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Telfairia occidentalis: A blood booster, an antioxidant and an antihyperglycaemic agent

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Abstract
Telfairia occidentalis (Hook F) (Fluted pumpkin) is an underutilized twining herb with dark-green leaves grown for its edible leaves and seeds. It is found in tropical regions especially in West and Central Africa. The seeds and leaves are used as food and in ethnomedicine but their compositional and medicinal contributions to human health are not yet well researched and well documented. The purpose of this review paper is to present available information on the nutritional quality and health benefits of *Telfairia occidentalis* leaves and its seeds highlighting the gaps in knowledge that require further research input. Knowledge about the nutrient composition of the leaves and seeds are available in literature. Significant research attention has been given to the haemoglobin boosting, antihyperglycaemic, and antioxidant properties of *T. occidentalis* leaves. The constituent phytochemicals require more research attention to elucidate the structural components and relate them to nutrition and their biological activities. The emerging health benefits and grey areas such as anti-sickling, anti-inflammatory, analgesics properties and spermatogenesis boosting properties/testicular damage require more research input. The paper also documents other potential uses of *T.occidentalis* to optimize its benefits as a source of nutrient and as a medicinal food.

Keywords: *Telfairia occidentalis*, leaves, seeds, roots, nutrient composition, blood boosting properties, anti-hyperglycaemic activity, antioxidant property

Introduction

Telfairia occidentalis belongs to the family Jollificeae and the sub-family Curcubitaceae. *T. occidentalis* Hook F. (Cucurbitaceae) is a drought resistant dioecious herb cultivated for its edible leaf and seeds in West and Central Africa. It is propagated using seeds. This leafy vegetable contains high amounts of fat (18%) vitamins and minerals (20%); proteins (29%) and phytochemicals (Akanbi *et al*., 2007) [6]. The leaves are rich in phosphorus, zinc, calcium, copper, and iron (Akanbi *et al*., 2007) [6]. Oyewole and Abakala, 2012) [40] observed the presence of alkaloids, tannins, phenols and saponins in *T. occidentalis*. The seeds are also rich in nutrients. It is a medicinal plant which contains substances that can be used for the synthesis of drugs (WHO, 2015). Several beneficial health effects have been attributed fluted pumpkin leaves (*Telfairia occidentalis*). The present review paper comprehensively documents the nutritional quality and beneficial effects of *T. occidentalis* as a blood booster; an antioxidant and an anti-diabetic herb for the management of type 2 diabetes. It also presents emerging medicinal effects of this plant product (such as its anti-sickling and anti-cancer properties).

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Fig 1: *Telfairia occidentalis* (a) leaves (b) seeds (c) pod

Methodology

Searches were made and relevant information obtained from online resources such as Google Scholar, PubMed, Medline and Web of Science data bases. Only recent and very important literature containing information on the nutritional and medicinal properties of *Telfairia occidentalis* was used for the review paper.

Ethnobotanical uses of T. occidentalis

T. occidentalis belongs to the Curucubitae family and is indigenous to the West Africa rain forest zone (longitude 7°–8° E and latitude 5°–6° N). It is a drought tolerant perennial tropical vine, grown for its green leafy vegetables, succulent shoots and edible seeds (Akanbi *et al*., 2007; Arowosegbe *et al*., 2015) [6, 8]. The common names are fluted pumkin, fluted gourd, ugu (Igbo language), ikong-ubong (Efik and Ibibio), *T. occidentalis* is used in traditional settings as blood tonic. The herbal preparation of this underutilized plant is used for the treatment of anaemia and diabetes in Nigeria (Badifu, 1993) [11]. It may be mixed with malted drink or milk and drunk as measure to quickly boost the level of blood. There is no dedicated specific report on the ethnobotanical uses of *Telfairia occidentalis*. The scientific awareness about this valuable vine is increasing nonetheless.

Composition of Telfairia occidentalis Leaves and Seeds

The leaves of *T. occidentalis* are rich in protein, calcium, phosphorus and iron as well as phytochemicals such as phenols and flavonoids. The amino acid profile of the leaf protein concentrate is better than FAO recommended standards except for aspartic acid. The female plant which bears the fruit is richer than the male counterpart in minerals and protein. The seeds of *T. occidentalis* (which are used for the propagation of this plant) are also rich in protein and contain significant amounts of fat (up to 45%). The fat contains 61% unsaturated fatty acids. Palmitic, stearic, oleic and linoleic acids stand out as the four main fatty acid constituents of *T.occidentalis* seeds.

Table 1: Composition of *Telferia occidentalis* male and female leaves.

Parameter	Male leaf	Female leaf
Proximate		
Moisture content (%)	12.52	11.74
Ash	6.02	8.02
Crude fibre	8.18	9.22
Crude protein	12.00	16.00
Crude fat	5.25	5.20
Minerals		
Calcium	7.593-7.626	8.43-8.46
Sodium	4.50-4.51	3.25-3.30
Magnesium	2.89-2.90	2.94-2.95
Manganese	2.28	2.54-2.55
Zinc	0.42	0.33
Iron	0.93-0.95	1.01-1.03
Lead	0.001	0.001
Copper	0.81	2.26-2.29
Vitamins		
B_1	0.61-0.63	0.62-0.64
B_2	0.12-0.63	0.62-0.64
B_3	0.16-0.17	0.52-0.53
B_6	0.41-0.42	0.38-0.40
B_{12}	0.52-0.53	0.51-0.52
C	12.33-12.35	14.20-14.22
Phytochemicals		
Alkaloids	0.12	0.11
Flavonoids	2,87	3.13
Cardiac glycosides	0.02	0.04
Saponin	0.08	1.12
Phenol	7.45	9.46
Tannin	0.86	0.87

Orole *et al.* (2020) [39].

Female plants have broad leaves, bigger stem and produce fruits. Male plants have smaller leaves, tinier stems and produce only flowers. The female leaf is richer in ash, crude fibre, crude protein, calcium, manganese, iron and copper, flavonoids, saponin and phenols than the male leaf. *T. occidentalis* leaves contains 5.25% fat and 37.7mg/g lipids (Teugwa *et al*., 2013) [46]. *T. occidentalis* leaves contains phospholipids (58%), glyco-lipids and neutral lipids. Long chain fatty acids were found in the fat from the leaves (Eseyin *et al*., 2014) [16]. The

phosphatidyl choline content of the lipid fraction of *T. occidentalis* leaves (26%) was higher than phosphatidyl ethanolamine (6.5 %), phosphatidyl inositol (4.4%), phosphatidyl serine (5.3 %), lysophosphatidyl choline (14.0%) and phosphatidylglycerine (1.6 %). Glycolipids (26.0 %) were present as well as monogalactosyldiglycerides (11.7 %). The mineral content (K, Cu, Fe, and Mn) of the leaves was also high.

The leaves of *T. occidentalis* are rich in proteins. Values between 12-29% have been reported by different authors (Akanbi *et al*., 2007; Orole *et al*., 2020) [6, 39]. Its protein has a rich amino acid profile and contains significant amounts of glycine, alanine, threonine, cysteine, tryptophan, arginine, aspartate, glutamine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, serine, tyrosine and valine. *T. occidentalis* leaves contain 455.3 mg/g amino acids out of which 256.1 mg/g (56.3%) were essential amino acids. Table 2 shows the amino acid composition of *T.occidentalis* leaves. The leaf protein is mainly made up of the globulin fraction (167.7mg/g) with lower amounts of glutelin (41.67mg/g); albumin (28.00mg/g) and prolamin (9.92mg/g). *T. occidentalis* leaf contains significant quantities of water soluble vitamins (thiamine, riboflavin, nicotinamide and ascorbic acid) (Kayode and Kayode, 2011) [25].

The stem and leaves contain alkaloids, flavonoids, tannins, anthraquinones, steroids and reducing sugars (Okonkon *et al*., 2012). Phytochemical screening of the crude and ethanol extracts by Eyesin *et al*. (2018) showed that *Telferia occidentalis* contains alkaloids, steroids, carbohydrates, flavonoids, and cardiac glycosides in significant amounts. Oladele *et al.* (2020) [38], investigated the bioactive constituents of the aqueous extracts of the leaves. The root contains tannins, reducing sugars, saponins, glycosides, sterols and triterpenoids.

Table 2: Amino acid composition of the leaf protein concentrates of *Telfairia occidentalis* (mg/g crude protein compared with FAO standards

Parameter	*T. occidentalis*	FAO standard
Lysine	26.5	5.7
Histidine	11.2	2.0
Arginine	58.3	-
Aspartic acid	4.1	9.25
Threonine	17.2	3.1
Serine	23.2	3.29
Glutamine	90.8	12.51
Proline	9.2	3.02
Glycine	19.9	3.40
Alanine	33.4	4.02
Cystine	6.4	2.7
Valine	24.8	4.3
Methionine	10.0	2.7
Isoleucine	22.1	3.2
Leucine	53.9	6.6
Tyrosine	12.8	5.2
Phenylalanine	32.2	5.2

(Guthrie, 1989; Adeyeye and Omolayo, 2011) [19, 4].

T. occidentalis leaf protein concentrate is deficient in only aspartic acid when compared with FAO standards for amino acids. Among the 20 amino acids required by humans for protein formation, twelve can be produced within the body, whereas the other eight, (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine must be obtained from the diet). The amino acids (asparagine, glutamine, serine, glycine, alanine, and leucine) are naturally involved in osmolyte synthesis, cell metabolism, ammonia detoxification, antioxidant activity and alkaloid synthesis (Moran-Palacio *et al*., 2014) [29]. A mixture of essential amino acids was found to stimulate the secretion of insulin.

Composition of *Telfairia occidentalis* Seeds.

The proximate composition of *Telfairia occidentalis* seed was reported as follows: Moisture content: 6.30 %; ash - 3.44 %; carbohydrate- (starch- 16.5-62.5; crude protein - 16.0 %. It also contains glucose, fructose, sucrose; sixteen amino acids with glutamic acid (16.4 g/100g) being the highest while lysine (2.6 g/100g) was lowest. Another report showed that the seeds contain 20.5% protein, 4.8% ash, 45% fat; 23% carbohydrates and 2.2% fibre. The dichloromethane fraction of *Telfairia occidentalis* seed (GC-MS analysis) contained pentadecanoic acid; 14-methyl-methyl ester; hexadecanoic acid; octadecanoic acid; octadecanoic acid methyl ester; heptadecanoic acid methyl ester; octadecaoyl chloride; 7,9, octadecanoic acid; 2,3 dihydroxypropyl ester; octadecanoic acid; 2,3 bis (trimethylsily)oxypropyl ester; 9-octadecanoic acid (Z)-2-hydroxy- (hydroxymethyl) ethyl ester. The lipid fraction of the seed contains glycolipid, (26%); phospholipids (58%): and neutral lipids (15%). Fluted pumpkin seed oil contains 61% unsaturated fatty acids. Chemical composition and oil characteristics vary in fluted pumpkin seeds from different origins and varieties (Stevenson *et al*., 2007). The oil extract of *T. occidentalis* seeds was found to contain nine compounds five of which were found in significant amounts (n-Hexdecanoic acid (35.23%), 9, 12, 15-octadecatrienal (12.4%), imidazolidinedione-5-methyl

(10.96%), L-Proline, 5-oxo-methyl ester (9.76%) and 3- (Prop-2-enoyloxy) tetradecane (8.96%). The four fatty acids found in significant quantities are palmitic, stearic, oleic, and linoleic acids (Stevenson *et al*., 2007). *T.occidentalis* seeds are therefore good sources of protein and fat; fibre, saponins, tannins and phenolic acid. They are also good sources of potassium, phosphorus and magnesium, while they contain moderate amounts of other minerals (calcium, sodium, manganese, iron, zinc, and copper). This implies that the carefully processed seed can be used as a food supplement.

Blood Boosting Properties of *T. occidentalis*

Lawal *et al*. (2015) [27] investigated the blood boosting properties of *T. occidentalis* leaves in Wister rats. The increase in the concentration of red blood cells caused by *Telfairia occidentalis* leaf extract became statistically significant ($p<0.05$) after 7 days of administration. Several constituents of *T. occidentalis* are required for the production of red blood cells. The amino acids in *T. occidentalis* leaves are used for the synthesis of the four globin components of the haemoglobin molecule. The vitamins and minerals are required for the synthesis of the other components of the haemoglobin molecule. *T. occidentalis* was also found to increase erythrocyte count and vigour in albino rats (Lawal *et al* (2015) [27].

In anaemic patients both the number and the volume of red blood cells are reduced (Ogbe *et al*., 2010). Iron deficiency anaemia causes poor physical and cognitive development, weakness and reduced work productivity. It leads to susceptibility to infectious diseases and even mortality (Dash *et al*., 2013) [15]. The methanol extract of *T. occidentalis* leaves was found to stimulate the production of red blood cells and white blood cells in mice (Lawal *et al*., 2015) [27]. Extracts from the leaf, stem and seeds of *T. occidentalis* convert methaemoglobin to haemoglobin in anaemic rabbits (induced with phenylhydrazine) (Iweala and Obidoa, 2009; Atabo *et al*., 2014) [21, 9]. The kidneys and the liver produce a hormone (erythropoietin) which regulates the production of red blood cells by the bone marrow. When oxygen levels in the cells are low, erythropoietin stimulates erythropoiesis (synthesis of red blood cells by the bone marrow). When the supply of oxygen to the kidney is low, the increased production of erythropoetin (EPO) stimulates the production of red blood cells in the bone marrow and the release of reticulolytes (immature red blood cells) into the blood stream, thereby increasing the oxygen carrying capacity of the red blood cells. Iron, Vitamin B_{12}, and Folate (Vitamin B_9), are also required for the production of red blood cells. Daily requirement (RDA) for iron is 11 mg for males; 15 mg for females (14-18 yrs.); 18 mg for females 19-50 yrs.; 8 mg for females more than 51yrs; 27 mg for pregnant females and 9 mg for lactating females. *T. occidentalis* leaves can supply 9-10 mg making it a good source of this haemoglobin building element. B_{12} requirements are: 1.8mcg for 9-13 yrs. and 2.4-2.8 mcg for 14 yrs. and above. The leaves are also good sources of vitamin B_{12} (0.5mg of vitamin B_{12}).

T. occidentalis aqueous leaf extracts when administered to experimental rats, increased the blood forming elements, by the 5th day after administration and the values became statistically superior to untreated samples ($p<0.05$) on the 7th day. There was 22% increase in red blood cell count (RBC); 25% increase in haemoglobin count (HB); 77% increase in white blood cell count (WBC) and 42% increase in packed cell volume (PCV) (Iweala and Obidoa, 2009) [21]. By the seventh day of administering *T. occidentalis* leaf extract induced 71% increase red blood cells; 39.6 % increase in Hb; 22.4% in WBC; 13% increase in PVC. A 9.96% decrease in glucose concentration due to treatment with *T. occidentalis* leaf was observed. In a study carried out by Obeagu *et al*. (2014) [31], 200-300 mg/kg ethanol extract of the leaves of *T. occidentalis* within 7 days of treatment, raised the haemoglobin concentration of the subjects (albino rats) by 40% and would be able to meet the Daily requirements of iron for adults (8-11mg per day) and at least half of the daily requirement of iron for pregnant women (27mg per day (US Dept of Health and Human Service)

Anti-Oxidant Properties of T.occidentalis Leaves

Development of many metabolic diseases is preceded by and associated with oxidative stress. Catalase is an antioxidant enzyme found in the peroxisome of cells. It protects the cells against harmful effects of lipid peroxidation. The hydroxyl radical is mainly responsible for lipid oxidation and biological damage in human cells. Super oxides get converted to hydroxyls which penetrate the cell membrane and trigger off lipoperoxidation. Oxidation of lipids destabilizes the integrity of the red cell membrane and promotes atherosclerosis which is accelerated by the increase in the level of low density lipoproteins. Breakdown products such as malonaldehyde are formed. In atherosclerosis, lipids are deposited in the lining of arteries. The fat deposits consist mainly of cholesterol and its esters which are attached to foam cells and macrophages on the walls of the arteries.

Hydrogen peroxide scavenging activity of water extract of *T. occidentalis* leaves was 91.53% (higher than that of ascorbic acid and gallic acid); 63.99 for hydroxyl radical (Oladele and Oyewole, 2020) [38]. *T. occidentalis* contains phytochemicals that scavenge DPPH radical in a dose dependent manner (Memariani *et al*., 2020) [28]. The leaves of *T. occidentalis* have been reported to exhibit chemo-suppressive properties (Igbeneghu and Abdul, 2014) [20]. Kayode *et al*. (2010) [24] investigated the effects of *T.occidentalis* on protein-energy-malnutrition (PEM) induced oxidative stress in Wister albino rats. They observed that *T. occidentalis* leaf extract, when co-administered with protein increased Superoxide dismutase (SOD) and catalase activities. The leaves of *T. occidentalis* were found to possess antioxidant properties (2018). Foods that contain antioxidants help the human body to prevent oxidative damage. Several researchers have documented the free radical scavenging ability of *Telferia occidentalis*. Water and ethanol extracts of this leaf prevent the formation of free radicals and scavenge already formed free radicals to prevent their cell damaging activities. These extracts increase the level of *in vivo* antioxidant enzymes such as superoxide dismutase and catalase (Kayode *et al., 2010) [24]. Antioxidants from external sources are most useful in combating these damages.*

There is dearth of scientific information on the effect of *Telfairia occidentalis* on the lipid profile and lipid related disorders of animals and humans (Eseyin *et al*., 2018) [17].

Anti-Oxidant Properties of T.occidentalis Seeds

Eseyin *et al*. (2018) [17] evaluated the 2, 2-diphenyl-1-picryl hydrazyl (DPPH) radical, nitric oxide, reducing power, hydrogen peroxide scavenging, and total antioxidant activities of the methanol extract, *n*-hexane, dichloromethane, ethyl acetate, butanol and aqueous fractions of *T. occidentalis* seeds. The dichloromethane fraction showed the highest DPPH radical scavenging, reducing power and total antioxidant activities. This fraction contained 9-octadecenoic acid, 10-hydroxyoctadecanoic acid, 4-(2, 2-Dimethyl-6-methylene cyclohexylidene)-2-butanol; 3-(3-hydroxybutyl)-2, 4, 4-trimethyl-2-cyclohexene-1-one and 1, 2-Benzenedicarboxylic acid disooctyl ester. Antioxidant defense systems removes the reactive oxygen species (ROS), thereby neutralizing free radicals and preventing cell damage. If however, a diseases generates a lot of free radicals, it can exceed the capacity of the body defense system. Daramola *et al*. (2016) [13] observed the antioxidant property of *T. occidentalis* seeds in rat ovaries. It can be concluded from the results obtained in this research work that the seed of *T. occidentalis* possesses antioxidant properties. *T. occidentalis* seed extract had the highest DPPH antioxidant activity comparable to that of ascorbic acid and it is an oily isolate containing 4-(2,2-Dimethyl-6- methylene cyclohexylidene)-2-butanol, 3-(3-hydroxybutyl)-2, 4, 4-trimethyl-2-cyclohexene-1-one and 1,2-benezenedicarboxylic mono (2-ethylhexyl) ester. This finding validates the health benefits of the seed of *T. occidentalis*. N-hexadecanoic acid, is one of the major compounds in the methanolic leaf extract of *T. occidentalis* (fluted pumpkin). It is a potent antioxidant and an anti-cancer agent.

The water extract of *Telfairia occidentalis* possess higher antioxidant activity than its ethanol extract. Its phenol content is 12.2%, while its reducing power at OD 700 is 1.9. The free radical scavenging activity is 92% while these values for the ethanol extract are: total phenol: 5.5%; reducing power at OD 700: 1.5; free radical scavenging activity: 25 % (respectively). The antioxidant activity is affected by the polyphenols (especially the free soluble phenol content); vitamin C content and the total flavonoid content. Research information about the anti-oxidant properties of the stem and root of *T.occidentalis* is still very scanty in literature.

Antidiabetic Activity of Telfairia Occidentalis

Type 2 Diabetes mellitus (DM) is characterized by high levels of blood glucose and abnormal carbohydrate, protein, and fat metabolism (Daramola *et al*., 2016) [13]. Secondary complications of diabetes include kidney failure, loss of vision, stroke, nerve damage and erectile dysfunction (ADA, 2011). Diabetes could cause a pregnant woman to lose her fetus and could also lead to pregnancy complications (WHO, 2016). Type 2 diabetes is associated with increased oxidative stress resulting from the continued production of reactive oxygen species while the natural antioxidant defenses decline. The high level of glucose in the blood causes the overproduction of superoxide radicals in the mitochondria thereby accelerating cell apoptosis (Kayode and Kayode, 2011) [25]. Diabetes may be treated with oral antihyperglycaemic drugs and insulin (ADA, 2011). *T.occidentalis* has been found useful for the dietary management of type 2 diabetes. Spectroscopic studies indicated that the biologically active compound of *T. occidentalis* that absorbed maximally at 290nm showed high antidiabetic properties. This strongly suggest that the antidiabetic components of *Telfairia occidentalis* may be structurally similar to mahanine, murrayanol alkaloids and Murrayanol (James *et al*., 2016). A quantity of 300mg/kg/day of *T.occidentalis* is required to demonstrate the hypoglycaemic effect. *T. occidentalis* contains alkaloids, alliin, ajoene, flavonoids, enzymes, and vitamin B. The biological activity of alkaloids and flavonoids include hypoglycemia, hypolipidemia, hypoazotemia, and hypotension. Eseyin *et al*. (2018) [17] confirmed that the ethanolic leaf extract of fluted pumpkin significantly lowered blood glucose levels. The phenolic extract also inhibited activities of α-glucosidase and α-amylase (enzymes associated with carbohydrate metabolism which is linked to type-II diabetes) in adult Wister rats in a concentration-dependent manner (Oboh *et al*., 2012) [32]. A 2, 2-diphenyl-1-picrylhydrazyl (DPPH) activity directed fractionation of the butanol fraction of the leaf extract has led to isolation of two active compounds identified as: kaempferol-3-O-rutinoside and Kaempferol (Aderogba *et al*., 2008) [1]. The globulin protein fraction of *T.occidentalis* seeds, decreases fasting blood glucose levels (Teugwa *et al*., 2013) [46]. Ethanol extract of *T. occidentalis* seeds was also effective in reducing blood glucose levels of experimental animals. In normoglycaemic rats, the beta cells of the Islet of Langerhans in the pancreas which secrete insulin are healthy and functional, but in alloxan induced diabetic rats, the pancreatic cells are non-functional, having lost the ability to secrete insulin. The seed of *T.occidentalis* has been found to possess hypoglycaemic activity. The leaf and the roots also possess similar activity. Alloxan causes selective necrosis of the beta cells of the pancreas thereby inhibiting the secretion of insulin (depending on the concentration of alloxan).

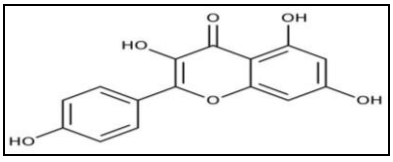

Fig 2: Kaempferol.

The presence of alkaloids and flavonoids in *T. occidentalis* extract may be responsible for the hypoglycemic effect observed in this study. Flavonoids are useful for managing type 2 diabetes and inflammations. This study showed that the effective dose of *Telfairia occidentalis* for its hypoglycemic effect to be felt is not less than 300 mg/kg/day. The hypoglycaemic effect may be demonstrated by stimulating the secretion of insulin from the Islet of Langerhans of the pancreas or it may increase the use of glucose by the cells. *T. occidentalis* exhibits hypoglycaemic properties in both normal and diabetic animal models (Onyeka *et al*., 2018) [41].
Telfairia occidentalis might be producing its hypoglycemic effect via stimulation of insulin secretion from the beta cells of the Islets of Langerhans or increased peripheral utilization of glucose by the cells. Ethanol extract of seeds, fruits and leaves *T. occidentalis* possess anti-hyperglycaemic activity (Teugwa *et al*., 2013) [46].

The Seeds
The seed extract showed significant anticancer activity with the hexane fraction demonstrating the highest activity. Electrophoretic studies showed that the crude extract and the fractions did not interact with DNA. The extract inhibited oxidative burst activity in whole blood, isolated polymorpho nuclear cells (PMNs) and mononuclear cells (MNCs) when two different phagocytosis activators (serum opsonizing zymosan-A and PMA). The extract also showed anti-inflammatory properties against egg albumin and oedema induced by xylene. GC-MS analysis revealed some pharmacologically active components which are responsible for its activities. Thus, the seed extract possesses anti-oxidative burst, anticancer, and anti-inflammatory activities.

Emerging health benefits of *T.occidentalis*
New medicinal effects of *T. occidentalis* are still emerging from research. Cyril-Olutoya and Agbedahunsi, 2015), investigated the use of ethanol extract of *T. occidentalis* for the treatment of sickle cell anaemia on red blood cells on which hypoxia has been induced for 1 hour (1h). *T.occidentalis* gave 95.5% reversal which was significantly higher than Ciklavit, thereby authenticating the ethnobotanical use of *T.occidentalis* for the treatment of sickle cell anaemia. Also, 6-octen-1-ol, 3,7dimethyl which is also found in pumpkin leaf possess antimicrobial activity. Analgesic activity of *T. occidentalis* leaves was observed by Okokon *et al*. (2012) [37]; regeneration of testicles (Oladele *et al*., 2017) [42]; restoration of electrolyte balance and renal oxidative damage (Oladele *et al*., 2017) [42] are some of the other emerging health benefits of *T. occidentalis*. Table 3 shows the health benefits of *T. occidentalis*.

Table 3: Overview of Health benefits of *Telfairia occidentalis*

Health benefit	References
Possess antioxidant property; ameliorates oxidative brain damage and oxidative liver damage;	(Okonkon *et al*., 2012; Oladele *et al*., 2020; Kayode *et al*., 2010; Aderogba *et al*., 2008; Onyeka *et al*., 2018; Dasgupta and Dei, 2007; Jimoh, 2018; Zheng and Wang, 2001;
Boosts spermatogenensis and prevents testicular damage	Nwangwa *et al*., 2007
Prevents anaemia; helps reduce resistance to malaria drugs; antisickling agent	Lawal *et al*., 2015; Dash *et al*., 2013; Iweala and Obidoa, 2009; Atabo *et al*., 2014; Cyril-Olutayo and Agbedahunsi, 2015; Adetutu and Tijani, 2013.
Analgesics	Okonkon *et al*., 2012.
Restoration of electrolyte balance and prevention of renal oxidative damage	Oladele *et al*., 2017
Possess antihyperglycaemic effect	Teugwa *et al*., 2013; Okonkwo *et al*., 2018; James *et al*., 2016; Aderogba *et al*., 2008; Arowosegbe *et al*., 2015; Eseyin *et al*., 2014; Aworunse *et al*., 2018.
Anti-inflammatory effect	Oluwole *et al*., 2003
Antimicrobial properties	Oyewole and Abakala, 2012.

Safety of *Telfairia occidentalis*
No toxic effects have been associated with the leaves and seeds and the aerial parts. *T.occidentalis* root has been reported to be toxic (Ogbonnaya and Uadia, 2016) [34]. The toxicity depends on the solvent used for its extraction. Ogbonnaya and Uadia (2016) [34]. dedicated their research to establishing the toxicity of *T.occidentalis* roots. They observed that the levels of enzyme bio-markers (aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), superoxide dismutase and catalase) were raised in the presence of the *T.occidentalis* root extract. Non-polar solvents extract more of the toxic principles than their polar counterparts, with increased toxicity as the non-polarity of the solvent increases (Kirkman and Gaetani, 2007) [26]. Ingestion of this toxic principle decreases the level of the antioxidant enzyme catalase which prevents the formation of lipid hydroperoxides (Kirkman and Gaetani, 2007) [26]. In contrast to superoxide dismutase, catalase level was significantly decreased in the liver and serum of experimental animals (Kirkman and Gaetani, 2007) [26]. This observation implies the presence of toxic principles in the extracts that adversely affected the activity of catalase. It should be noted also that the toxic effect of *Telfaria occidentalis* root was highest in the

group administered with ethyl acetate extract compared to other solvents. More of the toxic principles were extracted in the diethyl ether extract making it the most toxic. Worthy of mention, however, is the fact that the pattern of increase in LDL-cholesterol was diethyl ether > methanol > aqueous extracts. This further buttressed the fact that the toxic principles of the root extract of *Telfairia occidentalis* are essentially non-polar. It further suggests that free radical formation is the underlying mechanism of toxicity of the root extract of *T. occidentalis*. It has been reported that superoxide dismutase is the major antioxidant enzyme offering protection against oxidative damage in the liver (Romao, 2015) [44]. It is also plausible to mention that more radicals were generated when diethyl ether extract was administered because it is the most non-polar of the three solvents used for extraction. The observation of testicular damage by *T. occidentalis* (Adisa *et al*., 2014) [5] is somewhat contrary to observations by Nwangwa *et al*. (2007) [30] which suggested that T. occidentalis boosts spermatogenesis and regeneration of the testicle. More research would be required to establish whether these results are related to the plant part used; concentration effects and the like.

Conclusion

T. occidentalis leaves contain more vitamins and minerals while the seeds contain more fat. The female *T. occidentalis* leaf is richer in many vitamins, minerals, and phytochemicals than the male leaf. There is substantial evidence to show that *T. occidentalis* leaves (which is the most studied part) possess blood boosting, antioxidant and anti -hyperglycemic properties. Its use as an anti-sickling, anti-cancer and antimicrobial agent is still emerging. Even the seeds and the roots are associated with anti-diabetic properties although the root contains a toxic principle. There is need to intensify research efforts on the health benefits and medicinal value of this plant giving attention to the all parts of the plant and to deduce the molecular mechanism of action for the identified medicinal uses. Studies with human subjects and clinical trials are very scanty in literature and also require urgent research attention**.** Some authors associate only the ethanol extract of the leaf with antidiabetic properties, while others indicate that both aqueous and ethanol extracts possess antidiabetic properties. Further research should be carried out to validate the antihyperglycaemic activities of the solvent fractions of the leaf and seeds of *T. occidentalis*. The leaves have received the greatest research attention. Most of the researches are limited to animal experiments. Clinical tests, involving human subjects, still need to be done. There is need to explore other therapeutic uses of this vine.

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