the four weeks, the male rats in the four groups were made have overnight fast by withdrawing all solid meals except water. The following morning, blood samples were then collected and sent to the chemical pathology laboratory for examination/estimation.

During data collection, the mean weight of each group before and after the test diet was estimated. The mean serum total cholesterol, LDL, HDL and VLDL were estimated and recorded. The mean group faecal content was also estimated and recorded. The growth rate was calculated as the percentage of the ratio of the weight gained during the treatment period of the number of days constituting the treatment period and was presented as follows:

$$\frac{\text{Final weight} - \text{initial weight}}{\text{Number of days treated}} \times \frac{100\text{gm/day}}{1}$$

The mean weight increase was expressed as the percentage of the initial weight. Initial and final body weight of each male rat was measured and the mean weight for each group determined. Mean weight increase or decrease was calculated as the percentage of the ratio of the weight gain to initial body weight and was presented as follows:

$$\frac{\text{Final weight} - \text{initial weight}}{\text{Initial weight}} \times \frac{100\text{gm/day}}{1}$$

Data analysis was done as data collected was statistically analyzed using computerized data base of SPSS version 15. A p-value of 0.05 was taken to be significant. The student t-test was used to determine the significant difference and illustrations of the results were done in tables and figures.

Results

No death of experimental male rat was observed. The effect of hyperlipidemic diet on weight gain and growth rate is represented in Table 3. Hyperlipidemic diet on body weight showed an increase in body weight gain compared with the control. The mean weight increase (%) for the hyperlipidemic diet treated male rat groups treatment versus control were (2.81±0.13 versus 12.38±1.34). result showed that mean weight gain values were high in the intervention than in the control group. That is, the body weight gain were significantly high ($P<0.05$) in the hyperlipidemic diet treated groups compared to the control. Therefore, there were significantly ($P<0.05$) increase in growth rate intervention versus control (1.82±0.09 versus 0.41±0.06). In view of the above, the intervention groups produced significant ($P<0.05$) increase in the body weight gain and also increased growth in the intervention groups compared with the control.

Table 3: The mean group weight gain in (gms) after feeding the rats with basal home meals for four weeks (N=40)

	Group A	Group B	Group C	Group D	P-value
	70.20	80.30	90.00	85.50	
	90.10	82.40	87.30	92.20	
	67.30	75.30	85.00	90.10	
	88.20	87.40	86.10	87.20	
	93.10	90.50	90.45	90.44	
	90.50	90.46	90.60	90.35	**0.452**
	80.32	80.50	85.00	80.45	
	82.00	85.35	83.10	80.20	
	79.30	80.25	80.02	80.35	
	97.40	79.30	76.40	75.50	
Mean	84.64	83.58	85.40	85.23	

Values = mean ± SD Average = 84.71 ± 8.75; $P>0.452$

There was significant increase in the serum-total cholesterol and LDL among the intervention groups when compared with the control group ($P<0.02$). There was no significant decrease in HDL among the intervention group when compared with the control group ($P>0.32$). Similarly, there was no significant increase in VLDL among the intervention groups when compared with the control group ($P>0.22$). There was significant decrease in serum-total cholesterol and LDL among the intervention groups treated with the different tomato preparations when compared with the control group ($P<0.02$). There was increase in HDL among the intervention groups when compared with the control group. There was significant increase of fats in the faecal content among the intervention groups treated with three different tomato preparations when compared with the control group ($P<0.01$). Table 3 showed the mean group weight after feeding the 40 male rats with home diets for 4 weeks. There was no significant difference in the mean weight gain among the four groups ($P>0.452$).

Table 4: The effect of hyperlipidemic diet on mean body weight and growth rate on Male Wister rats.

Parameters	Control	Hyperlipidemic diet
Initial wt (gm)	84.64 ± 1.23	84.73 ± 1.24
Final body wt (gm)	102.02 ± 0.10	114.31 ± 1.20
% Mean wt increase	2.53 ± 0.2	34.9 ± 0.13
% Growth rate (gm)	57.66	98.6

Value = Mean ± SD *Represents statistical significance ($P<0.05$)

Table 4 showed the effect of hyperlipidemic diets on mean body weight and growth rate of Wister male rats. The male rats treated with hyperlipidemic diets showed an increase in mean body weight of 34.91±0.13. This was significant when compared with the control of value 2.53±0.02 ($P<0.05$). There was also increase in the percentage growth rate of male rats treated with hyperlipidemic diets, 98.6%. This was significant when compared with the rats treated with basal home diets of value 57.66% ($P<0.05$).

Table 5: The effect of hyperlipidemic diets on lipid profile of male Wister rats

Parameter	Group A	Group B	Group C	Group D	P-value
TC	190.00+0.2	220.00+0.42	222.00+0.8	225.00+0.64	0.02
LDL	380.00+0.3	440.00+0.45	448.00+0.23	450.00+0.33	0.01
HDL	45.00+0.1	40.00+0.23	40.00+0.5	39.00+0.32	0.32
VLDL	150.00+0.1	160.00+0.24	160.00+0.5	161.00+0.25	0.22
Ratio (TC/HDL)	4.22+0.10	5.50+0.25	5.55+0.40	5.77+0.20	0.01

Value are mean + SD *Represents statistical significance ($P<0.05$) A = represent control

Table 5 showed the effect of hypolipidemic diets on the group mean serum lipid profile. There was increase in the serum total cholesterol. This increase was significant when compared with the control ($P<0.02$). There was increase in the LDH and this increase was significant when compared with the control ($P<0.01$). There was no significant increase in HDL among the hyperlipidemic diet treated groups when compared with the control ($P>0.32$). Similarly, there was no significant increase in VLDL among the hyperlipidemic diet treated groups when compared with the control ($P>0.22$). The ratio TC/HDL was also significant when compared with the control.

Table 6: The effect of dietary supplement with the three (3) different tomato preparations on body weight hyperlipidemic male rats

Parameter (wt/gm)	Group A (control)	Group B (raw tomatoes)	Group C (tomato juice)	Group D (cooked tomatoes)
Initial wt (gm)	114.36+0.35	114.36+0.50	114.00+0.45	114.56+0.32
Final wt (gm)	115.42+0.05	100.32+0.32	99.12+0.50	98.94+0.23
Diff. in Mean wt	1.06+0.30	-14.04+0.23	-15.18+0.40	-15.62+0.23
% Mean wt	0.93+0.30	-12.27+0.13	-13.05+0.30	-13.63+0.25
% Growth rate	3.10+0.05	-40.90+0.32	-43.50+0.87	-45.43+0.71
ANOVA	0.32	0.2	0.2	0.2
T-test	$P<0.05$	$P<0.05$	$P<0.05$	$P<0.05$

Values = mean + SD *Represents statistical significance ($P<0.05$) - Represent decrease Diff, represent difference in mean weight

Table 6 showed the effect of the three different preparations of red tomatoes on body weight and growth rate on Wister male rats. The male rats treated with the three different tomatoes preparation showed a significant weight decrease when compared with the control ($P<0.05$). The percentage mean weight decrease is seen more with group treated with cooked tomatoes 13.63+0.25%, followed by the group treated with tomato juice 13.05+0.30% and the least was seen with the group treated with raw tomatoes 12.27+0.13% when compared with the control 1.5+0.20%. The decrease in body weight was significant when compared with the control ($P<0.02$). There was also a significant decrease in growth rate when compared with the control ($P<0.02$).

Table 7: The effect of dietary intervention with the three different tomato preparation and atherogenic index of hyperlipidemic rats

Parameters (mg)	Group A (control)	Group B (raw tomatoes)	Group C (tomato juice)	Group D (cooked tomatoes)
TC	220.0+0.23	195.0+0.03	190.0+0.02	160.0+0.03
LDL	400.0+0.24	395.0+0.04	390.0+0.02	360.0+0.05
HDL	45.00+0.02	46.00+0.04	48.00+0.10	54.00+0.30
VLDL	160.0+0.32	155.0+0.30	155.0+0.35	154.0+0.23
Ratio: TC/HDL	4.88	4.24	3.96*	2.96*
T-test	$P>0.05$	$P>0.05$	$P<0.05$	$P<0.05$

Values = mean + SD * Represents statistical significance ($P<0.05$) Group A represent control

Table 7 showed the groups mean total serum lipid profile after treating the male rats with the three different tomato preparations. There was significant decrease in serum total cholesterol in group D treated with cooked tomatoes when compared with the control ($P<0.02$). There was also significant decrease in LDL in the intervention Group D treated with cooked tomatoes when compared with the control. There was gradual increase in the HDL among the intervention groups when compared with the control. The increase was significant in group D treated with cooked tomatoes when compared with the control ($P<0.03$). There was no significant change in VLDL among the intervention groups when compared with the control ($P>0.32$). There was a significant decrease in the atherogenic index or the ratio of TC/HDL among the intervention groups. This significant decrease was noticed between groups C and D treated with tomato juice and cooked tomatoes ($P<0.01$).

Table 8: Groups mean percentage faecal fat content following dietary supplement with the three different tomato preparations in male Wister rats (N=20)

Parameters (mg/ 100%)	Group A (control)	Group B (raw tomatoes)	Group C (tomato juice)	Group D (cooked tomatoes)	P-value
Crude fat	10.0+0.01	25.0+0.30*	32.0+0.13*	65.0+0.21*	0.01

Values = mean + SD
* Represents statistical significance ($P<0.05$)

Table 8 showed the percentage mean faecal fat content in male Wister rats treated with the three different tomato preparations. There was significant increase in faecal fat content among the intervention groups when compared with the control ($P<0.01$). The greatest increase in faecal fat content was seen in the group treated with cooked tomatoes and tomato juice.

Discussion

When the male rats were fed with the home based diet, there was no significant weight changes among the four groups. When the male rats were fed with hyperlipidemic diets for one month, there was great increase in weight gain among groups B, C, and D when compared with the control group A. The increase in weight gain in the dietary treated groups B, C, and D was significant when compared with the control ($P<0.02$). This observation of increase in weight gain in the dietary treated groups were due to the effect of the hyperlipidemic diet contributed to the body fat about 34.91 percent of the total body weight. This observation agrees with the findings by Gerster (1997) [4] who reported that the customary hyperlipidemic diet was the most important environmental factor that influence increase in weight gain. The author further concluded that hyperlipidemia induced by exogenous dietary fat contribute to excessive weight gain and obesity.

When the male rats in the intervention groups B, C, and D were fed with hyperlipidemic diets for one month, there was moderate increase in serum total cholesterol, low density lipoprotein, decrease in high density lipoprotein and increase in very low density lipoprotein. This increase in serum total cholesterol was due to increased activity of lipoprotein lipase induced by the presence of dietary fats in the gastro intestinal tract. The increased activity of the enzyme lipase increases the absorption of digested fats and consequently increase the serum total cholesterol, low density lipoprotein, decrease the high density lipoprotein and increase very low density lipoprotein. A similar observation was reported by Draz (1997) [3] that feeding male rats with hyperlipidemic diets increases the serum total cholesterol, low density lipoprotein, decrease high density lipoprotein and increase very low density lipoprotein.

This finding demonstrates the activity of lycopene present in red tomatoes in lowering the serum total cholesterol, low density lipoprotein, increasing high density lipoprotein levels by inhibiting the activity of lipoprotein lipase and indirectly reducing the digestion and absorption of dietary fats induced by the hyperlipidemic diet. Lycopene has no effect on very low density lipoprotein because of the high concentration of triglycerides and low cholesterol content in the very low density lipoprotein. This is relevant in the prevention and judicious management of hyperlipidemia. The ratio of total cholesterol to HDL decreases among the intervention groups with the least seen group D treated with cooked tomatoes. This indicated that the smaller the ratio the more protective is lycopene to the heart. The study showed that lycopene helps in the excretion of dietary fats in faeces by reducing the digestion and absorption of dietary fats from the guts. This helped in weight reduction. This is in line with the finding by Basu (2007) [1] who highlighted the importance of lycopene in management of NCDs and weight loss. This study have filled the gap in the existing measures of using appropriate diets to prevent and judicious management of hyperlipidemia that is responsible for cardiovascular risk factors.

Summary, Conclusions and Recommendation

The assessment of the effect of the three preparations of tomatoes showed that the cooked tomatoes have the greatest effect of reducing the activity of the enzyme lipase. This is because lycopene present in the cooked tomatoes was more readily absorbed in the intestine and thus has a higher concentration in the blood. The higher the concentration of lycopene in the blood, the more effective it is on serum lipid metabolism. This can be used as weight reducing agent since it lowers the intestinal fat absorption and increases faecal fat content. People that eat diets rich in red tomatoes will have significant reduction in their cardiovascular symptoms. People that consume tomato-based diet have Lower Density Lipoprotein (LDL), increases Higher Density Lipoprotein (HDL) and protection of the cellular fat molecules that are responsible for the formation of artherosclerosis, the agent that initiates ischaemic heart disease in humans. Dietary red tomatoes rich in lycopene may play a significant role in the reduction of plasma cholesterol and indirectly in the reduction of cardiovascular diseases.

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