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Review Article

Gongronema Latifolium: A Phytochemical, Nutritional and Pharmacological Review

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Abstract

Gongronema latifolium (Amaranth globe) is popularly known for its nutritional and medicinal values. The health benefits of different parts of this plant cannot be over emphasized especially in traditional medicine. The phytochemical evaluation of the plant showed the presence of flavonoids, saponins, alkaloids, steroids, glycosides among others. The nutritional composition includes carbohydrates, protein, amino acids, vitamins, minerals and fats. Pharmacological activities of the plant such as antioxidant, hypoglycemic, hypolipidemic, hepatoprotective and antimicrobial are well documented. This review is to provide detailed information on the phytochemical composition, nutritional values, ethno medicinal uses and pharmacological activities of *Gongronema latifolium*.

Keywords: *Gongronema latifolium*, phytochemistry, ethno medicinal uses, pharmacological activity, nutritional value.

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Introduction

The tropical rainforest is the most biologically varying ecosystem on earth and it is enriched with enormous natural plant resources with rich dietary and medicinal properties utilized locally in folkloric medicine (Dalziel, 1937). Although modern medicine may be available in developing countries, the use of herbs in treatment of diseases has often gained popularity for historical and cultural reasons (Nwangwu *et al.,* 2009), making traditional medicine an unavoidable global discuss. The use of medicinal plants is one of the primary complementary advances to medicine in many parts of the world (American Society for Testing and Materials, 2001). The presence of wide range of bioactive phytochemicals and secondary metabolites has made plants promising source of modern synthetic drugs for management of several diseases. One of the basic principles of medicinal herbs is that all constituents in the whole plant extract work collectively to achieve therapeutic efficacy (WHO, 1996). The use of plant extracts in treatment and prevention of diseases have shown a comprehensive framework of healing by stimulating the body's own innate healing capacities in a manner that is safe and effective (Tietz, 1976).

Gongronema latifolium (Amaranth globe) is a tropical rainforest plant which belongs to the family Asclepiadaceae and genus *Gongronema* (Okafor and Ejiofor, 1996). It is commonly grown in West Africa and is locally called "Utasi" by the Ibibios, Quas and Efiks; "Utazi" by the Igbos in South East and "Arokeke" by the Yorubas in South Western part of Nigeria. In Ghana and Senegal, the plant is referred to as "Akan-Asante aborode" and "Sever gasule" respectively (Hutchinson, 1973). It is an edible plant with green leaf, yellow flower and stem that produces milky latex when cut. It has a characteristic sharp, bitter and slightly sweet taste, especially when eaten fresh.

Gongronema latifolium (G. latifolium) is widely believed to have strong nutritional and medicinal values. The leaf is rich in fats, proteins, vitamins, minerals and essential amino acids (Eleyinmi, 2007). It is commonly used in soup as vegetable, or dried and applied as powdery spice. It is also consumed fresh and can be used in salad preparations (Dalziel, 1937; Morebise *et al.,* 2002; Ugochukwu *et al.,* 2003). In Sierra Leone, the root and stem are used as chewing stick or liquor. The liquor is obtained by boiling the sliced plant with lime juice or infused in water for over 3 days. It is then taken as a purgative for colic and stomach pains as well as to treat symptoms of worm infection (Okafor, 1975; Onike, 2010). Apart from its nutritional values, *G. latifolium* is believed to possess strong medicinal qualities due to its composition of different active chemicals. Some of the medicinal values of *G. latifolium* have also been scientifically validated. The present review is focused on the detailed phytochemical, nutritional, ethno medicinal and pharmacological updates of this plant.

The Plant: Gongronema Latifolium

Origin and Distribution

G. latifolium is of West African Origin (Nelson, 1965). It is found throughout Nigeria and other tropical countries such as Guinea-Bissau, Western Cameroon and Sierra Leone (Owu *et al.,* 2012). It is an edible rainforest plant indigenous to South Eastern part of Nigeria. It is indicated as one of the aromatic plants of medicinal importance from Nigeria (Ogunwade *et al.,* 2007).

G. latifolium has a very widespread distribution in the tropical and subtropical regions especially in West African countries (such as Nigeria, Cote d'Ivoire, Sierra Leone, Ghana and Senegal) and America, with an average abundance in Northern and South Eastern Asia (Agbo *et al.,* 2005). It is widely dispersed in the African forest and family farms as wild, semi- wild and cultivated (Okafor, 1980). It can be propagated by seed or stem (Softwood, semi-hardwood and hardwood) cuttings (Agbo and Obi, 2006).

Morphology

G. latifolium is a climbing perennial shrub up to 5m long. It climbs by twining around a support and can also run along the ground producing adventitious roots. The stem is hollow, soft and hairy with woody base and contains the latex. The leaves are green, simple, opposite and occasionally whorled, usually without stipules and the margins

are nearly always entire; Petiole is about 3cm long; blade is broadly ovate to almost circular with deeply cordate base, acuminate apex and 3-veined basis (Mosango, 2011).

The flowers are bisexual, small, regular, yellow and fragrant; pedicel is 2-4mm long; calyx lobes are elliptical to rounded and hairy at apex; corolla is tubular up to 5mm long, companulate at apex, hairy inside or not with five triangular ovate lobes; corona has five lobes which are fleshy, cream, brown at base, and shorter than stamina column; stamens have five short appendages, resting on the short conical style apex. Filaments are connected into a tube; anthers are erect with membranous apical appendages; there are two pollinia per pollinarium; ovary is superior. Inflorescence has a terminal and axillary cymose panicle up to 13cm long (Hutchinson and Dalziel, 1931; Mosango, 2011).

The fruit is a dehiscent seed pod called a follicle which is oblong-lanceolate. The color of the fruit varied from green in small fruits to dark brown, then to black at maturity. During maturity stage, the fruit splits open length wise, along the seam releasing the seeds. The seeds are flat, coma shaped and attached to a white silky tuft (pappus) which aids dispersal. They are strongly compressed and measure about 0.5cm in length (Mosango, 2011; Osuagwu, *et al.*, 2013).

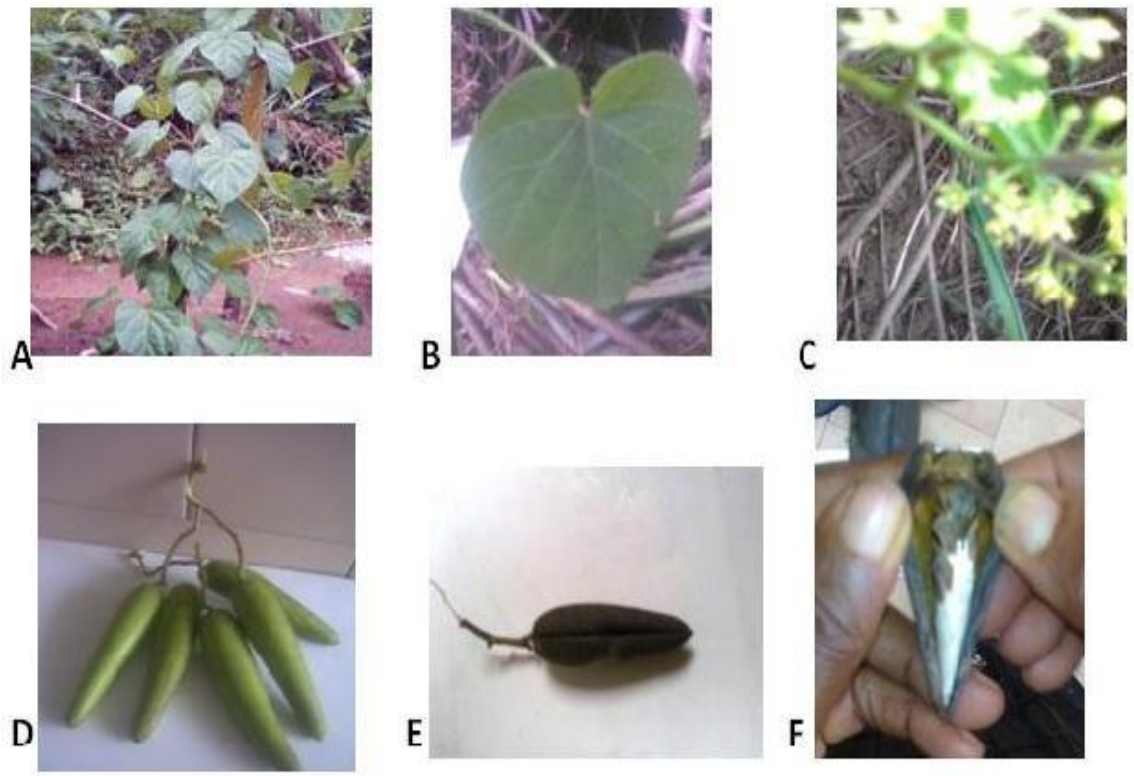

Fig. 1: The plant of *Gongronema latifolium* (Osuagwu *et al.*, 2013).
A: Leaves of *G. latifolium* plant, **B:** A single leaf of *G. latifolium*, **C:** The inflorescence, **D:** A bunch of the fresh fruits, **E:** A dry fruit showing the single seam, **F:** Opened dry fruit showing seed arrangement with tuft of pappus.

Phytochemistry

Phytochemical are naturally occurring non-nutritive plant chemicals that are largely responsible for the protective health benefits of these plant-based foods beyond those conferred by their vitamins and minerals. They are not required by human body for sustaining life, but recent research findings indicate that they can also protect human against diseases (Saidu and Okorocha, 2013). Reports on phytochemical analyses of different parts of *G. latifolium* have shown the plant to be rich in quite a good number of phytochemical components (Table 1).

Table 1: Phytochemical constituents of various parts of *Gongronema latifolium.*

Parts	Constituents	Author(s)
Leaves	Saponins, proteins, carbohydrates, resins, flavonoids, alkaloids, glycosides, terpenoids, steroids, fats and oil, phytate, anthranoids, anthraquinones, cyanogenic glycoside, glycides, phblobatannins, hydroxymethyl anthraquinones, polyphenols, reducing compounds, tannins, oxalate, cardiac glycosides, β-sistosterol, essential oils, lupenyl esters, pregnane esters, hydrogen cyanide, biurate, phytosterols, terpenes, anthocyanidins,	Morebise *et al.,* 2002; Edet *et al.,* 2009; Iweala and Obidoa, 2009; Aka *et al.,* 2011; Alobi *et al.,* 2012; Enemor *et al.,* 2014; Ezekwe *et al.,* 2014; Ugadu and Ibiam, 2014
Root	Hydrogen cyanide, saponins, flavonoids, alkaloids, tannins, glycosides, reducing sugars polyphenols	Antai *et al.,* 2009; Egbung *et al.,* 2011
Fruit	Alkaloids, tannins, saponins, flavonoids, phenols, phytic acid, hydrocyanic acid	Osuagwu *et al.,* 2013
Stem	Hydrogen cyanide, saponins, flavonoids, alkaloids, tannins	Egbung *et al.,* 2011

These chemical compounds are associated with bioactivities having health impacts. Important phytochemicals obtain from *G. latifolium* plant and their health benefits are as indicated below:

Flavonoids are known to inhibit formation of plagues in arteries and so prevent artherosclerosis, hypertension and other cardiovascular diseases (Cook Samman, 1996; Vaya and Aviram, 2001). They are also very important antioxidants that mop up reactive oxygen radicals known to be involved in many conditions that cause cancers, diabetes, inflammatory diseases and neurodegenerative diseases (Ugochukwu *et al.,* 2003). Saponins lower cholesterol and glucose level. They are also involved in ulcer protection and certain antimicrobial activity (Cheeke, 1997; Ukwe *et al.,* 2010). Alkaloids are involved in antimicrobial and hypoglycemic activities (Punitha *et al.,* 2005). Resins and essential oils have also been involved in antimicrobial (Amvam Zollo *et al.,* 1998)), anti-inflammatory and antioxidant properties (Lemos *et al.,* 2006). Cardiac glycosides (mainly cardenolides and bufadienolide groups) are useful for treatment of heart conditions (Enemor *et al.,* 2014). β-sitosterol helps to reduce cholesterol absorption in the intestines (Rudkowska *et al.,* 2008).

Nutritional Values

Nutritionally, *G. latifolium* is a good source of protein, minerals and vitamins. Previous researches have shown that the leaves are suitable for use in food production due to their high amino acid contents (Osuagwu *et al.,* 2013).

The leaves can be eaten fresh, dried and used as local powdery spice or as vegetable for food preparations such as unripe plantain porridge, white soup, sauces and salads in which they add a bitter-sweet flavor (Morebise and Fafunso, 1998). They are also used to spice locally brewed beer (Adenuga *et al.,* 2010). *G. latifolium* leaves are rich in fats, proteins, vitamins, minerals and essential amino acids (Eleyinmi, 2007). Its protein content (27.2%) dry matter is quite high and compares favourably with percentage dry matter (DM) values reported for chickpea (24.0%), cowpea (24.7%), lentil (26.1%), green pea (24.9%), fluted pumpkin leaves (22.4%), *Hibiscus esculentus* (23%), *Tamarindus indica* (24.3%) and *Mucuna flagellipes* (24.9%) (Glew *et al.,* 1997; Akwaowa *et al.,* 2000; Ajayi *et al.,* 2006; Iqbal *et al.,* 2006). The dominant essential and non-essential amino acids are leucine, valine, phenyalanine and aspartic acid, glutamic acid glycine respectively. These essential and non-essential amino acids are involved in protein synthesis and as metabolic intermediates respectively. High concentration of vitamins (A, C, E, and niacin) is also indicated in the leaves of *G. latifolium* (Atangwo *et al.,* 2009). These vitamins have antioxidant activities. Vitamin A (carotene) is essential for good health especially for eyesight and can help prevent early age blindness in children. Vitamin C (ascorbic acid) is important for growth

and repair of tissues in all parts of the body. Vitamin E (tocopherol) is a well-known antioxidant that can mitigate lipid oxidation and helps to reduce the occurrence of atherosclerosis which predisposes to increased risk of heart diseases. The crude fat content of *G. latifolium* leaves (6.7% DM) compares favourably with percentage DM values reported for leafy vegetables like *Brachystegia eurycoma* (5.8%) and *Tamarindus indica* (7.2%) (Ajayi *et al.,* 2006). This fat content is a good source of energy for the body. Apart from energy, the lipid fraction of *G. latifolium* contain useful amount of essential fatty acids known as linoleic acids (31.1%) which is an important component of membrane phospholipid, a processor to arachidonic acid found in virtually all tissue membranes of humans (Glew *et al.,* 2004). Arachidonic acid is metabolized to various prostaglandins which regulate many normal processes including blood pressure and gastric acid secretion (Lauritzen *et al.,* 2001). Mineral elements like sodium, calcium, potassium, iron, magnesium are reported to be present in *G. latifolium* leaves (Eleyinmi, 2007).

Table 2: Nutritional values of *Gongronema latifolium* leaves.

Constituents	**% Composition (Alobi *et al.*, 2012)**	**% Dry matter (Dm) (Eleyinmi, 2007)**
Moisture	15.2	-
Fibre	6.3	10.8
Crude protein	33.2	27.2
Crude fat	16	6.07
Ash	1.3	11.6
Carbohydrate	43.7	-

Table 3: Mineral composition of *Gongronema latifolium* leaves (Eleyinmi, 2007)

Mineral Element	**Composition (mg/kg)**
Sodium Na	110
Potassium K	332
Calcium Ca	115
Phosphorus Ph	125.3
Cobalt Co	116
Magnesium Mg	54
Copper Cu	43.5
Iron Fe	7.8
Zinc Zn	13.4
Lead Pb	0.2
Cadmium Cd	0.1

Table 4: Vitamin composition of *G. latifolium* leaves (Adaobi *et al.,* 2012).

Vitamin	**Composition**
Vitamin A (carotene)	360 1µ/100g
Vitamin E (tocopherol)	45 1µ/100g
Vitamin C (ascorbic acid)	290 1µ/100g
Vitamin B_2 (Riboflavin)	0.97%
Vitamin B_1 (thiamine)	0.15%
Vitamins B_3 (Niacin)	0.82%

Table 5: Amino acid composition of *G. latifolium* leaves (Eleyinmi, 2007).

Amino acid	% composition
Essential amino acid	
Theonine (thr)	3.75
Valine (val)	7.73
Isoleucine (Ic)	4.70
Leucine (leu)	8.97
Lysine (lus)	5.70
Tyrosine (tyr)	3.27
Methionine (met)	0.73
Phenylalanine (phe)	6.30
Non-essential amino acid	
Arginine (Arg)	7.69
Aspartic Acid (Asp)	13.78
Glutamic acid(Glu)	11.9
Serine (Ser)	6.22
Histidine (His)	1.40
Glycine (Gly)	10.31
Alanine (Ala)	7.61

Ethnomedicinal Uses

G. latifolium is highly medicinal in nature. The fundamental ingredients used for medicinal purposes are stored in the various parts of the plant such as the fruits, seeds, leaves, root and stem. The method of preparing and using this plant for medicinal purposes mainly depends on the part of the plant where the active ingredient is present. The vital ingredients stored in the leaf can be extracted either through blending, chewing or infusing in hot water and allowed to cool before drinking. The fruits and seeds can be chewed. The roots cannot be chewed rather it has to undergo decoction (Okpala, 2015). An infusion or decoction of the whole plants (the leaves, stems and roots) is used traditionally in the treatment of: Digestive problems such as dyspepsia, anorexia, colic and stomach ache, constipation, dysentery and intestinal worms (Oliver-Bever, 1986; Morebise *et al.*, 2006; Nwinyi *et al.*, 2008; Owu *et al.*, 2012).

Hyperglycemia and hypertension (Ugochukwu *et al.*, 2003).

Liver damage associated with alcoholism and viral hepatitis (Akerele *et al.*, 2008).

Abdominal pain after child birth and womb cleansing (Okpala, 2015).

Malaria (due to its bitterness) (Morebise and Fafunso, 1998).

Cough, wheezing and asthmatic attacks (Essien *et al.*, 2007; Mosango, 2011).

A decoction of *Gongronema latifolium* (Utazi), *mormodica charantia* (balsam pear) and *ocimum gratissimum* (fever plant) is usually given to patients been treated for hepatitis to help cleanse and rebuild their liver (Ihesie, 2015).

Table 6: Some medicinal uses of different parts of *Gongronema latifolium.*

Parts	Medicinal uses	Method of extraction
Leaves	Dysentery, antihelmintic, catarrh, congested chest, running nose, cough, viral hepatitis, bilharzias, malaria, hypertension, diabetes, asthma, constipation, nausea, and anorexia	Maceration
Root	Sickle cell anemia, relieve wheezing associated with asthma	Decoction
Stem	Purgative, hypertension and diabetes	Decoction
Fruit	Laxative	Chewing
Latex	Dental caries	

Table 7: Ethno medicinal uses of *G. latifolium.*

Country	Usage	Author(s)
Ghana	The boiled fruit is used as laxative	Akuodor *et al.,* 2010; Mosango, 2011.
Nigeria	The leaves are used for fowl cough, malaria, nausea, diabetes, hypertension constipation, relieve wheezing in asthmatic patients, bilharzoisis, viral hepatitis, general antimicrobial agent, asthma, sickle cell anemia, stimulate appetite, reduce post-partum contraction and enhance return of the menstrual cycle after childbirth.	Morebise and Fafunso, 1998; Morebise *et al.,* 2006; Essien *et al.,* 2007 Akerele *et al.,* 2008; Okore *et al.,* 2014; Okpala, 2015
Senegal	The leaves are rubbed on the joints of small children to help them walk	Akuodor *et al.,* 2010; Mosango, 2011.
Sierra Leone	For colic and stomach pain and for worms	Deighton, 1957; Okafor, 1975

Tested Pharmacological Activities

There are various reports on the pharmacological actions of *G. latifolium* based on modern scientific investigation.

Hypoglycemic Activity

Aka *et al.,* (2011) investigated the antidiabetic activity of aqueous extract (AE) and methanol extracts and fractions of G. *latifolium* in alloxan-induced diabetic rats. The methanol extract (ME) was separated into fractions by column chromatography to yield methanol fraction (MF), n-hexane fraction (HF) and chloroform fraction (CF). The result indicated that intraperitoneal injection of AE, ME, CF, HF, and MF (at doses of 200, 400 and 800 mg/kg/day) exhibited a significant ($P<0.05$) antidiabetic effect by ameliorating alloxan-induced increase in blood sugar. Antidiabetic potency of the extracts and fractions was in the order; MF>ME>AE>HF>CF. This result leads to credence to the use of G. *latifolium* in management of diabetes mellitus.

Adebajo *et al.,* (2012) investigated the *in vivo* glucose reducing and insulin stimulating abilities of combined root and stem methanolic extract of G. *latifolium* and its vacuum liquid chromatographic fractions (A1- A6) respectively in glucose loaded rats. The results showed the extract (100mg/kg) had a higher *in vivo* anti- hyperglycemic activity than A1- A6 indicating synergistic effect of the plant extract. Higher *in vivo* insulin release given by A5 (100mg/kg) than that of A6, agreed with their *in vivo* anti- hyperglycemic activities and confirmed insulin as an unreported mechanism of action of the plant.

Saidu and Okorocha, (2013) also reported that the methanolic leaf extract of G. *latifolium* at 200 and 300mg/kg body weight showed a dose dependent significant ($P<0.05$) reduction in blood glucose concentration in alloxan induced diabetic rats. According to Udo *et al.,* (2013), the ethanolic and aqueous leaf extracts treatment in rats caused a dose and time dependent decrease in the blood glucose level compared to control. Reduction in the levels of blood glucose was significant in ethanolic extract (100mg/kg) treatment for 7 and 21 days and aqueous extract treatment at dose levels of 25, 75, and 100mg/kg for 7 and 21 days.

Itelima *et al.,* (2014) observed a synergistic hypoglycemic potential when G. *latifolium* extract is combined with *Vermonia amygdalina* and *Viscum album* extracts in a diabetic mice.

Hypolipidemic Activity

A study was designed by Robert *et al.,* (2013) to investigate the hypolipidemic and hypoglycemic activities of ethanolic root extract of G. *latifolium* in streptozotocin induced diabetic rats. The diabetic rats were treated with 200 and 400mg/kg of the extract for 14 days. The results showed treatment with the extracts (at these doses) significantly reduced ($P<0.05$) serum glucose, triacylglycerol (TG), total cholesterol and very low density lipoprotein but increased high density lipoprotein in diabetic rats. There was no significant change ($P>0.05$) in serum low density lipoprotein. This suggests that the ethanolic root extract of G.

latifolium has hypolipidemic and antidiabetic properties. The ethanolic leaf extract of G. *latifolium* at 100mg/kg in diabetic rats significantly (P<0.05) decreased triglyceride levels and normalized total cholesterol concentration in the serum (Ugochukwu *et al.,* 2003).

Nephroprotective Activity

According to Onuoha and Chinaka (2013), the aqueous leaf extract of G. *latifolium* at doses of 1ml once daily and 1ml twice daily showed a significant dose dependent reduction in urea and creatinine levels in rats induced with carbon tetrachloride (CCl_4). Urea and creatinine levels are markers for kidney dysfunction. Hence the leaf extract helps in reversing the damage done to kidney cells. Nnodim *et al.,* (2014) also reported that leaf extract of G. *latifolium* at 250 and 500mg/kg b. wt. produced a significant (p<0.05) decrease in urea and creatinine levels when compared with control in chloroquine induced nephrotoxic rats. This implies that the leaf extract attenuated the kidney derangement induced by chloroquine.

Hepatoprotective Activity

Hepatoprotective potential of ethanolic leaf extract of G. *latifolium* in acetaminophen-induced hepatic toxicity in male albino rats was investigated. The extract was administered at the doses of 200, 400 and 600mg/kg b. wt. orally for 21 consecutive days. The result showed a significant decrease (P<0.05) in the serum liver enzymes (alanine transaminase ALT, aspartate transaminase AST and alanine phosphatase ALP) of all the test animals treated with the extract compared to negative control. Total protein, albumin and globulin concentration reduced significantly after administration of acetaminophen, but were stabilized even at the lowest concentration of the leaf extract administered. Bilirubin levels which were significantly increased by acetaminophen were also stabilized upon the extract administration (Imo *et al.,* 2015).

Another study by Akpan and Ekpo (2015) was aimed at determining some biomarkers of oxidative stress and liver damage in diabetic rats consuming diet continuing *G. latifolium* leaves so as to evaluate the involvement of the diets in the management of oxidative stress and liver damage common among diabetics. The results showed that diabetic rat consuming *G. latifolium* leaves had significant (P<0.05) reduction in malondialdehyde (MDA) concentration and in the levels of ALT, AST and ALP in the serum and liver tissue homogenate and a significant increase in the activities of glutathione peroxidase, superoxide dismutase and catalase relative to diabetic control. The results for diets were generally superior to insulin. Hence it is concluded that *G. latifolium* leaves have protective effect on oxidative stress and liver damage associated with diabetes mellitus.

Male Antifertility

The effect of aqueous extracts of *Ocimum gratissimum, G. latifolium* and a bi-herbal formulation of both herbs on epididymal sperm characteristics and testosterone levels in male albino rats were investigated. After 6 weeks of treatment, *Ocimum gratissimum* (300 and 500mg/kg) and *G. latifolium* (300 and 500mg/kg) showed not only an appreciable dose dependent morphological changes but also decreases in sperm motility, sperm count and sperm viability at P< 0.05 when compared against the control. There was a moderate change in the groups treated with bi-herbal formulation at similar doses when compared with the control as against mono extract which have a more pronounced negative effect. The testosterone levels were appreciably similar across all groups this suggests that extended treatment with *Ocimum gratissimum* or *G. latifolium* can negatively affect the sperm characteristic. But there is possibility of protection on seminal parameters by an herbal formulation of both extracts (Ezeonwu, 2013).

Antioxidant Activity

Nwanjo *et al.,* (2006) designed a study to investigate the anti-lipid peroxidative effects on aqueous extract from *G. latifolium* leaves in streptozotocin-induced diabetic rats. The results showed the extract significantly increased (P< 0.05) the activity of superoxide dismutase and decreased levels of plasma MDA, a lipid peroxidation marker. This suggests that aqueous extract of *G. latifolium* leaves possess anti-lipid peroxidative property.

According to Ugochukwu and Babady (2002), oral administration of aqueous and ethanolic leaf extracts of *G. latifolium* in streptozotocin induced diabetic rats significantly increased superoxide dismutase (SOD), glutathione reductase, glutathione peroxidase and glucose-6-phosphate dehydrogenase (G6PD) activities. Reduced Glutathione level was increased while lipid per oxidation was decreased.

Ugochukwu *et al.,* (2003) also showed that oral administration of ethanolic leaf extract to diabetic rats produced antioxidant activity by increasing the antioxidant enzymes (superoxide dismutase and glutathione peroxidase) activities and decreasing serum malondialdehyde levels which indicate decrease in lipid peroxidation.

Uso and Akpan (2015), also reported that the antioxidant effectiveness of *G. latifolium* leaf is higher when it is combined with *Ocimum gratissimum*. This might be connected with the synergistic interactions of several bioactive principles present in these leaves.

Anti-Inflammatory Activity

According to Morebise *et al.,* (2002) the aqueous dried leaf extract of G. *latifolium* significantly ($p<0.05$) inhibited carrageenan induced rat paw oedema, carrageenan induced leucocyte migration in mice and dye leakage induced by intraperitoneal injection of acetic acid in mice.

Morebise *et al.,* (2005) also reported that the methanolic leaf extract of *G. latifolium* significantly inhibited nystatin-induced rat paw oedema and also significantly stabilized erythrocyte membrane subjected to heat and hypotonic solution-induced lyses.

Hematological Effect

Akinnuga *et al.,* (2011) investigated the effect of ethanolic leaf extract of *G. latifolium* on hematological parameters in rats. The rats were giving 175mg/kg (low dose), 350mg/kg (medium dose) and 500mg/kg (high dose) of the extracts orally for 14days. The result showed that red blood cell (RBC) count significantly decreased in low, medium and high dose groups compared with the control group. Also significant decreases in the levels of white blood cell (WBC) count, platelet count, packed cell volume (PCV) and hemoglobin (Hb) concentration were observed. The decreases were dose dependent. The Mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) except mean corpuscular volume (MCV) significantly decreased in high dose group only. The result suggests that incessant consumption of the leaves is not advisable. The effect of ethanolic root extracts of *G. latifolium* on some hematological parameters in rats after 14 days of administration were evaluated by Antai *et al.,* (2009). The extract showed little or no effect on RBC count, PCV, MCV and MCH. But low dose of the extract (100mg/kg) significantly increased the Hb concentration, lymphocytes and eosinophils why high dose (200mg/kg) significantly increased WBC count and monocytes. MCHC, neutrophils and basophils were dose dependently decreased.

Agbai *et al.,* (2014) also reported that low dose concentration of ethanolic leaf extract of G. *latifolium* (200mg/ kg) and *Ocimum gratissmum* (200mg/kg) and/ or their combined extracts (400mg/kg) significantly ($P<0.05$) increased PCV, Hb concentration and RBC count without significant change in MCV, MCH and MCHC levels in alloxan-induced diabetic rats when compared with control.

Electrolyte Balance

The ethanolic leaf extract of G. *latifolium* significantly increased the blood levels of sodium Na, Potassium K, calcium Ca, zinc Zn and bicarbonate HCO_3 in a dose dependent fashion in rats exposed to ethanol after 21days of treatment. Hence G. *latifolium* restored blood electrolyte homeostasis altered as a result of exposure to ethanol (Ali *et al.,* 2015).

Hemostasis

Oguwike *et al.,* (2013) evaluated the effect of aqueous leaf extract of G. *latifolium* at 0.1ml once daily and 0.1ml twice daily on hemostatic and hematological indices in female albino rats. The results showed a dose dependent significant ($P<0.05$) decrease in the hemostatic indices (bleeding and clotting time) of those rats fed with

the extract when compared with the control. This decrease is of great advantage to the health of newly delivered mothers these shows that *G. latifolium* aqueous leaf extract possesses an element that can affect coagulation of blood. The extract also significantly decreased the hematological parameters (Hb concentration, total WBC count, PCV and platelet count) in the test rats.

Anti-Ulcer Activity

Ethanol extract from the leaf (200mg/kg b. wt.) of *G. latifolium* was administered to both streptozotocin-induced diabetic rat and control groups orally for 14 days. Gastric acid secretion was measured and ulcer was induced using ethanol and four-hour pyloric ligation. The extract administered increased the stimulated gastric acid secretion to a level significantly ($P<0.05$) higher than control. The extract also significantly ($P<0.05$) reduced ulcer scores in both ulcer models and increased mucus weight in the diabetic groups. These results suggest that *G. latifolium* antiulcerative activity is due to its prevention of chemical induced stomach injury (Owu *et al.*, 2012).

Gastric Emptying

The effects of methanolic leaf extract of G. *latifolium* on gastric emptying of semi-solid meals in healthy dogs were investigated sonographically. The extract was given at doses of 100, 250 and 500mg/kg to the test groups while the prokinetic group ingested 0.05mg/kg capsule of metoclopramide. Measurement of gastric emptying begins 30 minutes before and immediately after ingestion of the test meal, and thereafter every 15 minutes for 4 hours. This was followed by further measurements every 30 minutes for another 2 hours. No significant difference in gastric emptying between the low those (100mg/kg) and control groups was noted. Gastric emptying of the prokinetic group was significantly faster than that of the control group. The gastric emptying of moderate (250mg/kg) and high dose (500mg/kg) dose groups was significantly slower than that of control group. This delay in gastric emptying curses reduction in post prandial blood glucose (Ogbu *et al.*, 2013).

Anticancer Activity

Iweala *et al.*, (2015) reported that the leaf extracts of G. *latifolium* exhibit strong inhibitory activity against human lung carcinoma and human breast adenocarcinoma *in vitro*. The extract also exhibited free scavenging activity against 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) *in vitro*.

Immunomodulatory Effect

Egba *et al.*, (2014) evaluated the immunomodulatory potential of oral administration of methanolic extract of *G. latifolium* leaves on wistar albino rats. The rats were given 2% pyrogallol in order to suppress immune system, then treated with 200 and 400mg/kg of the extract for 21 days. The result showed no significant ($p>0.05$) difference in heamatological indices (PCV, Hb concentration and total WBC count). Significant ($P<0.05$) increase was seen in interferon-gamma while non-significant increase was obtained tumor necrosis factor-α and interleukin 2. the primary and secondary humoral antibody titre showed the significant ($P<0.05$) increase and the delayed type hypersensitivity (DTH) also indicates the significant increase. Hence, *G. latifolium* leaf extract generally show immunostimulatory effect and so is useful in treatment of several diseases caused by immune dysfunction. According to Akpan and Effiong (2015), consumption of *G. latifolium* leaf diets by streptozotocin-induced diabetic rats caused a significant decrease in the level of CD_4^+ cell count, WBC, platelets, monocyte and neutophils and a significant increase in RBC count, Hb, lymphocyte, eosinophil, PCV, MCH and MCHC relative to diabetic control. Consumption of diet containing *G. latifolium* leaves has positive effect on immunological and heamatological abnormalities associated with diabetes mellitus.

Antimicrobial Activity

The methanolic leaf extract of G. *latifolium* showed inhibitory activity against *salmonella enteritidis*, *salmonella cholerasius ser typhimurium*, *pseudomonas aeruginosa* and *listeria monocytogenes* while the aqueous leaf extract showed inhibitory activity against *E.coli* and *p.aeruginosa* (Eleyinmi, 2007). According to Nwinyi *et al.*, (2008) the ethanolic leaf extracts

show more inhibitory effect than aqueous extracts against *Escherichia coli* and *staphylococcus aureus*. The diameter of zones of inhibition was between 6 and 10mm while minimum inhibitory concentrations (MIC) were 10.0 and 2.5mg/ml respectively for the aqueous and ethanolic extracts. Omodamiro and Ekeleme, (2013) also reported that the ethanolic leaf extract show a significant dose dependent inhibition of *staphylococcus aureus*, *streptocollus pneumonia*, E. *coli*, *proteus mirabilis* and *pseudomonas aeruginosa*. Orji *et al.,* (2015) also reported that the hot water, ethanolic and methanolic leaf extracts inhibited the growth of *collectotrichum* species isolated from spoilt tomatoes. Hence G. *latifolium* leaves can be used to treat some related microbial infection.

Tissue Regenerative and Restorative Potentials

Edet *et al.,* (2013) assessed the effect of *G. latifolium* aqueous and ethanolic leaf extracts on the histology of pancreas, kidney, heart, and liver tissues of diabetic male rats. The pancreas of diabetic rats which showed reduction in beta-cell density and size, distorted reticular support and infiltration of inflamed cells recovered upon treatment with 400mg/kg extract showing distinct and highly populated beta and alpha cells. The renal tubules of diabetic rat kidneys indicated inflammation and obscured borders between convoluted tubules. However, treatment with the extract caused a restoration and regeneration of these inflamed cells. No significant change in heart tissues was observed within the period except that the myocytes of extract-treated rats were multinucleated and hypertrophied. No significant change was observed in the histology of the liver. This possible regenerative, protective and restorative effect of *G. latifolium* extract against hyperglycemic-induced tissue toxicity may be attributed to their phytochemical content.

Future Prospect

Drug Production

This review has revealed *G. latifolium* to contain metabolites that influence biological processes and reverse disease state. Hence, there is need to extract and isolate each individual chemical compound and use them to manufacture therapeutic drugs just as some plant have yielded important drugs. For example, Artemisinin is obtained from *Artemisia anua* (Gulati *et al.,* 1996).

Food and Medicinal Supplement

This review has shown that *G. latifolium* has a concentration of nutritionally important minerals and vitamins and hence is used as vegetable. So, research should look into the possibility of producing the nutritional supplements as its vegetable form is perishable and cannot be stored for a long time.

Economic and Ecological Value

So much emphasis is laid on its nutritional and medicinal values without mentioning the economic and ecological importance. Research should look into the cash income and ecological significance to help contribute to the conservation of this plant as constant exploitation may lead to extinction.

Drink Production

Bearing in mind of the result of its application as substitute to hops in beer production, the application of the *G. latifolium* extract in other drink production (particularly bitter drinks) is an interesting area of research to look into.

Conclusion

This review has scientifically justified some traditional uses of *G. latifolium* in the management of human diseases. Hence, exploiting all the qualities of this plant may offer solutions to some prevailing clinical and nutritional conditions; since it is becoming obvious that the natural vegetation around us is enriched with solutions to most of our health challenges and the extent to which we discover it have great implications to dealing with these challenges. Hence, extensive research on its pharmacodynamics, kinetics, proper standardization and clinical trials is necessary to exploit their therapeutic uses in combating various diseases.

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