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Preliminary Studies on the *In vitro* Antioxidant Potential and Vitamin Composition of Selected Dietary Fruits Consumed in Alice region of South Africa

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Abstract: The present study investigated total phenols, flavonoids and vitamins composition in a selection of fruits; {orange (*Citrus sinensis*), red apple (*Mallus pumila*), carrot (*Daucus carota*), pear (*Pyrus calleryana*), golden apple (*Mallus pumila*), pawpaw (*Carica papaya*), pineapple (*Ananas comosus*) and banana (*Musa acuminate*)} consumed in Alice region of South Africa. The antioxidative capacity of these fruits were also determined using ferric reducing power, Lipid Oxidation (LO), 1,1-diphenyl-2-picrylhydrazyl (DPPH), 2,2'-azino-bis-3 ethylbenzothiazoline-6-sulfonic-acid (ABTS), Nitric Oxide (NO) and hydroxyl (OH) radicals. The contents of vitamin B_2, B_3 and vitamin C were also noted using standard methods. A significant variation in the phenols, flavonoids and vitamins contents across the fruit samples was observed. All the fruits tested besides pineapple showed a good reducing antioxidant power in a concentration dependent manner. The extracts of pawpaw, orange, banana and red apple relatively had higher antioxidant potential against DPPH and ABTS radicals among others. The fruits samples demonstrated considerable antioxidant potential against OH* and LO with IC_{50} values range from 0.511-1.067 mg mL^{-1} and 0.53-0.818 mg mL^{-1}, respectively. Some of the fruit samples depicted reasonable antiradical potential against NO* with IC_{50} range from 1.035-1.513 mg mL^{-1}. The fruits extract contained relatively higher concentration of vitamin C, vitamin B_2 and vitamin B_3 whereas pineapple and red apple extracts had lower content of vitamin B_2. Unfortunately, both vitamins (B_2 and B_3) were not found in banana. The result of antioxidant activities of these fruits provide evidences to support consumption practice of fruits varieties in the region to compensate nutrient deficiency and therefore could be a useful source to prevent diseases related to oxidative stress.

Key words: Tropical fruits, antioxidant activity, total phenol, total flavonoid, vitamins

INTRODUCTION

Oxidative stress is defined as imbalance between oxidative mechanisms and antioxidants in the biological system of an organism due to excessive production of free radicals which have been implicated in the causation of various human diseases (Oyedemi and Afolayan, 2011). Pathological conditions such as cancer, Alzheimer, diabetes, strokes, atherosclerosis, myocardial infarction, arthritis, asthma and Parkinson's diseases have been associated with low antioxidant status (Thomson, 1995). Fruits are known to be associated with medicinal properties and contain myriad of natural antioxidant agents such as phenols, flavonoids, vitamins and minerals which are inversely associated radical related diseases (Podsedek, 2007). These compounds are capable of donating hydrogen proton or electrons to the free radicals to prevent or alleviate the extent of oxidative damage that causes degenerative diseases (Hu, 2003). However, low dietary intake of fruit and vegetable has been an important modifiable risk factor contributing to the rising global burden of chronic diseases (WHO, 2005). To combat this challenge, increase consumption of fruits and vegetables should be encouraged. Several epidemiological studies have revealed convincing evidence of the significant role of fruits and vegetables consumption in the human system (Hu, 2003; Garcia-Alonso *et al.*, 2004; Lako *et al.*, 2007; Stangeland *et al.*, 2009).

Over the years, the use of synthetic antioxidant agents such as Butylated Hydroxyanisole (BHA), and tertiary Butyl Hydroquinone (BHQ) was restricted due to their toxicity, pathogenicity and carcinogenic effects in human. Consequently, there is an increasing trend of the consumer preference towards natural antioxidants and thus increase concern to investigating the effectiveness of naturally occurring compounds with antioxidant properties (Kaur *et al.*, 2007). The presence of phytochemicals together with vitamins in dietary fruits is now considered of crucial nutritional importance in the

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prevention of chronic diseases. For example, synergistic interaction of some phytochemicals such as phenols and flavonoids with vitamins C, E and β-carotene has been indicated as potent scavenger of free radicals induced oxidative stress (Harborne, 2005). However, the efficacy of various phytochemicals and nutrients composition in dietary fruits may be varies due to different geographical origin, harvesting time, edaphic and climatic factors (Harris, 1977).

Alice region is a local area in Nkonkobe Municipality situated between 32E47'S and 26E50'E and is located about 60 km south of King William's town with a population of 10, 000 people of which 57% of households live in poverty with serious nutritional problems (Oyedemi *et al*., 2009). The climate varies from hot in summer to extreme cold in winter, sometimes snow or frost with average annual rainfall of 640 mm, most rain fall during the summer (October-March). Mean monthly temperature range from 9°C in July to 22°C in January. The soils are typical Eastern Cape coastal geology, consisting of sedimentary formations, with pH ranging from 5.6 and 6.5 (Moyo *et al*., 2012). High prevalence of overweight, obesity, diabetes, cancer, heart and respiratory diseases represents a serious public health concern of the people living in this region due to socio demographic factors, eating practices and lack of nutritional knowledge. Van den Berg *et al*. (2012) reported about 42.2% of nursing students consumed less than recommended two or four servings of fruits per day. This data from eating practices among the students who are expected to be knowledgeable about dietary intake of fruits indicated the significance of nutritional knowledge on the health benefits of fruits consumption. Medoua and Oldewage-Theron (2011) demonstrated antioxidant properties and effect of cooking on thirteen foods samples comprising of fruits and vegetables that are readily available in the Vaal Region of South Africa. However, further study is needed to provide scientific information on the antioxidant properties of fruits consumed in other regions of South Africa due to different climatic, geographical and edaphic factors.

It is generally believe that fruits may have different antioxidant capacity based on climatic conditions and soil type especially in this region where potential usage and nutritional information on the fruits are rare with limited scientific investigation. Therefore, the objective of this study was to determine the antioxidant properties, total phenols, total flavonoids, vitamin B_2, vitamin B_3 and vitamin C in the selected fruits samples. Free scavenging capacities of these fruits against DPPH, ABTS, NO, OH and LO were also determined.

MATERIALS AND METHODS

Sample collection and preparation: Eight fresh ripe fruits were collected from the market in Alice region of Nkonkobe Municipality of South Africa, August 2011. These fruits include; orange (*Citrus sinensis*), red apple (*Mallus pumila*), carrot (*Daucus carota*), pear (*Pyrus calleryana*), golden apple (*Mallus pumila*), pawpaw (*Carica papaya*), pineapple (*Ananas comosus*) and banana (*Musa acuminate*). After washing of the fruits with distilled water, the edible portion was separated from the seeds, chopped samples (100 g each) were extracted with sterile distilled water in mixi-grinder (Blender HGB550: LASEC South Africa). After extraction, the juices were filtered from coarse debris using a clean cloth. The filtrate was immediately frozen at -40°C and lyophilized for 48 h using a freeze dryer (Savant Refrigerated vapor Trap, RV T41404, USA). The concentrated extracts from the fruits were weighed to calculate the yield and then stored at -4°C for future use.

Determination of moisture content: The moisture content was determined by air-drying 10 g of fruit samples in an oven at 105°C to a constant weight according to the Association of Official Analytical Chemists Method (AOAC, 2005).

Determination of vitamins composition: The riboflavin (vitamin B_2) content in the fruits extracts was determined spectrophotometrically following the method of AOAC (1999) while vitamin C content in the various fruits extracts was done titrimetrically according to the method described by Barakat *et al*. (1993). The amount of niacin in the fruits extract was also evaluated using the method described by AOAC (1999).

Determination of total phenol content: Total phenol content of various fruits extracts was determined using the modified method of Koncic *et al*. (2010) with the Folin-Ciocalteu reagent. An aliquot of the extract (1 mg mL^{-1}) was mixed with 5 mL Folin-Ciocalteu reagent (1:10 diluted with distilled water) and 4 mL (75 g L^{-1}) of sodium carbonate. The tubes were vortexed for 15 sec and allowed to stand for 30 min at 40°C for colour development. The absorbance of blue coloured was then measured at 765 nm using the AJI-C03 UV-VIS spectrophotometer. The calibration curve was prepared in the same manner using tannic acid (0.02-0.5 mg mL^{-1}) prepared in distilled water. Results were expressed as mg g^{-1} of tannic acid equivalent. All samples were analyzed thrice and results averaged.

Determination of total flavonoid content: The amount of flavonoids in the fruits extracts was determined by using the aluminium colorimetric method (Zhishen *et al*., 1999). A volume of 0.5 mL from the sample solution (1 mg mL^{-1}) of the fruits extracts was mixed to 2 mL of distilled water and then 0.15 mL of sodium nitrite ($NaNO_2$, 5% w/v). The reaction mixture was allowed to stand for 6 min after which 0.15 mL of aluminium chloride ($AlCl_3$, 10%), followed by adding 2 mL of sodium hydroxide (NaOH, 4% w/v) to the reaction mixture and left at room temperature for 15 min. The absorbance of pink colour which indicated the presence of flavonoids was measured at 510 nm using the AJI-C03 UV-VIS spectrophotometer. Total flavonoids contents were calculated as mg g^{-1} of quercetin equivalent. The calibration curve was prepared in the same manner using quercetin (0.02-0.5 mg mL^{-1}) prepared in distilled water. All samples were analyzed thrice and results averaged.

Antioxidant and free radicals scavenging assays: Ferric reducing power of the fruits samples was evaluated according to the method of Yen and Chen (1995). The free radical scavenging activity of the fruits extracts was measured against $DPPH^*$ using the method described by Liyana-Pathiranan and Shahidi (2005). The capacity of the fruits extracts to scavenge $ABTS^*$ was assessed using the method of Re *et al*. (1999). The procedure described by Ebrahimzadeh *et al*. (2008) was adopted to determine the scavenging activity of the fruits extracts against nitric oxide radical. The scavenging activity of the fruits samples against hydroxyl radical was also measured (Halliwell *et al*., 1987).

Assessment of lipid peroxidation: The effect of the fruits extracts was evaluated on lipid peroxide formation with an egg yolk homogenate using a modified Thiobarbituric Acid-Reactive Species (TBARS) assays (Dharmananda, 2003). The egg homogenate (0.5 mL, 10% in distilled water, v/v) and 0.1 mL of the fruits extracts was mixed in a test tube and made up to 1 mL with distilled water. A volume of 0.05 mL of 0.07M $FeSO_4$ was added to the above mixture and further incubated for 30 min, to induce lipid oxidation. Thereafter, 1.5 mL of 20% acetic acid (pH 3.5), 1.5 mL of 0.8% w/v TBA prepared in 1.1% w/v sodium duodecyl sulphate and 0.05 mL of 20% w/v TCA were added, vortexed and then heated in a boiling water bath for 60 min. After cooling, 5.0 mL of 1-butanol was added to each tube and centrifuged at 3000 rpm for 10 min. The absorbance of the upper layer solution was measured at 532 nm.

Statistical analysis: Data were expressed as means " SD (standard deviation) of three replicates and were statistically analyzed using one way analysis of variance (ANOVA). Values were considered significant at $p<0.05$ and $p<0.01$.

RESULTS

The results shown in Fig. 1 summarize the composition of vitamin B_2 (riboflavin) in the eight fresh fruits that are grown and regularly consumed in Alice region of South Africa. The amount of riboflavin in the fruit samples varied from 6.2-5.4 mg/100 g but was missing in banana. The data in Fig. 2 showed the variable amount

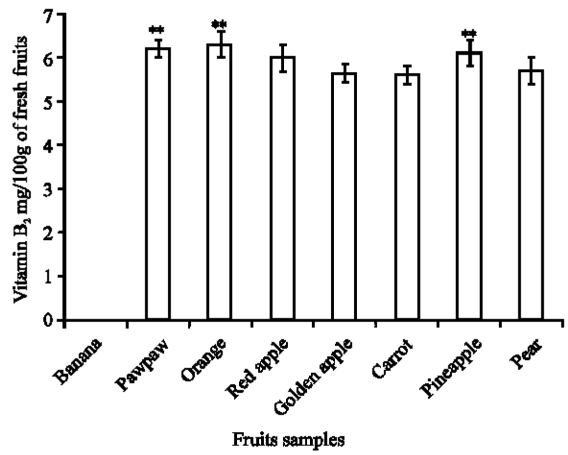

Fig. 1: Vitamin B_2 contents in different selected fruits available in the Alice region, Data are represented as mean (n = 3), **significant $p<0.05$ compared to other fruits

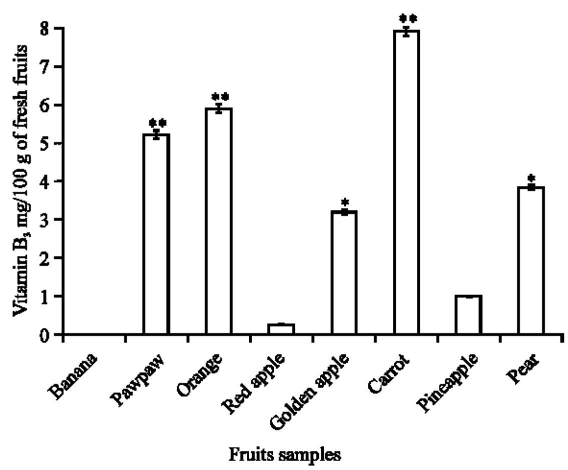

Fig. 2: Vitamin B_3 contents in selected fruits available in the Alice region Data are represented as mean (n = 3), **significant $p<0.05$ compared to red apple, golden apple and pear; *significant $p<0.01$ compared to other fruits

of niacin (vitamin B_3) obtained in the fruit samples tested which range from 7.8-0.2 mg/100g. The highest level of niacin was found in carrot, followed by orange, pawpaw, pear and golden apple. The red apple had the lowest values but not found in banana. The amount of vitamin C content in the tested fruits varied widely ranging from 5.24-0.14 mg/100 g as depicted in Fig. 3. Among the fruits evaluated, orange had the highest content of vitamin C followed by pawpaw and pineapple whereas the lowest content was found in banana, golden apple, pear, red apple and carrot in a decreasing order within the range of 0.50-0.14 mg/100 g.

The concentration-response curve for the reducing power (Fig. 4) was between the ranges of 14.09-1.96 mg ascorbic acid equivalent g^{-1}. The antioxidative properties of the fruits extracts in increasing concentrations are reflected through transformation of Fe^{3+} to Fe^{2+}. All the fruits tested apart from banana showed a good reducing power in a concentration dependent manner. The increasing antioxidant activity was in this order: banana<golden apple<pineapple<redapple<pear<carrot< Orange.

The moisture content from each fruit samples (10 g) range from 56.2-17.6% as shown in Fig. 5. The highest moisture content was found in pear, followed by pawpaw, banana, pineapple, red apple, orange and golden apple whereas the lowest content was found in carrot. Our data showed significant ($p<0.05$) difference between the moisture contents of these fruits.

Total phenols and flavonoids content in the fruit samples was depicted in Table 1. Data collected from this study revealed that both compounds are widely distributed in these fruits with varying composition. The reduction of phenolic content varies from 4.68-0.5 mg tannic acid equivalent/g and presented in this order; orange (*Citrus sinensis*)>red apple (*Mallus pumila*)>

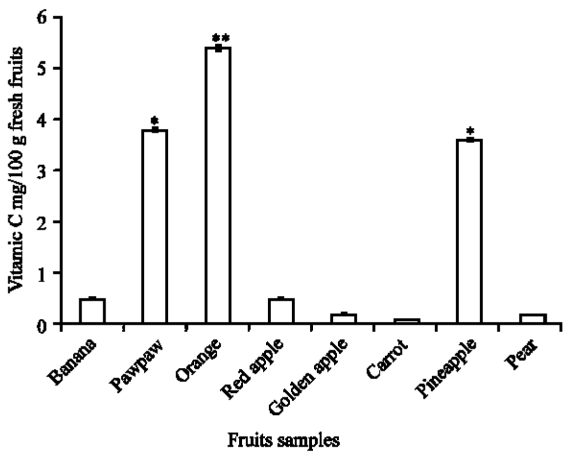

Fig. 3: Vitamin C contents in selected fruits available in the Alice region, Data are represented as mean (n = 3), $^{**}p<0.05$ compared to pawpaw and pineapple, $^{*}p<0.01$ compared to other fruits

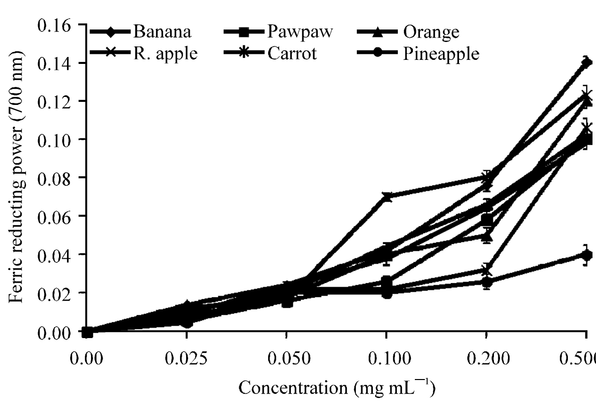

Fig. 4: Ferric reducing power of different fruits readily available in the Alice region, Data are represented as mean (n = 3)

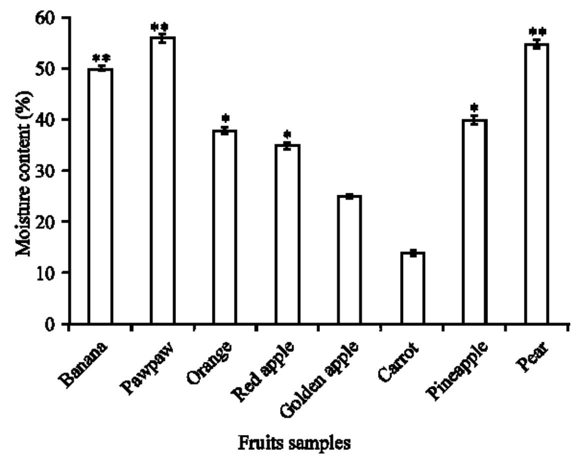

Fig. 5: Moisture content in different fruits available in the Alice region, Data are represented as mean (n = 3), *,**significant different at $p<0.001$ and 0.05, respectively

Table 1: Total phenols and flavonoids content in the fruits extracts

Fruit samples	Total phenol (mg g^{-1})	Total flavonoids (mg g^{-1})
Orange	4.68	1.33
Pineapple	1.34	2.17
Pawpaw	1.70	1.90
Carrot	2.01	1.15
Banana	0.55	1.17
Pear	1.82	0.97
Red apple	3.59	2.04
Golden apple	1.76	1.03
R^2	0.9365	0.9812
Regression equation	Y = 0.1216x	Y = 0.0255x
Fruits equivalent	Tannic acid	Quercetin

Table 2: Free radical scavenging potential of a selection of fruits readily available in the Alice region

	Free radical scavenging activities (IC_{50} mg mL^{-1})				
Fruit samples	DPPH	ABTS	NO	LPO	OH^{-}
Orange	0.36 ± 0.00^{c}	0.02 ± 0.01^{a}	1.44 ± 0.00^{c}	0.51 ± 0.03^{c}	0.72 ± 0.02^{c}
Pineapple	0.25 ± 0.01^{bc}	0.14 ± 0.02^{c}	1.04 ± 0.00^{b}	0.77 ± 0.02^{d}	0.74 ± 0.04^{c}
Pawpaw	0.16 ± 0.01^{b}	0.13 ± 0.02^{c}	1.28 ± 0.01^{bc}	0.71 ± 0.01^{d}	0.79 ± 0.05^{c}
Carrot	1.01 ± 0.02^{f}	0.07 ± 0.00^{b}	1.51 ± 0.06^{c}	0.88 ± 0.01^{e}	0.73 ± 0.02^{c}
Banana	0.41 ± 0.01^{d}	0.02 ± 0.01^{a}	2.27 ± 0.05^{d}	0.88 ± 0.00^{e}	0.52 ± 0.07^{a}
Pear	0.61 ± 0.02^{e}	0.20 ± 0.03^{d}	3.57 ± 0.03^{e}	1.07 ± 0.02^{f}	0.82 ± 0.05^{d}
Red apple	0.23±0.03bc	0.02 ± 0.05^{a}	NI	0.95 ± 0.01^{e}	0.70 ± 0.04^{b}
Golden apple	0.56 ± 0.01^{de}	0.29 ± 0.03^{d}	NI	1.07 ± 0.05^{f}	0.82 ± 0.05^{d}
Rutin	0.02 ± 0.01^{a}	0.012 ± 0.02^{a}	0.018 ± 0.03^{a}	-	-
BHT	0.03 ± 0.01^{a}	0.015 ± 0.01^{a}	0.02 ± 0.02^{a}	0.10 ± 0.03^{a}	-
Gallic acid	-	-	-	0.22 ± 0.04^{b}	-
Mannitol	-	-	-	-	0.57 ± 0.06^{a}

Data are expressed as Mean±standard deviation (n = 3); mean in the same column with different superscripts are significantly different using Duncan's multiple range test at $p<0.05$, NI: No inhibition

carrot (*Daucus carota*)>pear (*Pyrus calleryana*)>golden apple (*Mallus pumila*)>pawpaw (*Carica papaya*)> pineapple (*Ananas comosus*)>banana (*Musa acuminate*). The highest flavonoids content are those of pineapple, red apple, pawpaw, orange, carrot and banana. On the other hand, the lowest content of flavonoids was found in the golden apple and pears.

Table 2 shows the scavenging capacity of the fruits extract against DPPH radical. The fruits samples except golden apple, pear and carrot showed a significant antioxidant potential against DPPH radical with IC_{50} values range from 0.161-0.407 mg mL^{-1}. Though these fruits had a good scavenging capacity but significantly ($p<0.05$) lower in regards to the standard BHT (0.024 mg mL^{-1}) and rutin (0.019 mg mL^{-1}). Golden apple and pear exhibited moderate antioxidant capacity against DPPH radical with IC_{50} value of 0.557 and 0.613 mg mL^{-1}, respectively whereas carrot had a very low scavenging potential. The data obtained for orange, banana, carrot and red apple showed significant antioxidant capacity against ABTS radical. Other fruits evaluated had moderate scavenging potential against the radical with IC_{50} value between 0.132 and 0.292 mg mL^{-1}.

The scavenging capacity of the fruits extract against nitric oxide radicals was summarized in Table 2. The IC_{50} value of the fruits extract range between 1.035 and 3.571 mg mL^{-1}, the standard rutin and BHT was 0.018 and 0.017 mg mL^{-1}, respectively. The scavenging capacity displayed by the fruit extract was lower in comparison to the reference drugs. Pineapple had the best activity against the NO radical, followed by orange while the least value was obtained in pear.

The inhibitory concentration of the fruits extracts and standard mannitol against OH* was presented in Table 2. Among the eight fruits, banana displayed better hydroxyl radical scavenging properties with IC_{50} value of 0.522 mg mL^{-1} followed by red apple with minimum concentration of 0.698 while the least values were obtained in pear and golden apple with IC_{50} value of 0.818 mg mL^{-1}.

Data obtained for the lipid peroxidation showed a moderate scavenging capacity of the fruits samples. Fifty percent inhibition of the peroxides by the fruit samples between the range of 0.511 and 1.067 mg mL^{-1}. Orange had a better capacity to deplete lipid peroxidation followed by pawpaw, pineapple, carrot, banana, red apple, pear and golden apple with IC_{50} values of 0.511, 0.707, 0.768, 0.875, 0.953 and 1.067 mg mL^{-1}, respectively. Generally, results obtained in this study depicted low antioxidant potential of fruit samples against lipid peroxidation in regards to the standard BHT and gallic acid with IC_{50} value of 0.102 and 0.215 mg mL^{-1}, respectively.

DISCUSSION

Riboflavin (vitamin B_2) is a water soluble vitamin and central component of co-enzymes such as Flavin Adenine Dinucleotide (FAD) and flavin mononucleotide (FMN) which are required for the maintenance of immune system in man (Dashak *et al*., 2001). Eating fruits rich in riboflavin has been shown to prevent cataracts and acts as an anti-aging medium. However, lack of this vitamin could cause skin lesion, hair loss and migraine headache (Dashak *et al*., 2001). The antioxidant potential of this vitamin against the formation of hydroperoxide such as H_2O_2 and ROOH has been reported (Toyosaki *et al*., 1988). Our data showed a significant amount of riboflavin in the tested fruit correspond to the recommended daily intake of fruit and may perhaps provide additional nutrients to undernourished people that are predispose to various human diseases in the region.

Niacin (vitamin B_3) also known as nicotinic acid is water soluble vitamin; helps to improve blood circulation and synthesize various sex and stress-related hormones in the adrenal glands. It is a building block of several enzymes and co-enzymes which participate in cellular metabolisms (Toyosaki *et al*., 1988). Lack of this vitamin has been reported to cause pellagra, dementia and diarrhea which are generally treated with a nutritional balanced diet and niacin supplements (Toyosaki *et al*., 1988). The riboflavin and niacin contents observed in some fruits investigated in this study concurred with the report of Okwu (2005) in *G. kola* and *A. melegueta*. It can be inferred from this study that increased consumption of fruits such as orange and pawpaw could be a veritable source to balance daily recommended values of vitamins B_3 for human health benefits (Medoua and Oldewage-Theron, 2011). The increase consumption of fruits contained high concentration of niacin may improve symptoms associated with arthritis among the dwellers of the region and reducing the need for anti-inflammatory medications.

Ascorbic acid (vitamin C) is a water soluble vitamin present in citrus fruits. It plays a key role which includes synthesis of collagen, hormones, neurotransmitters and prevention of several human diseases induced by oxidative stress (Elliot, 1999). The disparity in vitamin C content as shown in this study could be assigned to climatic condition, species, harvesting condition and geographical location. Studies conducted by Kaur *et al*. (2007) found that majority of the world population are not consuming the actual amount of vitamin C needed to prevent oxidative damage in the biological system because of less intake of fruits. Therefore ample intake of these fruits that contain appreciable amount of vitamin C could be of health benefit (Wargovich, 2000). Unfortunately, vitamin C was not found in banana which is contrary to the findings of Lim *et al*. (2007). The reason was not investigated but could be linked to above mentioned factors and hence suggest consumption of fruits varieties to compensate for nutrient deficiency in some fruits.

The antioxidative potential of fruit juices has been closely related to their total phenolics contents. These compounds are important plant components with significant antioxidant capacities and wide range of biological activities through various mechanisms of action (Ferguson, 2001). Both phenols and flavonoids have been indicated in several studies as potent antioxidants against free radicals (Bagchi *et al*., 1997; Oyedemi and Afolayan, 2011). The present study indicated variation of phenols and flavonoids contents in the fruits sample which could be attributed to genetic factors, environmental conditions, maturity and degree of ripeness (Howard *et al*., 2000). These factors could also justify disparity in the composition of phenols and flavonoids in these fruits compared to those reported elsewhere (Howard *et al*., 2000; Melo *et al*., 2006). It is well known that fruit consumption pattern display seasonal variability which further complicates the comparison of results within and across countries (Pomerleau *et al*., 2004). In this study, the increase level of phenols and flavonoids may be responsible for the degree of antioxidant potentials. Some of the fruits such as orange, red apple, pawpaw and pineapple had variation of both compounds but showed strong antioxidant potential. Daily consumption of the recommended dietary intake of these fruits could boost the health status of the people living in this region.

The reducing power of many food samples has been used to correlate their antioxidant potential based on their ability to donate electron to Fe (III) in a redox linked colorimetric reaction (Rathee *et al*., 2007). The reduction capacity of antioxidant compounds or natural products is recognised among various mechanisms to test antioxidant properties of natural products (Oyedemi and Afolayan, 2011). Reductones in fruits extracts are known to be responsible for breaking the free radical chain reaction through electron or hydrogen donation. Addition of Fe (III) to the reduced product in the reaction mixture leads to the formation of intense Perl's Prussian blue which has strong absorbance at 700 nm. An increase in the absorbance of the reaction mixture indicates an increase in the antioxidant capacity of the fruit samples. In this study, the changes of yellow colour of the test solution to various shades of blue and green demonstrated the reducing power of fruit samples. Our observation showed that the fruit samples had electron donor capacities to neutralize free radicals though lower when compared with standard drugs (BHT, vitamin C and rutin).

DPPH is stable nitrogen centered radical commonly used as a substrate to determine free radical scavenging activity of natural compounds in a relatively short time compared to other methods. This radical becomes stable diamagnetic molecule by accepting electron or hydrogen from antioxidant agents. Upon reaction of DPPH radical with antioxidant molecules, the colour change from purple to yellow this could be related to electron or hydrogen donating capacity from antioxidant agents (Oyedemi *et al*., 2010). The increased reduction of DPPH radical is proportional to the amount of antioxidant in a giving volume of fruit extracts which is measured quantitatively at 517 nm. All the fruits samples except golden apple, pear and carrot showed significant antioxidant activity against DPPH radical. Golden apple and pear had moderate antioxidant capacity whereas carrot had the lowest antioxidant potential as shown in

Table 2. Unfortunately, carrot which exhibited noticeable amount of flavonoids, phenols and vitamin C registered the lowest radical scavenging activity while banana without flavonoids and vitamin C had a better radical scavenging property. Though, vitamin C and flavonoids were missing in banana but may contain other antioxidant compounds and/or nutrients that are not investigated in this study. The components of most fruits are different from those reported elsewhere due to environmental growth variation and/or difference in the maturation stage of the fruits hence responsible for different antioxidant capacities. Consumption of these fruits could serve as additional supplement to prevent or control chronic diseases such as diabetes, cancer and cardiovascular diseases in the diagnosed people with any of the diseases of this region.

ABTS is a blue chromophore generated by the reaction of potassium persulphate with ABTS for 12-14 h in the dark. It is frequently used in phytomedicine research to measure the antioxidant properties of hydrogen-donating and chain-breaking of antioxidant agents. In this study, the fruit extracts and standard BHT or rutin scavenged the ABTS radical in a concentration dependent manner. Fruit samples efficiently scavenged ABTS radicals generated by the reaction between ABTS radical and ammonium persulphate (Table 2). The data obtained for orange, banana, carrot and red apple showed potent antioxidant activity but markedly lower in comparison to the standard drugs. Other fruits had moderate scavenging potential against ABTS radical and thus support consumption of fruit varieties. The present study demonstrated the capability of the fruits extract to scavenge radicals in different systems and thus suggest its usefulness as therapeutic agent for the treatment of pathological diseases related with free radicals. It is advisable based on this study, that the local people should increase fruits consumption to prevent the prevalence of human diseases induced by free radicals.

Nitric oxide is a free radical synthesized during conversion of arginine to citrulline by nitric oxide synthases (Shami *et al*., 1995). It produces potent oxidant peroxynitrite when combine with superoxide which could cause apoptosis or necrosis of the cells depending on the concentrations. Consequently, it is necessary to search for natural products of plant origin that can quench this radical. The protective mechanism could be linked to the activation of the transcription factor in the iNOS gene expression as a response to inflammation (Shami *et al*., 1995). The scavenging capability of the fruits extracts against nitric oxide radicals is shown in Table 2. The fruit extracts exhibited scavenging activity but significantly lower as compared to the reference drugs. This finding serves to encourage the people of the region to increase consumption of pineapple and orange in their daily dietary intake of fruits and hence could prevent carcinogenesis.

The hydroxyl radical scavenging activity of the fruits sample was determined according to deoxyribose degradation in Fenton type reaction system. It is a species capable of damaging various biological molecules including DNA, protein and polyunsaturated fatty acid in the membrane (WHO, 2005). The inhibitory concentration of the eight fruit samples and standard mannitol was presented in Table 2. The fruits extracts did not have significant effect against hydroxyl radical. Again, consumption of fruits varieties could enhance plasma antioxidant potential against some free radicals induced degenerative diseases that are common among Alice region dwellers.

Lipid peroxidation is one of the major outcomes of free radical-mediated injury to tissue. The oxidation of lipids alters the physicochemical properties of membranes that result to severe cellular dysfunction (Dharmananda, 2003). Increased consumption of fruits such as orange, pawpaw and pineapple with promising activity against lipid peroxides formation could play a crucial role in protecting the membrane bilayers from cellular dysfunction.

Fruits with high moisture content promote microbial susceptibility and enzyme activity as a result can affect the storage life (OMAFRA, 2011). The low moisture content found in golden apple, carrot and orange as compared to others could prolong their shelf life due to limited microbial contamination.

Conclusively, the results obtained from this study demonstrated potent antioxidant capacity of fruits such as orange, pineapple, banana, pawpaw and red apple despite and thus suggest their usefulness as therapeutic agent against pathological diseases induced by free radicals. Fruits with low or moderate antioxidant potentials have other nutritional benefits which are not investigated in this study. In addition, combination of these fruits as fruits salads and or otherwise may possibly increase their free radicals scavenging properties. The difference in the antioxidant capacity across the fruits indicated variation in the phytochemical and vitamin compositions. Our findings exhibited significant source of natural antioxidant in some fruits but further study is needed to confirm the relationship between their antioxidant values and modulation of oxidative stress markers *in vivo*.

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