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Comparative Effect of Garden Egg Fruit, Oat and Apple on Serum Lipid Profile in Rats Fed a High Cholesterol Diet

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Abstract: The purpose of the present study was to compare the effect of *Solanum melongena* (garden egg plant), apple and oat on serum lipid profile of rats fed a hypercholesterolemic diet. One hundred rats were grouped into five groups of 20 animals each; one group was fed with grower's marsh alone and acted as the sham control. One group was fed grower's marsh and 3% cholesterol and served as the test control. The other three groups were fed with the grower's marsh, 3% cholesterol and either of 4% apple, oat, or garden egg plant for a period of one month. After 2 weeks, half of the animals in each group were sacrificed for mid-term studies. The results obtained indicate that garden egg plant significantly ($P<0.05$) reduced weight gain of rats and feed efficiency compared with the other supplementations. Garden egg plant significantly ($P<0.05$) reduced serum total cholesterol, triglyceride and increased serum HDL-cholesterol compared with oat and apple in both the mid-term and full-term studies. The study suggests that garden egg plant has a more hypolipidemic effect than apple and oat.

Key words: Cholesterol, garden egg plant, apple, oat

Introduction

Epidemiologic studies support the view that consuming diets rich in fruits and vegetables is associated with a reduced incidence of chronic pathologies such as diabetes, obesity and cardiovascular diseases (Rimm *et al*., 1996; Joffe and Robertson, 2001). Cardiovascular diseases (CVD) constitute one of the leading causes of death amongst the middle aged and the elderly of Western societies. Elevation of serum cholesterol, more particularly low-density lipoprotein cholesterol (LDL-c), is a primary risk factor for cardiovascular disease. Many studies have clearly shown that the reduction of LDL-c levels and the increase of high-density lipoprotein cholesterol (HDL-c) reduce the risk of cardiovascular events and overall mortality (Schaefer *et al*., 1997; Cleeman, 1997).

Extensive studies on experimental animals indicate that the addition of different types of dietary fibre may have different effects on cholesterol metabolism. Vigne *et al*. (1987) showed that consumption of pectin lower serum cholesterol and its fractions in rats while wheat bran and cellulose do not have any effect on serum lipids. Another study by Omoruyi and Adamson (1994) reported that inclusion of 4% cellulose in diet reduced total cholesterol, triglycerides and LDL-cholesterol levels significantly in plasma of diabetic rats. Soluble fibre particularly gums are also known to have serum cholesterol lowering effects (Brown, 1999). In these studies purified sources of fibre were used but however unprocessed plant products which are especially rich in fibre are now enjoying certain popularity because of their reported physiological roles on human metabolism (Chaney, 1997). Some foods such as apples and oats are good sources of soluble fibre like pectin and guar gum and have been shown to lower serum cholesterol concentrations in hypercholesterolemia (Keenan *et al*., 1991; Anderson *et al*., 1990; Aprikian *et al*., 2001).

In Western countries, apples represent an important part of fruit consumption and, in some areas, they are the first fruits consumed where they are consumed in a variety of forms such as fresh fruit, juice, cider mashed apples. The fiber content of apples is not particularly high (2–3%) and soluble fibers, especially pectin, represent < 50% of the fiber in apples (Cara *et al*., 1993). Oats on the other hand are a common component of breakfast diet in Western countries. Consumption of oats has been shown to lower serum cholesterol concentrations in animal models (Zhang *et al*., 1994). As apples and oats form important contributors to the nutrient intake in Western societies, the same is true for garden egg plants (*Solanum melongena*) in Nigeria where it is widely consumed. These foods vary in their type of fibre and content, while garden eggs are richer in insoluble fibre, oats and apple contain more soluble ones (Ejoh *et al*., 1996).

Studies on the effect of unprocessed foods on serum lipid profile is lacking, even fewer studies exist on garden egg plant. The present study was undertaken to assess the influence of whole garden egg plant in comparison to apples and oats on serum lipid profile in rats fed a high cholesterol diet.

Table 1: Percent composition of diets

	Diet groups				
Parameters	SMC	TCO	GCO	GCA	GCG
Grower's mash	100	99.7	95.7	95.7	95.7
Cholesterol	-	0.30	0.30	0.30	0.30
Oats	-	-	4.00	-	-
Apples	-	-	-	4.00	-
Garden egg	-	-	-	-	4.00
Total	100.0	100.0	100.0	100.0	100.0

SMC = Sham control rats fed grower's mash only, TCO = Test control rats fed grower's mash and Cholesterol, GCO = Group fed grower's mash, cholesterol and Oats, GCA = Group fed grower's mash, Cholesterol and Apple, GCG = Group fed grower's mash, Cholesterol and Garden egg fruit.

Materials and Methods

Experimental design: Wistar strain male albino rats (obtained from the animal unit of Department of Pharmacology and Toxicology of the Faculty of Pharmacy, University of Benin, Benin City, Nigeria.) weighing between 150 and 170g were distributed into five groups with twenty rats each such that the weight difference between the groups was about 0.4g. The animals were housed individually in stainless steel cages with wire mesh floor to prevent coprophagy. One group of rats was fed grower's mash only (product of Bendel Feeds and Flour Mills, Ewu, Edo State, Nigeria) and the animals in the other groups were fed the grower's mash with 3% cholesterol (product of Merck, Germany). The diet of three of these four groups was also further supplemented with either 4% dried ground oats, apples or garden eggs. The composition of diets for the various groups of rats is presented in Table 1. The rats were allowed food and water freely throughout the experimental period which lasted for 4 weeks after a 3 day adaptation period with the various diets. Midway into the test period (2 weeks) half of the animals in each group were sacrificed for midterm studies after an 18 hour fast under chloroform anesthesia. During the study period, food intake was measured daily, while weight gain was recorded weekly. All these animal treatment were carried out in accordance with the principles of laboratory animal care of the NIN guide for Laboratory Animal Welfare as contained in the NIN guide for grants and contracts, vol. 14, No. 3, 1985. At the end of the study period, the remaining animals in each group were fasted for 18 hours and sacrificed after chloroform anesthesia.

Collection of blood samples: While under chloroform anesthesia blood was collected from each rat via heart puncture and transferred into sample tubes, where they were allowed to coagulate. The serum from each blood sample was recovered by centrifugation at 3,000 rpm.

Biochemical analysis: Serum total cholesterol concentration was estimated using Randox laboratories (England) kit based on the enzymatic end point method. The serum HDL-cholesterol was determined by the method of Hiller (1987). Serum triglyceride levels were determined by the method of Stens and Myers (1975). LDL-cholesterol and very low density lipoprotein in the serum were obtained by subtracting the value for HDL-cholesterol from total cholesterol.

Statistical analysis: The results are expressed as Mean ± S.E.M. Analysis of variance was used to test for differences in the groups. Duncan's multiple range tests were used to test for significant differences between the means (Sokal and Rohlf, 1969).

Results

The body weight gain, food intake and feed efficiency of the rats at the end of four weeks is presented in Table 2. The results obtained show that similar levels ($P>0.05$) of food was consumed by the rats in the sham control group (SMC) fed with grower's mash only, the test control (TCO) fed with grower's mash and cholesterol, and with rats fed grower's mash, cholesterol and apple (GCA). The level consumed in these groups were however significantly ($P<0.05$) lower than that consumed by the rats fed grower's mash, cholesterol and oat (GCO) and those fed grower's mash, cholesterol and garden egg fruit (GCG). The GCO fed rats gained the highest weight while the GCG rats gained the least. Similar weight gains ($P>0.05$) were recorded in the SMC, TCO and GCA fed rats. The feed efficiency which was taken as body weight gained/food consumed revealed that the GCO fed rats had the highest feed efficiency which was significantly different ($P<0.05$) from the other groups. Statistically similar ($P>0.05$) feed efficiency was recorded in the SMC, TCO and GCA fed rats, these however were significantly higher ($P<0.05$) than those recorded in the GCG fed groups which had the least feed efficiency. The study shows that food intake, body weight gain and feed efficiency are altered in rats by the different types of diet, with oats having the most effect.

Table 3 presents the mid-term serum lipid profile of the rats in the diet groups. Inclusion of cholesterol in the diet of the rats, significantly raised serum total cholesterol (TC), LDL+VLDL-cholesterol and triglyceride levels. HDL-cholesterol in contrast was reduced by feeding the rats with cholesterol. Supplementing the hypercholesterolemic diet with oat, apple or garden egg fruit significantly ($P<0.05$) reduced TC, LDL+VLDL-cholesterol and triglyceride when compared with the TCO. Feeding rats with the GCG diet significantly raised HDL-cholesterol when compared with the other diet supplementations. This study reveals that oat, apple and garden egg fruits reverse hyperlipidemia in rats.

The serum lipid profile of the rats after four weeks of feeding with the various diets is presented in Table 4. A similar pattern was observed in the various groups as

Table 2: Bodyweight gain, feed intake and feed efficiency of rats in the experimental groups at the end of four weeks

	Diet groups				
Parameters	SMC	TCO	GCO	GCA	GCG
Bodyweight gain (g)	1.21 ± 0.2[a]	1.28 ± 0.05[a]	2.66 ± 0.2[b]	1.10 ± 0.09[a]	0.73 ± 0.06[c]
Feed intake (g/day/rat)	18.19±2.3[a]	17.43±2.1[a]	25.23±2.2[b]	17.16±2.6[a]	27.50± 3.3[b]
Feed efficiency (g/bodyweight/g feed)	0.07 ± 0.003[a]	0.07 ± 0.004[a]	0.11 ± 0.03[b]	0.06 ± 0.003[a]	0.03 ± 0.004[c]

SMC = Sham control rats fed grower's mash only, TCO = Test control rats fed grower's mash and 0.3% Cholesterol, GCO = Group fed grower's mash, 0.3% cholesterol and 4% Oats, GCA = Group fed grower's mash, 0.3% Cholesterol and 4% Apple, GCG = Group fed grower's mash, 0.3% Cholesterol and 4% Garden egg fruit. Values are means ± S.E.M, n=10. Means of the same row followed by different letters differ significantly (P<0.05).

those recorded after 2 weeks of feeding except that the amounts.

Discussion

It is believed that the incidence of CVD related deaths in Nigeria is on the rise and high blood pressure is a major contributor to these diseases. Cholesterol and triglycerides are important lipids associated with CVD and other diseases. The deleterious effect of hyperlipidemia underscores the need for research on its management. Thus this study reports contribution of apples, oats and garden egg fruit; which are mostly consumed in between meals, to hyperlipidemia.

The amount of food consumed is related not only to its nutrient/caloric content (Eriyamremu and Adamson, 1994), but also its palatability. The lack of change in food intake and weight gain of rats with the inclusion of cholesterol in the diet which was observed in this study corroborates earlier observations of Cho *et al.* (1985) and indicates that the inclusion of cholesterol to the grower's mash did not significantly alter the palatability of the diet or its nutrient content. Though the caloric value of the diets used in this study was not determined, but if differences occur, then it may in part account for the observed differences in the amount of food consumed by the rats in the different groups (Table 2). It may imply that the GCO and the GCG diets have lower calorie content and to make up for calorie demand, the animals ate more. However, the weight gained by the rats appear to be related to the amount of food consumed, therefore calorie content of the diets alone may not account for food consumption. The observed increase in the weight gained by rats fed the GCO and the recorded feed efficiency by this group of rats indicates that this diet is better utilized by rats compared with the others. However in a study with overweight women, oat did not significantly alter weight while apples reduced weight (Conceicao *et al.*, 2003). Thus the result of this study on the effect of apples on rat weight corroborates those made by Conceicao *et al.* (2003) in over weight women. Soluble fibres particularly pictens and gums have been reported to lower blood lipid levels (Chen *et al.*, 1981). Some foods such as oat, apple and garden egg fruit are known to have varying amounts of fibre and it is not surprising therefore that inclusion of oat, apple and garden egg fruit in the diets of the rats lowered blood lipid levels (Table 3 and 4). There are two sources of cholesterol viz; exogenous source from the diet and endogenous source where its synthesis is de novo. The GCO and GCG fed rats consumed the most diet which did not reflect an increase in the total cholesterol levels thereby emphasizing the effect of the oats and garden egg plant on the endogenous source of cholesterol.

Soluble fibers reduce the levels of blood cholesterol by 5 to 15% in experimental animals and in humans (Behall, 1997) through a number of mechanisms. One possible mechanism may be by the effect of fibre on enterohepatic circulation through sequestration and binding of bile acids. Another possible mechanism is that soluble fibres are fermented in the colon into short chain fatty acids (SCFA) (Cummings and MacFarlene, 1991). Of the SCFA produced by colonic fermentation, propionate has been shown to lower the hepatic synthesis of cholesterol and triglycerides (Chen *et al.*, 1984). As the fiber content of apples is not particularly high (Cara *et al.*, 1993), it will not produce high levels of fermentation products and thus its effect on blood cholesterol levels may not be exerted by propionate production in the colon. This also may have accounted for the high triglyceride level observed in the GCA fed rats compared with the GCO and GCG fed ones (Table 3 and 4).

High plasma HDL-cholesterol represents an increased mobilization of cholesterol from the adipose tissue to the liver where it is metabolized. This is desirable as it indicates a reduced risk for cardiovascular diseases and hypertension. Garden egg plant increased plasma HDL-cholesterol level compared with GCA and GCO (Table 3 and 4) and may be beneficial since studies have unequivocally established an inverse relationship between HDL-cholesterol and incidence of cardiovascular diseases (Becque *et al.*, 1988; Kwiterovich, 1997). In contrast, VLDL+LDL-cholesterol represent mobilization of fats from the liver to adipose tissue. LDL carry 60% to 70% of total cholesterol in the serum (Beynen and Kritchevsky, 1986) and also VLDL is the main carrier of triglycerides, thus the high level of plasma VLDL+LDL particles observed in TCO fed rats

Table 3: Serum lipid profile of rats in the diet groups after two weeks

	Diet groups				
Parameters	SMC	TCO	GCO	GCA	GCG
Total Cholesterol (mg/dl)	104.0 ± 2.3[a]	134.0 ± 5.0[b]	79.0 ± 3.0[c]	79.5 ± 2.5[c]	72.0 ± 2.0[d]
HDL-Cholesterol (mg/dl)	35.0 ± 2.0[a]	29.0 ± 1.0[b]	30.0 ± 1.2[b]	31.0 ± 1.4[b]	34.0 ± 1.5[a]
LDL-Cholesterol + VLDL (mg/dl)	69.0 ± 2.2[a]	105.0 ± 4.1[b]	49.0 ± 2.0[c]	48.5 ± 1.5[c]	38.0 ± 1.5[d]
Triglyceride (mg/dl)	77.0 ± 3.0[a]	127.0 ± 3.0[b]	77.5 ± 3.1[a]	80.5 ± 3.0[a]	72.5 ± 2.1[c]

SMC = Sham control rats fed grower's mash only, TCO = Test control rats fed grower's mash and 0.3% Cholesterol, GCO = Group fed grower's mash, 0.3% cholesterol and 4% Oats, GCA = Group fed grower's mash, 0.3% Cholesterol and 4% Apple, GCG = Group fed grower's mash, 0.3% Cholesterol and 4% Garden egg fruit. Values are means ± S.E.M, n=10. Means of the same row followed by different letters differ significantly (P<0.05).

Table 4: Serum lipid profile of rats in the diet groups after four weeks exposure

	Diet groups				
Parameters	SMC	TCO	GCO	GCA	GCG
Total Cholesterol (mg/dl)	109.5 ± 4.5[a]	167.0 ± 5.1[b]	87.0 ± 4.5[c]	97.0 ± 2.5[d]	95.5 ± 2.5[d]
HDL-Cholesterol (mg/dl)	39.5 ± 2.5[a]	30.5 ± 1.5[b]	33.5 ± 1.3[b]	37.5 ± 2.5[a]	44.5 ± 2.0[c]
LDL-Cholesterol + VLDL (mg/dl)	70.0 ± 4.0[a]	137.0 ± 4.5[b]	53.5 ± 2.2[c]	59.5 ± 2.5[c]	50.5 ± 3.5[d]
Triglycerides (mg/dl)	83.0 ± 2.5[a]	140.0 ± 3.9[b]	85.0 ± 3.0[a]	87.0 ± 2.7[a]	81.0 ± 3.0[b]

SMC = Sham control rats fed grower's mash only, TCO = Test control rats fed grower's mash and 0.3% Cholesterol, GCO = Group fed grower's mash, 0.3% cholesterol and 4% Oats, GCA = Group fed grower's mash, 0.3% Cholesterol and 4% Apple, GCG = Group fed grower's mash, 0.3% Cholesterol and 4% Garden egg fruit. Values are means ± S.E.M, n = 10. Means of the same row followed by different letters differ significantly (P<0.05).

compared with the SMC (Table 3 and 4) is an indication of high circulating levels of both triacylglycerol and cholesterol which improves the chances of lipid deposition on arterial walls and blood lipid related diseases. As the GCO, GCA, and the GCG diets lowered plasma VLDL+LDL compared with the TCO diet, it is not surprising that they also lowered plasma triglyceride level. Controversy exists as to the exact effect of *S. melongena* on plasma lipid. Studies by Mitschek (1970) showed that a preparation of *S. melongena* prevented both hypercholesterolemia and the formation of atheromas in the aorta of rabbits fed high cholesterol diets. However, Kritchevsky *et al*. (1975) did not confirm these findings in rats fed diets containing 1% *S. melongena* fruit or leaf powders. Recently, Jorge *et al*. (1998) studied the effects of *S. melongena* on plasma lipid levels, where they fed rabbits a cholesterol-rich diet and administered 10 ml/day of eggplant juice (10:7, whole fruit:water) for 4 weeks. The authors concluded that eggplant juice administered to hypercholesterolemic rabbits significantly reduced weight, plasma cholesterol levels, aortic cholesterol content. A similar observation with garden egg plant juice infusion has been reported in humans (Guimaraes *et al*., 2000). It is evident from our results that the whole garden egg plant also has a hypocholesterolemic effect as the juice.

As the blood lipid profile results obtained for both the 2 weeks and 4 weeks study periods show a similar trend, the present investigation therefore suggests that duration of feeding with the various study diets do not significantly alter their effects on the blood lipid studied and that their hypocholesterolemic effect can be detected after two weeks of feeding.

In conclusion, the present study suggests that oat, and garden egg plant reduce plasma LDL+VLDL levels more efficiently than apple. Also the study shows that garden egg plant increased plasma HDL which is an indication of the beneficial effects of this fruit in blood lipid.

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