**Chapter 9**

**Antioxidant Properties of Selected African**

**Vegetables, Fruits and Mushrooms: A Review**

R.U. Hamzah, A.A. Jigam, H.A. Makun and E.C. Egwim

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/52771

**1. Introduction**

Africa is blessed with vast amount of vegetables, fruits and mushrooms which are

consumed for their nutrients or for their medicinal purposes. In recent years these

vegetables, fruits and mushrooms have been shown to possess valuable antioxidants of

great nutritional and therapeutic values. Antioxidants are substances which when present at

low concentration compared to those of an oxidizable substrate [1] significantly delay or

prevent the oxidation of that substrate. They are capable of preventing or attenuating

damages such as lipid peroxidation, oxidative damage to membranes, glycation of proteins

and inactivation of enzymes caused by free radicals. There are several evidences that show

that oxidative stress resulting from reactive oxygen species including free radicals such as

hydroxyl (OH.), superoxide (O2**.**-), nitric oxide (NO**.**), nitrogen dioxide (NO2**.**-), peroxyl

(ROO**.**) and non free radical like hydrogen peroxide and singlet oxygen play an important

role in the development of several pathological conditions such as lipid peroxidation,

protein oxidation, DNA damage and cellular degeneration. These have been implicated in

the aetiology of these pathological conditions related to cardiovascular diseases, diabetes,

inflammatory diseases, cancer, Alzheimer and Parkinson disease, monogolism, ageing

process and perhaps dementia [2,3-4, 5] .

Free radicals and other reactive oxygen species are constantly formed in the human body

during normal cellular metabolism e. g during energy production in the mitochondria electron

transport chain, phagocytosis, arachidonic acid metabolism, ovulation, fertilization and in

xenobiotic metabolism [6]. They can also be produced from external sources such as food,

drugs, smokes and other pollution from the environment [7]. Organisms are endowed with

endogenous (catalase, superoxide dismutase, glutathione peroxidase/reductase) and

exogenous (vitamin C, E, β-carorene) antioxidant defense system against reactions of free

radicals. However the generation of free radicals in the body beyond its antioxidant capacity

leads to oxidative stress which has been implicated in the aetiology of several pathological

204 Mycotoxin and Food Safety in Developing Countries

conditions such as lipid peroxidation, protein oxidation, DNA damage and cellular

degeneration related to cardiovascular disease, diabetes, inflammatory disease, cancer and

parkinson disease [8]. As a result of this much attention is been focused on the use of

antioxidants especially natural antioxidant to inhibit and protect damage due to free radicals

and reactive oxygen species. Synthetic antioxidant such as butylated hydroxyanisole(BHA),

tert-butylated hydroxyquinone and butylated hydroxytoluene have been of utmost concern to

many researcher because of their possible activity as promoters of carcinogenesis[9] Plant

based antioxidant are now preferred to the synthetic ones because of their safety.

Epidemiological studies have shown that the consumption of vegetables and fruits can

protect humans against oxidative damage by inhibiting or quenching free radicals and

reactive oxygen species [8].Many plants including fruits and vegetables are recognized as

sources of natural antioxidants that can protect against oxidative stress and thus play an

important role in the chemoprevention of diseases that have their aetiology and

pathophysiology in reactive oxygen species (10, 11-12]. These positive effects are believed to

be attributable to the antioxidants; particularly the carotenoids, flavonoids, lycopene,

phenolics and β-carotene [13] Mushrooms which have long been appreciated for their

flavour and texture are now recognized as a nutritious food as well as an important source

of biologically active compounds of medicinal value [14]. Mushrooms accumulate a variety

of secondary metabolites, including phenolic compounds, polyketides, terpenes and

steroids. Also, a mushroom phenolic compound has been found to be an excellent

antioxidant and synergist that is not mutagenic [15]. Studies have shown that tropical

mushrooms are highly rich in proteins, minerals, vitamins, crude fiber and carbohydrate

with low fat and oil content. The protein content of mushrooms has been reported to be

twice that of vegetables and four times that of oranges and significantly higher than that of

wheat [16, 17]. The high level of vitamins in mushrooms particurlary vitamin C and D has

been reported as responsible for its antioxidative activity [17, 18]. Mushrooms contains also

an appreciable quantities of crude fibres, although, little information exist on Total Dietary

Fibre (TDF) content of mushrooms. The crude fibre content values reported from many

studies suggest that mushrooms are potential sources of dietary fibre [16]. Mushrooms

generally contain low fat and oil content [16]**.** Because of the low fat and oil content, they are

recommended as good source of food supplement for patients with cardiac problems or at

risk with lipid induced disorders.

Also a lot had been reported on the nutrient; antinutrient and mineral composition of some

edible mushrooms in Nigeria [19, 20] however there are few reported data on the antioxidant

properties of commonly consumed mushrooms. This Chapter is therefore intended to discuss

the antioxidant properties of selected African vegetables fruits and mushrooms.

**2 Antioxidant properties of selected vegetables**

**2.1. *Vernonia amygdalina* (VA)**

*Vernonia amygdalina* is a perennial shrub that belongs to the *Asteraceae* family and is

popularly called bitter leaf in English a. It is known as ‘Grawa’ in Amharic, ‘Ewuro’ in

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 205

Yoruba, ‘Etidot’ in Ibibio, ‘Onugbu’ in Igbo, ‘Ityuna’ in Tiv, ‘Ilo’ in Igala ‘Oriwo’ in Edo and

‘Chusar-doki’ in Hausa.It has petiolate leaves of about 6mm diameter and ellicptic in shape.

The leaves are green with a characteristic odour and bitter taste [21]. They are well

distributed in tropical African and Asia and are commonly found along drainage lines and

in natural forest or commercial plantation.

In most part of Africa, the leaves of VA are used as soup condiments after washing or boiled

to get rid of the bitter taste. Specifically it is used to prepare the popular Nigerian bitter leaf

soup, “onugbo” and as spice in the Cameroon dish called “Ndole” [22].

VA has a long history of use in folk medicine particularly among the sub Saharan African.

Huffman and Seifu [23] reported the use of VA in the treatment of parasite related disease in

wild chimpanzee in Tanzania. This necessitated quite a great number of researches to test

the efficacy of different part of the plant in managing a wide array of ailments [22, 24]. Many

traditional medicine practitioners use different parts of the plants in treating various

ailments for instance the whole plant is being used as antihelminth, antimalaria and as a

laxative [25]. Others use the aqueous extract of the leaves as a digestive tonic, appetizer and

for treatment of wounds [26]. The decotion from leaves is used in the treatment of malaria

fever in Guinea and cough in Ghana [24]. The leaf is also in Ethiopia as hops in preparing

beer [27]. In Malawi and Uganda it is used by traditional birth attendants to aid expulsion of

placenta after birth, aid post-pertum uterine contraction, induce lactation and control

postpartum haemorrhage.

Their traditional use is not limited to human alone, in northern Nigeria it has been added to

horse feed to provide a strengthening or fattening tonic *chusan Dokin* in Hausa.

Different extracts of VA has been shown to posses antioxidant properties both invitro and

invivo. Ayoola et al [28] showed the invitro antioxidant properties of the ethanolic extract of

leaves of VA using the diphenyl picyryl hydrazyl radical (DPHH) scavenging test. *V.*

*amygdalina* was shown to have moderate inhibition of 77.7% thus indicating the scavenging

ability of the vegetable. Also the aqueous and ethanolic extract of VA has further been

shown to have potent antioxidant properties as they were able to inhibit bleaching of Bcarotene,

oxidation of linoleic acid and lipid peroxidation induced by Fe2+/ ascorbate in a rat

liver microsomal preparation. This study showed that the antioxidant activity of the

ethanolic extracts was higher than that of the aqueous extracts, and compared favourably

with synthetic antioxidant BHT and BHA [29]. However another study reported that

methanol extract displayed highest antioxidant activity followed by acetone and water

extract [30].

Adesanoye and Farombi [31] reported the hepatoprotective activities of the aqueous extract

of *Vernonia amygdalina* leaves against carbon tetrachloride-induced hepatotoxicity and

oxidative stress in mice. Administration of *Vernonia amygdalina* resulted in accelerated

reversion of hepatic damage via reduction of liver marker enzymes like ALT, AST, ALP,

Lactate dehydrogenase and bilirubin. Similarly antioxidant enzymes such as superoxide

dismutase, glutathione S-transferase and reduced glutathione concentration and catalase

activity were increased significantly at different doses of the methanolic extract of VA. This

206 Mycotoxin and Food Safety in Developing Countries

study is in agreement on previous work reported on the antioxidant properties of VA on

aacetaminophen induced hepatotoxicity in mice [32]. The presence of flavonoids, phenols

and other phytochemicals in this vegetable have been attributed to its antioxidant properties

Further confirmation of the antioxidant activities of VA was carried out by Oloyede and

Ayila [33]. They investigated the antioxidant activity of different extracts, aqueous,

methanol, hexane, ethylacetate and butanol extracts of *Vernonia amygdalina* using three

methods: scavenging effect on 2,2-diphenyl-1-picryhydrazyl radical (DPPH), hydroxyl

radical and peroxide oxidation by ferric thiocynate method. All fractions showed significant

antioxidant activity (p<0.05) when compared with antioxidant standards like butylated

hydroxyl anisole (BHA), ascorbic acid and α-tocopherol used in the assay. This plant

contains natural antioxidants against aqueous radicals and reactive species ions [30].

Oxidative stress has been implicated in numerous human diseases including cancer,

atherosclerosis, diabetes, malaria, iron overload, rheumatoid arthritis, Parkinson disease,

and in HIV infection and AIDS [1]. This term actually refer to the imbalance between the

generation of reactive oxygen species and the activity of the antioxidant

defenses[34].Reactive oxygen comprises both free radicals such as hydroxyl (OH!),

superoxide (O2**.**-), nitric oxide (NO. ), nitrogen dioxide (NO2**.**-), peroxyl (ROO.) and lipid

peroxyl (LOO. And non free radical or oxidants like hydrogen peroxide (H2O2 ), ozone (O3 ),

singlet oxygen (1O.), hypochlorous acid (HOCl), nitrous acid (HNO3 ), peroxynitrite

(ONOO¯), dinitrogen trioxide (N2O3 ), lipid peroxide (LOOH), oxidants, although, they can

easily lead to free radical reactions in living organisms [35]. Many of these ROS serve useful

physiological functions but can be toxic when generated in excess or inappropriate

environment thus causing oxidative damage to membranes and enhanced susceptibility to

lipid peroxidation or enzyme inactivation.

*Vernonia amygdalina* has been used in various part of Africa for the treatment of several

ailments ranging from diabetes, malaria, cancer and for general wellbeing. This local

treatment has been backed up in recent times scientifically.

Nwanjo [36] reported the antidiabetic effect of the aqueous extract VA in streptozotocin

induced diabetic rats. He showed in his finding that VA was capable of reducing plasma

glucose, triglycerides, and LDL-cholesterol and the marker of oxidative stress

malondialdehyde. These may be due to decreased oxidative stress which may be via direct

scavenging of the ROS or by increasing the synthesis of antioxidant molecule [37].

Recently Akpaso et al [21] showed that the antidiabetic effect of the combined leaf extracts

of *vernonia amygdalina* (bitter leaf) and *Gongronema latifolium* on the pancreatic β – cells of

streptozotocin – induced diabetic rats. The extracts were observed to increase the animal

body weight against the loss in weight in the diabetic group. In the same manner the serum

glucose significantly decreased after 28days of treatment with the combined extract.

Regeneration of islets cells was explained to be the one of the possible cause as there will be

an increase in insulin production and secretion [38]. Previous studies by Ebong et al [39]

reported this possible synergestic action using the extracts of Azadirachta indica and VA. It

has been clearly demonstrated that *Vernonia amygdalina* extract contains active ingredients

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 207

such as vernoniosides, glucosides, (VA) flavonoids and antioxidants [40] which may be

responsible for their potentials in reversing pancreatic damage caused by STZ or alloxan in

experimental animals. It was proposed that sesquiterpene lactones and the bitter principle of

the plant may also be responsible for insulin production, stimulation and release of

pancreatic islets from the beta-cells [41]. On the other hand, tannin, flavoniods glycosides

and phytosterols of the plant may also act as alpha glucosidase inhibitor which contributed

to the hypoglycemic effect of the plant.

Cancer has become a serious global problem. Prostate cancer and breast cancer are the most

diagnosed non-skin cancers in men and women respectively. Breast cancer represents 15%

of new cases of all cancers [42] while prostate cancer represents 15.3% of all cancers in men

in the developed countries [43]. *V. amygdalina* Del. is increasingly becoming a strong

contender for cancer management. Coumarins, flavonoids, sesquiterpene lactones and

edotides may be the principles in VA that are responsible for its anticancer activity [44-46].

It was reported that the aqueous extract of VA exhibited a cytotastic action on cultured

human breast tumour cells (MCF-7) growth in vitro. This implies tumour stabilization or

preventive effects in vivo [46]. Fractions of *Vernonia amygdalina* extract were found to inhibit

DNA synthesis. However the physiological concentrations of the water-soluble *Vernonia*

*amygdalina* extract potently inhibited DNA synthesis in a concentration-dependent manner

both in the presence and absence of serum [27]. It was also reported that fractions of hexane,

chlorofrm, butanol and ethylacetate extracts of VA was capable of inhibiting the growth of

human breast cancer cells even at very low concentrations of 0.1 mg/ml to concentration of 1

mg/ml, the inhibition was as high as 98% for some fractions of the extract [47]

Cold water, hot water and ethanol extract were found to induce apoptosis against acute

lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) from the patients with

IC50 ranging between 5 to 10 μg/ml. Ethanol extract was found to be most effective against

both ALL and AML when compared to cold and hot water extract [48. Petroleum ether/

ethyl acetate leaf extract also possessed cytotoxic effect towards human hepatoblastoma

(HepG2) and urinary bladder carcinoma (ECV-304) cell lines [49]. These findings establish

the usefulness of *V. amygdalina* Del. in managing breast cancer.

Bioactive peptides from the aqueous extract of the plant leaves (edotides) have been shown

to be potent in managing cancer by its activity on mitogen activated protein kinases and

signal transduction pathways [46, 50].

*Vernoninia amgdalina* leaf is a vegetable with several potentials in the prevention and

treatment of various ailments associated with oxidative stress.

**2.2. *Telfairia occidentalis* (T.O.)**

*Telfairia occidentalis* Hook f. commonly called fluted pumpkin occurs in the forest zone of

West and Central Africa, most frequently in Benin, Nigeria and Cameroon. It is a popular

vegetable all over Nigeria. It has been suggested that it originated in south-east Nigeria and

was distributed by the Igbos, who have cultivated this crop since time immemorial [51]. It is

208 Mycotoxin and Food Safety in Developing Countries

a vigorous perennial vine, growing to 10m or more in length. The stems have branching

tendrils and the leaves are divided into 3– 5 leaflets. The fruits are pale green, 3 – 10 kg in

weight, strongly ribbed at maturity and up to 25cm in diameter. The seeds are 3– 5cm in

diameter [52]. The leaf is consumed in different parts of the country because of the

numerous nutritional and medicinal attributes ascribed to it. It has different traditional

names; among Igbos, it is known as “Ugu”, “iroko” or aporoko in Yoruba, ubong in Efik,

umee in Urhobo and umeke in Edo [53]. Young succulent shoots and leaves are used as

vegetables in the eastern part of Nigeria. The herbal preparation of the plant has been

employed in the treatment of sudden attack of convulsion, gastrointestinal disorders,

rmalaria and anaemia [54].Also the plant has agricultural and industrial importance in

addition to its nutritional value [55].

Quite a number of researchers in the field of medical sciences have observed free radical

scavenging ability and antioxidant property in *Telfairia occidentalis*. The darkish green leafy

vegetable of *Telfairia occidentalis* and extracts (such as aqueous and ethanol extracts) from the

leaves have been found to suppress or prevent the production of free radical and scavenge

already produced free radical, lower lipid peroxidation status and elevates antioxidant

enzymes (such as superoxide dismutase and Catalase) both in vitro and *in vivo* ([56,57-

61,62]. They reported that extracts of this vegetable using various solvents were able to offer

a chemopreventive and protective effects on oxidative stress induced serum and organs like

kidney, liver and brain. Studies have shown that T.O. leaves are rich in antioxidants such as

ascorbic acid and phenols [63, 64].

Specifically Oboh et al [57] in their study showed the antioxidant properties of T. O. by

assessing their total phenolic content, reducing property and free radical scavenging

properties against DPHH radical. From that study the aqueous extracts had a significantly

higher total phenol content than the ethanolic extracts which clearly indicates that the

phenols present in *Telfairia occidentalis* leaves are more water soluble than ethanol,

consequently, the aqueous extracts could be a more potent antioxidant than the ethanolic

extracts. this gives credit to the fact that aqueous extracts of the leaf is presently used in the

management and prevention of anaemia and diabetes. This high phenol content in the

aqueous extracts could have contributed to the prevention/ management of hemolytic

anaemia [65] diabetes [66] which is associated with free radical damage.

Antioxidants may been classified into two separate groups: those that suppress the

generation of reactive oxygen species and those that scavenge the reactive oxygen species

generated[57] . Also in the same study it was observed that the aqueous extract had a

significantly higher reducing power and higher free radical scavenging ability than the

ethanolic extracts. The higher phenolic content in the aqueous extract would have accounted

for the higher ability of the aqueous extract to reduce Fe (III) to Fe (II) in the FRAP test for

reducing ability [67]. Also the chelating properties of phenols have been reported to have

high reducing power [68] which clearly indicate that *Telfairia occidentalis* leaf antioxidant

potentials will be more harness in its aqueous extraction than the ethanolic extraction and

this is in accord with the form in which the plant is presently been used. Furthermore, the

high reducing power and free radical scavenging ability of the extracts clearly indicate that

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 209

both extracts of *Telfairia occidentalis* could suppress the generation of free radical and scavenge

free radical. Protocatechiuc acid (PRA) and caffeic acid was shown to be the main

polyphenolic compound present in the leaves of T.O.[69]. Cafeic acid is a phenollic compound

present in the plant kingdom [70]. It is known to have a large number of physiological

activities including anti-inflammatory, anti allergic and anti tumour [71, 72, 73]. They also

revealed in their study the high flavonoid content, total antioxidant content, lipid peroxidation

inhibition, free scavenging activity towards hydroxyl radical and superoxide scavenging

abilities of *Telfairia occidentalis* amongst other vegetables. Therefore the consumption of leaves

of T O will provide adequate antioxidants capable of preventing diseases arising from

oxidative stress thus promoting the general well being of an individual.

The hepatoprotective properties of polyphenol extracts on T O leaves on acetaminophen

induced liver damage was observed [58]. It was demonstrated that the soluble free

polyphenol had a higher protective effect on the liver than bound polyphenol in this

vegetable. This agrees with previous studies where correlation was reported between

antioxidant properties and total polyphenolic content of some commonly consumed

vegetables and fruits [56, 57, 74, 75,] Free phenolics are more readily absorbed and thus

exert beneficial bioactivities in early digestion. The significance of bound phytochemicals to

human health is however not clear [75, 76] and Chu et al 2002.

*Telfairia occidentalis* leaves have been reported to also be protective against liver damage [76,

77]. The use of the leaves in folk medicine in Nigeria in the treatment of certain diseases in

which the participation of reactive oxygen species have been implicated could be as a result

of the antioxidant and free radical scavenging ability [62].

Oxidative stress which have been implicated in quite a number of diseases such as anaemia,

malaria, diabetes cancer and so on have been reported to be relieved by antioxidants inherent

in vegetables, fruits and other plants. It is to this end that Salama *et al* [78] reported that

aqueous extract of *Telfairia occidentalis* leaves reduces blood sugar and increases

haematological and reproductive indices in male rats. *T. occidentalis* actually caused significant

increases in packed cell volume, haemoglobin concentration, red blood cell count and white

blood cell count in addition to a significant decrease in blood glucose. The increase in the

hematological indices observed in this study is consistent with the observations made when

rats were fed with the diet preparation of the air-dried leaves of *T. occidentalis* for four weeks

[79] This study has also shown for the first time that new blood cells would have started

appearing in the circulation after the fifth day of treatment with *T. occidentalis* and the increase

would become significant after the seventh day of treatment and beyond. This increase is due

to the chemical composition of *Telfairia occidentalis* particularly the presence of the vitamin A

and C which are well known antioxidants capable of scavenging free radicals [80]. Some of

these constituents are well-established haemopoietic factors that have direct influence on the

production of blood in the bone marrow. For instance, iron is a well known haemopoietic

factor [81]. Also the amino acids derived from *T. occidentalis* could also be used for the

synthesis of the globin chains of the haemoglobin and this could also contribute to the increase

in haemoglobin concentration. The significant increase observed in this study is however

inconsistent with the insignificant change in haematological parameters observed when birds

210 Mycotoxin and Food Safety in Developing Countries

were fed with the dietary preparation of the sun-dried leaves of the plant [82]. The

insignificant change observed with the sun-dried leaves might be due to the denaturing of the

active ingredients especially proteins in the leaves during exposure to sunlight. In addition,

the inconsistence may be an indication of a species variation in the responses to the effects of

the plant. In the same study the leaves were observed to reduce blood sugar significantly, an

indication of its hypoglycemic properties. This was confirmed in recent study on the

comparative hypoglycemic properties of the ethanolic and aqueous extracts of leaves and

seeds of this plant [83]. The hypoglycemic property is more in the leaves and was concluded to

be better extracted with ethanol than water.

In the same way it was shown that this leave extract improve sperm motility, viability and

counts generally improving sperm quality [78]. This is attributed to the actions of some of its

active ingredients which have well documented spermatogenic activities. In this respect,

studies have shown that nutritional therapies with zinc [84], vitamin C [85], vitamin E [86]

and arginine [87] proved beneficial in treating male infertility. Therefore it may be very

useful in the treatment and management of infertility especially that associated with

reduction in sperm performance.

The antianaemic potentials of the aqueous extract of leaves of *Telfairia occidentalis* extracts

against phenyl hydrazine-induced anaemia in rabbits was investigated [88]. Anaemia

constitutes a serious health problem in many tropical countries because of the prevalence of

malaria and other parasitic infections. In anaemia there is decreased level of circulating

haemoglobin, less than 13 g dL-1 in male and 12 g dL-1 in females [89]. In the tropics, where

malaria is endemic, between 10 to 20% of the population presents less than 10 g dL-1 of

Haemoglobin [90]. Children are more vulnerable. The leaves are rich in iron and play a key

role in the cure of anaemia, they are also noted for lactating properties and are in high

demand for nursing mothers [91].

Elaboration of the therapeutic effect of *Telfairia occidentalis* on protein energy malnutrition-

Induced liver damage was specifically emphasized in previous study [61]. The protein

deficient diet caused a significant increase in hepatic malondialdehyde (MDA) level and the

liver function enzymes alkaline phosphatase (ALP), alanine amino transferase (ALT) and

aspartate amino transferase (AST) activities in the serum. It also caused a marked reduction

in glutathione level, significant decrease in the antioxidant enzymes superoxide dismutase

(SOD) and catalase (CAT) and significant damage to the hepatocytes. Recovery diets of

protein alone and protein supplemented with *T. occidentalis* had significant effects on all the

parameters. The MDA level and the serum liver function enzymes were significantly

reduced while glutathione and antioxidant enzymes levels were markedly increased and a

highly significant hepatocyte healing observed in the histology images.

**2.3. OCIMUM**

The genus ocimum is represented by over 50 species of herbs and shrubs in Africa. *Ocimum*

*basilicum* and *Ocimum gratissimum* are known in Africa to manage different diseases. They

belong to the family of plant known as Lamiaceae [92]. Local names of different species of

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 211

ocimum in various ethnic groups include *Efirin* (Yoruba), *neh-anwu* (Ibo), *ntion* (Efik) and

*dai-doya ta gida* (Hausa). The leaves can be petiolate or sessile, often toothed at the margin.

They are erected and have characteristic pleasant aroma due to their volatile oil [92].

*Ocimum gratissimum* leaf or the whole plant is known to be popular treatment remedy for

diarrhoea [93]. The plant is rich in voltile oils, which contain up to 75 percent of thymol, the

antimicrobial activity of which is well known. Infact, the antimicrobial activity of the watersaturated

oil had been shown to be proportional to the thymol content [94].

*Ocimum gratissimum* is effective in the management of upper respiratory tract infection,

diarrhoea, headache, skin disease, pneumonia, fever, and conjuctivities.[95]. Traditionally

*Ocimum basilicum* (basil) has been used as a medicinal plant for various ailments, such as

headaches, coughs, diarrhoea, constipation, warts, worms and kidney malfunction. It is also

thought to be an antispasmodic, stomachicum, carminative, antimalarial, febrifuge and

stimulant [96, 97]. Ethnobotanical surveys report the traditional utilization of basil as a

veterinary medicinal plant as well. Basil oil, especially the camphor containing oil, has

antibacterial properties. The vapour of boiling leaves is inhaled for nasal or bron-chial

catarrh and colds. The leaves may be rubbed between the palms and sniffed for colds. It

cures stomach- ache and constipation. The leaves are crushed and the juice is used as

vermifuge. It is further used to repel mosquitoes and as a broom to sweep chicken house in

order to get rid of fleas.

Reactive oxygen species (ROS) have been implicated in some of the disorders associated

with the traditional uses of some vegetables, such as malaria, anaemia, gastrointentional

tract disorders, diabetes mellitus and inflammatory injury. Hence this forms the basis for the

investigation of the antioxidant properties of some of these vegetables in order to validate

the acclaimed traditional use.

A comparative study on the antioxidant properties of two Nigerian species of Ocimum

showed that the methanolic extract of *Occimum gratissimum* posses a higher polyphenolic,

flavonoid comoponent and free radical scavenging activities when compared to the

methanolic extract of *O. basillicum* [98]. Thus this may be reason behind wider utilization of

*O. gratissimum* in Nigerian folk medicine than *O. basillicum.*

Basil has been shown to contain *flavonoid* glycosides (0.6–1.1%) and flavonoid aglycones. A

flavone, xanthomicrol (5, 4’-dihydroxy-6, 7, 8-trimethoxyflavone) was isolated from the

leaves of a Nigerian *O.basilicum* [99, 100]. Basil herb *(O.basilicum)* contains apart from

essential oil and flavonoids also tannins and polyphenols (2.2–2.3%)[ 99, 100].

The phytochemical and antioxidant activity of methanolic and aqueous extract of *Ocimum*

*gratissimum* (OG) were investigated and the results showed the presence of flavonoids,

steroids, cardiac glycosides, tannins, phlobatannins in both extract [101]. The methanoilic

extract of OG was shown to exhbit a higher DPHH scavenging activity (84.6%) at 250 μg/ml

and a reductive potential of 0.77 at 100 μg/ml comparable with those of gallic acid, 91.4% at

250 μg/ml and ascorbic acid, 0.79 at 60 μg/ml as standards for DPPH scavenging activity

and reductive potential, respectively. Thus OG - leaf extracts possess antioxidant potential

probably because of its phytochemical constituents which has also been reported in other

212 Mycotoxin and Food Safety in Developing Countries

studies [102,103-104]). Also the hepatoprotective effect of extract of leaf of OG was also

reported [105].

The methanolic extract of leaf of OG was also shown to be capable of scavenging the free

radiacal 2,2-diphenyl-1-picrylhydrazyl (DPPH.) radical, superoxide anion radical (O2.–),

hydroxyl radical (.OH), nitric oxide radicals (NO.), as well as inhibiing lipid peroxidation,

using appropriate assay systems compared to natural and synthetic antioxidants.

The analgesic and hepatoprotective activity of the methanolic extract of *Ocimum gratissimum*

(L.) leaves in carbon tetrachloride hepatoxic - albino rats was reported. A significant

decrease in the liver enzmes were observed in the the hepatoxic albino rats after treatment

with the methanolic extract of OG thus showing its protective effect on the damaged liver

[106].

**2.4. *Adansonia digitata***

Baobab (*Adansonia Digitata* L) is a tree found widely throughout Africa and known locally in

African countries as the “tree of life” due to its ability to sustain life owing to its water

holding capacity, as well as its many traditional medicinal and nutritional uses [107]. The

baobab tree is an important food, water and shelter source in many African countries [108].).

*Adansonia digitata* is commonnly called *Kukah* by the Hausa of Northern Nigeria, Niger

*konian,* Kenyans *Mwambom*, Mali *sira*, Senegal, *gou*i ([109]). *Adansonia digitata* is one of eight

species of the *Adansonia* genus, and its name originates from the fact that the oblong leaves

of the tree, often formed in groups of five, look like the fingers or digits of the human hand.

It is a deciduous tree which has four growth phases and produces a fruit consisting of a

yellowish-white pulp which has a floury texture and numerous hard, round seeds, enclosed

in a tough shell [107].

The leaves of the baobab tree are a staple for many populations in Africa, especially the

central region of the continent [110, 111]. During the rainy season when the baobab leaves

are tender, the leaf is harvested fresh. During the last month of the rainy season, leaves are

harvested in great abundance and are dried for domestic use and for marketing during the

dry season. The leaves are typically sun-dried and either stored as whole leaved or pounded

and sieved into a fine powder [112]. The Powdered leaves are used as a tonic and an antiasthmatic

and known to have antihistamine and anti-tension properties. The leaves are also

used to treat insect bites, guinea worm and internal pains, dysentery, diseases of the urinary

tract, opthalmia and otitis ([109].). In Indian medicine, powdered leaves are similarly used to

check excessive perspiration ([109].). Baobab leaves are used medicinally as a diaphoretic, an

astringent, an expectorant and as a prophylactic against fever [113].

Baobab leaves have been investigated in an attempt to identify the potential bioactives

associated with this part of the plant [12,114,115-116,117. Certain bioactive compounds may

be responsible for the treatment of certain ailments, as well as containing properties that can

be beneficial to overall health. Examples of such bioactive compounds include tannins,

phlorotannins, terpenoids, glycosides, saponins and terpenoids [116] as well as antioxidants

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 213

including flavonoids and polyphenols [114]. The chemical profile of the methanolic and

aqueous extracts of the leaves of the plant was also investigated [118]. They reported the

presence of glycosides, phytosterols, saponins, protein and amino acid, phenolic compounds

and tannins, gums, mucilage and flavanoids. Only few authors have investigated the

vitamin A content of baobab leaves. Scheuring *et al*. [119] found that the simple practice of

drying baobab leaves in the shade protects against deterioration of provitamin A. The

selection of small leaves further increased provitamin A by 20%. The combination of small

leaves and shade drying enabled the retention of the provitamin content up to 27 μg retinol

equivalent per gram of dried leaf powder. Other authors mention the carotenoid content of

baobab leaves [120,121].

Literature review revealed a great variation in reported values of nutrient contents of

baobab part. According to Chadare *et al* [122] the causes of these variations are not well

known, however they made several assumptions. The variation may be due to the quality of

the sample, the provenance of the sample, the age of the sample, the treatment before

analysis, the storage conditions, the processing methods, a probable genetic variation, and

the soil structure and its chemical composition.

It is a known fact that the consumption of antioxidant-rich foods can contribute to the

prevention of oxidation in the human cell, hence of some diseases. In addition to the general

chemical composition of baobab pulp and leaves discussed previously, the antioxidant

content of the aqueous extract of wild plants including *Adasonia digitata* was investigated

[123]. They showed that baobab leaves have an antioxidant content of 7.7 μmol/g dw

expressed as Trolox equivalents. This result is almost 1000 times lower than composition

and nutritional value of baobab foods the one reported by Vertuani *et al.* (2002), who found

that the water-soluble antioxidant capacity of dry baobab leaves was 6.4 mmol Trolox

equivalent/g. These antioxidant activities were measured in fresh raw material and the effect

of cooking and storage is not well known. Only Tarwadi and Agte [125] reported the

antioxidative activity of some fruits and root vegetables before and after cooking. The

antioxidant activity was measured as the inhibition of thiobarbituric acid reactive

substances (TBARS), superoxide radical scavenging activity (SOSA), and ferrous iron

chelating ability (FICA). They reported that there were significant cooking losses for each of

the assessed antioxidant parameters.

*A. digitata* leaves, fruit-pulp and seeds have earlier been reported to show antiviral activity

against influenza virus, herpes simplex virus and respiratory syncytial virus and polio [117].

Chemical analyses have reported the presence of various potentially bioactive ingredients

including triterpenoids, flavonoids and phenolic compounds [122]. These bioactive

compounds especially flavonoids and phenolic may be responsible for the nutritive and

medicinal properties of this vegetable.

Karumi *et al* [125] also reported the gastro protective effect of *Adansonia digitata* leaf on

ethanol induced ulceration. This study elucidated a significant dose- dependent increase

both in preventive ratio and percentage ulcer reduction after pretreatment with *Adansonia*

*digitata* leaves. Ethanol is an established ulcerogen especially in empty stomach [126]. The

214 Mycotoxin and Food Safety in Developing Countries

ulcerogenicity of ethanol is due to intracellular oxidative stress producing mitochondrial

permeability, transition and mitochondrial depolarization which results to the death of cells

in gastric mucosa [126,127]. This is because of its congestive inflammation and tissue injury.

It is a known fact that flavonoids and anti-oxidant (Vit A, E and C) present in this plant has

protective role. This view is supported by the fact that gastric mucosa is known to have

certain antioxidant activity thereby reducing mucosal damage mediated by free

radicals[128] which in turn attack cell membrane causing a lipid derived free radicals such

as conjugated diene and lipid hydroperoxides which are extremely reactive and unstable.

This study corroborate with previous report on the anti-ulcerative properties of the aqueous

extract of *Adasonia digitata* leaves against ethanol induced ulceration in rats [129]. Although

the precise mechanism of action of *A. digitata* is not clear, it was proposed that the

gastoprotective role of this vegetable extract may be partly due to its high content of

flavonoids and antioxidant [130] which are well known compounds that prevent and

combat the formation of reactive oxygen species. Another possible mechanism is the fact

that the leaves being an astringent may have precipitated microproteins on the site of ulcer

thereby forming an impervious protective pellicle over the lining to prevent absorption of

toxic substance and resist the attack of proteolytic enzymes [131].

**2.5. *Corchorus olitorius***

*Corchorus olitorius (*Linn). is a leafy vegetable that belongs to the family tiliaceae and

commonly called jute mallow in English and “ewedu” in the south western Nigeria. It is an

animal herb with a slender stem and an important green leafy vegetable in many tropical

area including Egypt, Sudan, India, Bangladesh, in tropical Asia such as Philippine and

Malaysia, as well as in tropical Africa, Japan, the Caribbean and Cyprus [132]. The plant is

widely grown in the tropics for the viscosity of its leaves. The leaves (either fresh or dried)

are cooked into a thick viscous soup or added to stew or soup and are rich sources of

vitamin and minerals [133]. Nutritionally, *C. olitorius* on the average contain 85-87 g H2O,

0.7 g oil, 5 gcarbohydrate, 1.5 g fiber 250-266 mg Ca, 4.8 mg Fe, 1.5 mg 300010 vitamin A, 0.1

mg thiamine, 0.3 mg riboflavin, 1.5 mg nicotinamide, and 53-100 mg ascorbic acid per 100 g

[134]

In West African countries including Ghana, Nigeria and Sierra Leone, the vegetable is

cultivated for the stem bark which is used in the production of fibre (Jute) and for its

mucilaginous leaves which are also used as food vegetable [135] The leaf extract of the plant

is also employed in folklore medicine in the treatment of gonorrhea, pain, fever and tumour

[136]. It is reportedly consumed as healthy, vegetable in Japan because of its rich contents of

carotenoids, vitamin B1, B2, C and E, and minerals [137]. Its leaves and roots are eaten as

herbal medicine in South East Asia [136]. In some part of Nigeria leaves’ decoction used for

treating iron deficiency, folic acid deficiency, as well as treatment of anaemia. Leaves also

act as blood purifier [138] and the leaf twigs is used against heart troubles [139] while cold

leaf infusion is taken to restore appetite and strength, leaves used for ascites, pains, piles,

tumours, gonorrhoea and fever [140]

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 215

The hepatoprotective effect of the ethanolic etract of ewedu amongst other vegetables

against CCl4 induced hepatic damage in rats was studied [141]. Ethanolic extracts of

*Corchorus olitorious* was shown to produce a significant hepatoprotective effect by decreasing

serum and liver levels of ALT, AST, and total protein at dose of 250 and 500mgkg-1 in carbon

tetrachloride induced hepatotoxic rats [141]. Their result also shows a significant inhibition

of lipid peroxidation as illustrated by the decreased value on the MDA Values.

The phenolic antioxidants in the leaves of *Corchorus olitorious* was identified to include

phenolic [5-caffeoylquinic acid (chlorogenic acid), 3, 5-dicaffeoylquinic acid, quercetin 3-

galactoside, quercetin 3-glucoside, quercetin 3-(6-malonylglucoside), and quercetin

3-(6-malonylgalactoside) (tentative)] were identified from the leaves of *Corchorus olitorious L*.

by NMR and FAB-MS. The contents of these phenolic compounds, ascorbic acid, and alphatocopherol

in *C. olitorius* leaves were determined, and their antioxidative activities were

measured using the radical generator-initiated peroxidation of linoleic acid. The results

obtained showed that 5-caffeoylquinic acid was a predominant phenolic antioxidant in C.

olitorius leaves (phenolic antioxidants from the leaves of *Corchorus olitorius L.* None of these

phenolic compounds was detected in recent study on the chemical composition and invitro

antioxidant properties of some selected vegetables [69]. Only caffeic acid acid was present to

significance in the vegetable by the GC-MS analysis. Caffeic acid is a phenolic compound

widely present among many plants which has been studied extensively and known to share

a spectrum of physiological activities including anti-inflammatory anti-allergic and anti

tumour [142-144] They further investigated the peroxidation inhibitory capacity of

corchorus oliotorius among other vegetables and they resolved that though all vegetables

evaluated were able to inhibit lipid peroxidation, the consumption of the vegetables

especially *Vernonia amygdalina* and *Corchorus olitorious* may afford a better cytoprotective

effects. Further results from these study showed that the ethanolic extract of *Corchorus*

*olitorious* and other evaluated vegetables has high superoxide and hydrogen peroxide

scavenging ability of *Corchorus olitorious* which could possibly be due to the presence of

caffeic acid, flavonoids and in general the high total antioxidants.

Oboh *et al* [145] carried out a comparative study of the antioxidant properties of hydrophilic

extract (HE) and lipophilic extract (LE) constituents of the *Corchorious olitorius*. HE and LE of

the leaf were prepared using water and hexane, respectively and their antioxidant

properties were determined. HE showed a significantly higher (1,1-diphenyl-2-

picrylhydrazyl radical-scavenging ability ,reducing power ,trolox equivalent antioxidant

capacity than LE. conversely, LE showed a significantly higher hydroxyl scavenging activity

than HE while there was no significant difference in their Fe(II) chelating ability. The higher

1,1-diphenyl-2-picrylhydrazyl radical-scavenging ability, reducing power and trolox

equivalent antioxidant capacity of the hydrophilic extract may be due to its significantly

higher total phenol (630.8 mg/100 g), total flavonoid (227.8 mg/100 g) and non-flavonoid

polyphenols (403.0 mg/100 g), and its high ascorbic acid content (32.6 mg/100 g). While the

higher OH. Scavenging ability of LE may be due to its high total carotenoid content (42.5

mg/100 g). Therefore, the synergistic antioxidant activities of the hydrophilic and lipophilic

constituents may contribute to the medicinal properties of *C. olitorius* leaf [145].

216 Mycotoxin and Food Safety in Developing Countries

Further study illustrated the the protective effect of aqueous extract of *Corchorus olitorius*

leaves (AECO) against sodium arsenite-induced toxicity in experimental rats [146]. A

significant inhibition of hepatic and renal antioxidant enzymes such as superoxide

dismutase, catalase, glutathione-S-transferase, and glutathione peroxidase and glutathione

reductase were observed. The level of reduced glutathione decreased while the levels of

oxidized glutathione and thiobarbituric acid reactive substances in the selected tissues were

increased following arsenic intoxication. Treatment with AECO at doses of 50 and 100mg/kg

body weight p.o. for 15days after arsenic intoxication significantly improved hepatic and

renal antioxidant markers in a dose dependant manner. AECO treatment also significantly

reduced the arsenic-induced DNA fragmentation of hepatic and renal tissues. Histological

studies on the ultrastructural changes of liver and kidney supported the protective activity

of the AECO [146]. Thus aqueous extract of *Corchorus olitorius* leaves is significant in

protecting animals from arsenic induced hepatic and renal toxicity.

**2.6. *Gongronema latifolium***

*Gongronema latifolium* belongs to the family of Asclepiadaceae family. The plant common

name is amaranth globe. The parts commonly used are leaves, stem and root. The origin of

the plant is traced to Nigeria in West Africa. *Gongronema latifolium is* called *madumaro* by

Yoruba ethnic group in Nigeria commonly called ‘utazi’ by the Ibo of south eastern part if

Nigeria. It is a tropical rainforest plant primarily used as spice and vegetable in traditional

folk medicine [147,148]. They are sharp-bitter, sweet and widely used as a leafy vegetable

and as a spice for sauces, soups and salads. *Gongronema latifolium* is widely used in West

Africa for medicinal and nutritional purposes. An infusion of the aerial parts is taken to treat

cough, intestinal worms, dysentery, dyspepsia and malaria. It is also taken as a tonic to treat

loss of appetite. In Sierra Leone an infusion or decoction of the stems with lime juice is taken

as a purge to treat colic and stomach-ache. In Senegal and Ghana the leaves are rubbed on

the joints of small children to help them walk. The boiled fruits in soup are eaten as a

laxative. In Nigeria a leafy stem infusion is taken as a cleansing purge by Muslims during

Ramadan. A decoction of leaves or leafy stems is commonly taken to treat diabetes and high

blood pressure. The latex is applied to teeth affected by caries. It is also taken for controlling

weight gain in lactating women and overall health management. Asthma patients chew

fresh leaves to relieve wheezing. A cold maceration of the roots is also taken as a remedy for

asthma [149]. A decoction of the roots, combined with other plant species, is taken to treat

sickle cell anaemia. A maceration of the leaves in alcohol is taken to treat bilharzia, viral

hepatitis and as a general antimicrobial agent [150].The leaves are used to spice locally

brewed beer. In Sierra Leone the pliable stems are used as chew sticks. The bark contains

much latex and has been tested for exploitation.

Phytochemical screening of Gongronema latifolium vegetable showed the presence of

alkaloids, tannnis, glycosides, polyphenols, saponins and flavonoids [151, 152]. Other

chemical analyses on the leaves revealed several 17β-marsdenin derivatives (pregnane

glycosides) as well as β-sitosterol, lupenyl cinnamate, lupenyl acetate, lupeol, essential oils

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 217

and saponins. The essential oil from the leaves contains as main components linalool

(19.5%), (E)-phytol (15.3%) and aromadendrene hydrate (9.8%) [151, 153-154].

Hepatoxicity induced by carbon tetrachloride in albino rats was found to be relieved by the

ethanolic extract of *Gongronema latifolium* GLE [155]. Carbon tetrachloride induction in the

rats resulted in hepatic injuries hence the marker of liver damage AST and ALT was

reported to be significantly high in carbon tetrachloride induced rats however ALP was not

siginificantly increased. It is well documented from histological studies on the liver that

necrosis in the centrilobular zone is a major cause of carbon tetrachloride induced acute liver

injury [156]. Treatment with the ethanol extract of *Gongronema latifolium* was shown to

reduce the AST and ALT concentration significantly. Reduced levels of ALT and AST in rats

treated with the extract could be attributed to the ability of the GLE to prevent the

metabolism of carbon tetrachloride into more toxic metabolite and minimized the

production of free radicals and also boost the activities of the scavengers of free radicals

[157] thus minimizing hepatocellular injury produced. No evident increase or decrease in

the level of ALP was observed. Absence of any concomitant increase of decrease on the ALP

levels, under experimental conditions, was attributed to the fact that the single dose,

intraperitioneal injection of the carbon tetrachloride at the pre-stated concentration/dosage,

may not have caused any significant (P<0.05) billiary tract obstruction or disease [158] while

causing acute hepatocellular injury [159]. Also the protective role of *Gongronema latifolium* in

acetaminophen induced hepatic toxicity in Wistar rats was elucidated by [160]. Serum

enzyme activities such as AST, ALTand ALP were increased following acetaminophen and

caffeine administration in their study. The increase in liver enzymes following

acetaminophen administration has earlier been reported by [39,161]. It has been reported

that acetaminophen could be bioactivated enzymatically by cytochrome P4502EI in both

liver and kidney. The metabolic activation by reactive intermediate N-acetyl

parabenzoquinoneimine is believed to play an important role in acetaminophen mediated

toxicity [162]. The proinflammatory cytokines such as tumor necrosis factor (TNF-a) and

interleukin-la, that are released in response to acetaminophen intoxication are thought to be

responsible for some pathological manifestations of acetaminophen induced toxicity [161].

However, the simultaneous administration of acetaminophen, caffeine and extract of *G.*

*latifolium* significantly lowered AST, ALT and ALP concentrations when compared with

those that received acetaminophen only and acetaminophen and caffeine. This is in line with

the work of [155, 163].The mechanism by which *G. latifolium* lowered liver enzymes may be

attributed to their ability to maintain liver cell integrity. It can therefore be concluded that

acetaminophen offer protection against acetaminophen and caffeine induced hepatoxicity.

Earlier the oral administration of aqueous and ethanolic extract of *Gonogronema latifolium*

was shown to possess’ antidiabetic properties on streptozotocin-induced diabetic [147]. Also

both extracts were shown to significantly increase the activity of superoxide dismutase and

the level of reduced glutathione. The aqueous extract further increased the activity of

glutathione reductase while the ethanolic extract caused a significant increase in the activity

of glutathione peroxidase and glucose-6-phosphate dehydrogenase and a significant

decrease in lipid peroxidation.

218 Mycotoxin and Food Safety in Developing Countries

*Gongronema Latifolium* has also been shown to possess antiplasmodal activity; this supports

the traditional use of the leaf extract of the plant for local treatment of malaria. Akuodor

[164] and his team in their review stated that *Gongronema Latifolium* (madumaro) is used in

South Eastern Nigeria to treat various ailments such as cough, loss of appetite, malaria and

stomach disorders.The liquor usually obtained after the plant is sliced and boiled with lime

juice or infused with water over three days is usually taken as a purge for colic and stomach

pains. Various parts of the plant, particularly the stems and leaves are used as chewing

sticks or liquor in Sierra Leone. It is also used to treat symptoms related to worm infections.

*Gongronema Latifolium* is good for maintaining healthy blood glucose level and has

antibacterial activity.

It was also reported that the ethanol extract of *Gongronema Latifolium* leaves when evaluated

were found to possess anti-ulcer, analgesic and antipyretic activities. The plant enjoys

reputation as a remedy for inflammation, bacteria, ulcer, malaria, diabetes and analgesic

[164].

Other researches show its antimalarial effect, anti-inflammatory properties, and antisickling

properties [165, 166]. This vegetable is reservoir of many antioxidants capable of preventing

and treating different diseases.

**2.7. *Gnetnum africanum***

*Gnetum africanum* is one of the most popular leafy vegetable in Nigeria which is gaining

popularity as a delicious food leaf in other African countries such as Cameroon, Gabon,

Congo and Angola [167]. It is called with different Local names: ‘fumbwa’ (DRCongo),

‘okok’, ‘eru’ (Cameroon), ‘afang’, ‘okazi’ (Nigeria). G. africanum, a lone genus belonging to

the family Gnataceae is a dioecious wild undestorey liana that grows on trees in the humid

forest of Africa [168].

The leaves of *G africanum* are elliptic in shape and are lined with reticulate veins comparable

to those of a dicotyledonous angiosperm [169]. Its leaves are eaten as a vegetable, either raw

or finely chopped and cooked; they are also widely used as an ingredient in soups and

stews and are much in demand for their nutritional and therapeutic properties. It is

traditionally used in the treatment of enlarged spleen, sore throat and as as a cathartic [170].

It is also used to relief nausea and neutralizes poison in Congo as well as been applied

externally to manage boils, warts and used to reduce child birth pain. The leaves of *A.*

*Gnetum* species are also used as a disinfectant for wounds treat heamorrhoid and increase

blood production in the human organism [171].

In Nigeria, the leaf of *G. africanum* is used in the treatment of an enlarged spleen, sore

throats and as a cathartic [171]. In Ubangi (DR Congo), it is used to treat nausea and is

considered to be an antidote to some forms of poison [171. In Congo-Brazzaville, the leaves

of both species are used as a dressing for warts and boils and a tisane of the cut-up stem is

taken to reduce the pain of childbirth [ 172].*Gnetum africanum* is also reported to be used for

medicinal purposes in Mozambique [173].

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 219

The leaves have very high nutritional value and constitute an important source of protein,

essential amino acids and mineral elements [168]. Flavonoids, phenols anthocyanins have

been shown to be present in the leaves of *Gnetum africanum* [174]. As is already know

flavonoids is a class of secondary plant phenolics with powerful antioxidant properties.

Phenols are regarded as the most important oxidative components of plants, hence

correlation between the concentration of total plant phenolics and total antioxidant

capacities have been reported [175]. The presence of these phytochemicals agrees with

previous work of Iweala et al [176] who elucidated the presence of phenolic substances,

flavonoids, anthocyanidins, phytosterols, tannins, saponins, alkaloids, glycosides,

cyanogenic and cardiac glycosides ingnetum africanum leaves. Long term feeding of

*Gnetum africanum* supplemented diet caused significant increase in weight, haemoglobin

and white blood cells [176]. Glutathione s transferase and superoxide dismutase where

increased significantly while lipid peroxidation and serum protein was reduced

significantly with supplementation of Gnetum africanum supplemented diet. The gain in

weight was explained o be due to the presence of high quality nutrient present in this leafy

vegetable while reduction in protein may be a consequence of indigestibility and

unavalaibilty of protein content of *Gnetum africanum*. The presence of invitro antioxidants

lile flavonoids and phenolic substance was reported to be responsible for the decrease in

lipid peroxidation and increase in GST and SOD as well as increase in haemoglobin and

white blood cells [176]. Also a recent study on the biochemical and histological changes in

paracetamol induced hepatoxic rats showed that consumption of *Gnetum africanum*

supplemented diet reduced liver necrosis caused by paracetamol induction [177]. They also

reported that lipid peroxidation was significantly reduced in the diet supplemented group.

Although the precise mechanism for this protective role was not reported, it may be

associated to presence of flavonoids and phenolic compounds in the vegetable. In a more

recent study [174] as earlier reported also evaluated the invitro antioxidant properties of the

methanolic extract of two leafy vegetables telfaira occidenatalis and *Gnetum africanum*. They

revealed that both vegetable extracts had strong DPHH radical and hydroxyl radical

scavenging ractivities compared to the water soluble natural antioxidant ascorbic acid.

Howevever *Telfaira occidentalis* extract was concluded to posses more scavenging activities

than *Gnetum africanum*. The potent antioxidant activity of the two methanolic extracts might

result from their high content of polyphenolic compound.

**3. Antioxidant properties of selected fruits in African**

Africa is blessed with several varieties of fruits which are either consumed for their

nutrients or for their medicinal values. They are known to be rich with antioxidants that

help in lowering incidence of degenerative diseases such as cancer, arthritis, arteriosclerosis,

heart disease, inflammation, brain dysfunction and acceleration of the ageing process

[6,178,179]. Antioxidants are substances which when present at low concentration are

capable of preventing or delaying oxidative damage of lipids, proteins and nucleic acids by

reactive oxygen species. These reactive oxygen species include reactive free radicals such as

superoxide, hydroxyl, peroxyl, alkoxyl and non- radicals such as hydrogen peroxide,

220 Mycotoxin and Food Safety in Developing Countries

hypochlorous, etc. They scavenge radicals by inhibiting initiation and breaking chain

propagation or suppressing formation of free radicals by binding to the metal ions, reducing

hydrogen peroxide, and quenching superoxide and singlet oxygen [180]. The most abundant

antioxidants in fruits are polyphenols, Vitamin C, Vitamins A, B and E while carotenoids are

present to a lesser extent in some fruits. These polyphenols, most of which are flavonoids,

are present mainly in ester and glycoside forms [181]. The defensive effects of the natural

antioxidants in fruits and vegetables are related to the three major groups: vitamins,

especially vitamin C; phenolics; and carotenoids, especially β-carotene [182]. Vitamin C and

phenolics are known as hydrophilic antioxidants, while carotenoids are known as lipophilic

antioxidants. The antioxidant properties of a number of tropical fruits have been

investigated on an individual basis using different analytical methods [183-185].

**3.1. *Psidium guajava L.***

One of the most gregarious of fruit trees, the guava, *Psidium guajava* L belongs to the myrtle

family (Myrtaceae), is almost universally known by its common English name or its

equivalent in other languages. In Africa the names are: *gwaabaa* (Hausa); *woba* (Efik); *ugwoba*

(Igbo); *guafa* (Yoruba) *ugwaba* in Efik [186]. Guava fruit, usually 4 to 12 centimetres (1.6 to 4.7

in) long, are round or oval depending on the species [187]. The outer skin may be rough,

often with a bitter taste, or soft and sweet. Varying between species, the skin can be any

thickness, is usually green before maturity, but becomes yellow, maroon, or green when

ripe. Guava fruit generally have a pronounced and typical fragrance, similar to lemon rind

but less sharp. Guava pulp may be sweet or sour, tasting something between pear and

strawberry, off-white ("white" guavas) to deep pink ("red" guavas), with the seeds in the

central pulp of variable number and hardness, depending on species.

Guava is a good source of minerals like iron, calcium, and phosphorus as well as many

vitamins like ascorbic acid, pantothenic acid, vitamin A, carotenoids such as B- carotene and

lycopene, and niacin [188]. Single common guava (P. guajava) fruit contains about four

times the amount of vitamin C as an orange [189]. The fruit has also been shown to contain

saponin combined with oleanolic acid. Morin-3-O-α-L-lyxopyranoside and morin-3-O-α-Larabopyranoside

and flavonoids, phenolic compounds such as ellagic acid, anthocyanin,

guaijavarin, and quercetin are also reported [189]. chemical analysis of guava plant extract

have revealed the presence of anti-microbial compounds [190], tannins, phenol triterpenes,

flavonoids, guajivolic acid, guajavanoic acid, linolenic acid, linoleic acid, guavacoumaric

acid, galaturonic acid, asphaltic acid, benzaldehyde, essential oils, saponins, carofenoid,

cectin, fibre ,fatty acids and a high content of vitamins C and A in its fruit [191].

The hydrophilic and lipophilic antioxidant properties of guava fruits were reported by

Thaipong [192]. They concluded from their investigation that both white and pink flesh

guavas fruits showed high hydrophilic antioxidant activity and compounds for phenolic

and vitamin C indicated that regular consumption of guava might be beneficial to health.

Also hydrophilic antioxidant activity, the major activity, had high correlations with both

total phenolic and vitamin C indicating that the use of the total phenolic or vitamin C

content to determine antioxidant activity level in guava fruit was feasible. Phenolic and

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 221

vitamin C are the major contributors to the antioxidant activity of guava fruits, while the

contribution of carotenoid is negligible.

A comparative study of the antioxidant properties of several tropical fruits showed that

guava possess primary antioxidant potential, as measured by scavenging DPPH and iron

(III) reducing assays [193]. Primary antioxidants scavenge radicals to inhibit chain initiation

and break chain propagations. This characteristic of guava is attributed to its high total

phenolic compounds. This result is in agreement with the report of a study which

enumerated the antioxidant activity of guava fruits [194] thus the fruit of guava can be

harnessed either for protective or preventive roles against diseases arising from oxidative

stress

**3.2. *Carica papaya***

The papaya is the fruit of *Carica papaya* which belongs to the genus Carica in the myrtle

family (Caricaceae). The papaya is one of native plants of Central America but is wide

spread throughout tropical Africa. It is a berry developing from syncarpous superior ovary

with parietal plancentation [195]. It is popularly called pawpaw. Pawpaw fruit is one of the

most nutritional fruits grown and consumed in Africa. A green papaya fruit has been

reported to provides 26 calories, 92.1 g H2O, 1.0 g protein, 0.1 g fat, 6.2 g total carbohydrate,

0.9 g fiber and 0.6 g ash{ [196]. USDA National Nutrient database recorded an orangefreshed

papaya (per 100 g) contained 39 calories, 88.8 g H2O, 0.61 g protein, 0.14 g fat, 9.81 g

total carbohydrate, 1.8 g fiber, 0.61 g ash. Additionally, Oyoyede [197] tested the chemical

profile of unripe pulp of *carica papaya* and reported papaya fruit was very rich in

carbohydrate (42.28% starch, 15.15% sugar) but low levels of fat. Papaya fruit also contains

high levels of vitamin C (51.2 mg/100g), vitamin A precursors including β-carotene (232.3

μg/100g), and β-cryptoxanthin (594.3 μg/100g), as well as magnesium (19.2-32.7 mg/100g),

which has been reported by Wall [198] Papaya fruit also contains papain which is a major

component of papaya latex and widely applied for meat tenderisation.In recent years,

papain and other endopeptidases have been proven to have several medical benefits, such

as defibrinating wounds and treatment of edemas [199]. In some African countries, such as

Gambia, tropical papaya is used to treat paediatric burns due to its proteolytic enzymes.

Exception of papain, other endopeptidases, such as leukopapain and chymopapain, is also

able to facilitate wound cleaning, promoting growth and improving the quality of the scar.

Some physical behavious (such as color and size) of papaya fruit are various due to various

cultivars.

Though *C. papaya* is an edible and flavorful fruit, it has been used throughout Africa for its

medicinal benefits since it was introduced from the Americas. *C. papaya* has been used as

treatment for numerous maladies, ranging from gastrointestinal disorders to asthma and

sexually transmitted diseases. Perhaps the most common use of *C. papaya* is that of its been

an antihelmintic. Often, the plant is boiled along with herbal adjuvants in order to expel

worms [200]. A decoction made from the seeds of *C. papaya* has been used to much the same

effect. The leaves have also been used in infusions to treat internal parasites [201].

222 Mycotoxin and Food Safety in Developing Countries

Along with its use as an antihelmintic, *C. papaya* has been used to treat numerous

gastrointestinal disorders. The whole fruit of *C. papaya* has also been boiled and used as an

infusion in order to treat stomach ulcers In Madagascar, a tea made of from *C. papaya* leaves

has also been used in order to treat gastric ulcers as well as general gastric discomfort [202].

In the Congolese region of Africa, a decoction made of the ripe seeds is said to be a very

effective treatment of dysentery [203]. *C. papaya* is also thought to be effective in treatment of

malaria. Along with the leaves of *Azadirachta indica*, *C. papaya* has been used as a steam

treatment for malaria [201]. The fruit of *C. papaya* has also been used as a popular

hepatoprotective agent. In cases of jaundice and hepatitis, immature fruit is either eaten or

used in a decoction [200]. Most studies reported that papaya fruits and its leaves had high

antioxidant capacity due to their high contents of vitamin B (in leaves), vitamin C, E (in

fruits), and carotenoids [193, 203,204].

Recently Oloyede *et al* [205] reported the antioxidative properties of ethyl acetate fraction of

unripe pulp of carica papaya in mice. Quercetin and β-sitosterol were isolated from the

methanolic extract and later liquid-liquid extract of unripe carica papaya fruits using soxhlet

apparatus. They further investigated the invitro antioxidant properties of this fruit in mice

and the result showed a significant increase (p<0.05) in the activities of Gluthaione

reductase, Glutathione peroxidase, Gluthathione, and Glucose-6-phosphate dehydrogenase

with a slight reduction in catalase activity in the ethyl acetate fraction in the liver. On the

other hand No significant change in activities of GR, GST and CAT were observed in groups

of animals administered ethyl acetate (100mg/kg) or Aqueous extract when compared to

control that received distilled water only, but renal GPx activity decreased following

administration of ethyl acetate fraction. It is likely that quercetin and β-sitosterol may be

responsible for the antioxidant potential demonstrated by the ethyl acetate fraction from

unripe fruit. Therefore it was suggested that carica papaya unripe fruit may be useful in the

management of diseases such as diabetes, sickle cell anaemia and cardiovascular diseases

where free radicals are often generated

**3.3. *Citrullus lanatus***

Watermelon (*Citrullus lanatus*) which belong to the family of is a vine-like flowering plant

originally from southern Africa [206] . The watermelon fruits loosely considered a type of

melon has a smooth exterior rind(green, yellow and sometimes white) and a juicy, sweet

interior flesh usually deep red to pink but sometimes orange, yellow and even green if not

ripe. [206].water melon rinds are also edibles but most people avoid eating them due their

unpleasant flavor.

*C. lanatus* is an annual herb with long (up to 10 m) stems lying or creeping on the ground,

with curly tendrils. Leaves are 5-20 by 3-19 cm, and hairy, usually deeply palmate with 3-5

lobes, on 2-19 cm long petioles. Fruits vary considerably in morphology, size range from

about 7cm in diameter to over 20cm. In addition, they vary in colour from pale yellow or

light green (wild form) to dark green (cultivars), and with or without stripes; the pulp varies

from yellow or green (wild forms) to dark red (cultivars). The flesh amounts to about 65% of

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 223

the whole fruit, and of this 95% is water. The plant has become naturalized in many drier

parts of West Africa [207, 208].

Water melon fruit is a good source of, amino acid citrulline, vitamin A, vitamin C, the

antioxidant lycopene, Beta carotene and potassium. Cucurbitacin the bitter principle in some

species has diuretic and purgative properties. The fruit has but few medicinal uses in West

Africa; Bitter forms are used in Senegal as a drastic purge and are considered poisonous [209].

Some other ethno-medicinal uses of the fruit include diuretic, purgative, remedy for urinary

conditions suggestive of gravel and stone in the bladder, gonorrhoea and leucorrhoea in

women [210,211].

lycopene and citrulline have been shown to be present in this fruit and are helpful in

preventing some chronic diseases[212]. The amount of lycopene in watermelon is highly

variable, but generally exceeds that of tomato.Citrulline is present in all parts of the fruit

[213]. Lycopene was found to be relatively stable in fresh cut watermelon, and could

increase slightly in whole fruit held at room temperature [214]. Seedless watermelon

generally had more lycopene than seeded types, and lycopene was present in red fleshed

fruit, with small amounts in orange fleshed watermelon, and none in yellow fleshed types.

Lycopene has been extensively studied for its antioxidant and cancer-preventing properties,

in contrast to many other food phytonutrients, whose effects have only been studied in

animals, lycopene has been repeatedly studied in humans and found to be protective

against a growing list of cancers, these cancers now include prostate cancer, breast cancer,

endometrial cancer, lung cancer and colorectal cancers [215,216]. The antioxidant function of

lycopene lies in its ability to help protect cells and other structures in the body from oxygen

damage. Protection of DNA (our genetic material) inside of white blood cells has also been

shown to be an antioxidant role of lycopene [217]. The amino acid citrulline in watermelon

is a known stimulator of nitric oxide. Nitric oxide is known to relax and expand blood

vessels much like the erectilw dysfunction drug Viagra and may increase libido [218]. The

health benefit of watermelon fruit is associated with its status as a powerful antioxidants

found in vit A, lycopene and beta carotene. These helps to neutralize free radicals hence can

be use in the the prevention of diseases associated with oxidative stress such as diabetes,

asthma, artherosclerosis and so on.

**3.4. *Persea Americana***

*Persea americana* belongs to the family *Lauraceae*a along with cinnamon, camphor, and bay

laurel. . Avocados are commercially valuable and are cultivated in tropical and

Mediterranean climate throughout the world. They are a green skinned, fleshy body that

may be pear shaped egg shaped or spherical and ripens after harvesting. It is commonly

called in English as avocado, in Yoruba “igba”, ibo “Ube-beke” and Swahili “mparachichi,

mpea, mwembe mafuta”.

Avocado has been shown to possess valuable phytochemicals. These compound classes may

be divided into alkanols (also sometimes termed "aliphatic acetogenins"), terpenoid

glycosides, various furan ring-containing derivatives, flavonoids, and a coumarin. The

224 Mycotoxin and Food Safety in Developing Countries

highly functionalized alkanols [218,219-221] of avocado have exhibited quite diverse

biological properties thus far. For example, Oberlies *et al* isolated 1, 2, 4-trihydroxyheptadec-

16-ene, 1, 2, 4-trihydroxyheptadec-16-yne , and 1, 2, 4 -trihydroxynonadecane from the

unripe fruits of *P. americana*, and found these substances to be moderately cytotoxic when

evaluated against a small panel of cancer cell lines [219].Kawagishi *et al* isolated 5 alkanols

from avocado fruits with "liver suppressing activity" (as determined by the changes in

plasma levels of alanine aminotransferase and aspartate aminotransferase), including

compounds 9-11[221]

Avocado has sometimes received the reputation as a fruit too high in fat. While it is true that

avocado is a high-fat food (about 85% of its calories come from fat), the fat contained in

avocado is unusual and provides research-based health benefits. The unusual nature of

avocado fat is threefold. First are the phytosterols that account for a major portion of

avocado fats. These phytosterols include beta-sitosterol, campesterol, and stigmasterol and

they are key supporters of our inflammatory system that help keep inflammation under

control [222]. The anti-inflammatory benefits of these avocado fats are particularly welldocumented

with problems involving arthritis. Second are avocado's polyhydroxylated

fatty alcohols (PFAs). PFAs are widely present in ocean plants but fairly unique among land

plants—making the avocado tree (and its fruit) unusual in this regard. Like the avocado's

phytosterols, its PFAs also provide us with anti-inflammatory benefits [223]. Third is the

unusually high amount of a fatty acid called oleic acid in avocado. Over half of the total fat

in avocado is provided in the form of oleic acid—a situation very similar to the fat

composition of olives and olive oil. Oleic acid helps our digestive tract form transport

molecules for fat that can increase our absorption of fat-soluble nutrients like carotenoids

[224]. As a monounsaturated fatty acid, it has also been shown to help lower our risk of

heart disease [225]. Hence its reputation as a fruit high in fat is of great importance in

maintain the the integrity of the heard. Like other high-fat plant foods (for example, walnuts

and flaxseeds), avocado provides unique health benefits precisely because of its unusual fat

composition.

Avocados are also good source of Vitamin K, dietary fiber, Vitamin B6, Vitamin C, Folate

and copper. Avocados are also a good source of potassium: they are higher in potassium

than a medium banana. They also contains essential nutrients such as carbohydrates, sugar,

soluble and insoluble fiber, It is also good source of oil containing monounsaturated fat its

oil contents varies depending on its varieties and the period of extraction of oil by cold-press

process. Avocado is a rich source of mineral [226]. The presence of the above mentioned

phtytochemicals and vitamins makes avocado fruit a rich source of antioxidants hence

capable of preventing quite a large number of diseases which are usually as a result of

excessive free radical generation. For instance avocado has the ability to help prevent the

occurrence of cancers in the mouth, skin, and prostate gland. This has been studied at a

preliminary level by health researchers, mostly through the use of cancer cells or lab studies

involving animals and their consumption of avocado extracts. But even though this anticancer

research has been limited with respect to humans and diet, it is believed that the

preliminary results are impressive. The anti-cancer properties of avocado are definitely

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 225

related to its unusual mix of anti-inflammatory and antioxidant nutrients [227]. That

relationship is to be expected since cancer risk factors almost always include excessive

inflammation (related to lack of anti-inflammatory nutrients) and oxidative stress (related to

lack of antioxidants). But here is where the avocado story gets especially interesting. In

healthy cells, avocado works to improve inflammatory and oxidative stress levels. But in

cancer cells, avocado works to increase oxidative stress and shift the cancer cells over into a

programmed cell death cycle (apoptosis), lessening the cancer cell numbers [228]. In other

words, avocado appears to selectively push cancer cells "over the brink" in terms of

oxidative stress and increase their likelihood of dying, while at the same time actively

supporting the health of non-cancerous cells by increasing their supply antioxidant and antiinflammatory

nutrients.

**4. Antioxidant properties of mushrooms**

Mushrooms have been used for many years as nutritional food and food flavouring

materials as well as medicines [229]. Because of their flavour and aroma, mushrooms are

greatly appreciated in many countries. According to the definition of Chang and Miles [230],

a mushroom is ‘a macrofungus with a distinctive fruiting body, which can be hypogeous or

epigeous, large enough to be seen with the naked eye and to be picked by hand’. They

constitute at least 14 000 and perhaps as many as 22 000 known species. The number of

mushroom species on the earth is estimated to be 140 000, suggesting that only 10% are

known [231]. Research indicates mushrooms have potential antiviral, antimicrobial,

anticancer, antihyperglycemic, cardioprotective, and anti-inflammatory, activities.

A number of bioactive molecules, including antitumor substances, have been identified in

many mushroom species. Polysaccharides are the best known and most potent mushroom

derived substances with antitumor and immunomodulating properties [232,233].

Historically, hot-water-soluble fractions (decoctions and essences) from medicinal

mushrooms, i.e., mostly polysaccharides, were used as medicine in the Far East, where

knowledge and practice of mushroom use primarily originated [234). Mushrooms such as

*Ganoderma lucidum* (Reishi), *Lentinus edodes* (Shiitake*), Inonotus obliquus* (Chaga) and many

others have been collected and used for hundreds of years in Korea, China, Japan, and

eastern Russia. Those practices still form the basis of modern scientific studies of fungal

medical activities, especially in the field of stomach, prostate, and lung cancers. It is notable

and remarkable how reliable the facts collected by traditional eastern medicine are in the

study of medicinal mushrooms [235].

They are reputed to possess anti-allergic and anticholesterol activities. Aqueous extracts

from *Pleurotus sajor caju* have been proven good in renal failure [236] showed mushrooms

cure epilepsy, wounds, skin diseases, heart ailments, rheumatoid arthritis, cholera besides

intermittent fevers, diaphoretic, diarrhea, dysentery, cold, anesthesia, liver disease, gall

bladder diseases and used as vermicides.

*Ganoderma lucidum* are known to lower blood pressure and serum cholesterol concentration

of hypertensive rats [237]. *Lentinus tigrinus* and *G. lucidium* are proved anticholesterolmic

226 Mycotoxin and Food Safety in Developing Countries

[238]. *Lentinus edodus* has been used to enhance vigour, sexuality, energy and as an anti

aging agent [239]. Lentinan sulphate obtained from *Lentinus* species inhibits HIV [239]. Jong

et al. [240] reported that mushrooms cause regression of the disease state. Puffballs have

been used in urinary infections [241]. Maitake extract has been shown to kill HIV and

enhance the activity of T-helper cells [242,243] *Ganoderma* nutriceuticals have also exhibited

promising antiviral effects like, anti-hepatitis B [243]Kino et al., 1989), anti-HIV [245,246]Kim

et al., 1993; Liu and Chang, 1995). Dreyfuss and Chapela ([247] reported hundreds of

secondary metabolites of fungal origin possessing biological activity. Mushrooms act as

biological response modifiers by promoting the positive factors and eliminating the negative

factors from the human body and thus regarded as the fourth principal form of the

conventional cancer treatment.

*Karst* is believed to act as an anti-inflammatory and antidiabetic agent [248]. It is also used

by Indian tribals for treating joint pain [249] Various reported medicinal uses of mushrooms

like *reishi, cordyceps, enoki, maitake*, *lion’s mane* and *splitgill* have been reported for cancer

treatment; *shiitake, blazei, reishi, enoki, cordyceps, maitake, mesima* and oyster were found

effective against cholesterol reduction. Reishi, cordyceps, shiitake and maitake is used for

reducing stress. Lion’s mane has been used for memory improvement; reishi for inducing

sleep cordyceps for physical endurance and sexual performance, reishi, cordyceps, chaga

and lion’s mane for asthma and allergy treatment. They are also believed to be a good health

elevator [250]. Auricularia species were used since times for treating hemorrhoids and

various stomach ailments [251]. Pleurotus tuber-regium mushroom have been used for

curing headache, high blood pressure, smallpox, asthma, colds and stomach ailments

[252,253]. It has been reported *that P. ostreatus* lowers the serum cholesterol concentration in

rats [254]. Puffballs (*Clavatia*, *Lycoperdon*) have been used for healing wounds [255]. Fresh

mushrooms are known to contain both soluble and insoluble fibres; the soluble fibre is

mainly beta-glucans polysaccharides and chitosans which are components of the cell walls

[256]. Soluble fibre present in mushrooms prevents and manages cardiovascular diseases

[257]. Wasser [258] reported that mushroom health supplements are marketed in the form of

powders, capsules or tablets made of dried fruiting bodies, extracts of mycelium with

substrate, biomass or extract from liquid fermentation. *P. sajor-caju* has been found to be

inductive for growth of probiotic bacteria [259]. *Cordyceps sinensis* also treated as half

caterpillar and half mushroom has been known and used for many centuries in traditional

Chinese medicine. *Cordyceps* has been used to induce restful sleep, acts as anticancer,

antiaging, and antiasthama agents besides proved effective for memory improvement and

as sexual rejuvenator [260].

The antioxidant properties of mushroom have been reported. They are regarded as

organisms which possess naturally occurring antioxidants. This is correlated with their

phenolic and polysaccharide compounds [261]). Mau et al. [262] found antioxidant

properties of several ear mushrooms. Tyrosinase from *A. bisporus* is antioxidant [180].

Lakshmi et al. [263] determined antioxidant activity of *P. sajor caju*. [264] observed that

triterpenoides are the main chemical compounds in *G. lucidium.*

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 227

Three species of *Pleurotus florida, P. pulmonarius and P. citrinopileatus* were examined for their

antioxidant potentialities with a view to popularize medicinal mushrooms among common

middle class people at low-cost instead of administering costly medicines. Reducing power,

chelating activity of Fe2+ and total phenol were observed to be higher in *P. florida* than in *P.*

*pulmonarius* and *P. citrinopileatus* respectively. Among antioxidative enzymes, *P. florida*

exhibited highest peroxidase and superoxide dismutase (SOD) where as catalase activity

was found to be highest in *P. pulmonarius* [265]. The alcohol and aqueous extracts of *G.*

*lucidum* and *C. sinensis* showed a high anti-oxidative activity by giving protection against

oxidative DNA damage[ 266]. The reducing power and chelating activity of Fe2+ of *G.*

*lucidum* and *C. sinensis* ethanol extract has been shown to increase with increase in

concentration. The *G. lucidum* ethanol extract showed higher anti-oxidative properties than

*C. sinensis*, probably due to differences in the compounds present in the fruiting bodies

[267]. Previous workers obtained 6.001+0.04 μmg-1, 7.501+0.10 μmg-1 and 6.72+0.05 μmg-1 of

phenol components in ethanol extract of *P. sajor-caju, P. florida* and *P. aureovillosus*

respectively [268, 269]. It is showed that antioxidant activity of *Phellinus rimosus* seems to be

more effective than the *Pleurotus florida, P. sajour-caju* and *G. lucidum* [263,270]. Fruiting

bodies of medicinal mushroom (*G. lucidum*) contain polysaccharides, triterpenoids,

adenosine, germanium, protein (L2-8), amino acids which have been found to have

antitumor and immuno-modulating affect [271]. Methanol extract of *P. rimosus* have been

shown to effectively reduce ferric ion in FRAP assay and scavenged DPPH radicals [272].

Extracts from fruiting bodies and mycelia of *G. lucidum* occurring in South India were found

to possess *in vitro* antioxidant activity [266] and antimutagenic activities [263]. Antioxidant

assays of the ethyl acetate, methanol and aqueous extract of *G. lucidum* effectively scavenged

the O2 and OH radicals [272]. However the aqueous extract was not effective to inhibit the

ferrous ion induced lipid peroxidation [266] The extract showed significant reducing power

and radical scavenging property as evident from FRAP assay [272] and DPPH radical

scavenging assay [263,272]. The antioxidant potential of *L. edodes* methanol extract was

investigated in the search for new bioactive compounds from natural resources. The

measured DPPH radical scavenging activity is depicted by Sasidharan et al. [273]. The free

radical scavenging activities were 39.0%, 41.0% and 66.00% for the *L. edodes* extract, vitamin

E and BHT, respectively. The EC50 value is 4.4 mg/mL (y = 11.7x - 1.693, R2 = 0.988) which is

the concentration of the crude extract that decreases the initial DPPH radical concentration

by 50%. Effectiveness of antioxidant properties was found to be inversely correlated with

EC50 values. Cheung and Cheung [274] also reported the antioxidant activity of *L. edodes*

against lipid peroxidation. They found that the low molecular weight sub-fraction of the

water extract of *L. edodes* had the highest antioxidant activity against lipid peroxidation of

rat brain homogenate, with IC50 values of 1.05 mg/mL. In addition**,** other mushrooms have

also been reported to possess antioxidant activity. Wong and Chye [275] reported the

antioxidant activity of *Pleurotus porrigens, Hygrocybe conica, Xerula furfuracea (Rooted oude),*

*Schizophyllum commune, Polyporus tenuiculus (Pore fungus)* and *Pleurotus florida*. Petroleum

ether (PE) and methanolic extracts from these edible wild mushrooms were effective in

DPPH radical scavenging and metal chelating ability. PE extracts were more effective than

228 Mycotoxin and Food Safety in Developing Countries

methanolic extracts in antioxidant activity using the DPPH, whereas methanolic extracts

were more effective in reducing power and metal chelating ability.

**5. Chemoprotective effects of African vegetables, fruits and mushrooms**

**against mycotoxin induced oxidative stress and diseases**

There are compelling evidences to show that mycotoxins are amongst the dietary factors

that contribute to the risk of several types of diseases. The toxicologist and Nutritionist

are particularly interested in mycoxins such as aflatoxins, ochratoxin A, fumonisins,

Zeralenone and deoxynivalenol as they are attributed to the implication of several disease

conditions.

Aflatoxin BI is the commonest form of Aflatoxin which is produced by *Apergillus flavus*. It is

has been implicated in quite a number of diseases including, kwarshiorkhor, hepatitis, lung

cancer, and liver cancer. It can either cause cancer alone or in synergy with hepatitis [276].

Cancer is induced by Aflaxoxin BI via metabolic activation by CYP3A4, CYP3A5 and/ or

CYP1A2 [277, 278] to exo-8,9-epoxide which can form adduct with DNA leading to guanine

nucleotide substitutions [279] specifically to codon 249 of the p53 gene [280].

Epidemiological studies have shown increased codon- 249 p53 mutations in areas of high

aflatoxin B1 exposure [281]. Since hepatitis B virus and aflatoxin exposure have also been

linked to hepatocellular carcinoma, recent studies have shown the interactive effect of

increasing p53 mutation in persons with hepatitis B and coexposure to aflatoxin [282].

Ochratoxin A, a toxin produced by *Aspergillus ochraceus, Aspergillus carbonarius* and

*Penicillium verrucosum,* is one of the most abundant food-contaminating mycotoxins [283]. It

is found as contaminant in human foods, including various cereals, coffee, cocoa, wines and

dried fruits. Depending on the dose, OTA may be carcinogenic, genotoxic, immunotoxic or

teratogenic and even neurotoxic [284]. Exposure to OTA has been associated with the

incidence of a kidney disease in humans, involving chronic interstitial nephritis as well as

tumours of the urinary tract termed Baslkan Endemic Nephropathy (BEN) because of its

geographical distribution [285]. It has been reported that occurrence of OTA with aflatoxin

B1 in the same crop potentiates the mutagenic ability of the latter [286].

Zearalenone (ZEA) is a mycotoxin produced mainly by fungi belonging to the genus

Fusarium in foods and feeds. It is frequently implicated in reproductive disorders of farm

animals and occasionally in hyperoestrogenic syndromes in humans. It is found

worldwide in a number of cereal crops such as maize, barley, wheat, oats and sorghum

[287]. A wide variety of clinical effects attributed to zearalenone have been described in

the literature. Decreased fertility, abnormal estrus cycles, swollen vulvas, vaginitis,

reduced milk production and mammary gland enlargement are the most common

findings reported in cattle and swine. ZEA binds to estrogen receptors influencing

estrogen dependent transcription in the nucleus [288]. Receptor binded by ZEA has been

shown to inhibit the binding estrogenic hormones in rat mammary tissues [289]. It was

reported also by Hagler [290] that zearalenone causes hyperoestrogenism in swine. The

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 229

potential for Zearelenon to stimulate growth of human breast cancer cells has also been

demonstrated [291].

Fumonisins are a family of toxic and carcinogenic mycotoxins produced by *Fusarium*

*verticillioides* (formerly *Fusarium moniliforme*), a common fungal contaminant of maize [292]

Studies have shown the implication of fumonisins in the aetiology of a number of diseases

such as rat liver cancer and haemorrhage in the brain of rabbits [293]. It has been reported

that Fumonisin induce apoptosis in cultured human cells [294] and nephrotoxicity in certain

animals [295].

Although fumonisin contaminated food has not been conclusively linked to human health

harzards however a few studies have associated consumption of maize contaminated with

fuminisins to human oesophageal carcinoma in some parts of South Africa and China [296].

Recently fumonisin toxicity has been linked reactive oxygen species (ROS) damage. For

Instance It was reported that there was increase in lipid peroxidation, production of ROS,

increase in caspase-3- like protease activity, internucleosomal DNA fragmentation and

intracellular reduction of glutathione in human U-118MG glioblastoma cells treated with

fumonisin B1 [297].

Deoxynivalenol (also called DON or vomitoxin) is one of an array of trichothecene

mycotoxins produced by *Fusarium graminearum* and several other species of Fusarium that

cause Fusarium head blight (also called FHB or scab) of wheat, barley, and other grasses and

ear and stalk rot of corn. DON does not constitute a significant threat to public health. In a

few cases short-term nausea and vomiting have been recorded [298].

The protective effect of various extract of *Vernonia amygdalina* on breast and prostate

cancer has earlier been reported above. Mycotoxins such as Aflatoxin B1 are potent

causative agent of several forms of cancer and this result from oxidative damage on

macromolecules like DNA, proteins, lipids and carbohydrates. Vegetables, fruits and

mushrooms have been reported to be reservoirs of antioxidants capable of scavenging and

chelating reactive oxygen species thus preventing and protecting against such diseases

arising from mycotoxin induced oxidative damage. For instance It was shown in a study

that a diet incorporated with VA protected weanling albino rats against aflatoxin B1-

induced hepatotoxicity [299]

Recent findings on the cause of cancer reveal that the damage caused by free radical to

DNA is one of the reasons for carcinogenesis. The *Ocimum sanctum* has been well known

for its antioxidant property with active ingredient such as eugenol and hence the plant

has been studied for its anticancer activity. The protective effect of alcoholic extract of the

leaves of

*Ocimum sanctum* on 3-methylcholanthrene (MCA), 7,12-dimethyl-benzanthracene (DMBA)

and aflatoxin B, (AFB(1)) induced skin tumorigenesis in a mouse model was reported[300].

The extract of *Ocimum sanctum* leaf was shown to provide protection against chemical

carcinogenesis in one or more of the following mechanisms: (i) by acting as an antioxidant;

(ii) by modulating phase I and II enzymes; (iii) by exhibiting antiproliferative activity [300].

230 Mycotoxin and Food Safety in Developing Countries

Treatment with aqueous and ethanolic extracts of *Ocimum sanctum* at 50μg/ml in mice

bearing Sarcoma-180 solid tumors mediated a significant reduction in tumor volume and an

increase in lifespan.These findings conclude *Ocimum sanctum* extracts possess anticancer

activity [301].

Several studies have been reported to show that different types of fruits and vegetables are

valuable sources of nutraceuticals. According to several studies as noted above these fruits

and vegetables have high values of important nutrients and phytochemicals which exhibit

antioxidant functions hence many form of diseases arising from the consumption of

mycotoxin contaminated food can be protected. Lycopene, a carotenoid is present in many

fruits and vegetables; such as grapefruit, guava, watermelon ansd pawpaw however,

tomatoes and processed tomato products constitute the major source of lycopene [302].

Several studies have indicated that lycopene is an effective antioxidant and free radical

scavenger. Lycopene, because of its high number of conjugated double bonds, exhibits

higher singlet oxygen quenching ability compared to β-carotene or α-tocopherol [303]. In *in*

*vitro* systems, lycopene was found to inactivate hydrogen peroxide and nitrogen dioxide

[304, 305]. Using pulse radiolysis techniques, Mortesen *et al.* [306] demonstrated its ability to

scavenge nitrogen dioxide (NO2·), thiyl (RS·) and sulphonyl (RSO2·) radicals. Lycopene is

highly lipophilic and is most commonly located within cell membranes and other lipid

components. It is therefore expected that in the lipophylic environment lycopene will have

maximum ROS scavenging effects. Hsiao et al. [307] showed the scavenging activity of

lycopene on DPPH radical in rat brain homogenates and its ability to inhibit nitric oxide

formation in cultured microglia stimulated by lipopolysaccharide. They further reported the

protective effect of lycopene on ischemic brain injury *in vivo.*Epidemiological data strongly

imply that lycopene consumption and tomato products contribute to prostate cancer risk

reduction via different mechanisms which cooperate in reducing the proliferation of normal

and cancerous prostate epithelial cells thereby reducing DNA damage and improving

oxidative stress defense from free radicals arising from mycotoxins. . The mechanisms

include inhibition of prostatic IGF-I signaling, IL-6 expression, and androgen signaling

([308] Moreover, lycopene improves gap-junctional communication and induces phase II

drug metabolizing enzymes as well asoxidative defense genes. Lycopene was also

demonstrated to inhibit mitogen-activated protein kinases, such as ERK1/2, p38 and JNK,

and the transcription factor, nuclear factor-kappaB [309]

Mushrooms have been reported as useful in preventing diseases such are hypertension,

hypercholesterolemia, cancer and other diseases linked to reactive oxygen species damage

their extracts may act as biological response modifiers with anticancer activities. Though the

mechanism of their antitumor actions is still not completely understood, stimulation and

modulation of key host immune responses by these mushroom polymers appears central.

A study on the protective effect of some edible mushrooms on aflatoxin B1 induction

revealed that mushroom at low doses of 100mg/Kg and 200mg/Kg body weight significantly

reduced aflatoxin B1 toxicity [310]. The Liver function enzymes, AST. ALT and marker of

kidney function, uric acid and creatine was shown to be reduced significantly on treatment

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 231

with the extract of mushroom species while the antioxidant superoxide dismustase was

significantly increased when compared to the aflatoxin B1 induced rats.

**6. Conclusion**

This chapter has reviewed only few vegetables, fruits and mushrooms with

chemopreventive and antioxidant properties in African which validates some of the

acclaimed traditional use. There is still a great deal of vegetables, fruits and mushrooms in

African whose antioxidant studies has been carried out both at the preliminary and

advanced stage. The consumption of these vegetables, fruits and mushrooms is capable of

preventing and protecting against some of the diseases arising from the ingestion of

mycotoxin contaminated foods in both humans and livestock.

**Author details**

R.U. Hamzah, A.A. Jigam, H.A. Makun, and E.C. Egwim

*Department of Biochemistry, Federal University of Technology, Minna, Niger State, Nigeria*

**7. References**

[1] Halliwell, B. and Gutteridge., J.M. Free radicals in biology and medicine. Clarendon

press, Oxford. Press: Oxford; 1989.

[2] Aruoma O. I. Methodological considerations for characterizing potential antioxidant

actions of bioactive components in food plants. Mut. Res. 2003; 523 – 524:9-2.

[3] Knekt, P.; Kumpulainen, J.; Järvinen, R.; Rissanen, H.; Heliövaara, M.; Raunanen, A.;

Hakulinen, T.; Aromaa, A.. Flavonoid intake and risk of chronic diseases. Am. J. Clin.

Nutr., 2002; 75: 560-568

[4] Amin, I, Zamaliah, M. M, and Chin, W. F. (2004)Total Antioxidnat activity and phenolic

contented of selected vegetables*. Food Chem*: 87: 581-586.

[5] Sahlin, E., Savage, G.P. and Lister, C.E. Investigation of the antioxidant properties of

tomatoes after processing. Journal of Food composition and Analysis. 2004; 17: 635-647.

[6] Halliwell B, Gutteridge JMC. Free Radicals in Biology and Medicine. Fourth Edition,

Oxford University Press, Oxford, UK, 2007.

[7] Miller, R.A., Britigan, B.E. Role of oxidants in microbial pathophysiology. *Clin.*

*Microbiol. Rev.* 1997;1 0 ;1 – 18..

[8] Ames BN, Shigenaga MK, Hagen TM Oxidants, antioxidants, and the degenerative

diseases of aging. Proc Natl Acad Sci 1993; 90:7915-22.

[9] Atiqur, Rahman, Mizanur, Rahman M, Md Mominul *et al*., 2008. Free radical

scavenging activity and phenolic content of *Cassia sophera*. L: *Afr. J. Biotechnol*. 7

(10):1591-1593.

[10] Dragland S, Senoo H, Wake K. et al. Several culinary and medicinal herbs are important

sources of dietary antioxidants. Nutr. 2003; 133(5):1286-1290.

232 Mycotoxin and Food Safety in Developing Countries

[11] Odukoya, O.A., A.E. Thomas and A. Adepoju-Bello, 2001. Tannic acid equivalent and

cytotoxic activity of selected medicinal plants. West Afr. J. Pharm., 15: 43-45.

[12] Atawodi SE (2005). Antioxidant potential of African medicinal plants. Afr. J. Biotechnol.

4(2):128-133.

[13] Amin I, Zamaliah MM, Chin WF. (2004)Total antioxidant activity and phenolic content

in selected vegetables. *Food Chem.*; 87:581–586.

[14] Breene, W. (1990). Nutritional and medicinal value of speciality mushrooms. Journal of

Food Production 53, 883-894.

[15] Fasidi IO Studies on *Volvariella esculenta* mass singer, Cultivation on Agricultural

Wastes and Proximate Composition of Stored Mushrooms, *Food Chemistry*, 1996; 55:161

– 163.

[16] Okwulehie IC and Odunze ET Evaluation of the Myco-chemical and Mineral

Composition of Some Tropical Edible Mushroom. *Journal of Sustainable Agriculture and*

*Environment,* 2004 6:1; 63-70.

[17] Bano ZS and Rajarathnam.( 1981). Studies on the Cultivation of Pleurotus Species.

*Mushroom J*., 101:243 – 245.

[18] Kurasawa S L, Sugahana J and Hayashi J Studies on Dietary Fibre of Mushroom and

Edible Wild Mushroom and Plants. *Nut. Rep. Int.*1982; 26:167-173.

[19] Ola, F.L. and G. Oboh, 2000. Nutritional Evaluation of Cassia siamea Leaves. J.

Technosci., 4: 1-3.

[20] Adejumo, T. O. and Awosanya, O. B. 2005. Proximate and mineral composition of four

ediblemushroom species from South Western Nigeria. African Journal of Biotechnology

4 (10): 1084-1088.S

[21] Akpaso, M. I., Atangwho, I J., Akpantah, A., Fischer1, V. A. Igiri, A. O and Ebong, P. E.

Effect of Combined Leaf Extracts of *Vernonia amygdalina* (Bitter Leaf) and *Gongronema*

*latifolium* (Utazi) on the Pancreatic β-Cells of Streptozotocin- *British Journal of Medicine &*

*Medical Research* 2011 *1(1): 24-34.*

[22] Yeap, S. K. ,.Ho, W Y. Beh, , B. K., Liang, W. S., Ky, H., Yousr1 A. N and Alitheen, B.

*Vernonia amygdalina*, an ethnoveterinary and ethnomedical used green vegetable with

multiple bioactivities. Journal of Medicinal Plants Research 2010; 4(25): 2787-2812

[23] Huffman MA, Seifu M . Observation on the illness and consumption of a possibly

medicinal plant Vernonia amygdalina (Del.), by a wild chimpanzee in the Mahale

Mountains National Park, Tanzania. Primates 1989; 30: 51-63.

[24] Ijeh, I. I. and Ejike. C.E. C. C. Current perspectives on the medicinal potentials of

Vernonia amygdalina Del Journal of Medicinal Plants Research 2011; 5(7): 1051-1061.

[25] Igile, G. O., Olezek, W., Jurzysata, M., Burda, S., Fafunso, M., Fasanmade, A.A.

Flavonoids from Vernonia amygdalina and their antioxidant activities. Journal of

Agricultrual and Food Chemistry 1994; 42 (11): 2445 –2448.

[26] Iwu MM .Empirical investigation of dietary plants used in Igbo- Ethnomedicine. In:

Iwu MM. Plants in indigenous medicine and diet. Nina Etkined Redgrove Publishers

Co, New York, 1986: 131-50.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 233

[27] Farombi, E. O. and Owoeye, O.Antioxidative and Chemopreventive Properties of

Vernonia amygdalina and Garcinia biflavonoid Int. J. Environ. Res. Public Health 2011

8; 2533-2555.

[28] Ayoola GA, Coker HAB, Adesegun SA, Adepoju-Bello AA, Obaweva K, Ezennia EC,

Atangbayila TO (2008). Phytochemical screening and antioxidant activities of some

selected medicinal plants used for malaria therapy in Southwestern Nigeria. Trop. J.

Pharm. Res., 7: 1019-1024.

[29] Owolabi MA, Jaja SI, Oyekanmi OO, Olatunji J Evaluation of the Antioxidant Activity

and Lipid Peroxidation of the Leaves of *Vernonia amygdalina*. J. Compl. Integr. Med.

2008; 5: 21.

[30] Erasto P, Grierson DS, Afolayan AJ. Evaluation of antioxidant activity and the fatty acid

profile of the leaves of *Vernonia amygdalina* growing in South Africa. Food Chem.2007b;

104: 636-642.

[31] Adesanoye, O.A.; Farombi, E.O. Hepatoprotective effects of *Vernonia amygdalina*

(astereaceae) in rats treated with carbon tetrachloride. *Exp. Toxicol. Pathol*. 2010, *62*, 197-

206.

[32] Iwalokun BA, Efedede BU, Alabi-Sofunde JA, Oduala T, Magbagbeola OA, Akinwande

A. Hepatoprotective and antioxidant activities of *Vernonia amygdalina* on

acetaminophen-induced hepatic damage in mice. J. Med. Food 2006; 9: 524-539.

[33] Oloyede, G.Kand Ajila J. M . Vernonia Amygdalina Leaf Extracts: A Source Of

Noncytotoxic Antioxidant Agents. EJEAFChe 2012; 11 (4): 339-350.

*[34]* Aruoma OI (1993). Experimental tools in free radical Biochemistry in: O:I. Aruoma (ed)

free radical in tropical disease. Harwood Academic Publishers, U.S.A pp 233 – 267.

[35] *Genestra M (2007).* Oxyl radicals, redox-sensitive signalling cascades and antioxidants*.*

*Cell Signal 19, 1807–1819.*

[36] Nwanjo HU (2005). Efficacy of aqueous leaf extract of *Vernoniaamygdalina* on plasma

lipoprotein and oxidative status in diabetic rat models. Nig. J. Physiol. Sci., 20: 39-42.

[37] Gutpa, S., Shukla, R., Prabhu, K.M., Agarwal, S., Rusia, U. and Murthy, P.S. (2002).

Acute and chronic toxicitystudies on partially purified hypoglycemic preparation from

water extract of bark of Ficus bengalensis Ind. J.Cli. Biochem., 17: 56-63

[38] Atangwho IJ, Ebong PE, Egbung GE, Eteng MU, Eyong EU (2007a).Effect of *Vernonia*

*amygdalina* Del. on liver function in alloxaninduced hyperglycaemic rats. Journal of

Pharmacy and Bioresources,4, R Retrieved January 13, 110, from

http://ajol.info/index.php/jpb/article/view/32107.

[39] Ebong PE, Atangwho IJ, Eyong EU, Egbung GE (2008) The antidiabetic efficacy of

combined extracts from two continental plants: *Azadirachta indica* (A. Juss) (Neem) and

*Vernonia amygdalina* (Del.) (African bitter leaf). Am. J. Biochem. Biotechnol., 4: 239-244.

[40] Jisaka M, Ohigashi H, Takegawa K, Hirota M, Irie R, Huffman MA, Koshmizu K

(1993a). Steroid gluccosides from *Vernonia amygdalina,* a possible chimpanzee medicinal

plant. Phytochem., 34: 409-413

[41] Osinubi AAA (2007). Effects of Vernonia amygdalina and chlorpropamide on blood

glucose. Med.J. Islam. World Acad. Sci., 16: 115-119.

[42] American Cancer Society (ACS) (2010). Cancer facts and letters. Atlanta GA, pp. 9-11.

234 Mycotoxin and Food Safety in Developing Countries

[43] Parkin OM, Bray FI, Devesa SS (2001) Cancer burden in the year 2000: the global

picture. Eur. J. Cancer, 37(8): 54-66.

[44] Jisaka M, Ohigashi H, Takagaki T, Nozaki H, Tada T, Hiroto M, Irie R, Huffman MA,

Nishida T, Kagi M, Koshimizu K (1992). Bitter steroid glucosides, vernoniosides A1, A2,

A3 and related B1 from a possible medicinal plant - *Vernonia amygdalina* used by wild

chimpanzees.Tetrahedron, 48: 625-632.

[45] Wall ME, Wani MC, Manikumar G, Abraham P, Taylor H, Hughes TJ, Warner J,

MacGivney R (1998). Plant antimutagenic agents,flavonoids. J. Nat. Prod., 51: 1084-1089.

[46] Izevbigie EB (2003). Discovery of water-soluble anticancer agents (edotides) from a

vegetable found in Benin City, Nigeria. Exp. Biol. Med., 228: 293-298.

[47] Oyugi DA, Luo X, Lee KS, Hill B, Izevbigie EB (2009). Activity markers of the antibreast

carcinoma cell growth fractions of Vernonia amygdalina extracts. Exp. Biol.

Med., 234: 410-417.

[48] Khalafalla MM, Abdellatef E, Daffalla HD, Nassrallah AA, Aboul-Enein KM, Lightfoot

DA, Cocchetto A, El-Shemy HA (2009). Antileukemia activity from root cultures of

*Vernonia amygdalina.* J. Med. Plants Res., 3: 556-562.

[49] Froelich S, Onegi B, Kakooko A, Schubert C, Jenette-Siems K (2006). In vitro

antiplasmodial activity and cytotoxicity of ethnobotanically selected east African plants

used for the treatment of malaria. Planta Medica, 72: https://www.thiemeconnect.

de/ejournals/abstract/plantamedica/doi/10.1055/s-2006- 949815.

[50] Izevbigie EB, Byrant JL, Walker A (2004). A novel natural inhibitor of extracellular

signal-regulated kinases and human breast cancer cell growth. Exp. Biol. Med., 229: 163-

169.

[51] A.A.A. Kayode and O.T. Kayode, 2011. Some Medicinal Values of *Telfairia occidentalis*: A

Review. *American Journal of Biochemistry and Molecular Biology, 1: 30-38.*

[52] FAO. Some medicinal plants of Africa and Latin America. FAO Forestry Paper, 67.

Rome 1989.

[53] Akoroda, M.O., 1990. Ethnobotany of *Telfairia occidentalis* (cucurbitaceae) among Igbos

of Nigeria. Econ. Bot., 44: 29-39.

[54] Gbile, Z.O., 1986. Ethnobotany, Taxonomy and Conservation of Medicinal Plants. In:

The State of Medicinal Plants Research in Nigeria, Sofowora, A. (Ed.). University of

Ibadan Press, Ibadan, Nigeria.

[55] Oboh, G., 2005. Hepatoprotective property of ethanolic and aqueous extracts of *Telfairia*

*occidentalis* (Fluted Pumpkin) leaves against garlic-induced oxidative stress. J. Med.

Food, 8: 560-563.

[56] Oboh, G. and A.A. Akindahunsi, 2004. Change in the ascorbic acid, total phenol and

antioxidant activity of sun-dried commonly consumed green leafy vegetables in

Nigeria. Nutr. Health, 18: 29-36.

[57] Oboh, G., E.E. Nwanna and C.A. Elusiyan, 2006. Antioxidant and antimicrobial

properties of *Telfairia occidentalis* (Fluted pumpkin) leaf extracts. J. Pharmacol. Toxicol.,

1: 167-175.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 235

[58] Nwanna, E.E. and G. Oboh, 2007. Antioxidant and hepatoprotective properties of

polyphenol extracts from *Telfairia occidentalis* (Fluted Pumpkin) leaves on

acetaminophen induced liver damage. Pak. J. Biol. Sci., 10: 2682-2687.

[59] Adaramoye, O.A., J. Achem, O.O. Akintayo and M.A. Fafunso, 2007. Hypolipidemic

effect of *Telfairia occidentalis* (fluted pumpkin) in rats fed a cholesterol-rich diet. J. Med.

Food, 10: 330-336.

[60] Emeka, E.J.I. and O. Obidoa, 2009. Some biochemical, haematological and histological

responses to a long term consumption of *Telfairia occidentalis*-supplemented diet in rats.

Pak. J. Nutr., 8: 1199-1203.

[61] Kayode, O.T., A.A. Kayode and A.A. Odetola, 2009. Therapeutic effect of telfairia

occidentalis on protein energy malnutrition-induced liver damage. Res. J. Med. Plant, 3:

80-92.

[62] Kayode, A.A.A., O.T. Kayode and A.A. Odetola, 2010. *Telfairia occidentalis* ameliorates

oxidative brain damage in malnorished rats. Int. J. Biol. Chem., 4: 10-18.

[63] Oboh, G., 2005. Hepatoprotective property of ethanolic and aqueous extracts of *Telfairia*

*occidentalis* (Fluted Pumpkin) leaves against garlic-induced oxidative stress. J. Med.

Food, 8: 560-563.

[64] Oboh, G. and A.A. Akindahunsi, 2004. Change in the ascorbic acid, total phenol and

antioxidant activity of sun-dried commonly consumed green leafy vegetables in

Nigeria. Nutr. Health, 18: 29-36.

[65] Oboh, G., 2004. Prevention of garlic-induced hemolytic aneamia by some tropical green

leafy vegetables. Biomed. Res., 15: 134-137.

[66] Baynes, J.W., 1991. Perspective in diabetes: Role of oxidative stress in development

complications in diabetes. Diabetes, 40: 405-412.

[67] Amic, D., D. Davidovic-Amic, D. Beslo and N. Trinajstic, 2003. Structure-radical

scavenging activity relationship pf flavonoids. Croatia Chem. Acta, 76: 55-61.

[68] Blazovics, A., A. Lugasi, K. Szentmihalyi and A. Kery, 2003. Reducing power of the

natural polyphenols of *Sempervivum tectorum in vitro* and *in vivo*. Acta Biol. Szeg., 47: 99-

102

[69] Salawu O. S, Akindahunsi, A.A. and Comuzzo, P. chemical composition and invitro

antioxidant Activities of some Nigerian vegetables. Journal of Pharmacology and

Toxicology 2006(1)5: 429-437

[70] Duke, J.A., 1992. Handbook of Biological Active Phytochemicals and Their Activity. 1st

Edn., CRC Press, New York, ISBN-10: 0849336708.

[71] Moreira, A. S., V. Spitzer, E.E. Schapoval and E.P. Schenkel. Anti-inflammatory activity

of extracts and fractions from the leaves of Gochnatia polymorpha. Phytother. Res.,

2000;14:638-640.

[72] Hudson, E. A., P. A. Dinh, T. Kokubun, M.S. Simmonds and A. Gescher, 2000.

Characterization of potentially chemopreventive phenols in extracts of brown rice that

inhibit the growth of human breast and colon cancer cells. Cancer Epidemiol. Biomark.

Prev., 9: 1163-1170.

[73] Soleas, G.J., Grass, P. D. Josphy, D.M. Goldberg and E.P. Diamandis. A comparison of

the anticarcinogenic properties of four red wine polyphenols. Clin. Biochem;35: 119-124

236 Mycotoxin and Food Safety in Developing Countries

[74] Sun J, Chu YF, Wu X and Liu RH (2002). Antioxidant and antiproliferative activities of

common fruits. J. Agric. Food Chem., 50: 7449-7454.I

[75] Chu YF, Sun J, Wu X and Liu RH (2002). Antioxidant and antiproliferative activities of

common vegetables. *J. Agric. Food Chem*., 50: 6910-6916.

[76] Eseyin, O.A., A.C. Igboasoiyi, E. Oforah, P. Ching and B.C. Okoli, 2005. Effects of leaf

extract of *Telfairia occidentalis* on some biochemical parameters in rats. Global J. Pure

Applied Sci., 11: 77-79.

[77] Kayode, A.A.A. and Kayode, O.T. . Some Medicinal Values of *Telfairia occidentalis*: A

Review. American Journal of Biochemistry and Molecular Biology, 2011; 1: 30-38.

[78] Salman,T.M, Olayaki, L. A. and. Oyeyemi, W. A. Aqueous extract of Telfairia

occidentalis leaves reduces blood sugar and increases haematological and reproductive

indices in male ratsAfrican Journal of Biotechnology . 2008; 7 (14:) 2299-2303.

[79] Alada, A.R.A., 2000. The haematological effect of *Telfairia occidentalis* diet preparation.

Afr. J. Biomed. Res., 3: 185-186.

[80] Fasuyi, A.O., 2006. Nutritional potentials of some tropical vegetable leaf meals chemical

characterization and functional properties. Afri. J. Biotechnol., 5: 49-53.

[81] Ganong WF (2005). A review of medical physiology. Appleton and Lange; p. 496.

[82] Fasuyi AO, Nonyerem AD . Biochemical, nutritional and haematological implications of

*Telfairia Occidentalis* leaf meal as protein supplement in broiler starter diets. Afr. J.

Biotechnol.2007; 6(8): 1055-1063.

[83] Eseyin O. A. Ebong, P., Eyong , E. U., Umoh,E Awofisayo, O. Comparative

Hypoglycaemic Effects of Ethanolic and Aqueous Extracts of the Leaf and Seed of

*Telfairia Occidentalis. Turk J. Pharm. Sci 2010;. 7 (1),:29-34, 2010.*

[84] Tikkiwal M, Ajmera RL, Mathur NK . Effect of zinc administration on seminal zinc and

fertility of oligospermic males. Indian. J. Physiol. Pharmacol. 1987;31; 30-34.

[85] Dawson EB, Harris WA, Rankin WE, Charpentier LA, McGanity WJ.Effect of ascorbic

acid on male fertility. Ann. N. Y. Acad. Sci. 1987; 498: 312-323.

[86] Vezina D, Mauffette F, Roberts KD, Bleau G . Selenium-vitamin E supplementation in

infertile men. Effects on semen parameters and micronutrient levels and distribution.

Biol. Trace. Elem. Res. 1996; 53: 65- 83.

[87] Scibona M, Meschini P, Capparelli S, Pecori C, Rossi P, Menchini Fabris GF . L-arginine

and male infertility. Minerva. Urol. Nefrol, 1994;. 46: 251-253.

[88] Ogbe, R. J.,, Adoga, G. I. and Abu, A. H. Antianaemic potentials of some plant extracts

on phenyl hydrazine-induced anaemia in rabbit. Journal of Medicinal Plants Research

2010; 4(8): 680-684.

[89] Okochi, V.I., J. Okpuzor and L.A. Alli, . Comparision of an african herbal formula with

commercially available haematinics. Afr. J. Biotechnol.,2003; 2: 237-240.

[90] Diallo, A., M. Gbeassor, A. Vovor, K. Eklu-Gadegbeku and K. Aklikokou *et al*.,. Effects

of *Tectona grandis* on phenylhydrazine induced anaemia in rats. Fitoterapia, 2008;` 79:

332-336.

[91] Okoli, B.E. and C.M. Mgbeogu, 1983. Fluted Pumpkin, *Telfairia occidentalis*: West African

vegetable crop. Econ. Bot.,1983; 37: 145-149.

[92] Mindel E. H, Herb Bible. Simon and Schuster, New York (1992) pp. 55-59. 2. J.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 237

[93] Dalziel, J. M. Useful Plant of West Tropical Africa, Crowns Agents for Overseas

Government, London, (1956).

[94] F. El-Said, E. A. Sofowora, S. A Malcolm and A. Hofer, An Investigation into the

Efficacy of Ocimum Gratissimum (Linn) as Used in Nigerian Native Medicine. Planta

Medica., 17, 195 (1969).

[95] F. D. Onajobi, Smooth Muscle Contracting Lipid Soluble Principles in Chromatographic

Fractions of Ocimum Gratissimum, J. Ethnopharmacol., 18, 3-11(1986).

[96] Wome B. Febrifuge and antimalarial plants from Kisangani, upper Zaire. Bulletin de la

Societe Royale de botanique de Belgique, 115, 1982:243–250.

[97] Giron LM, Freire V, Alonzo A and Vaceres A.Ethnobotanical survey of the medicinal

flora used by the cribs of Guatemala. J. Ethnopharmacol., 34, 1991:173– 187.

[98] Omale J., Olajide J. E. and Okafor P.N. Comparative Evaluation Of Antioxidant

Capacity And Cytotoxicity Of Two Nigerian *Ocimum* Species Int. J. Chem. Sci.: 6(4),

2008, 1742-1751

[99] Viorica H. Polyphenols of *Ocimum basilicum* L.Chujul Med., 60, 1987:340–344.

[100] Fatope MO and Takeda Y. The constituents of the leaves of *Ocimum basilicum.* Planta

Medica,54, 1988: p-190.

[101] Akinmoladun, A C. Ibukun, E. O., Afor, E., Obuotor E. M., and Farombi E.O.

Phytochemical constituent and antioxidant activity of extract from the leaves of *Ocimum*

*gratissimum*. Scientific Research and Essay Vol. 2 (5), pp. 163-166, May 2007.

[102] Dubey NK Tiwari TN Mandin D Andriamboavonjy H Chaumont JP Antifungal

properties of *Ocimum gratissimum* essential oil (ethyl cinnamate chemotype). Fitoterapia

2000; 7(15): 567-569.

[103] Sulistiarini D, Oyen LPA, Nguyen Xuan Dung *Ocimum gratissimum* L. In: Plant

Resources of South-East Asia. No. 19: Essentialoils Plants. Prosea Foundation, Bogor,

Indonesia. 1999;. 140-142.

[104] Holets FB, Ueda-Nakamura T, Filho BPD, Cortez DAG, Morgado-Diaz JA, Nakamura

CV (2003). Effect of essential oil of *Ocimum gratissimum* on the trypanosomatid

*Herpetomonas samuelpessoai.* Act. Protonzool 42: 269-276.

[105] Awah F. M. and Verla,A. W. Antioxidant activity, nitric oxide scavenging activity and

phenolic contents of Ocimum gratissimum leaf extract. Journal of Medicinal Plants

Research 2010;4(24), pp. 2479-2487

[106] Uhegbu, F.O. Elekwa,I., Akubugwo, E. I. Godwin C. C. and Iweala, E E.J. Analgesic

and Hepatoprotective Activity of Methanolic Leaf Extract of Ocimum gratissimum (L.)

Research journal of medicinal plant 2012; 6[1]:108-115.

[107] Wickens GE, Lowe P .The Baobabs: Pachycauls of Africa, Madagascar and Australia,

Springer; 2008.

[108] Venter F, Venter J (1996). Baobab In Making the most of indigenous trees. Briza

publications, Pretoria, South Africa, 196; 26-27.

[109] Sibibe M, Williams JT .Baobab – *Adansonia digitata*. Fruits for the future. Int. Centre

Underutil. Crops, Southampton, UK, 2002;

238 Mycotoxin and Food Safety in Developing Countries

[110] Yazzie D.; VanderJagt D. J.; Pastuszyn A.; Okolo A.; Glew R. H., (1994), The amino

acid and mineral content of baobab (Adansonia digitata L.) leaves. Journal of Food

Composition and Analysis, 7, (3), 189-193

[111] Gebauer J, El-Siddig K, Ebert G (2002). Baobab (Adansonia digitata L.): A review on a

multipurpose tree with promising future in the Sudan. Gartenbauwissenschaft, 67: 155-

160.

[112] Sidibe, M., Scheuring, J.F., Tembely, D., Sidibé, M.M., Hofman, P., Frigg, M. (1996).

*Baobab – Homegrown Vitamin C for Africa.* Agroforestry Today, 8 (2), 13-15.

[113] Wickens, G.E. Chapter 15: *The uses of the baobab (Adansonia digitata* L.) *in Africa.* In:

*Taxonomic aspects of African economic botany,* editor, Kunkel, G., 1979.

[114] Vertuani S, Braccioli E, Buzzoni V, Manfredini S (2002). Antioxidant capacity of

Adansonia digitata fruit pulp and leaves. Acta Phytotherapeutica, 86: 2

[115] Vimalanathan S, Hudson JB (2009). Multiple inflammatory and antiviral activities in

Adansonia digitata (Baobab) leaves, fruits and seeds. J. Med. Plants Res., 3: 576-582.

[116] Masola SN, Mosha RD, Wambura PN (2009). Assessment of antimicrobial activity of

crude extracts of stem and root barks from *Adansonia digitata* (Bombacaceae) (African

baobab). Afr. J. Biotechnol., 8: 5076-5083.

[117] Anani K, Hudson JB, de Souzal C, Akpagana K, Tower GHN, Amason JT, Gbeassor M

(2000). Investigation of medicinal plants of Togo for antiviral and antimicrobial

activities. Pharm. Biol., 38: 40-45.

[118] Shri V T, Ramprasath. D, Karunambigai.K. Nagavalli. D, Hemalatha. S . Studies of

Pharmacognostical Profiles of *Adansonia digitata* Linn.Ancient Science of Life 2004; 24(2).

[119] Scheuring J.F., Sidibé M. and Frigg M. (1999). Malian agronomic research identifies

local baobab tree as source of vitamin A and vitamin C. *In Sight of Life Newsletter* pp 21-

24.

[120] Sena L.P., Vanderjagt D.J., Rivera C., Tsin A.T.C., Muhamadu I., Mahamadou O.,

Millson M., Pastuszyn A. and Glew R.H. (1998). Analysis of nutritional components of

eight famine foods of the Republic of Niger. *Plant Foods for Human Nutrition* 52 (1), 17-

30.

[121] Nordeide M.B., Hatloy A., Folling M., Lied E. and Oshaug A. (1996). Nutrient

composition and nutritional importance of green leaves and wild food resources in an

agricultural district, K outiala, in Southern Mali. *International Journal of Food Sciences and*

*Nutrition* 47 (6), 455-468.

[122] Chadare, F.J., Linnemann, A.R., Hounhouigan, J.D., Nout, M.J.R., Van Boekel, M.A.J.S.

(2009). Baobab Food Products: A Review on their Composition and Nutritional Value.

Critical Reviews in Food Science and Nutrition, 49, 254-274.

[123] Cook J.A., Vanderjagt D.J., Dasgupta A., Mounkaila G., Glew R.S., Blackwell W. and

Glew R.H. (1998). Use of the Trolox assay to estimate the antioxidant content of

seventeen edible wild plants of Niger. *Life sciences* 63, 105-110.

[124] Tarwadi K. and Agte V. (2005). Antioxidant and micronutrient quality of fruit and root

vegetables from the Indian subcontinent and their comparative performance with green

leafy vegetables and fruits. *Journal of the Science of Food and Agriculture* 85, 1469-1476.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 239

[125] Karumi Y, Augustine AI, Umar IA (2008). Gastroprotective effects of aqueous extract

of Adansonia digitata leaf on ethanol-induced ulceration in rats. J. Biol. Sci. 8: 225-228.

[126] Hirokawa, T., Boon-Chieng, S. and Mitaku, S. (1998) SOSUI: Classification and

Secondary Structure Prediction System for Membrane Proteins. Bioinformatics

(formerly CABIOS), 14(4), 378-379.

[127] Hernandez, J.A., A. Jimenez, P. Mullineaux and F. Sevilla, 2000. Tolerance of pea

(*Pisum sativum* L.) to long term salt stress is associated with induction of antioxidant

defences. Plant Cell Environ., 23: 853-862.

[128] Penisi, A., Piezzi, R., 1999. Effect of dehydroelucidine on mucus production. A

quantitative study. Digestion Disease Sciences 44, 708–712.

[129] Bagchi D., Carry, O., Tran, W., Krolin, T.,Bagchi, D. J.,Garry, A., Bagchi, M.,Mitra, S.,

and Stohs, S. Stresss, diet and alcohol induced oxidation gastrointestinal mucosal injury

in rats and protection by bismuth and subsalicylate. J.Applied Toxicol.,1998;18(1): 3-13.

[130] Arrigori, O. and De Tullio, M. C. Ascorbic acid: Much more than just an antioxidant.

Biochem. Biophys. Acta, 2002;1569(1-3): 1-9.

[131] Nwafor, P. A., K. D. Effraim and T. W. Jacks.Gastroprotecitve effects of Aqueous

extract of Kaya sinegalensis on indomethecin induced ulceration in rats. West Afri. J.

Pharmacol.Drug Res.,1996; 12:45-50.

[132] Samra, I., Piliz, S., Ferdag ,C.(2007):Antibacterial and antifungal activity of *Corchorus*

*olitorius* L. (Molekhia extracts) *international Journal of natural and Engineering Sci*. 1 (3) 39-

61.

[133] Tindall, H.D. (1983.) Vegetables in the tropics. Macmillan, London. Pp. 325-379

[134] Oke,O.I.(1968): Chemical changes in some Nigerian vegetables during growth.

*ExperimentalAgriculture* 4: 345-349.

[135] Zakaria, Z.A., Somchit, M.N., Zaiton, H., Mat-Jais, A.M., Suleiman, M.R., Farah,

W.,Nazaratul- Marawana, R. and Fatimah, C.A.(2006): The invitro antibacterial activity

of *Corchorous olitorius* extracts. *Int. J . of Pharmacology* 2(2) 213-215.

[136] Ndlovu, J. and Afolayan, A.J.(2008): Nutritional analysis of the south African wild

vegetable *Corchorus olitorius* L. *Asian J of Plant Science* 7 (6) 615-618.

[137] Zeghichi, S.S., Kallithkara and Simopoulos, A.P. (2003): Nutritional composition of

molehiya (*Corchorus olitorius*) and Stamnagathi (*Cichorium spinosum*) in: plants in human

health and nutrition policy (eds. Simopoulus A.P. and C. Gopalan). Karger, Basel pp 1-

22.

[138] Aiyeloja AA, Bello OA (2006). Ethnobotanical potentials of common herbs in Nigeria:

A case study of Enugu state. Educ. Res. Rev., 1 (1): 16-22.

[139] Fondio L, Grubben GJH (2004). Corchorus olitorius L. In: Grubben GJH, Denton OA

(Editors). PROTA 2: Vegetables/Légumes. [CD-Rom].PROTA, Wageningen,

Netherlands.

[140] .Fasinmirin JT, Olufayo AA (2009). Yield and water use efficiency of jute mallow

*Corchorus olitorius* under varying soil water management strategies. J. Med. Plants Res.,

3(4): 186-191.

240 Mycotoxin and Food Safety in Developing Countries

[141] S.O. Salawu and A.A. Akindahunsi. Protective Effect of Some Tropical Vegetables

Against CCl4 -Induced Hepatic Damage Journal of Medicinal Food. June 2007, 10(2):

350-355.

[142] Soleas, G. J., Grass, L.,Josphy, P. D., Goldberg, D. M. and Diamandis, E. P. A

comparison of the anticarcinogenic properties of four red wine polyphenols. Clin.

Biochem, 35: 119-124.

[143] Moreira, A. S, Spitzer, V.,Schapoval, E. E. and Schenkel, E. P. Anti-inflammatory

activity of extractsand fractions from the leaves of Gochnatia polymorpha. Phytother.

Res. 2000;14: 638-640.

[144] Kimata, M. , Inagaki, N and Nagai. Effect of luteolin and other flavonoids on IGEmediated

allergic reactions. Planta Med., 2000; 66: 25-29.

[145] Oboh, G · Raddatz, H · Henle, T Characterization of the antioxidant properties of

hydrophilic and lipophilic extracts of Jute (Corchorus olitorius) leaf. Epub 2009;60

(2):124-34.

[146] Das AK, Bag S, Sahu R, Dua TK, Sinha MK, Gangopadhyay M, Zaman K, Dewanjee S.

Protective effect of Corchorus olitorius leaves on sodium arsenite-induced toxicity in

experimental rats. Food Chem Toxicol. 2010 ;48(1):326-35.

[147] Ugochukwu NH, Babady NE. Antihyperglycemic effect of aqueous and ethanolic

extracts of *Gongronema latifolium* leaves on glucose and glycogen metabolism in livers of

normal and streptozotocin-induced diabetic rats. Life Sci. 2003;73(15):1925–1938. doi:

10.1016/S0024-3205(03)00543-5.

[148] Ugochukwu NH, Babady NE, Cobourne M, Gasset SR. The effect of *Gongronema*

*latifolium* leaf extract on serum lipid profile and oxidative stress of hepatocytes of

diabetic rats. J Biosci. 2003;28:1–5.

[149] Sonibare, M.A. & Gbile, Z.O. Ethnobotanical survey of anti-asthmatic plants in south

western Nigeria. African Journal of Traditional, Complementary and Alternative

Medicine 2008; 5(4): 340–345.

[150] Burkill, H.N., The useful Plants of West Tropical Africa, Kew, published by Royal

Botanic Gardens. 2nd Edition,1985; 456-596.

[151] Morebise, O., Fafunso, M.A., Makinde, J.M., Olajide, O.A. & Awe, E.O.

Antiinflammatory property of the leaves of Gongronema latifolium. Phytotherapy

Research 2002; 16(1): 75–77.

[152] Atangwho IJ, Ebong PE, Eyong EU, Williams IO, Eteng MU, Egbung GE (2009b).

Comparative chemical composition of leaves of some antidiabetic medicinal plants:

Azadirachta indica, Vernonia amygdalina and Gongronema latifolium Afr. J. Biotech.,

8: 4685- 4689.

[153] Schneider C, Rotscheidt K, Breitmaier E. 4 new pregnane glycosides from *Gongronema*

*latifolium* (Asckepiadaceae) Liebigs Annalen Der Chemie. 1993;10:1057–1062.

[154] Morebise O, Fafunso MA. Antimicrobial and phytotoxic activities of saponin extracts

from two Nigerian edible medicinal plants. Biokemistri. 1998;8(2):69–7.

[155] Etim, O.E., Akpan, E.J. & Usoh, I.F. Hepatotoxicity of carbon tetrachloride: protective

effect of Gongronema latifolium. Pakistan Journal of Pharmaceutical Sciences. 2008;

21(3): 269–274.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 241

[156] Shi J, Asiaki K, Ikawa Y and Wake K.. Evidence of hepatocyte apoptosis in rat liver

after the administration of carbontetrachloride. *J. Med. Res.2003;* 4: 1-8.

[157] Chung HS, Chong LC, Lee SK, Shamon LA, Breemen RBV, Mehta RG, Farnsworth NR,

Pezzuto JN and Kinghorn AD Flavonoids constituents of chlorinzan diffused with

potential cancer chemopreventive activity. J. Agric. Food Chem.,1999; 47:35-4.

[158] Wettstern M, Gerol W and Hausinger D.Hypoxia and CCl4-induced liver injury, but

not acidosis, impair metabolism cysteinyl. Hepatol.,1990; 11: 866-873

[159] Recknagel RO. Carbon tetrachloride hepatotoxicity. Pharmacol. Rev., 1987;19: 145-195

[160] Ita SO, Akpanyung EO, Umoh BI, Ben EE, Ukafia SO. Acetaminophen induced hepatic

toxicity: protective role of Ageratum conyzoides. Pak J Nutr 2009; 8(7): 928-932. .

[161] Nnodim J. Emejulu A. The protective role of Gongronema latifolium in acetaminophen

induced hepatic toxicity in Wistar rats. Asian Pacific Journal of Tropical Biomedicine

201); 5151-5154.

[162] Raucy JL, Lasker JM, Lieber CS, Black M. Apap activation by human liver cytochromes

P4502EI and P4501A2. Arch Biochem Biophys 1989; 271: 270-283.

[163] Kumarappan C, Vijayakumar M, Thilagam E, Balamurugan M, Thiagarajan M, Senthil

S, et al. Protective and curative effects of polyphenolic extracts from Ichnocarpus

frutescense leaves on experimental hepatotoxicity by carbon tetrachloride and

tamoxifen. Ann Hepatol 2011; 10(1): 63-72.

[164] Akuodor, G.C., M.S. Idris-Usman, C.C. Mbah, U.A. Megwas and J.L. Akpan *et al*.

Studies on anti-ulcer, analgesic and antipyretic properties of the ethanolic leaf extract of

*Gongronema latifolium* in rodents. Afr. J. Biotechnol.2010; 9: 2316-2321.

[165] Eguyoni, A., Moody, J.O. & Eletu, O.M., 2009. Anti-sickling activies of two

ethnomedicinal plant recipes used for the management of sickle cell anaemia in Ibadan,

Nigeria. African Journal of Biotechnology 8(1): 20–25.

[166] Etetim, E.N., Useh, M.F. & Okokon, J.E., 2008. Pharmacological screening and

evaluation of antiplasmodial activity of Gongronema latifolium (utazi) against

Plasmodium berghei berghei infection in mice. Nigerian Journal of Health and

Biomedical Sciences 7(2): 51–55.

[167] Eyo E and Abel U (1983): Chemical composition of amino – acid content of Gnetum

Africanum leaves, *Nig J*. *Nutr. Sci*, 4, 52 – 57.

[168] Mialoundama, F. 1993. Nutritional and socio-economic value of *Gnetum* leaves in

Central African forest. *In* Hladik, C.M. *et al*., *Tropical forests, people and food: Biocultural*

*interactions and applications to development*. Carnforth, UK: Parthenon Publishing Group.

[169] Doyle, J. A. Molecules, morphology, fossils and the relationship of Angiosperms and

Gnetales. Mol. Phylogenet, Evol., 448-462.

[170] Burkill, H.M. *The Useful Plants of West Tropical Africa. Volume 2: Families E-I*. Kew. Royal

Botanic Gardens, Kew. 1194;90-94.

[171] Ndam M,J.P Nkefor and P. Blackmore(2000): Domestication of Gnetum africanum and

G.buchholzianum, an over exploited wild forests vegetable of the Equato – Congolian

Region. In press XVIth AETFAT proceeding.

[172] Bouguet, A. 1969. *Féticheurs et medicines traditionnelles du Congo (Brazzaville),*Paris:

ORSTOM.

242 Mycotoxin and Food Safety in Developing Countries

[173] Watt, J.M.A & M.G. Breyer-Brandwijk. 1962. *The medicinal and poisonous plants of*

*Southern and Eastern Africa*. Edinburgh: E & S Livingstone.

[174] Akintola A. O, Ayoola P.B, and Ibikunle, G.J Antioxidant Activity of Two Nigerian

Green Leafy Vegetables. Journal Of Pharmaceutical and Biomedical Sciences 2012.;14:

15 1-5.

[175] Moskotivz J, Yim K.A, Choke P.B (2002): Free radicals and disease. Arch Biochem.

Biophys, volume 397, pp: 354-59.

[176] Iweala, E.E.J., F.O. Uhegbu and O. Obidoa, 2009. Biochemical and histological changes

associated with long term consumption of *Gnetum africanum* Welw. Leaves in Rats.

Asian J. Biochem., 4: 125-132.

[177] Iweala, E. J. and Osundiya O. A. (2010). ). Biochemical, Haematological and

Histological Effects of Dietary supplementation with leaves of Gnetum africanum welw

on paracetamol induced Hepatotoxicity in Rats. International Journal of pharmacology

(6): 872-879.

[178] Feskanich, D., Ziegler, R. G., Michaud, D. S., Giovannucci, E. L., Speizer, F. E., Willett,

W. C., et al. Prospective study of fruit and vegetable consumption and risk of lung

cancer among men and women. Journal of the National Cancer Institute, 2000;92:1812–

1823.

[179] Gordon, M. H. (1996). Dietary antioxidants in disease prevention. Natural Product

Reports, 265–273.

[180] Shi, H. L., Noguchi, N., & Niki, E. Introducing natural antioxidants. In J. Pokorny et al.

(Eds.), Antioxidants in food: practical applications. Woodhead Publishing Ltd. and CRC

Press.2001.

[181] Fleuriet, A., & Macheix, J. J.. Phenolic acids in fruits and vegetables. In C. A. Rice-

Evans & L. Packer (Eds.), Flavonoids in health and disease. Marcel Dekker Inc..2003.

[182] Klein, B. P., & Kurilich, A. C. Processing effects on dietary antioxidants from plant

foods. HortScience,2000; 35(4): 580-584.

[183] Jimenez-Escrig, A., Rincon, M., Pulido, R., & Saura-Calixto, F. Guava fruit (Psidium

guajava L.) as a new source of antioxidant dietary fiber. Journal of Agricultural and

Food Chemistry 2001; 49: 5489–5493.

[184] Leong, L. P., & Shui, G. (2002). An investigation of antioxidant capacity of fruits in

Singapore markets. Food Chemistry, 76, 69–75.

[185] Someya, S., Yoshiki, Y., & Okubo, K. (2002). Antioxidant compounds from bananas

(Musa Cavendish). Food Chemistry, 79, 351–354.

[186] Okujagu, T. F., Etatuvie Sam O., Ifeyinwa E., Jimoh B., Nwokeke. Book of abstract of

published Research finding on Nigerian Medicinal plant and traditional medicine

practice. 2005; 1: 90.

[187] Dey, Kanny Lall: The indigenous drugs of India - short descriptive notices of the

principal medicinal plants met with in British India. 2nd edition. Thacker, Spink & Co.

1896. Calcutta.

[188] Mercadante AZ, Steck Z, Pfander H. Carotenoids from guava (*Psidium guajava* L.):

isolation and structure elucidation. *J Agric Food Chem* 1999;47:145-51.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 243

[189] Misra K, Seshadri TR. Chemical components of the fruits of *Psidium guajava*.

*Phytochemistry* 1968; 7:641-45.

[190] Arima, H.; Danno, G.: Isolation of antimicrobial compounds from guava (*Psidium*

*guajava* L.) and their structural elucidation. Bioscience, Biotechnology and Biochemistry.

2002;66(8) 1727-1730.

[191] Suntornsuk, L. Quantitation of vitamin C content in herbal juice using direct titration.

*J. Pharm. Biomed. Anal*. 2002;28(5) : 849 -855.

[192] Thaipong K, Boonprakob U, Crosby K, Cisneros-Zevallos L, Byrne D (2006).

Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant

activity from guava fruit extracts. J. Food Compos. Anal. 19: 669-675.

[193] Lim Y.Y., Lim, T.T., and Tee J.J.. Antioxidant properties of several tropical fruits: A

comparative study. Food Chemistry 2007); 103:1003–1008.

[194] Jimenez-Escrig, A.. Guava fruit (Psidium Guajava L.) as a new source of antioxidant

Dietary fiber. J. Agric. Food. Chem. 2002;49(11): 5489-93.

[195] Rice RP, Rice LW, Tindall HD (1987). Pawpaw. In: Fruits and vegetable production in

Africa. A Textbook. Macmillan publishers ltd, London.1987, p170.

[196] Dukes, J.O., (1992). Handbook of medicinal herbs, CRC Press, N.Y., pp: 11-30, 102.

[197] Oyoyede, O. L. Chemical profile of unripe pulp of carica papaya. Pak. J. Nutri. 2005;

496: 379-381.

[198] Wall.,M .M. Ascorbic acid, vitamin A, and mineral composition of banana (Musa sp.)

and papaya (Carica papaya) cultivars grown in Hawaii.Journal of Food Composition

and Analysis; 2006(19); 434–445.

[199] Nitsawang S, Hatti-Kaul R, Kanasawuda P 2006. Purification of papain from *Carica*

*papaya* latex: aqueous two-phase extraction versus two-step salt precipitation. *Enzyme*

*Microb Technol 39*: 1103-1107.

[200] Neuwinger HD. African Traditional Medicine: A Dictionary of Plant Use and

Applications. Stuttgart, Germany: Medpharm Gmbh Scientific Publishers; 2000

[201] Iwu, Maurice. Handbook of African Medicinal Plants. Boca Raton, FL: CRC Press;

1993.

[202] Novy JW. Medicinal plants of the eastern region of Madagascar. J Ethnopharmacol.

Jan 1997;55(2):119-126

[203] Tona L, Kambu K, Ngimbi N, Cimanga K, Vlietinck AJ. Antiamoebic and

phytochemical screening of some Congolese medicinal plants. J Ethnopharmacol.

May1998;61(1):57-65.

[204] Setiawan, B., Sulaeman, A., Giraud, D. W., & Driskell, J. A. (2001). Carotenoid content

of selected Indonesian fruits. Journal of Food Composition Analysis, 14, 169–196..

[205] Oloyede O., Franco, J., Roos Dl, Rocha, J., Athayde, M. Boligon A. Antioxidative

Properties of Ethyl Acetate Fraction of Unripe Pulp of Carica Papaya In Mice 2011; 1 (3):

409-425.

[206] Koocheki, A., S.M.A. Razavi, E. Milani, T.M. Monghadam, S. Alamatiyan and S.

Izadkhah..Physical properties of watermelon seed as a function of moisture content and

variety. *Int. Agrophysics, 2007;* 21: 349-359.

244 Mycotoxin and Food Safety in Developing Countries

[207] Vaughan JG, Geissler C. The new Oxford book of food plant (second edition), Oxford

University press. 2009; Pp 348.

[208] Janiene E . Citrullus lanatus (Thunb.)Matsun. & Nakai. http://www.FAO/Watermelon

citan 2010

[209] Florabase. Flora of western Australia, Plant description by Amanda Spooner, James

Carpenter, GillianSmith and Kim Spence 2007,

http://florabase.calm.wa.gov.au/browse/profile/7370. Accessed on 15/12/2011.

[210] Plants for a future. http://www.ptaf.org/database/plants.php/Citrullus+lanatus

Accessed on 06/12/2011.

[211] Schaefer H, Renner SS. Phylogenetic relationships in order cucurbitales and a new

classification of the gourd family cucurbitaceae. *Taxon.* 2011; 60(1): 122-138

[212] Edwards AJ, Vinyard BT, Wiley ER et al. Consumption of watermelon juice increases

plasma concentrations of lycopene and beta-carotene in humans. J Nutr

2003;133(4):1043-50.

[213] Collins JK, Wu G, Perkins-Veazie P, Spears K, Claypool PL, Baker RA, Clevidence BA.

Watermelon consumption increases plasma arginine concentrations in adults.

Nutrition. 2007;23(3):261-6.

[214] Perkins-Veazie P, Collins JK. Carotenoid changes of intact watermelons after storage. *J*

*Agric Food Chem*. 2006;54(16):5868-74.

[215] Jian L, Lee AH, Binns CW. Tea and lycopene protect against prostate cancer. Asia Pac J

Clin Nutr. 2007; 1:453-7.

[216] Erhardt JG, Meisner C, Bode JC, Bode C. Lycopene, beta-carotene, and colorectal

adenomas. *Am J Clin Nutr*. 2003 ;78(6):1219-24.

[217] Wood, Rebecca. The Whole Foods Encyclopedia. New York, NY: Prentice-Hall Press;

1988.

[218] Kashman Y, Neeman I, Lifshitz A. New compounds from avocado pear. Tetrahedron

1969;25:461731.

[219] Oberlies NH, Rogers LL, Martin JM, McLaughlin JL. Cytotoxic and insecticidal

constituents of the unripe fruit of *Persea americana*. J Nat Prod 1998;61:781-5.

[220] Rodriguez-Saona C, Millar JG, Trumble JT. Isolation, identification, and biological

activity of isopersin: a new compound from avocado idioblast oil cells. J Nat Prod

1998;61:1168-70.

[221] Kawagishi H, Fukumoto Y, Hatakeyama M, He P, Arimoto H, Matsuzawa T, *et al*.

Liver injury suppressing compounds from avocado (*Persea americana*). J Agric Food

Chem 2001;49:2215-21.

[222] Ojewole JA, Kamadyaapa DR, Gondwe MM et al. Cardiovascular effects of Persea

americana Mill (Lauraceae) (avocado) aqueous leaf extract in experimental animals.

Cardiovasc J Afr. 2007;18(2):69-76.

[223] Rosenblat G, Meretski S, Segal J et al. Polyhydroxylated fatty alcohols derived from

avocado suppresses inflammatory response and provides non-sunscreen protection

against UV-induced damage in skin cells. Arch Dermatol Res. 2010

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 245

[224] Naveh E, Werman MJ, Sabo E et al. Defatted Avocado Pulp Reduces Body Weight and

Total Hepatic Fat But Increases Plasma Cholesterol in Male Rats Fed Diets with

Cholesterol. J. Nutr., 2002; 132: 2015 - 2018.

[225] Guzmán-Gerónimo RI and Dorantes L. Fatty acids profile and microstructure of

avocado puree after microwave heating. Arch Latinoam Nutr. 2008;58(3):298-302.

[226] Batista Cadeno, A., Cerezal Mezquita, P. and Funglay, V. (1993). E.I. Aguacate (persea

Americana) Nutritional Composition of Avocado Pear, (63):63-69

[227] Donnarumma G, Paoletti I, Buommino E et al. AV119, a Natural Sugar from Avocado

gratissima, Modulates the LPS-Induced Proinflammatory Response in Human

Keratinocytes. Inflammation. 2010

[228] Ding H, Han C, Guo D et al. Selective induction of apoptosis of human oral cancer cell

lines by avocado extracts via a ROS-mediated mechanism. Nutr Cancer. 2009;61(3):348-

56.

[229] Tel G, Apaydn M, Duru ME, Öztürk M. Antioxidant and Cholinesterase Inhibition

Activities of Three *Tricholoma* Species with Total Phenolic and Flavonoid Contents: The

Edible Mushrooms from Anatolia. Food Anal. Methods 2012;5:495–504.

[230] Chang ST, Miles PG. Mushrooms biology—a new discipline. Mycologist 1992;6:64–5.

[231] Lindequist U, Niedermeyer THJ, Julich W. The Pharmacological Potential of

Mushrooms. eCAM 2005;2(3)285–299.

[232] Tzianabos Ao: Polysaccharide immunomodulators as therapeutic agents: structural

aspects and biologic function. Clin Microbiol Rev 2000; 13: 523-533,.

[233] Reshetnikov SV, Wasser SP, Tan KK Higher Basidiomycota as a source of antitumor

and immunostimulating polysaccharides. Int J Med Mushrooms 2001;3:361–394.

[234] Hobbs C.Medicinal value of Lentinus edodes (Berk.) Sing. (Agaricomycetideae). A

literature review. Int J Med Mushrooms 200; 2:287–302.

[235] Stamets P .Growing gourmet and medicinal mushrooms, 3rd edn. Ten Speed Press,

Berkeley, Calif 2000.

[236] Bahl N. Medicinal value of edible fungi. In: Proceeding of the International Conference

on Science and Cultivation Technology of Edible Fungi. Indian Mushroom Science II,

1983; 203-209.

[237] Kabir Y, Kimura S, Tamura T. Dietary effect of *Ganoderma lucidum* mushroom on blood

pressure and lipid levels in spontaneously hypertensive rats (SHR). J. Nutr. Sci.

Vitaminol., 1988;34: 433-438.

[238] Ren L, Visitev AV, Grekhov AN, Tertov VV, Tutelyan VA. Antiatherosclerotic

properties of macrofungi. *Voprosy Pictaniya*, 1989;1: 16- 19.

[239] Gareth JEB Edible Mushrooms in Singapore and other South East Asian countries. The

Mycologist, 1990; 4: 119-124.

[240] Jong SC, Birmingham JM Medicinal benefits of the mushroom Ganoderma. Adv. Appl.

Microbiol., 1991; 37: 101-134.

[241] Buswell JA, Chang ST (1993). Edible mushrooms attributes and applications. In:

*Genetics and breeding of edible mushrooms* (Chang, S.T.J. Buswell, J.A and Miles PG (Eds).

Gordon and Breach, Philadelphia, pp. 297-394.

[242] Nanba H (1993). Maitake mushroom the king mushroom. Mushroom News, 41: 22-25.

246 Mycotoxin and Food Safety in Developing Countries

[243] King TA (1993). Mushrooms, the ultimate health food but little research in U. S to

prove it. Mushroom News, 41: 29-46.

[244] Kino KY, Yamaoka K., Watanabe J, Kotk SK, Tsunoo H (1989). Isolation and

characterization of a new immunomodulatory protein Zhi-8 (LZ-8) from *Ganoderma*

*lucidum*. J. Biol. Chem., 264: 472- 478.

[245] Kim BK, Kim HW, Choi EC (1993). Anti-HIV activity of *Ganoderma lucidum*. J. Biol.

Chem., 264: 472-478.

[246] Liu FO, Chang ST (1995). Antitumor components of culture filtrates from *Tricholoma*

*sp*. World J. Microbiol. Biotechnol., 11: 486-490.

[247] Dreyfuss MM, Chapela IH (1994). Potential of fungi in the discovery of natural

products with therapeutic potential (Gull, V.P. ed.) Bulterworth- Heinemann, Boston

MA, pp. 49-80.

[248] Teow SS (1997). The effective application of *Ganoderma* nutriceuticals. In: Recent

progress in *Ganoderma lecidum* research (Kim BK, Moon CK, Kim TS eds.). Seoul Korea.

Pharm. Soc. Korea, pp. 21-39.

[249] Harsh NSK, Rai BK, Tiwari DP (1993). Use of *Ganoderma lucidum* in folk medicine. J.

Trop. Biodivers., 1: 324-326

[250] Mizuno T (1996). Oriental medicinal tradition of Ganoderma lucidum (Reishi) in India.

In: Ganoderma lucidum (Mizuno,T and Kim,B.K eds.). Li Yang Pharm. Co. Ltd., Seoul,

Korea, pp. 101-106.

[251] Chang ST, Buswell JA (1996). Mushroom Nutriceuticals. World J. Microbiol.

Biotechnol., 12: 473-476.

[252] Oso BA (1997). *Pleurotus tuber-regium* from Nigeria. *Mycologia* 69: 271-279.

[253] Fasidi IA, Olorunmaiye KS (1994). Studies on the requirements for vegetative growth

of *Pleurotus tuber regium* (Fr) Singer. Mushroom Food Chem., 50: 397-401.

[254] Bobek P, Ozdin L, Kuniak L (1996). Effect of oyster mushroom (*Pleurotus ostreatus*) and

its ethanolic extract in diet on absorption and turnover of cholesterol in

hypercholesterolemic rat. Nahrung, 40: 222-224.

[255] Delena T (1999*).* Edible and useful plants of Texas and South west –A practical guide

university of Texas press, pp. 542.

[256] Sadler M (2003). Nutritional properties of edible fungi. Br. Nutr. Found. Nutr. Bull. 28:

305-308.

[257] Chandalia M, Garg A, Lutjohann D, von Bergmann K, Grundy SM, Brinkley LJ (2000).

Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. N.

Eng. J. Med., 342:1392-1398

[258] Wasser SP (2005). Reishi or Lingzhi (*Ganoderma lucidum*). Encyclopedia of Dietary

Supplements, Marcel Dekker, Germany, pp. 603-622.

[259] Oyetayo VO, Oyetayo FL (2005). Preliminary investigation of health promoting

potentials of *Lactobacillus fermentum* OVL and *Plerotus sajor caju* administered to rats.

Pakistan J. Nutr., 4: 73-77.

[260] Sharma TK (2008). Vegetable caterpillar, Science Reporter. 5th May ISBN 0036-8512.

National institute of science communication and information resources (NISCAIR),

CSIR, pp. 33-35.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 247

[261] Mau, J. L., Tsai, S. Y., Tseng, Y. H., & Huang, S. J. (2005). Antioxidant properties of hot

water extracts from Ganoderma tsugae Murrill. LWT Food Science and Technology, 38,

589-597.

[262] Mau CN, Huang SJ, Chen CC (2004). Antioxidant properties of methanolic extract

from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus* mycelia. Food

Chem., 87: 111-118.

[263] Lakshmi, B., Tilak, J.C., Adhikari, S., Devasagayam, T.P.A., Janardhanan, K.K. (2004).

Evaluation of antioxidant activity of selected Indian mushrooms. Pharmaceutical Biol.,

42, 179-185.

[264] Russell R, Paterson M (2006). *Ganoderma* – A therapeutic fungal factory

Phytochemistry. J. Phytochem., 67: 1985-2001

[265] Khatun, S., Bandopadhyay, S., Mitra, S., Roy, P., Chaudhuri, S.K., Dasgupta, A.,

Chattopadhyay, N.C. (2009). Nutraceutical and antioxidative properties of three species

of *Pleurotus* mushrooms. Proc. 5th Int. Medicinal Mushroom Conference, Mycological

Society of China, Nantong, China. pp. 234-241.

[266] Jones, S., Janardhanan, K.K. (2000). Antioxidant and antitumor activity of *Ganoderma*

*lucidum* (Cart. Fr.) P.Karst.-Reishi (Aphyllophoromycetidae) from South India. Int. J.

Med. Mushroom, 2, 195-200

[267] Singh, R.P., Mishra, K.K., Singh, M. (2006). Biodiversity and utilization of medicinal

mushrooms. J. Mycol. Pl. Pathol., 3, 446-448.

[268] Laganathan, K.J., Gunasundari, D., Hemalatha, M., Shenbhagaraman, R., Kaviyarasan,

V. (2010). Antioxidant and phytochemical potential of wild edible mushroom

*Termitomyces reticulatus*: Individual cap and stipe collected from South Eastern Part of

India. Int. J. Pharm. Sci., 1(7), 62-72.

[269] Laganathan, K.J., Ramalingam, S., Venkatasubbu, V., Venketesan, K. (2008). Studies on

the phytochemical, antioxidant and antimicrobial properties of three indigenous

*Pleurotus* species. Journal of Molecular Biology & Biotechnology, 1, 20-29.

[270] Ajith, T.A., Janardhanan, K.K. (2003). Cytotoxic and antitumor activities of a polypore

macrofungus *Phellinus rimosus* (Berk) Pilat, J. Ethnopharmacol. 84, 157-162.

[271] Singh, R.P., Pachauri, V., Verma, R.C., Mishra, K.K. (2008). Catepillar fungus

(*Cordyceps sinensis*). A review. J. Eco-Friendly Agric., 3(1), 1-15.

[272] Ajith, T.A., Janardhanan, K.K. (2007). Indian Medicinal Mushrooms as a Source of

Antioxidant and Antitumor Agents. J. Clin. Biochem. Nutr., 40, 157-162.

[273] Sasidharan, S., Aravindran, S., Lachimanan, Y.L., Ratnasamy, V., Saravanan, D.,

Santhanam, A. (2010). *In vitro* antioxidant activity and hepatoprotective effects of

*Lentinula edodes* against paracetamol-induced hepatotoxicity. Molecules., 15, 4478- 4489.

[274] Cheung, L.M., Cheung, P.C.K. (2005). Mushroom extracts with antioxidant activity

against lipid oxidation. Food Chem., 89, 403-409.

[275] Wong, J.Y., Chye, F.Y. (2009). Antioxidant properties of selected tropical wild edible

mushrooms*.* J. Food Compos. Anal., 22, 269-277.

[276] Groopman JD, Kensler TW The light at the end of the tunnel for Chemical specific

biomarkers: daylight or headlight? Carcinogenesis 1999; 20:1-11.

248 Mycotoxin and Food Safety in Developing Countries

[277] Ueng YF, Shimada T, Yamazaki H, Guengerich FP. Oxidation of aflatoxin B1 by

bacteria recombinant human cytochrome P450 enzymes. Chem. Res. Toxicol. 1995;. 8:

218-225.

[278] Wang H, Dick R, Yin H, Licad-Coles E, Kroetz DL, Szklarz G, Harlow G, Halpert JR,

Correia MA . Structure-function relationships of human liver cytochrome P450 3A:

Aflatoxin B1 metabolism as a probe. Biochemistry 1998; 37: 12536-12545

[279] Lilleberg SL, Cabonce MA, Raju NR, Wagner LM, Kier LD. Alterations in the p53

tumor suppressor gene in rat liver tumors induced by afatoxin B1. Prog. Clin. Biol. Res.

1992; 376:203-222.

[280] Aguilar F, Hussdain SP, Cerutti P. Aflatoxin B1 induces the transversion of GT in

codon 249 of the p. 53 tumor suppressor gene in human hepatocytes. Proc. Natl. Acad.

Sci. USA. 1993; 90: 8586-8590.

[281] Greenblatt MS, Bennett WP, Hollsten M, Harris CC . Mutations in the p53 tumor

suppressor gene: clues to cancer etiology and molecular pathogenesis. Cancer Res. 1994;

54: 4855-4878.

[282] Lunn RM, Zhang YJ, Wang LY, Chen CJ, Lee PH, Lee CS, Tsai WY, Santella RM. p.53

Mutations, chronic hepatitis B virus infection, and aflatoxin exposure in hepatocellular

carcinoma in Taiwan. Int. J. cancer 1997; 54: 931-934

[283] Al-Anati L, Petzinger E (2006). "Immunotoxic activity of ochratoxin A". *J. Vet.*

*Pharmacol. Ther.*2006; 29 (2): 79–90.

[284] Neal GE, Judah DJ (2000). Genetic implications in the metabolism and toxicity of

mycotoxins. In Molecular Drug Metabolism and Toxicology (eds) Williams GM,

Aruoma OI, OICA Intl.(UK) Limited Lond. pp. 1- 15.

[285] Petkova-Bocharova T, Castegnaro M, Michelon J, Maru V. Ochratoxin A and other

mycotoxin in cereals from an area of Balkan endemic nephropathy and urinary tract

tumors in Bulgaria In Mycotoxins, Endemic Nephropathy and Urinary Tract Tumors

(eds) Castegnaro M, Plestina R, Dirheimer G, Chemozensky IN, Barsch H.1991; 245-253.

IARC Scientific Publications: Lyon.

[286] Sedmikova M, Resinerora H, Dufkova Z, Burta I, Jilek F .Potential harzard of

simulataneous occurrence of aflatoxin B1 and ochratoxin A. Vet Med. 2001; 46:169-174.

[287] D’Mello, J. P. F., and A. M. C. Macdonald. Mycotoxins. Animal Feed Sciences

Technology.1997; 69: 155-166.

[288] Kolb, E. Recent knowledge on the mechanism of action and metabolism of

mycotoxins. Zeitschrift Gesamte Innovation in Medicine. 1984; 39: 353-358.

[289] Boyd, P. A. and Wittliff, J. L. Mechanism of Fusarium mycotoxin action in mammary

gland. Journal of Toxicology Environment of Health. 1978; 4:1-8.

[290] Hagler, W. M. Jr., N. R. Towers, C. J. Mirocha, R. M. Eppley, and W. L. Bryden.

Zearalenone: Mycotoxin or mycoestrogen? In B. A. Summerell, J. F. Leslie, D.

Backhouse, W. L. Bryden and L. W. Burgess (Eds). Fusarium: Paul E. Nelson Memorial

Symposium. APS Press, St. Paul, Minnesota 2001; 321–331.

[291] Ahamed, S. Foster, J. S., Bukovsky, A and Wimalasena, J. Signal transduction through

the ras/ERK pathway is essential for the mycoestrogen zearelenone –induced cell cycle

progression in MCF-7 cells. Molecular carcinogenesis, 2001; 30:88-98.

Antioxidant Properties of Selected African Vegetables, Fruits and Mushrooms: A Review 249

[292] Marasas WF, Riley RT, Hendricks KA, Stevens VL, Sadler TW, Gelineau-van Waes J,

Missmer SA, Cabrera J, Torres O, GelderblomWC, Allegood J, Martinez C,

Maddox.Fumonisins disrupt sphingolipid metabolism, folate transport, and neural tube

development in embryo culture and in vivo: a potential risk factor for human neural

tube defects among populations consuming fumonisin contaminated maize.

J.Nutr.2004; 134 (4):711-716.

[293] Marasas WFO Fumonisins: their implications for human and animal health. Nat.

Toxins. 1995; 3: 193-198.

[294] Tollenson WH, Dooley KL, Sheldon WC, Thurman JD, Bucci TJ, Howard PC. The

mycotoxin fumonisin induces apoptosis in cultured human cells and in livers and

kidneys of rats. In: Jackson LS et al.,(eds) Fumonisins in food, Advances in

Experimental Med. And Biol. Plenum Press, New York. 1996; 237-250.

[295] Howard PC, Eppley RM, Stack ME, Warbritton A, Voss KA, Lorentzen RJ, Kovach

RM, Bucci TJ. Fumonisin b1 carcinogenicity in a two-year feeding study using F344 rats

and B6C3F1 mice. Environ Health Perspect. 2001; 109 (2):277–282.

[296] IPCS. (International Program on Chemical Safety) Environ. Health Criteria 219-

Fumonisin B1 WHO, Geneva. 2000; 1-150.

[297] Stockmann-Juvala H, Mikkola J, Naarala J, Loikkanen J, Elovaara E, Savolainen K.

Fumonisin B1-induced toxicity and oxidative damage in U-118MG glioblastoma cells.

Toxicology 2004; 202(3): 173-83.

[298] Perkowski J, Chelkowski J, Wakulinski W. Deoxynivalenol and 3-acetyldeoxynivalenol

in wheat kernels and chaff with head fusariosis symptoms. Nahr Food.

1990; 34:325–328.

[299] Ijeh II, Obidoa O Effect of dietary incorporation of Vernonia amygdalina Del. on

AFB1-induced hepatotoxicity in weanling albino rats. Jamaican J. Sci. Tech., 2004; 15:

32-36.

[300] Rastogi, Shipra; Shukla, Yogeshwer; Paul, Bhola N.; Chowdhuri, D. Kar; Khanna,

Subhash K.; Das, Mukul. Protective effect *of* Ocimum sanctum on 3*-*

methylcholanthrene*,* 7*,* 12*-*dimethylbenz(a)anthracene and aflatoxin *B1* induced skin

tumorigenesis in mice. Toxicology and Applied Pharmacology 2007; 224(3):228-240.

[301] Karthikeyan K, Gunasekaran P, Ramamurthy N, Govindasamy S. Anticancer activity

of *Ocimum sanctum*, Pharm. Biol., 1999; 37(4):285-290.

[302] Nguyen ML, Schwartz SJ. Lycopene: chemical and biological properties. Food

Technol. 1999; 53: 38-45.

[303] DiMascio P, Kaiser S, Sies H: Lycopene as the most effective biological carotenoid

singlet oxygen quencher. Arch Biochem Biophys 1989; 274: 532–538*.*

[304] Bohm F, Tinkler JH, Truscott TG: Carotenoids protect against cell membrane damage

by the nitrogen dioxide radical. Nature Med 1995;1: 98–99.

[305] 305. Lu Y, Etoh H, Watanabe N: A new carotenoid, hydrogen peroxide oxidation

products from lycopene. Biosci Biotech Biochem 1995;59: 2153–2155.

[306] Mortensen A, Skibsted LH: Relative stability of carotenoid radical cations and

homologue tocopheroxyl radicals. A real time kinetic study of antioxidant hierarchy.

FEBS Lett1997; 417: 261–266.

250 Mycotoxin and Food Safety in Developing Countries

[307] Hsiao G, Fong TH, Tzu NH, Lin KH, Chou DS, Sheu JR . A potent antioxidant,

lycopene, affords neuroprotection against microglia activation and focal cerebral

ischemia in rats. In Vivo 2004; 18(3):351-6.

[308] Wertz K, Siler U, Goralczyk R. Lycopene: modes of action to promote prostate

health.Arch Biochem Biophys. 2004; 430(1):127-34.

[309] Kim GY, Kim JH, Ahn SC, Lee HJ, Moon DO, Lee CM, Park YM. Lycopene suppresses

the lipopoly-saccharide-induced phenotypic and functional maturation of murine

dendritic cells through inhibition of mitogen-activated protein kinases and nuclear

factor-kappaB. Immunology 2004; 113(2): 203-11.

[310] Q.A. Nogaim, H.A.S. Amra and S.A. Nada. The Medical Effects of Edible Mushroom

Extract on Aflatoxin B1. Journal of Biological Sciences, 2011; 11: 481-486.