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Full Length Research Paper

Comparative evaluation of antioxidant effects of watermelon and orange, and their effects on some serum lipid profile of Wister albino rats

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The comparative antioxidant effects of watermelon and orange, and their effects on serum (high density lipoproteins) HDL-cholesterol and (low density lipoproteins) LDL-cholesterol in normal rats given varying doses of the juices were investigated. 120 g/70 kg body weight was used as the standard dose, and the animals were given the normal dose, × 1.5, and × 2.0 of the normal dose, orally, for a period of six weeks. Our findings showed that watermelon juice caused a dose related decrease in SOD activity at weeks three and six, while orange juice caused a dose related increase in superoxide dismutase (SOD) activity. They both showed catalase activity lower than that for control, and at high doses, both showed increased activity of catalase. Both juice caused a dose related increase in HDL-cholesterol, with no significant difference ($p > 0.05$) between them. And, watermelon caused a dose related decrease in LDL-cholesterol, while orange caused a dose related increase in LDL-cholesterol. But, LDL concentration for orange treated test groups were shown to be higher than that for watermelon treated test groups. These show that both fruits are complimentary, as the shortcoming of one is made up for by the other. So, for full health benefit, it is better to consume both at the same time.

Key words: Antioxidants, dose related, superoxide dismutase (SOD), catalase, (high density lipoproteins) HDL-cholesterol, (low density lipoproteins) LDL-cholesterol, normal dose.

INTRODUCTION

In the biochemistry of living organisms, antioxidants are molecules that serve to detoxify reactive oxygen intermediates in the body. Free radicals are substances in the body that can cause a great deal of damage. They are able to oxidize cholesterol, making it stick to blood vessel walls, where it can lead to heart attack and stroke (Edward et al., 2003). Because low density lipoproteins (LDLs) transport cholesterol to the arteries and can be retained their by arterial proteoglycans starting the formation of plaques, increased levels are associated with atherosclerosis, and thus heart attack, stroke, and peripheral vascular disease (O'Keefe et al., 2004). LDL poses a risk for cardiovascular disease when it invades the endothelium and becomes oxidized, since the oxidized form is more easily retained by the proteoglycans. A complex set of biochemical reactions regulates the oxidation of LDL, chiefly stimulated by the presence of free radicals in the endothelium. Nitric oxide down-regulates this oxidation process catalyzed by L-arginine. In a corresponding manner, when there are high levels of asymmetric dimethylarginine in the endothelium, production of nitric oxide is inhibited and more LDL oxidation occurs (Trinder, 1969). It is hypothesized that high density lipoproteins (HDL) can remove cholesterol from atheroma within arteries and transport it back to the liver for excretion or re-utilization. HDL serves to remove cholesterol from the peripheral cells to the liver, where the cholesterol is converted to bile acids and excreted into the intestine (Haines, 2001). An inverse relationship

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between HDL-cholesterol levels in serum and the incidence (prevalence of coronary heart disease) has been demonstrated in a number of epidemiological studies. The importance of HDL-cholesterol as a risk factor for coronary heart disease, blood vessel injury through its antioxidant and anti-inflammatory functions, among other effects is now recognized (Ensminger et al., 1983)

Watermelon (*Citrullus lanatus*) is a member of the Cucumbitaceae family. It is an excellent source of the potent carotenoid antioxidant “lycopene”. This powerful antioxidant travels through the body neutralizing free radicals (Erhardt et al., 2003). A cup of watermelon provides 24.3% of the daily value of vitamin C, and through its beta carotene, 11.1% of the daily value of vitamin A (Edwards et al., 2003). The antioxidant function of lycopene is its ability to help protect cells and other structures in the body from oxygen damage and has been linked in human research to prevention of heart disease. Protection of DNA inside white blood cells has also been shown to be an antioxidant role of lycopene (Edward et al., 2003). Before cholesterol can be deposited in the plaques that harden and narrow arteries, it must be oxidized by free radicals. With its powerful antioxidant activity, lycopene can prevent LDL-cholesterol from being oxidized (Johnson et al., 1997). Research indicates that diets low in carotenoids can increase the body’s susceptibility to damage from free radicals. As a result, over the long term, carotenoid-deficient diets may increase tissue damage from free radical activity, and increase risk of chronic diseases like heart disease and cancers (Clinton, 1998).

Orange (*Citrus sinensis*) belongs to the genus citrus, of the family Rutaceae. It is a popular fresh fruit, people like to consume because of its tangy taste and nutritive values (Edward, et. al., 2003). Oranges are rich in vitamin C and also provides some vitamin A. These vitamins serve as antioxidants, preventing the attack of free radicals on the cells of the body (Erhardt et al., 2003). Orange is rich in a compound called liminoid, which combats cancer of the colon, stomach, breast, lung, skin, and mouth. Orange peels have alkaloid synephrine, which can cut down the production of cholesterol in the liver. The antioxidant elements in oranges combat oxidative stress that oxidizes the LDL in the blood. Oranges protect the skin from damage caused by free radicals, thus helping you look young and glowing

The aqueous extract of *Citrulus lanatus* has been known to be a good source of glucose, fibre and also an excellent source of vitamin C, lycopene, and beta carotene (Erhardt et al., 2003). *C. sinensis* is also a good source of vitamin A and an excellent source of vitamin C (Fridovich, 1977). Vitamin C being the major vitamin contained in both fruits. Epidemiologically, it has been shown that antioxidant may reduce or inhibit the effect of oxidative stress in tissues and organs of the body (Recknagel, 1967). Vitamin C is a highly effective antioxidant, acting to lessen oxidative stress (Combs, 2001). Long term intake of vitamin C could cause nausea, excess urination, kidney damage and necrosis (Jacobs et al., 1999). Eating foods rich in lycopene, beta carotene and vitamin C may not inhibit the activity of other antioxidant enzymes in plasma (Pellegrini et. al., 2000). Thus, the aim of this research is to comparatively evaluate the antioxidative properties of watermelon and orange, to determine the effects of their long term consumption on serum LDL-cholesterol and HDL-cholesterol, and also to assess the ability of their antioxidants to affect the activity of the other antioxidant enzyme in the system.

MATERIALS AND METHODS

Experimental animals

Thirty-five albino rats of the Wistar strain weighing between 70 to 156 g were obtained from the National Institute of Medical Research, Lagos, Nigeria. The rats were kept in clean disinfected cages with raised wire floor in the animal house, with 12 h light/dark cycle and 50 to 60% relative humidity at a temperature of about 30°C and allowed to acclimatize to the new environment for two weeks, with free access to water and feed (Guinea growers mash). The rats were treated according to the Nigerian guidelines for the care and use of laboratory animals. The rats were then weighed and randomized into seven groups (namely A, B, C, D, E, F and G) of five animals each. Group A rats were the control rats while groups B to G served as tests.

Plant materials (fruits)

Fresh ripened Watermelon and Orange fruits were obtained from local dealers in Benin City, Edo State (Nigeria) and were identified and authenticated by a taxonomist in the Department of Plant Science, University of Benin, Nigeria.

Preparation of juice

Watermelon; the red pulp was homogenized in a blender and filtered with the use of a readymade filter pan (the filter pan is equivalent to four folds of bandage or sheet of cheese cloth), and weighed. Orange; the juice was squeezed out and filtered to remove the seeds and fibers, after which it was weighed.

Administration of juice

Using 120 g/70 kg body weight as standard (normal) dose (Mendosa, 2003), groups B and E were given normal dose of watermelon and orange juice respectively, groups C and F were given ×1.5 of the normal dose of watermelon and orange juice respectively, and groups D and G were given ×2.0 of the normal dose of watermelon and orange juice respectively. The juices were administered, orally, once a day, for a period of six weeks. The control group received equivalent amount of water, via the same route. The body weights of the animals were obtained prior to administration of juice (after acclimatization), three weeks of juice administration and six weeks of juice administration.

Sample collection

At week three and six, blood samples were collected from the rats,

Table 1. Effects of watermelon and orange juice on serum SOD activities (U/L) of normal rats.

Weeks	Control	Watermelon			Orange		
	A	B (ND)	C (×1.5 ND)	D (×2.0 ND)	E (ND)	F (×1.5 ND)	G (×2.0 ND)
Three	2.88 ± 0.57	$3.33 \pm 0.21^{+}$	2.75 ± 0.54	$2.65 \pm 0.22^{++,\times+}$	$0.68 \pm 0.10^{\times\times}$	2.33 ± 0.76	$1.19 \pm 0.10^{\times,\times+}$
Six	2.90 ± 0.24	$2.72 \pm 0.64^{++}$	1.71 ± 0.37	$1.08 \pm 0.36^{\times+,+\times}$	$1.95 \pm 0.23^{\times\times}$	1.99 ± 0.53	$2.49 \pm 0.37^{\times,\times+}$

ND = Normal Dose (120g/70kg body weight). ×1.5 ND = 1.5 times ND; ×2.0 ND = 2 times ND.
n = 5, $^{+}p < 0.05$ compared to control, $^{++}p > 0.05$ compared to control, $^{\times\times}p < 0.05$ compared to control, $^{\times}p < 0.05$ compared to control, $^{\times+}p < 0.05$ group D compared to group G, $^{+\times}p < 0.05$ compared to control.

Table 2. Effects of watermelon and orange juice on serum catalase activities (U/L) of normal rats.

Weeks	Control	Watermelon			Orange		
	A	B (ND)	C (×1.5 ND)	D (×2.0 ND)	E (ND)	F (×1.5 ND)	G (×2.0 ND)
Three	0.507 ± 0.01	$0.410 \pm 0.01^{+}$	0.423 ± 0.03	$0.443 \pm 0.02^{++,\times}$	$0.491 \pm 0.02^{\times\times}$	0.414 ± 0.01	$0.485 \pm 0.02^{++,+\times}$
Six	0.512 ± 0.02	$0.414 \pm 0.03^{+}$	0.451 ± 0.01	$0.475 \pm 0.02^{++,\times}$	$0.515 \pm 0.02^{\times\times}$	0.434 ± 0.01	$0.507 \pm 0.01^{++,+\times}$

ND = Normal Dose (120g/70kg body weight). ×1.5 ND = 1.5 times ND; ×2.0 ND = 2 times ND.
n = 5, $^{+}p < 0.05$ compared to control, $^{++}p < 0.05$ group D compared to group G, $^{\times}p < 0.05$ compared to control, $^{\times\times}p > 0.05$ compared to control, $^{+\times}p > 0.05$ compared to control.

after a 12 h fast, via the tails, for SOD, Catalase, LDL-cholesterol and HDL-cholesterol determination, using the spectophotometry method (i.e. using their respective reagents kits from Randox Laboratory Limited, U.K.).

Statistical analysis

Data are mean ± SEM of five independent determinations. Statistical Analysis was by student t-test at p < 0.05 using SPSS 17.0.

RESULTS

This study carried out on watermelon and orange juice showed their comparative effects on SOD, Catalase, HDL and LDL. Table 1 shows the effects of watermelon and orange juice at different concentrations on the SOD activity of normal rats. Administration of watermelon juice at ×2 normal dose caused no significant difference ($^{++}p > 0.05$) in the activity of SOD at week three when compared to the control. However, administration of normal dose (group B) of watermelon juice caused a significant increase ($^{+}p < 0.05$) when compared to the control, within the same period of time. Also there was a general dose related decrease in the activity of SOD, as shown. But the administration of orange juice at ×2 normal dose (group G) caused a significant decrease ($^{\times}p < 0.05$) in SOD activity when compared to the control, after three weeks of administration. The normal dose (group E) of the orange juice caused a more significant decrease ($^{\times\times}p < 0.05$) in SOD activity, when compared to the control. Comparing the SOD activity at the third week for group D and group G, treated to ×2 normal dose of watermelon and orange juice respectively, showed a significant difference ($^{\times+}p < 0.05$), with the activity for watermelon higher than that for orange. At the sixth week of administration, watermelon at ×2 normal dose (group D), caused a significant decrease (+×p < 0.05) in the activity of SOD, when compared to the control (group A). The group treated to normal dose of watermelon (group B) showed no significant difference ($^{++}p > 0.05$) compared to control. There was also a dose related decrease in SOD activity after treatment with watermelon at week six. However, group E treated to normal dose of orange, at week six showed a significant decrease ($^{\times\times}p < 0.05$) in SOD activity when compared to the control group, while group G treated to ×2 normal dose of orange juice also showed a significant decrease ($^{\times}p < 0.05$) in SOD activity when compared with the control. There was also a significant difference (×+p < 0.05) in the activity of SOD between groups D and G, with that of D (treated to ×2 normal dose of watermelon juice) lower than that of G (treated to ×2 normal dose of orange juice). Table 1 also showed a dose related increase in the activity of SOD at the sixth week in the groups treated to orange juice.

Table 2 shows the effects of Watermelon and Orange juice on serum catalase activities of normal rats. Administration of watermelon juice at weeks three and six, was shown to cause a dose related increase in the activity of catalase. Group B (given normal dose of watermelon juice) showed a significant decrease ($^{+}p < 0.05$) when compared to the control group (A). Group D (given ×2 normal dose of watermelon juice), also showed a significant decrease (×p < 0.05) when compared to the control group. Administration of orange juice at weeks three and six caused no significant difference ($^{\times\times}p > 0.05$)

Table 3. Effects of watermelon and orange juice on serum HDL concentration (mg/dl) of normal rats.

Weeks	Control	Watermelon			Orange		
	A	B (ND)	C (×1.5 ND)	D (×2.0 ND)	E (ND)	F (×1.5 ND)	G (×2.0 ND)
Three	148.5 ± 10.5	160.8 ± 8.3^{+}	173.2 ± 12.4	180.5 ± 9.6$^{\times,+\times}$	158.3 ± 10.5^{++}	175.4 ± 9.5	182.6 ± 6.8$^{\times\times,+\times}$
Six	152.8 ± 8.5	158.4 ± 11.6^{+}	169.3 ± 10.8	185.6 ± 7.3$^{\times,+\times}$	162.7 ± 8.9^{++}	171.6 ± 10.7	187.3 ± 11.7$^{\times\times,+\times}$

Key: ND = Normal Dose (120g/70kg body weight). ×1.5 ND = 1.5 times ND; ×2.0 ND = 2 times ND.
n = 5, $^{+}p < 0.05$ compared to control, $^{++}p < 0.05$ compared to control, $^{\times}p < 0.05$ compared to control, $^{\times\times}p < 0.05$ compared to control, $^{+\times}p > 0.05$ group D compared to group G.

Table 4. Effects of watermelon and orange juice on serum LDL concentration (mg/dl) of normal rats.

Weeks	Control	Watermelon			Orange		
	A	B (ND)	C (×1.5 ND)	D (×2.0 ND)	E (ND)	F (×1.5 ND)	G (×2.0 ND)
Three	135.8 ± 5.8	128.6 ± 8.6^{+}	122.4 ± 9.3	115.3 ± 8.4$^{\times,+\times}$	118.2 ± 7.8^{++}	116.3 ± 8.3	125.6 ± 5.1$^{\times\times,+\times}$
Six	140.2 ± 6.3	120.5 ± 5.1^{+}	116.8 ± 6.5	104.7 ± 7.6$^{\times,+\times}$	122.4 ± 8.3^{++}	123.7 ± 7.3	135.2 ± 8.1$^{\times\times,+\times}$

ND = Normal Dose (120g/70kg body weight). ×1.5 ND = 1.5 times ND; ×2.0 ND = 2 times ND.
n = 5, $^{+}p < 0.05$ compared to control, $^{++}p < 0.05$ compared to control, $^{\times}p < 0.05$ compared to control, $^{\times\times}p < 0.05$ compared to control, $^{+\times}p < 0.05$ group D compared to group G.

in activity of catalase in group E (given normal dose) as compared to the control, and group G (given ×2 normal dose) also showed no significant difference ($^{+\times}p > 0.05$) in the activity of catalase, as compared to the control group. However, there was a significant difference (++p < 0.05) between the activity of catalase of groups D and G, at weeks three and six, with that of group G (given orange juice) higher than that of group D (given watermelon).

Table 3 shows the effects of watermelon and orange juice on serum HDL concentration of normal rats. Administration of watermelon and orange juice caused a significant dose related increase in the concentration of HDL-cholesterol at weeks three and six. Group B (given normal dose of watermelon) showed a significant increase ($^{+}p < 0.05$) in the HDL levels as compared to the control group, at weeks three and six. Group D (given ×2 normal dose of watermelon) also showed a significant increase ($^{\times}p < 0.05$) in the HDL levels when compared to the control group. There was also a significant increase ($^{++}p < 0.05$) in the HDL concentration in group E (given normal dose of orange juice) as compared to control, and a significant increase ($^{\times\times}p < 0.05$) in the concentration of HDL in group G (given ×2 normal dose of orange juice) as compared to that of the control group. Groups D and G when compared, showed no significant difference ($^{+\times}p > 0.05$) in the concentration of HDL-cholesterol.

Table 4 shows the effects of Watermelon and Orange juice on serum LDL concentration of normal rats. Administration of watermelon juice was shown to cause a dose related decrease in the concentration of LDL-cholesterol at weeks three and six, while administration of orange juice rather caused a dose related increase in LDL levels, only at week six. Group B (given normal dose of watermelon juice) showed a significant decrease ($^{+}p < 0.05$) in the concentration of LDL at weeks three and six, as compared to the control group. Group D (given ×2 normal dose of watermelon juice) also showed a significant decrease ($^{\times}p < 0.05$) in the LDL concentration when compared to the control at weeks three and six. As shown, orange juice however, caused a significant reduction ($^{++}p < 0.05$) in LDL levels in group E (given normal dose) as compared to the control, and a significant decrease ($^{\times\times}p < 0.05$) in group G (given ×2 normal dose). Comparison of group D and G, given ×2 normal dose of watermelon and orange juice respectively, however showed a significant difference ($^{+\times}p < 0.05$) in LDL-cholesterol concentration, with that of group G higher than that of group D.

DISCUSSION

Over the past years, antioxidants have attracted considerable interest in the scientific community as potential treatment for a wide variety of disease states, including cancer and inflammatory diseases (Aruoma et al., 1991). Antioxidants are effective because they are willing to give up electrons to free radicals. When free radicals gain electrons from antioxidants, they no longer need to attack the cell and the chain reaction of oxidation is broken (Dekker et al., 1996). After donating an electron, antioxidants become free radicals by definition, but antioxidants in this state are not harmful because they have the ability to accommodate a change in electron without becoming active. However, antioxidant supply is not limited as one antioxidant can only react with a single free radical. Therefore, there should be constant supply of antioxidants either exogenously or through supplement (Jie et al., 2002). The sources of these exogenous antioxidants like watermelon and orange have been known for long and are widely consumed for their various health benefits. Our study showed that, after administration of watermelon juice for a period of three weeks, the SOD activity of the experimental animals decreased steadily. This decrease is however dose related, with the highest dose causing the lowest activity. While administration of orange juice for the same period of time rather showed a fluctuation in the activity of SOD. But, at the sixth week of juice administration, watermelon still caused a dose related decrease in the activity of SOD, while orange caused a dose related increase in the activity of SOD. This may suggest that excess consumption of watermelon over a long period of time may have a negative effect in the supply of useful antioxidant like SOD, while excess consumption of orange over a long period of time may be beneficial as it showed a positive effect in the supply of antioxidant like SOD. Some research indicates that under certain circumstances, lycopene (and other carotenoids), abundant in watermelon, can become oxidized in the body, and may subsequently behave like free radicals and cause cellular damage. Cigarette smoke, for example, may cause lycopene to become oxidized. This may explain, at least in part, the research findings that cigarette smokers who take carotenoid supplements may have an increased risk of cancer or heart disease (Sies and Stahl, 1998). Superoxide dismutase is a class of closely related enzymes that change the structure of oxidants and break them down into hydrogen peroxide (Fridovich, 1977). The hydrogen peroxide is then broken down into water and tiny oxygen particles by Catalase. Catalase protects against lipid peroxidation and also participates in alcohol metabolism (Huber, 1980). Our findings showed that the administration of watermelon juice caused a slight dose related increase in the activity of catalase, at weeks three and six, while orange juice correspondingly showed a fluctuation, relative to the doses, in the activity of catalase. But the activity of catalase of the test groups, for both juice, were shown to be lower than that of the control. This may suggest that both juice had a general reducing effect on the activity of catalase. However, high doses of both watermelon and orange juice, as shown, caused an increase in the activity of catalase. Comparatively, orange juice was shown to cause a higher activity of catalase than watermelon. This may suggest that consumption of high amount of watermelon and orange juice may protect against lipid peroxidation, with orange been more beneficial. And as Pellegrini et al. (2000) stated, eating foods rich in lycopene, beta carotene and vitamin C may not inhibit the activity of other antioxidant enzymes in plasma.

Before cholesterol can be deposited in the plaques that hardens and narrow arteries, it must be oxidized by free radicals. An inverse relationship between HDL-cholesterol levels in serum and the incidence and prevalence of coronary heart disease (CHD) has been demonstrated in a number of epidemiological studies. The importance of HDL-cholesterol as a risk factor for CHD, blood vessel injury through its antioxidant and anti-inflammatory functions, are now recognized (Ensminger et al., 1983). Our result showed that the administration of watermelon and orange juice to the experimental animals for a period of three weeks caused a dose related increase in the concentration of HDL.

This trend was also observed at week six, with the values higher than the corresponding values at week three. The concentrations of HDL-cholesterol of the test animals in all instances were also shown to be higher than that of the control. This may be suggestive that, long time consumption of watermelon and orange juice and at higher doses can have a positive impact on raising HDL-cholesterol levels. However, comparing the HDL values of the test animals administered watermelon and orange juice, our findings showed no significant difference between them. A high level of HDL-cholesterol seems to protect against cardiovascular diseases. Cholesterol contained in HDL particles is considered beneficial for the cardiovascular health, in contrast to “bad” LDL-cholesterol (Emma, 2009). LDL is a lipoprotein that transports cholesterol and triglyceride from the liver to peripheral tissues. It enables fat and cholesterol to move within the water blood solution of the blood stream. LDL is often called bad cholesterol; hence low levels are beneficial (Cromwell and Otvos, 2004). Our findings revealed that at weeks three and six, administration of watermelon juice caused a dose related decrease in the levels of LDL, while correspondingly, administration of orange juice caused a rather dose related increase in LDL levels. It was also shown that the highest dose of orange juice (×2 normal doses) caused the highest level of LDL. And the LDL levels of the test groups treated to orange juice were higher than that of the test groups treated to watermelon juice. This may point to the likely fact that high doses of watermelon may be beneficial, while high doses of orange may not, with respect to LDL-cholesterol lowering ability.

Conclusion

Our present study showed that long time consumption, and at a high dose, of watermelon has a negative impact on SOD activity, while long orange has a positive impact on SOD activity. It also showed that both juice, at high doses increases Catalase activity, but comparatively, orange caused a higher catalase activity than watermelon. Watermelon and orange juice showed no significant difference in their dose related increase in HDL-cholesterol concentration. But watermelon caused a dose related decrease in LDL, while orange caused a dose related increase in LDL. However, LDL values for orange were shown to be higher than that for watermelon. The elicitation of these is that both fruits are complementary as they tend to make up for each other's shortcomings. Thus, where one shows a negative impact, the other complements with its positive impact. For full benefit of the health effects of these fruits, consumption of mixtures of both is preferable.

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