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POTENTIALS OF SOME PLANT-DERIVED FOODS IN THE MANAGEMENT OF DIABETES AND ASSOCIATED COMPLICATIONS

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Abstract

Background and Objective: Diabetes is an insidious as well as a debilitating metabolic disease with variety of causes that could lead to severe complications in multiple organs within the body system. There has been no documented scientific evidence as regards total cure of this complex chronic disease; therefore, it demands a lifelong management. This has necessitated the recent evaluation of several plant derived foods as cost-effective alternatives in the management of diabetes and its associated complication.
Materials and Methods: This review is based on integration of information from multi-databases after a comprehensive literature search on the various plant derived foods that have been reported to have shown a certain degree of amelioration in the management of diabetes and diabetic complications.
Result and Discussion: Published reports suggest that oxidative stress primarily mediated by uncontrolled hyperglycemia play a pivotal role in the pathogenesis of diabetes and its associated complications. Therefore, various plant-derived foods are believed to delay, prevent or manage diabetes and its associated complications using different mechanisms which could be established through their potential to increase insulin sensitivity, free radicals scavenging abilities, hypolipidemic, hypoglycaemic, hypocholesterolemic, antioxidative, anti-inflammatory and inhibition of α-amylase and α-glucosidase activities.
Conclusion: Based on the evidence presented in this review, plant-derived foods possess bioactive constituents believed to be rich in antioxidants and proteins which may be responsible for their mode of actions; we propose that *Cucuma longa* (curcumin), *Garcinia kola* (kolaviron), *Telfairia occidentalis* and *Parkia biglobosa* be explored in the management of diabetes and its associated complications due to their outstanding beneficial effects.

Key words: Antioxidants, diabetes, diabetic complications, hyperglycemia, nutraceuticals, plant foods.

Introduction

The global burden of diabetes and diabetic complications has increased exponentially in recent years. Sedentary life-style, escalation in consumption of processed foods with a lot of preservatives, obesity, genetics and family history among others; have been implicated in the striking increases observed in the occurrence of this disease. This insidious disease appears to be one of the oldest diseases with severe economic and global health challenges (Hu, 2011; Olokoba et al., 2012). The incidence of diabetes varies from one geographical location to the other due to predisposing environmental and lifestyle associated factors. Recently, the International Diabetes Federation (IDF) reported that over four million people die from diabetes annually (Oputa and Chinenye, 2012). From literature search as at 2011, globally, it was estimated that 366 million people have diabetes and this value is likely to increase to about 552 million by 2030 (Olokoba et al., 2012; Siegel and Narayan, 2008).

Diabetes is a complex chronic disease with variety of causes thought to be a disease of the affluent, but unfortunately, it is now increasing in prevalence in developing countries where poverty level is very high (Kharkar et al., 2013). It is a life-threatening as well as lifestyle-modifying metabolic disease; characterized by abnormalities in carbohydrate, protein and fat metabolisms associated with deficiency in insulin secretion, insulin action or both, thereby resulting in hyperglycemia (American Diabetes Association, 2014). Documented evidence suggests that chronic hyperglycemia tends to be a primary cause of long-term dysfunction, damage and failure of various organs, particularly the kidneys, eyes, blood vessels, nerves, and heart (International Diabetes Federation, 2011).

Diabetes can be grouped into two major types: insulin dependent diabetes mellitus commonly called Type 1 diabetes and non-insulin dependent diabetes mellitus commonly called Type 2 diabetes (Khan et al., 2012; Modak et al., 2007). Type 1 diabetes can occur at any age, even though higher rate of incidence in children and young adults are documented in literature. Primarily, Type 1 diabetes occurs due to autoimmune destruction of pancreatic beta cells which results in deficiency of insulin production within the body and subsequent insulin insufficiency in the body (Atkinson, 2012; Cooke and Plotnick, 2008). Type 2 diabetes accounts for approximately 90 - 95 % of all diabetic cases globally (International Diabetes Federation, 2011; Wang et al., 2013; Lin and Sun, 2010). Various metabolic irregularities leading to ineffective control of hyperglycemia associated with gradual dysfunction of pancreatic beta cells, distressed incretin physiology, compromised regulation of glucagon secretion and insulin resistance are the major predisposing factors implicated in type 2 diabetic conditions (Meece, 2007, Tikoo and Gupta, 2012; Cade, 2008).

Nephropathy, retinopathy and neuropathy among others are major specific complications associated with diabetes (Modak et al., 2007). The role of free radicals in the pathogenesis of diabetes and its associated complications is abundantly documented in literature (Ramachandran et al., 2011; Folli et al., 2011). Intense hunger, increase sugar level in the blood, extraordinary thirst concomitant with frequent urination and weight loss, blurred vision, mood swings, occasional nausea and vomiting, severe tiredness and weakness are common symptoms in both type 1 and type 2 diabetic conditions (Modak et al., 2007). Amelioration in individuals suffering from type 1 diabetes is achieved by absolute dependence on exogenous source of insulin whereas type 2 diabetic conditions can be ameliorated with dietary changes, exercise and medication (Joseph and Jini, 2011).

Over the years, various conventional drugs and synthetic chemical agents have been employed in the treatment and management of diabetes and diabetic complications; but up to date, none has been reported in literature to have provided absolute recovery from diabetes and its complication (Inzucchi et al., 2012). Added to this, the cost of medication therapy management, amount of medications and doses per day, development of resistance as well as lack of responsiveness in some patients to administered drugs and accompanied side effects of these drugs is of major global concern (Inzucchi et al., 2012; Rwegerera, 2014; Zammitt and Frier, 2005).

This has necessitated the search and evaluation of numerous plant-derived foods as cost-effective alternatives in the management of diabetes and its associated complications. Various plant-derived foods that have been employed in the management of diabetes and diabetic complications worldwide; possess bioactive constituents believed to be rich in antioxidants and proteins thereby giving plant-derived foods prominence. This review focuses on the various plant-derived foods that have been reported in literature to have shown a certain degree of amelioration in the management of diabetes and its associated complications.

Role of Oxidative Stress

Oxidative stress primarily mediated by hyperglycemia has been implicated in the pathogenesis of diabetes. Generation of free radicals especially reactive oxygen species (ROS) as a result of various metabolic abnormalities within the body has been identified as a possible mode of action by which oxidative stress come into play; eliciting obvious deleterious effects associated with this disease conditions (Tiwari et al., 2013; Giacco and Brownlee, 2010; Johansen et al., 2005). Oxidative stress promotes pancreatic β-cell dysfunction and death, because they are predominantly susceptible to it; leading to relative or absolute lack of insulin and insulin resistance as a result of gradual pancreatic β-cell dysfunction, which is responsible for insulin synthesis and secretion (Jaganjac et al., 2013).

Oxidative stress takes place when there is an overwhelming effect on the endogenous antioxidant system by free radicals generated as a result of overproduction and insufficient scavenging of these free radicals (Rahman, 2007). This state of imbalance (oxidative stress) plays a fundamental role in the manifestation of diabetes and its complications. Five key mechanisms have been identified in literature responsible for hyperglycemia induced diabetic complications. These are increased flux of glucose and other sugars through the polyol pathway, increased formation of advanced glycation end products (AGEs), increased expression of the receptor for AGEs and its activating ligands, activation of protein kinase C (PKC) isoforms, and increased hexosamine pathway flux (Giacco and Brownlee, 2010). Overproduction of ROS greatly contributes directly or indirectly to the perturbation of each of the pathways above, thereby enhancing the progression of diabetes and its associated complications.

Challenges with Current Anti-Diabetic Drugs

People affected by diabetes, irrespective of the type are expected to manage their blood glucose level via medication. Several studies reveal that side effects as a result diabetic medications and diabetes-associated complications are accountable for approximately 3.2 million deaths annually (Chawla et al., 2013). Body of evidence in literature reveals about five categories of oral drugs employed in the treatment of diabetes. This includes: biguanides, sulfonylureas, thiazolidinediones, meglitinides and alpha-glucosidase inhibitors (Inzucchi et al., 2012). Treatment with some of these drugs results in hypoglycemia and other severe side effects ranging from liver or renal function impairment to heart failure. Gastro-intestinal upset, fluid retention, edema or weight gain as well as nausea and diarrhea are negligible side effects (Brunetti and Kalabalik, 2012).

Added to these, poor health facilities and cost to access good health facilities in the developing countries where recently this disease is predominantly on the increase make it a little bit wearisome and frustrating for people with diabetes. For instance, majority of the people with type 1 diabetes do not get insulin injection as at when due and most of the drugs available are very expensive and not readily available (Irons and Minze, 2014). This has contributed in no small measure to non-adherence to therapies among diabetic patients (Blackburn et al., 2013). Consequently, evaluation of plant-derived foods in the management of diabetes and its complications are based on the aforementioned challenges.

Comparison between Nutraceuticals and Conventional Drugs

Naturally occurring bioactive components abundantly available in foods, spices, vegetables, herbal products and fruits, having the potential to delay, defend, control or even prevent the pathogenesis and progression of diseases as well as possessing health-promoting abilities with medicinal properties are generally referred to as nutraceuticals. Nutraceutical approach is mainly based on utilization of nutrition for alleviating ill-health or for general body fitness and wellness (Pandey et al., 2011). Conventional drugs are usually referred to as pharmaceuticals, made up of chemically active substances ingested for pre-protection or used mainly to treat diseases or illness. Majority of the conventional drugs have their drawbacks ranging from serious side effects to minor side effects. Nutraceuticals have been documented in literature to have competitive cost with few and transient side effects making it an attractive alternative in the management of human health and disease (Mishra, 2012).

Plant-Derived Foods and Nutraceuticals in the Management of Diabetes and Associated Complications

Various studies have established the potentials of plant-derived foods (natural products) and nutraceuticals in the management of diabetes and its associated complications (Table 1) in conjunction with lifestyle modifications and adjustment of dietary intake (Omar et al., 2010). Majority of the nutraceuticals presently in use have been reported to delay or prevent the pathogenesis of diabetes and its associated complications (fig 1). These nutraceuticals also regulates some of the biochemical and clinical outcomes of diabetes (Bahadoran *et al*., 2013; Davi et al., 2010). Studies have shown that the ability of a food substance to be able to retard the rate of absorption of glucose from ingested carbohydrate meals makes the food a potential candidate as a nutraceutical for the prevention of diabetes. A good example of a nutraceutical presently approved and commercially

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Table 1: Various plant-derived foods in the management of diabetes and its associated complications

S/N	Plant Name	Main active ingredients	Effects/Activities	Model Used	References
1	***Mangnifera indica***: Mango	Mangniferin	Antioxidative, Anti-inflammatory, Hypoglycaemic	Rat, Mice	Shah et al., 2010; Aderibigbe et al., 2001; Muruganandan et al., 2002; Muruganandan et al., 2005
2	***Carica papaya***: Pawpaw	Carotene, Riboflavin	Antioxidative, Hypoglycaemic, Hypolipidemic, Wound healing associated with diabetes complications	Rat	Collard and Roy, 2010; Juárez-Rojop et al., 2012
3	***Tetracarpidium conophorum***: African walnut	Tocopherol, Ascorbic acid	Antioxidative, Antihyperglycaemic	Rat	Onwuli et al., 2014; Abam et al., 2013
4	***Garcina kola***: Bitter kola	Kolaviron	Hypolipidemic, Hypoglycaemic	Rat	Adaramoye and Adeyemi, 2006
5	***Telfairia occidentalis***: Fluted pumpkin leaf	Ascorbic acid, Riboflavin, Thiamine	Inhibition of α-amylase and α-glucosidase activities	Rat	Kayode and Kayode, 2011; Oboh et al., 2012
6	***Vernonia amygdalina***: Bitter leaf	Tannins, Phytosterols Flavonoids	Anti-hyperlipidemia, Hypoglycaemic, Alpha-glucosidase inhibitor	Rat	Adaramoye et al., 2008; Yeap et al., 2010
7	***Allium sativum***: Garlic	Water-soluble sulphur compounds	Hypocholesterolemic	Human, Rat	Yeh and Liu, 2001; Eidi et al., 2006
8	***Cinnamomum verum***: Cinnamon	Polyphenols	Increases insulin sensitivity, Hypolipidemic, Hypoglycaemic	Human, Rat, Cultured cells	Anderson, 2008; Cao et al., 2010
9	***Cucuma longa***: Turmeric	Curcumin	Hypolipidemic, Hypoglycaemic	Rat, Mice	Kuroda et al., 2005; Masry, 2012
10	***Ocimum gratissimum***: Scent leaf	Tannins, Saponins, Flavonoids	Hypolipidemic, Hypoglycaemic	Rat	Mohammed et al., 2007; Oguanobi et al., 2012
11	***Parkia biglobosa***: African locust bean	Phenols	Hypolipidaemic, Hypoglycaemic, Inhibition of Alpha-Amylase	Rat	Adi et al., 2013; Odetola et al., 2006; Fred-Jaiyesimi and Abo, 2009
12	***Zingiber officinale***: Ginger	Shogaols, Gingerols, Zingerone	Hypolipidaemic, Hypocholesterolemic	Rat	Nwozo et al., 2014; Nammi et al., 2009; Li et al., 2012
13	***Piper guineense***: African black pepper	Protein, Alkaloids	Anti-hyperglycemic, Anti-hyperlipidemic	Rat	Udofia et al., 2014; Nwozo et al., 2012; Ekoh et al., 2014

available is glucomannan®, which is a natural fibre with the ability to lower the glycemic index of meals if it is taken as a drink or mixed with food. Fibres generally are reputed to have the ability to lower the glycemic index of carbohydrate meals. Beans have been reported to have a low glycemic index because of the presence of α-amylase inhibitors (McCarty, 2005).

A major polyphenolic compound chlorogenic acid present in coffee is suggested to be responsible for the documented reports that heavy consumption of coffee lowers an individuals' risk of having diabetes. Chlorogenic acid is suggested to have the ability of slowing down carbohydrate uptake by hindering intestinal glucose transport (McCarty, 2005; Johnston et al., 2003). Chlorogenic acid is also reported to inhibit the cellular activity of the enzyme glucose-6-phosphate translocase (Hemmerle et al., 1997). A nutraceutical made up of green coffee extract with 55% chlorogenic acid is available in the market. Barley malt extracts are also available in the market; their mechanisms of action are reported to be similar to that of metformin, in that, they possess the ability to activate AMP kinase (McCarty, 2005).

Biotin, a nutraceutical agent, has been demonstrated through animal and clinical studies to have the capability of assisting in glycemic control in diabetic individuals if taken at a high dose of 9-15 mg per day (Zhang et al., 1996; Zhang et al., 1997; Maebashi et al., 1993). Various animal studies and few clinical studies established the effect of supplementary magnesium on the preservation of adipocyte insulin sensitivity (McCarty, 2005). High magnesium administration was also shown to be useful in preventing onset of diabetes in obese prone experimental rodents (Lima et al., 1996). It is suggested that ample intake of calcium and vitamin D may be helpful in reducing the risk for diabetes by preserving insulin sensitivity, even though further research needs to be done to confirm this (McCarty, 2005).

Plant-Derived Foods and Diabetes Management

Fruits

Mangnifera Indica: Mango

Mango is a very important tropical fruit loved by most people for its juicy sweet pulp when ripe. The fruit is reputed to be a very good source of vitamin C. Various parts of this tropical plant is useful among traditional folks for treatment of various ailments and disease such as hypertension. The occurrence of phytochemicals such as flavonoids, mangniferin, polyphenolics, triterpenoids and some others in this plant accounts for its reported anti-inflammatory, analgesic and hypoglycaemic activities (Shah et al., 2010). Administration of the leaf extracts in experimental studies resulted in a decrease in the blood glucose level in glucose-induced hyperglycemic mice, indicating the plant could possess active constituent capable of decreasing the blood glucose (Aderibigbe et al., 2001). Administration of mangniferin, an active constituent extracted from *M. indica* intra-peritoneally to diabetic rats showed antioxidative potential as well as attenuation of glycosylated heamoglobin level (Muruganandan et al., 2002). Twenty-eight days chronic administration (10 and 20mg/kg) of mangniferin also exhibited a reduction in diabetic state of experimental rats (Muruganandan et al., 2005).

Carica Papaya: Pawpaw

Carica papaya is a tropical fruit commonly consumed in many parts of the world. It has a low calorific value (32 kcal/100g of ripe fruit) and is greatly enriched with various natural vitamins and minerals like folate, thiamine, riboflavin, calcium, niacin, potassium and iron. It is one of the best natural sources of vitamin A and vitamin C. It has a high content of carotene necessary for prevention of damages due to free radicals (Krishna et al., 2008). Fermented *C. papaya* fruit serves as a good antioxidant and thus a promising nutraceuticals. Oral administration of the preparation at 9g/day elicited an improvement in the antioxidant defence of elderly human subjects (Marotta et al., 2006). The fermented *C. papaya* fruit preparation was also demonstrated in animal study to be beneficial in the healing of wound associated with diabetes complications by influencing wound-site macrophages and angiogenic responses (Collard and Roy, 2010). Various experimental studies established the efficacy of *C. papaya* to improve various metabolic disorders associated with diabetes. Juarez-Rojop and co-workers reported that administration of aqueous extract of *C. papaya* leaves extract at varying concentration in drinking water (0.75, 1.5 and 3 g/100 mL) elicited a significant decrease in blood glucose as well as a reduction in plasma triacylglycerol in streptozotozin-induced diabetic rats. The extract also showed a remarkable antioxidant activity and improvement in the lipid profile as well as in liver and pancreas integrity of the rats (Juárez-Rojop et al., 2012).

Nuts

Tetracarpidium Conophorum: African Walnut

African walnut propagated basically for the production of nuts eaten as a delicacy is found to possess abundant bioactive constitutes rich in antioxidants and essential nutrients. Different parts of this plant have been documented in literature to have antioxidant, chelating, antimicrobial and anti-diabetic potentials (Onwuli et al., 2014; Abam et al., 2013). Onwuli and co-workers concluded in their study when they fed rats with varying doses of *T. conophorum* (21.3 g, 42.6 g, and 85.2 g); that *T. conophorum* nuts possess hypoglycaemic activity with the ability to ameliorate and decrease hyperglycemia, increase haemoglobin level as well as prevent diabetes mellitus-associated renal damage (Onwuli et al., 2014).

Garcina Kola: Bitter Kola

Garcina kola also known as bitter kola because of its taste contains pharmacologically bioactive compounds (Ikpesu et al., 2014). In order to justify its hypolipidemic and hypoglycaemic potential, Adaramoye and Adeyemi administered kolaviron (100 mg kg−1 body weight), a biflavonoid complex from *Garcinia kola* to STZ-induced diabetic rats and concluded that *G. kola* possess potent anti-diabetic agents which could also prevent complications associated with diabetes with great potential to effectively scavenge excessive free radicals generated (Adaramoye and Adeyemi, 2006).

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Vegetables

Telfairia Occidentalis: Fluted Pumpkin Leaf

Telfairia occidentalis is a common vegetable in Central and West Africa, especially in Nigeria, Cameroun and Benin Republic. The green leaves of the plant, which is greatly cherished as a staple vegetable has high iron as well as vitamin content. Various experimental studies established that the leaves have minerals such as phosphorus, calcium, potassium, magnesium, iron and sodium, rich in antioxidants and vitamins like riboflavin, nicotinamide, ascorbic acid and thiamine (Kayode and Kayode, 2011). It also has essential phytochemicals like phenols, tannins, saponins and alkaloids. *In vitro* and *in vivo* experiments have shown the antioxidant ability of the plant extracts by elevating the antioxidative enzymes such as catalase and superoxide dismutase, thus preventing free radical production as well as scavenging free radicals (Oboh et al., 2006). *T. occidentalis* leaf was also shown to inhibit the activities of α-amylase and α-glucosidase (500 μL and 50 μL respectively) which are key enzymes associated with type-2 diabetes (Oboh et al., 2012).

Vernonia Amygdalina: Bitter Leaf

Vernonia amygdalina is a tropical Africa shrub growing wildly or cultivated in different countries of sub-Saharan Africa. The leaves are dark green in colour with a peculiar odour and bitter taste (Oboh and Masodje, 2009). Adaramoye and co-workers established the anti-hyperlipidemia effect of *V. amygdalina* by administration of 200 mg/kg body weight of the extract on rats fed with high cholesterol diet. This resulted in a significant reduction in both plasma and post-mitochondrial fraction total cholesterol of the rats (Adaramoye et al., 2008). Various studies established the anti-diabetic effect of both the ethanolic and aqueous leaf extracts of the plant. The hypoglycaemic activity of the plant extracts may be due to the presence of tannins, phytosterols and flavonoids, which may act as alpha-glucosidase inhibitor (Yeap et al., 2010).

Spices

Allium Sativum: Garlic

Garlic is traditionally used as a spice for cooking various delicious dishes. Experimental studies have shown its anti-parasitic, antifungal, antiviral, antibacterial, anti-carcinogenic activities as well as anti-hypertensive (Corzo-Martínez et al., 2007). Garlic is made up of distinctive organosulphur compounds, which are responsible for its biological activities, flavour and unpleasant odour. Garlic preparation in the form of a supplement referred to as aged garlic extracts has been greatly studied for its bioactivity both *in vitro* and *in vivo*.

Aged garlic extracts has anti-oxidative activities and ability to scavenge ROS by promoting cellular enzymes such as glutathione peroxidase, superoxide dimutase, and catalase (Borek, 2001). Human and animal studies have successfully established the hypocholesterolemic activity of aged garlic extracts, due to the presence of water-soluble sulphur compounds capable of inhibiting hepatic cholesterol synthesis (Yeh and Liu, 2001). Aged garlic extracts has also been studied to be capable of reducing risks of cardiovascular diseases by selectively inhibiting platelet aggregation and adhesion (Steiner and Li, 2001). Ethanolic extracts of garlic administered at 0.1, 0.25 or 0.5 g/kg body weight to streptozotocin-induced diabetic rats showed that garlic is an excellent candidate to be explored in the management of diabetes (Eidi et al., 2006).

Cinnamomum Verum: Cinnamon

Addition of water-soluble cinnamon compound in meals could be effective in reducing risks associated with cardiovascular diseases and diabetes (Roussel et al., 2009). *In vitro* studies in animals and humans showed that polyphenols in cinnamon increases insulin sensitivity. Daily intake of 1 - 6 g of cinnamon by type-2 diabetic subjects led to a reduction in fasting blood glucose, total cholesterol, low-density lipoproteins cholesterol and triacylglycerol (Anderson, 2008). Experimental study on gene expression in cultured mouse adipocytes established that phenolic extracts of cinnamon has an insulin-like action and an insulin independent action on control of gene expression in adipocyte tissue (Cao et al., 2010).

Cucuma Longa: Turmeric

Turmeric is a rhizome plant that is traditionally used in various parts of the world as a spice, a food preservative and colourant. It is a vital home remedy for cough, cold, rheumatism, diabetic wounds, anorexia, and hepatic disorders amongst others (Chattopadhyay et al., 2004). Turmeric contains essential and fatty oils, small amount of carbohydrates, proteins and omega-3 fatty acids. It has 2 – 9 % of cucuminoids an important polyphenol depending on the variety. The whole turmeric preparation or its extract has been reported to have effect on cardiovascular disease, inflammations and cancer (Krishnaswamy, 2008).

Kuroda and co-workers showed the ability of turmeric extract to significantly suppress an elevation in blood glucose in type-2 diabetic mice and they suggested that curcumin in turmeric could be useful in attenuating diabetes in human if prepared as a functional food (Kuroda et al., 2005). Curcumin, the principal bioactive constituent in turmeric when administered in aqueous suspension (80 mg/kg body weight) to streptozotocin-induced diabetic rats instigated a significant reduction in oxidative stress parameters measured in the rats, especially ameliorating the extent of lipid peroxidation (El-Masry, 2012).

Ocimum Gratissimum: Scent Leaf

Ocimum gratissimum is an herbaceous plant usually grown in the tropical and subtropical regions for its medicinal and cookery (food spice) uses (Nweze and Eze, 2009). Aqueous extract of the leaf administered orally in a recent study shows the leaf exhibited significant hypoglycemic effects in streptozocin-induced diabetic rats. Notably, 500 mg/Kg body weight of the extract was identified as the effective antidiabetic dose which significantly lowered blood glucose level of the diabetic rats by 81.3 % after 24 h of extract administration. They concluded that *O. gratissimum* possesses antidiabetic properties, which indicate the presence of biologically active components, which may be worth further investigation and elucidation (Mohammed et al., 2007). Hypoglycaemic activity of *O. gratissimum* (100, 200, 300 mg/kg body weight of the aqueous extract) has also been reported in type 2 streptozotocin-induced diabetic rat model (Oguanobi et al., 2012).

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***Parkia Biglobosa*: African Locust Bean**

Parkia biglobosa is an important household spice commonly used in Nigeria and many other West African countries in the preparation of various foods as well as a seasoning agent in soups (Odetola et al., 2006). Many reports have justified and documented the use of several medicinal plants such as *P. biglobosa* in the treatment of various cardiovascular diseases such as hypertension, cardiac failure and cardiac disturbances. Medicinal and pharmacological investigations of *P. biglobosa* have shown that the fermented seeds had hepatoprotective, hypolipidaemic, antimicrobial and anti-inflammatory potential (Adi et al., 2013). Documented report reveals that both aqueous and methanolic extracts of *P. biglobosa* (6 g/kg body weight) possess hypoglycaemic activities against alloxan-induced diabetic models (Odetola et al., 2006; Fred-Jaiyesimi and Abo, 2009). Taken together, the aqueous extract demonstrated better therapeutic effect in managing diabetes and some of the complications associated with diabetes (Odetola et al., 2006).

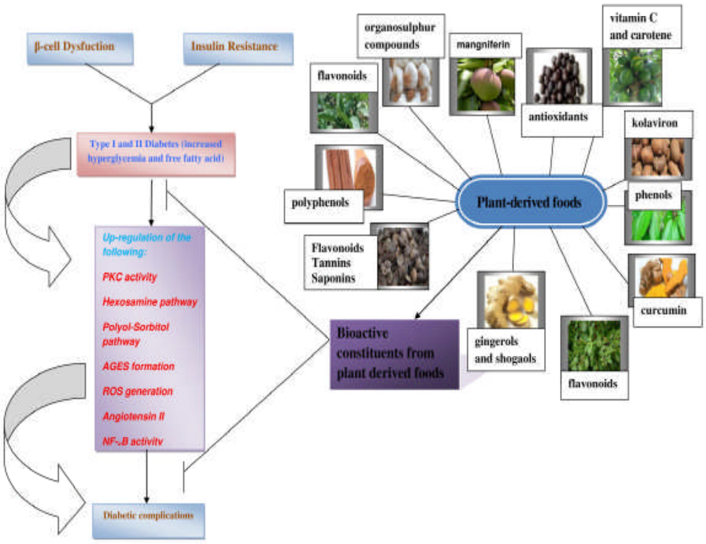

Figure 1: Proposed model of plant-derived foods in amelioration of diabetes and its associated complications.

***Zingiber Officinale*: Ginger**

Globally, *Zingiber officinale* is one of the most commonly consumed spices and functional food. Its involvement in the treatment of various ailments has been known for ages. Its hepatoprotective, anti-cancer, anti-inflammatory, analgesic and anti-clotting as well as anti-arthritic, anti-nausea, hypolipidaemic and hypocholesterolemic properties are reported recently in literatures (Nwozo et al., 2014; Al-Amin et al., 2006). *Z. officinale* possess essential volatile oils and non-volatile pungent compounds as its major chemical constituents. Terpenoids are the major components of the volatile oil while the non-volatile compounds abundant in *Z. officinale* are shogaols, gingerols, zingerone and paradols. In fresh and dried *Z. officinale*, gingerols and shogaols were identified as the major bioactive constituents (Nammi et al., 2009). In order to justifying the traditional use of *Z. officinale* in the management of metabolic diseases especially diabetes, scientific evidence has been documented in literature and most authors concluded that ethanolic extract of *Z. officinale* (100, 200 and 400 mg/kg body weight) showed conspicuous protective abilities in the control and treatment of diabetes and diabetic complications in animal models (Nammi et al., 2009; Li et al., 2012).

***Piper Guineense*: African Black Pepper**

Piper guineense is an important spice in West Africa, especially Nigeria, with both nutritional and medicinal values. Its high protein, alkaloid and iodine content makes it unique among other commonly used household spices (Umoh et al., 2013). Evaluation of *P. guineense* revealed that it is a promising candidate in the formulation of novel therapeutic drugs that would have significant effects in the management of inflammation and other related chronic diseases (Udofia et al., 2014; Nwozo et al., 2012). Recently, Ekoh and co-workers reported the anti-hyperglycemic and anti-hyperlipidemic effect of aqueous extracts of *P. guineense* (500 mg/kg body weight) in alloxan-induced diabetic rats. They concluded that the extract has the potential to manage diabetes and also reduce the risk of cardiovascular complications associated with diabetes (Ekoh et al., 2014).

Conclusion

As a result of exponential global increase in the prevalence of diabetes and its associated complications, and the aforementioned drawbacks associated with the current anti-diabetic drugs available in the market ranging from high cost of the drugs to adverse side effects as well as non-availability to obvious non-adherence to therapy among patients; therefore, it is highly imperative to explore plant-derived foods with proven pharmacologically-bioactive constituents as alternatives to the current anti-diabetic drugs in the management of diabetes and its associated complications. In our own opinion, based on recent documented reports on the mechanisms of action of various plant-derived foods reviewed in this paper, we propose that *Cucuma longa* (curcumin), *Garcinia kola* (kolaviron), *Telfairia occidentalis* and *Parkia biglobosa* will be excellent candidates that may be used on a broader base in humans to treat/prevent diabetes and its associated complications.

Autoimmune destruction of pancreatic beta cells and insulin resistance play a crucial role in the pathogenesis of type I and II diabetes which is associated with increased hyperglycemia and free fatty acid. Up-regulation of PKC activity - hexosamine pathway, polyol-sorbitol pathway, AGES formation, ROS generation, angiotensin II and $NF_{k}B$ activity (contributory factors) - leads to vascular complications. Plant-derived foods possess the protective ability to delay or prevent the pathogenesis of diabetes and its associated complications by inhibiting the up-regulation of some of these contributory factors or by acting as survival mechanisms directly on vascular cells.

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