COMPARATIVE STUDIES ON THE PROXIMATE COMPOSITIONS, MINERALS AND ANTI-NUTRITIONAL FACTORS IN THE LEAVES AND STEM OF *Grewia carpinifolia*

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Abstract
The leaves and stem of Grewia carpinifolia were evaluated for their nutritional and anti-nutritional composition. The results showed that the leaves had significantly higher (p<0.05) crude protein (18.7±0.06%), crude fat (5.19±0.02%), ash (9.92±0.03%) and gross energy (3.32±0.01Kcal/g) than the stem having crude protein (6.90±0.03%), crude fat (1.06±0.02%), ash (2.55±0.02%) and gross energy (1.67±0.01Kcal/g), while the stem had significantly higher (p<0.05) crude fibre (25.7±0.02%) and moisture (8.40±0.01%) compared to the leaves having crude fibre (16.10±0.02%) and moisture (6.32±0.48%). The leaves recorded significantly higher values (p<0.05) for all the minerals analysed, Ca (0.26± 0.01%), Mg (0.49±0.01%), K (0.92±0.01%), P (0.42±0.00ppm), Na (0.20±0.01ppm), Se (0.0083±0.00mg/kg), Fe (192.00±0.02mg/kg), Cu (4.91±0.02) and Zn (62.10±0.02mg/kg) as against the stem. For the antinutritional factors, the leaves showed significantly higher (p<0.05) concentrations of trypsin inhibitor (3.91±0.03TIU/mg), chymotrypsin inhibitor (8.42±0.03CU/mg), haemagglutinin (25.20±0.02HU/mg), oxalate (0.95±0.01%), phytate (1.29±0.02%), tannin (0.07±0.00), flavonoids (0.004±0.00%) and phenols (0.12±0.00%), while the stem recorded significantly higher (p<0.05) levels of saponin (0.57±0.00%), alkaloids (2.33±0.01%) and glycosides (0.24±0.00%). The study concluded that the leaves of Grewia carpinifolia had generally higher nutritional quality compared to the stem due to significantly higher crude protein, crude fat, ash, gross energy and mineral contents. However, there is the need to conduct research on the in vitro digestibility and toxicity assessment of G. carpinifolia, so as to standardize and maximize its nutritional potentials. G. carpinifolia could be a rich source of proteins if its antinutritional factors are adequately processed to reduce or eliminate them.

Keywords: *Grewia carpinifolia,* proximate analysis, minerals, anti-nutritional contents

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1.INTRODUCTION

*Grewia carpinifolia*Juss is a large flowering treewith stellate branches. The leaves are alternate; stipule minute, caduceus, petiole short the leaves margin are serrated or rarely lobed (Obidah *et al.* 2010). The leaves are used in the treatment of cutaneous and subcutaneous parasitic infection, viral infections (small-pox, chicken-pox and measles), venereal diseases, GIT disorders and also as analgesics (Obidah *et al.* 2010). In northwest Nigeria, *Grewia carpinifolia*stem is commonly used in treatment of dropsy, swellings, oedema and the flower is eaten as food (Goyal, 2012).
There is shortage of good and quality protein to meet the requirements of the ever increasing human and animal population and this has necessitated the search for additional protein sources (Singh *et al*. 2014). In Africa little information is available on the underutilized and unexploited plant resources, which are used in food system or in traditional medicine in the cure different diseases (Bienvenu *et al*. 2014). *G. carpinifolia* can be regarded as a lesser known and underexploited plant in Africa. In literature, there is very little information on the nutritional composition and anti-nutritional factors present in *G. carpinifolia* despite its numerous uses. This study was therefore carried as to provide this information.

2. MATERIAL AND METHODS

2.1 Collection and Preparation of Plant Materials

Fresh leaves and stem of *G. carpinifolia* were collected from the Botanical Garden,

University of Ibadan, Oyo State, Nigeria. The samples were identified and authenticated at the herbarium of the Forestry Research Institute of Nigeria (FRIN), Nigeria, where herbarium specimen (voucher number FHI 109693) was deposited.
The leaves and stem were air-dried under shade and ground using a mechanical blender into fine powder.

2.2 Determination of Proximate Analysis
The proximate analysis of the air-dried leaves and stem was determined by methods already described in literature (AOAC, 1999). These included the determination of crude protein, crude fat, crudefibre, ash, gross energy, moisture content, dry matter and the nitrogen free extract.

2.3 Analyses of the Mineral elements
The minerals analysed were sodium, potassium, magnesium, calcium, phosphorus, copper, zinc, iron and selenium. The sodium and potassium contents were determined by flamephotometry (Jenway Limited, Donmow Essex, UK) and phosphorus was determinedby the vanado- molybdate method (AOAC, 1995). Calcium, magnesium, iron, selenium, copper and zinc were determined after wet digestion with a mixture of nitric,sulphuric andperchloric acid using atomic absorption spectrophotometer (Buck Scientific,EastNorwalk, CT, USA).

2.4 Quantification of the Anti-nutritional Factors
Trypsin inhibitor activity of the samples was done based on the method of Liener (1979). Hemagglutinin levels were determined according to the method of Jaffe (1979). Phytates were analysed by the method of Maga (1983). Tannins were according to the method of Dawra *et al* (1988), while saponin levels were done based on the method of Brunner (1984). Total oxalates were quantitated according to the procedure of Fasset (1996). A complete detail of the methodology are reported in Soetan, (2012).

2.5 Statistical Analysis
The analyses were done in triplicates. The data obtained were expressed as mean ± standard error of the means (mean ± SEM). Significant differences were determined by the student t-test with Welch's correction (Bailey, 1992). The value of $p \leq 0.05$ was regarded as significant for statistical comparison in all cases. GraphPad Prism (Version 5.0, San Diego, CA) was the statistical package used.

3. RESULTS AND DISCUTION

The proximate composition of the leaves and stem of *G. carpinifolia*is presented in Table 1. The leaves of the plant had significantly higher ($p<0.05$) contents of crude protein, crude fat, ash and gross energy compared to the stem, while the moisture content of the samples were not significantly different.
The mineral composition of the leaves indicates that the leaves had significantly higher contents of all the minerals determined; Na, K, Mg, Ca, P, Cu, Zn, Fe and Se (Table 2).
The results of the anti-nutritional factors are presented in Table 3. There were significant differences between the leaves and the stem of *Grewia carpinifolia* antinutritional factors.

Table 1: Proximate composition of the leaves and stem of *Grewia carpinifolia*

Parameters	Leaves	Stem
Crude protein (%)	18.7±0.06	6.90±0.03*
Crude Fat(%)	5.19±0.02	1.06±0.02*
Crude Fibre (%)	16.10±0.02	25.7±0.02*
Ash (%)	9.92±0.03	2.55±0.02*
Moisture(%)	6.32±0.48	8.40±0.01
Gross Energy (Kcal/g)	3.32±0.01	1.67±0.01*

Results are shown as mean±standard error of mean. *indicates significant difference in means at $p<0.05$.

Table 2: Mineral composition of the leaves and stem of *Grewia carpinifolia*

Parameter	Leaves	Stem
%Ca	0.26±0.01	0.07±0.00*
%Mg	0.49±0.01	0.21±0.01*
%K	0.92±0.01	0.12±0.01*
P	0.42±0.00	0.19±0.00*
Na	0.20±0.01	0.03±0.01*
Se (mg/kg)	0.0083±0.00	0.0005±0.00*
Fe(mg/kg)	192.00±0.02	23.50±0.03*
Cu(mg/kg)	4.91±0.02	1.30±0.10*
Zn(mg/kg)	62.10±0.02	13.70±0.03*

Results are shown as mean±standard error of mean. *indicates significant difference in means at p<0.05.

The results of this study show that the leaves of *Grewia carpinifolia* had significantly higher (p<0.05) levels of crude protein (18.7±0.06%), crude fat (5.19±0.02%), ash (9.92±0.03%) and gross energy (3.32±0.01Kcal/g) than the stem having crude protein (6.90±0.03%), crude fat (1.06±0.02%), ash (2.55±0.02%) and gross energy (1.67±0.01Kcal/g). This shows that the leaves of *Grewia carpinifolia* is a potential source of protein, which could meet up with the shortage of supply of good quality protein to meet the requirements of the ever increasing human and animal population. This is in agreement with Singh *et al*. (2014) that leaf protein concentrates (LPC), which are concentrated forms of proteins isolated from plant foliage, are an inexpensive and very abundant sources of available protein and that their protein value equals that of most animal products. Much of the population of the developing countries exist under low standard conditions,and they feed on nutritionally inadequate diets (Maforah, 1994).

The food supplies are not enough to meet up with the high demand caused by the ever increasing population and this widening gap between food supply and demand can be addressed by increasing the food production and by supplementing the existing food resources with novel foodstuffs (Brunger, 2007). Leaf meals could be a potential source of proteins in developing countries.

The production of food protein from tree leaves seem to have a unique advantage as they do not involve recurring cost of cultivation (Tangka, 2003). The stem of *G. Carpinifolia* had significantly (p<0.05) crude fibre (25.7±0.02%) compared to the leaves having crude fibre of (16.10±0.02%). This shows that the stem of *G. Carpinifolia* is very rich in fibre and this could be used in the management of some chronic diseases, whose risk exposure are reduced by intake of high fibre diets.

Typical health benefits which are now believed to be associated with an increased intake of dietary fibre includes weight loss, protection against some types of chronic diseases like cancer, decrease in blood cholesterol levels, reduced insulin requirements for diabetes and blood-pressure regulation, reducing the risks of many disorders such as cardiovascular diseases, intestinal constipation, diverticulosis and obesity (Hung *et al*. 2003; Theuwissen and Mensink, 2008).

The medical importance of dietary fibre have been reviewed by Soetan and Olaiya, (2013). However, there is a need to balance the high level of crude fibre in the stem of this plant regarding diets of infants and weaning children. Bello *et al*. (2008) reported the need to keep fibre intake low in the diet of weaning children and infants because high fibre diet can cause gut mucosa irritation in weaning children. It also stimulates gut perturbation in piglets and chickens (Eromosele and Eromosele, 1991).

The stem of *G. carpinifolia* had low levels of crude fat, which means that it could be recommended as a diet for reducing weight, because low fat foods decreases cholesterol levels and reduces development of obeisity (Gordon and Kessel, 2002).

Table 3: Levels of some anti-nutritional factors in the leaves and stem of *Grewia carpinifolia*

Parameter	Leaves	Stem
Trypsin Inhibitor (TIU/mg)	3.91±0.03	0.12±0.01*
Chymotrypin inhibitor (CU/mg)	8.42±0.03	1.04±0.02*
Hemagglutinin (HU/mg)	25.20±0.02	3.25±0.02*
Oxalate (%)	0.95±0.01	0.42±0.00*
Phytate (%)	1.29±0.02	0.68±0.00*
Tannin (%)	0.07±0.00	0.01±0.00*
Saponin (%)	0.382±0.00	0.57±0.00*
Alkaloids (%)	1.51±0.03	2.33±0.01*
Flavonoids (%)	0.004±0.00	0.001±0.00*
Cyanogenic glycosides (%)	0.12±0.00	0.24±0.00*
Phenol (%)	0.12±0.00	0.02±0.00*

Results are shown as mean±Standard error of mean *indicates significant difference in means at $p<0.05$

The high ash content recorded for the leaves of *G. carpinifolia* is an insight that the leaves contained appreciable levels of nutritionally important minerals. The leaves of *G. carpinifolia* has appreciable levels of all the minerals analysed Ca (0.26± 0.01%), P (0.42±0.00ppm), Mg (0.49±0.01%), K (0.92±0.01%), Na (0.20±0.01ppm), Se (0.0083±0.00mg/kg), Fe (192.00±0.02mg/kg), Cu (4.91±0.02) and Zn (62.10±0.02mg/kg) and they were all significantly higher ($p<0.05$) than the minerals in the stem.

Minerals are inorganic substances found in all body tissues and fluids and they are important for the maintenance of some physicochemical processes which are essential to life . They are chemical substances utilized by the body in several ways and they play crucial roles in the nutrition of humans and animlas. (Rahman *et al*. 2014).

Every form of biological systems need inorganic elements or minerals for their normal life processes (Ozcan, 2003; Al-Groom *et al*. 2013). The metals also play important roles as structural and functional components of metalloproteins in living cells (Ansari *et al*., 2004).

For example, calcium and phosphorus are needed by children, pregnant and lactating humans and animals for development of bones and teeth (Margarat and Vickery, 1997), magnesium relaxes the muscles along the lung airways and plays important roles in some reactions involving phosphate transfer, which is required for the structural stability of nucleic acid and intestinal absorption (Appel, 1999). Magnesium also assists the activity of the immune system and it is involved in cell energy production and reproduction (Anhwange *et al*. 2004).

Potassium increases the utilization of iron in the body (Adeyeye, 2002), it is used for the management of hypertension (Arinathan *et al*. 2003). On the other hand, potassium activates nitric oxide, thus reducing pressure in the arteries, lowering the risk of hypertension (Brody, 2011). A high concentration of sodium in the diet raises the blood pressure and causes the risk of chronic hypertension through stiffening of arteries. Hypertension contributes to heart disease and stroke and these are the leading causes of death (Ossai, 2015). The adverse effect of intake of high sodium diet has been severally reported.

Selenium in addition to other trace elements like magnesium, zinc, chromium and manganese play a vital role in the action of insulin, including the activation of receptor sites (Esfahani *et al*., 2011), they also serve as cofactors or components of enzyme systems involved in glucose metabolism (Murray *et al*., 2000), increasing insulin sensitivity and acting as antioxidants in the prevention of tissue peroxidation.

Iron is required by pregnant humans and animals, nursing mothers, infants and the

elderly and it is very important in the prevention of anaemia and other associated diseases (Oluyemi *et al*. 2006).
Copper is an important mineral in the body as it is required in the utilization of iron during haemopoiesis. Copper is also involved in the metabolism of many key enzymes like cytochrome oxidase of the mitochondrial electron transport and cytosolic superoxide dismutase (Adewumi *et al*. 2007; Soetan *et al*. 2010).
Zinc is important for nucleic acid and protein synthesis and it is required for normal development of the body and during recovery from illness (Melaku *et al*. 2005). Zn is also responsible for several enzymatic processes and it is involved in wound healing, activities of genetic materials, proteins, immune reactions, development of the fetus and sperm production (Rahman *et al*. 2014). A review of the role of mineral elements abound in literature and have been reviewed by Soetan *et al*. (2010).
For the antinutritional factors, the leaves showed significantly higher ($p<0.05$) concentrations of trypsin inhibitor (3.91 ± 0.03U/mg), chymotrypsin (8.42 ± 0.03cy/mg), haemagglutinin (25.20 ± 0.02HU/mg), oxalate ($0.95\pm0.01\%$), phytate ($1.29\pm0.02\%$), tannin (0.07 ± 0.00), flavonoids ($0.004\pm0.00\%$) and phenols ($0.12\pm0.00\%$), while the stem recorded significantly higher ($p<0.05$) levels of saponin ($0.57\pm0.00\%$), alkaloids ($2.33\pm0.01\%$) and glycosides ($0.24\pm0.00\%$). However, the antinutritional factors recorded for the leaves and stem of *G. carpinifolia* in this study were within acceptable limits and were below toxic levels.
Antinutritional factors (ANFs) are substances naturally present in plants used as human foods and animal feeds. ANFs are present in almost every plant used as human foods and animal feeds (D'Mello, 2000; Soetan and Oyewole, 2009).
Through various mechanisms, these ANFs produce adverse effects on optimal utilization of nutrients (Akande *et al*. 2010). Classification of a substance as an ANF depends on the digestive capability of the animal ingesting the ANF (Akande *et al*. 2010). For instance, trypsin inhibitor is an antinutritional factor for monogastrics but they are not ANF for ruminants and so does not exert adverse effect on ruminants since trypsin inhibitors are degraded in the rumen (Cheeke and Shull, 1985).
At certain levels, some antinutritional factors have benefit to the body and are called phytochemicals. Phytochemicals are biologically active compounds of plants which have no established nutrients but are useful in the protection of the body against diseases (Ajayi *et al*. 2011). For example, tannins are important for wound healing, control of diarrhoea and prevention of hyperlipidaemia (Vivienne *et al*. 2014). Low levels of saponins promote health. They can reduce the uptake of glucose and cholesterol in the gastrointestinal tract through intra-lumenal physicochemical interaction (Ali, 2012). Saponins also have immune modulation, anti-carcinogenic and regulates tumour cell proliferation (Siegler, 1998). They form insoluble complexes with cholesterol and bile and make them unavailable for absorption (Oakenfull and Sidhu, 1990).
The pharmacological and other beneficial effects of antinutritional factors in plants have been reviewed by (Soetan, 2008).
Akande *et al*. (2010) reported that the major anti-nutrients commonly found in plants are saponins, tannins, oxalates, lectins (phytohaemagglutinins), cyanogenic glycosides, protease inhibitors, phytic acid, amylase inhibitors, chlorogenic acid, gossypol, toxic amino acids and goitrogens.
The *G. carpinifolia* leaves recorded significantly higher ($p<0.05$) trypsin inhibitor concentration of 3.91 ± 0.03U/mg as against the stem (0.12 ± 0.01 U/mg). Trypsin inhibitors are polypeptides and they form well characterized stable complexes with trypsin and this leads to obstruction of enzymatic action (Carlini and Udedibie, 1997).
They have growth-retarding property through inhibition of protein digestion (Akande *et al*. 2010) and McDonald *et al*. (1995) reported that pancreatic hyperactivity, leading to increased

trypsin and chymotrypsin production, which consequently results in loss of cystine and methionine is involved. Trypsin inhibitors reduce protein digestibility and cause pancreatic hypertrophy (Liener, 1976). The leaves also recorded significantly higher ($p<0.05$) chymotrypsin inhibitor (8.42±0.03CU/mg) compared to the stem (1.04±0.02CU/mg).

Haemagglutinins level of the leaves was 25.20±0.02HU/mg compared to the stem (3.25±0.02HU/mg).

Lectins (phytohaemagglutinins) can bind with carbohydrate membrane receptors (Pusztai, 1989). Lectins have several *in vivo* effects and when consumed in excessive amounts by susceptible individuals, they can cause severe intestinal damage, which disrupts food digestion, leading to nutrient deficiencies (Hamid and Masood, 2009). Lectins can also interact with enterocytes and interfere with the absorption and transportation of nutrients (especially carbohydrates) during digestion, causing intestinal epithelial lesions (Oliveira *et al*. 1989).

The oxalate concentration of the leaves was (0.95±0.01%) while that of the stem was (0.42±0.00%). Oxalates exert biochemical and physiological effects among whom are interference with calcium and magnesium metabolism and they react with proteins to form complexes which inhibits peptic digestion (Akande *et al*. 2010). However, oxalates do not usually have adverse effects on ruminants as a result of microbial decomposition of oxalates in the rumen (Oke, 1969).

Oxalic acid binds calcium and forms calcium oxalate which is insoluble and calcium oxalate adversely affects the absorption and utilization of calcium in the animal body (Olomu, 1995). The presence of oxalate in food also causes irritation in the mouth (Onyeike and Omubo-Dede, 2002).

The leaves of *G. carpinifolia* recorded significantly higher levels ($p<0.05$) of phytate (1.29±0.02%) relative to the stem (0.68±0.00%).

Phytic acids are found in abundance in the plant kingdom (Akande *et al*. 2010). Phytic acid could accumulate in storage sites in seeds and chelate other minerals, thereby forming complex salt phytate (Erdman, 1979). They chelate metal ions like calcium, copper, iron, magnesium, molybdenum and zinc, forming insoluble complexes that are poorly absorbed from the gastrointestinal tract and this can result in mineral deficiencies (Khare, 2000; Bello *et al*. 2008) and they also reduce bioavailability of zinc in human nutrition (Erdman, 1979).

Phytic acid forms protein and mineral-phytic acid complexes, leading to decreased bioavailability of protein and minerals (Khare, 2000). They also reduce the activity of gastrointestinal amylase, lipase, trypsin, pepsin and tyrosinase (Hendricks and Bailey, 1989; Khare, 2000).

The leaves of *G. carpinifolia* showed significantly higher levels ($p<0.05$) of tannin (0.07±0.00%) relative to the stem (0.01±0.00%). Tannins are water soluble phenolic compounds and they occur as hydrolysable tannins and condensed tannins (Akande *et al*. 2010). Tannins form complexes with dietary proteins and may bind and inhibit activities of endogenous proteins like digestive enzymes (Kumar and Singh, 1984).

Tannins interfere with protein digestion by causing anti-amylase and anti-trypsin activity. Tannins can also complex with vitamin B_{12} (Liener, 1980), can cause damage to the intestines, interfere with iron absorption and could also cause carcinogenic effect (Butler, 1989).

The stem of *G. carpinifolia* recorded saponin concentration of (0.57±0.00%) as against the leaves (0.38±0.00%) Saponins are bioactive compounds, which are mainly produced from plants, but are also produced by some marine organisms and plants (Thakur *et al*. 2011). They generally occur in form of steroid glycosides or polycyclic triterpenes (Kensil, 1996).

They exert adverse effects on animal metabolism and performance in several ways viz; reduction of nutrient absorption, reduction of growth rate, haemolysis of red blood cells, inhibition of smooth muscle activity, bloat in ruminants, inhibition of enzyme activities (Cheeke, 1971), alteration of cell wall permeability (Belmar *et al*. 1999) and reduction of nutrient absorption from the intestinal wall (Johnson *et al*. 1986).

In chicks, saponins reduce feed efficiency, inhibit growth and interfere with absorption of bile acids, cholesterol, dietary lipids and vitamins A and E (Jenkins and Atwal, 1994).

Saponins are also reported to have some pharmacological actions, among whom are application as vaccine adjuvants (Setzer and Setzer, 2003; Fuchs *et al*. 2009; Sun *et al*. 2009), reduction of serum cholesterol levels (Francis *et al*. 2002), abortifacient properties due to stimulation of release of luteinizing hormone (Francis *et al*. 2002), immunomodulatory actions (Sun *et al*. 2009), cytostatic and cytotoxic effects on malignant tumour cells (Bachran *et al*. 2008a), immunostimulatory effects (Sjolander *et al*. 1998) and synergistic enhancer of toxicity of immunotoxins (Heisler *et al*. 2005; Bachran *et al*. 2008b). Literature abounds with various pharmacological properties of saponins (Thakur *et al*. 2011; Soetan *et al*. 2014).

The alkaloids level of the stem of *G. carpinifolia* was 2.33$\pm$0.01% while that of the leaves was 1.51$\pm$0.03%. Alkaloids are a diverse class of allelochemicals, some of which have important dietary importance (Mulvihill, 1972), and some of them are teratogenic which can alter normal foetal development leading to foetal malformation if ingested by ewes.

Some other adverse effects of alkaloids are gastrointestinal upset and neurological disorders, especially when consumed in high doses (Osagie, 1998). Alkaloids are powerful pain relievers and they exert anti-pyretic action,stimulating, anesthetic action (Edeoga and Enata, 2001) and they have inhibitory activity against most bacteria (Al-Bayati and Sulaiman, 2008).

The leaves of *G. carpinifolia* recorded chymotrypsin inhibitor concentration of 8.42$\pm$0.03% while the stem recorded 1.04$\pm$0.02%. The chymotrypsin inhibitors have high proportion of cystine residues in their structure and are capable of inhibiting trypsin and chymotrypsin at independent binding sites (Liener and Kakade, 1980), but they posses a specificity directly primarily at chymotrypsin.

The flavonoid level of the leaves was 0.004$\pm$0.00% while that of the stem was 0.001$\pm$0.00%. Flavonoids arereported to possess antibacterial, anti-inflammatory, anti-allergic, antiviral and anti-neoplastic activities (Ali, 2009). They act as antioxidants which neutralize free radicals contributing to many health problems, including cancer, heart disease and aging (Stauth, 2007).

The stem of *G. carpinifolia* showed level of cyanogenic glycosides to be (0.24$\pm$0.00%) compared to the leaves (0.12$\pm$0.00%). Cyanogenic glycosides liberate hydrogen cyanide (HCN) from enzyme action (Purseglove, 1991) and HCN is very toxic to animals, even at low concentrations. They can cause cardiac arrest, respiratory failure and CNS dysfunction (D'Mello, 2000). Consumption of excessive amount of cyanide is associated with a neurological disease called Tropical Ataxis Neuropathy (TAN), which is linked with intake of high level of cyanide in cassava-based diet (Hassan and Umar, 2004).

The phenol level of the leaves was 0.12$\pm$0.00% while that of the stem was 0.02$\pm$0.00%. Phenols are known to have antimicrobial activity and they could be used in the treatment of skin diseases (Hussain *et al*., 2011) and they are also known to serve as antioxidants, mainly because of their redox properties.

They can also act as reducing agents, hydrogen donors and as a singlet oxygen quenchers and they have a metal chelation potential (Basile *et al*., 2005).

The phenols and other phenolic compounds in food crops are now receiving scientific attention due to their influence on the nutritional and sensory qualities of foods (Osagie, 1998). Some of the adverse changes that are seen during the post-harvest storage and processing of root and tuber crops of tropical origin are reported to be associated with the enzymatic browning reactions of phenolic substances (Osagie, 1998).

4. CONCLUSIONS

It is concluded that *G. carpinifolia* is rich in nutritional components and it has anti-nutritional factors, also known as phytochemicals, which could be exploited for medicinal purposes. This report is one of the few information on the nutritional and anti-nutritional components of the leaves and stem of *Grewia carpinifolia*, a lesser known and under-utilized plant in Africa. More research is required on the effects of different processing methods on the anti-nutritional factors of *G. carpinifolia*.

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