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A Focus on Four Popular "Functional Foods" as Part of a Strategy to Combat Metabolic Disease Through the Increased Consumption of Fruits and Vegetables

NATISHA DUKHI[1]* and MYRA TAYLOR[2]

[1]Department of Population Health, Health Systems and Innovation, Human Sciences Research Council, Cape Town, South Africa.
[2]Discipline of Public Health Medicine, University of KwaZulu-Natal, Durban, South Africa.

Abstract

Fruit and vegetable consumption is on the rise as an increasing number of people recognize their health promoting effects, which are mediated through phytochemicals with disease combatting properties. The aim of this paper is to identify the potential benefits of fruits and vegetables in chronic diseases such as diabetes mellitus and hypertension. An electronic search of databases such as Pubmed Central, Science Direct and Web of Science from the last 5 years was conducted. Four commonly consumed edible fruit and vegetables, namely, *Hypoxis hemmerocallidea* (African potato), *Moringa oleifera* (Moringa), *Persea americana* (Avocado) and *Psidium guajava* (Guava) and their potential role in the prevention and management of metabolic syndrome and other disorders, are presented. In this narrative review plant uses extend beyond traditional medicine and include usage in food preparation, beverages, as part of fragrances, culinary flavouring, as well as cosmetic use, but more importantly have potential in contributing to the amelioration of the deleterious effects of diseases/health conditions. In addressing disease states, including metabolic syndrome and other disorders, the interest in medicinal plants continues to grow with the possibility of novel compounds and/or new drug discovery. Alternative and affordable methods of large scale harvesting of medicinal plants, as well as identification and specificity of bioactive compounds as future therapeutics are essential for sustainability.

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Introduction

Fruit and vegetable consumption is on the rise as an increasing number of people recognize their health promoting effects, which are mediated through phytochemicals with antioxidant, anti-inflammatory and other disease combatting properties. This has

CONTACT Natisha Dukhi doctordukhi@gmail.com Department of Population Health, Health Systems and Innovation, Human Sciences Research Council, Cape Town, South Africa.

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been supported through studies showing efficacy in a range of chronic diseases through the reduction of oxidative stress in atherosclerosis, metabolic disease and risk of breast cancer[1]. Indeed, recent studies recommend seven or more servings per day compared to the Dietary Guidelines for Americans 2010, where a mean 4.7 servings of fruit and vegetables are recommended, while the Canadian food guide recommends a mean 5.16 servings[2]. In South Africa (SA), for school children and adults, the recommended vegetable and fruit intake is 400g/day which equates to 80g for each of five servings in a day[3]. The World Health Organization (WHO) recommends for adults, a 400g/day serving of fruits and vegetables as protection against cardiovascular disease and some forms of cancers[3]. The South African nutrition-related disease risk profile is characterized by the double burden of both over and undernutrition, as well as a deficiency of vitamin A[4]. Metabolic syndrome is recognized as a major contributor to the disease burden with a global prevalence ranging from 10-84% depending on the population and/or environment[5]. The syndrome contributes to the disease burden due to its association with prevalent traditional and non-traditional risk factors for cardiovascular disease (CVD). Traditional CVD risk factors that coexist include glucose intolerance, hypertension, dyslipidemia, insulin resistance and obesity. Non-traditional risk factors include inflammatory processes and abnormalities within the coagulation system[6]. The purported health promoting claims of combatting metabolic disease by including nutrition as part of the strategy require scientific validation and an appraisal of the literature. In this review we will focus on four commonly consumed edible herbs and fruits and their potential role in the prevention and management of metabolic syndrome, in particular. An electronic search of databases such as Pubmed Central, Science Direct and Web of Science from the last five years was conducted.

An important public health concern, metabolic syndrome is a major contributor to increased morbidity and mortality globally, and doubles the risk compared to individuals without the syndrome[5]. The specific aetiology of metabolic syndrome is unknown, however, the pathogenesis has been well described and includes three aetiological categories, namely, insulin resistance, obesity and a grouping of independent factors[7]. Notably, the majority of people with metabolic syndrome, present with insulin resistance and 'insulin resistance syndrome'[8,9]. Importantly, metabolic syndrome is considered a prediabetic state due to its association with insulin resistance and existence in type 2 diabetes[10]. Insulin resistance develops in the liver, adipose tissue and skeletal muscle, leading to hyperglycaemia and hyperinsulinemia. Once the pancreas can no longer produce insulin, the individual becomes hyperglycaemic, leading to type 2 diabetes mellitus (DM)[11]. The coexistence of CVD risk factors with insulin resistance, exacerbates CVD during metabolic syndrome[6]. In both developed and developing countries diabetes and obesity are rapidly increasing due to poor lifestyle practices that include low physical activity and a sedentary lifestyle, which are coupled with poor dietary habits and consuming foods high in sugars, fats and carbohydrates[5].

While lifestyle interventions may greatly improve insulin sensitivity through exercise and weight-loss, and delay diabetes progression, long-term maintenance is rather poor[12]. Pharmacological intervention through insulin sensitizers, antihypertensives and glucose and lipid lowering drugs in the treatment of the metabolic syndrome, is associated with poor patient compliance and high medical costs. In the search for both therapeutic and preventative strategies regarding metabolic syndrome, the use of plants/herbs and/or their bioactive compounds are worthy of consideration as medicinal plants in the treatment of the pathogenic processes, as well as in addressing the coexisting risk factors[12]. The efficacy of plants and/extracts in metabolic syndrome have been attributed to the diversity of active compounds with multiple mechanisms of actions that may work synergistically or potentiate the activity of each other[13,14].

Common Medicinal Plants as Functional Foods

There is intense and ongoing interest in medicinal plants and how they serve as functional foods, in the quest for strategies with fewer side effects. In SA, while some medicinal plants have been studied and explored extensively, the need exists for common plants to be investigated beyond the screening phase. This creates exciting opportunities for plant compound bioprospecting that may lead to novel

pharmaceuticals in the amelioration and prevention of chronic diseases[15]. This paper focusses on four popular medicinal plants/fruits and vegetables that can be classified as functional foods viz. *Hypoxis hemmerocallidea* (African potato), *Moringa oleifera* (Moringa), *Persea americana* (Avocado) and *Psidium guajava* (Guava). Both African potato and moringa have been well documented in disease states and are consumed for traditional purposes, while avocado and guava are popularly consumed and easily available fruits in South Africa. These fruits and vegetables were chosen for the review based on their traditional and current potential benefits in diabetes and cardiovascular disease/ hypertension. They can be grown in the homesteads, thus becoming easily accessible to people, as well as being commercially available[16]. The plants will be discussed from the perspective of their traditional uses, phytochemistry and potential future uses of these edible/medicinal plants.

***Hypoxis Hemmerocallidea* (African potato)**

Hypoxis hemmerocallidea, belonging to the Hypoxidaceae family, is commonly referred to as African potato, is used as a medicinal plant for benign prostate hypertrophy and as a laxative. However, its uses have extended beyond the traditional uses and in South Africa the African potato, together with the 'cancer bush' or Sutherlandia frutescens, it is considered one of the two most important medicinal plants used to treat patients with HIV/AIDS. The SA Ministry of Health endorsed these medicinal plants for management of HIV/AIDS[17,18]. Laboratory, anecdotal and folkloric evidence, indicate that some bioactive compounds of the African potato display antioxidant, antidiabetic, antineoplastic, anti-inflammatory and anti-infective properties. The African potato bioactive constituents cannot only be attributed to stigmasterol and rooperol, as other bioactive compounds are yet to be identified[28]. Reports in the literature show abundant support for its cardiovascular effects. Ojewole *et al.,* (2006) found that bradycardia and short-duration hypertension were observed in guinea pigs and rats in vitro and in vivo respectively[29]. Earlier in vivo studies using primates found that the purified extract of the corm (rooperol) increased myocardial contractility[30]. Later on Ker (2005) found that chronic ingestion of African potato aqueous extract in the form of tea resulted in ventricular tachycardia in male human subjects[31]. This has resulted in conflicting cardiovascular observations and therefore suggests that the African potato corm contains bioactive compounds with cardiovascular properties. This may also provide some credence for the use of the African potato in rural communities in the treatment and/or management of hypertension and heart related conditions[31].

Both as a traditional medicine source and as an edible/medicinal plant, the African potato requires further research and a need for it to be propagated. African potato is not only used within SA and neighboring countries but it is also exported to Europe and countries in the Far East[32], creating the need for sustainability in its supply. However, mass propagation is difficult, although the African potato is grown easily in a wide range of environments. Thus, a large-scale propagation method must be implemented that can supply the population with the required materials that are cost-effective for medicinal purposes[15].

***Moringa Oleifera* (Moringa)**

Moringa oleifera, belonging to the Moringaceae family, is commonly referred to as horseradish, drumstick tree, moringa, bean oil tree and peperwortelboom (Afrikaans)[20]. Moringa is a versatile plant, with medicinal, nutritive and water purification properties. There are approximately 13 moringa species, of which *Moringa oleifera* is the most commonly known species, due to its easy growth and accessibility. Less is known of the other species which need to be further explored[33]. The nutritive properties are universal throughout the moringa plant and therefore the leaves, pods, seeds, flowers, roots, exudates and bark can be consumed[34]. Moringa has numerous essential phytochemicals present in the seeds, leaves and pods, and impressively has more than seven times the amount of vitamin C compared to oranges, nine times more protein compared to yoghurt, 10 times more vitamin A compared to carrots, 15 times more potassium than consuming bananas, 17 times more calcium than drinking milk and 25 times more iron than consuming spinach[35]. There are also high concentrations of folic acid, copper, β-carotene, nicotinic acid, phosphorus, α-tocopherol, riboflavin and pyridoxine present in moringa, as well as the presence of the 10 essential amino acids in the leaves[36]. Micro and macronutrients such as copper, zinc, iron, magnesium, calcium and

Table 1: Four common/popular "functional foods" with their traditional and current possible uses against metabolic syndrome

Fruit/Vegetable	Family	Common	Origin name/s	Traditional uses	Current possible uses against metabolic syndrome and other disorders	References
Hypoxis hemmerocallidea	Hypoxidaceae	African potato, inkamfe (isiZulu); starflower; sterretjie (Afrikaans), moli kharatsa (Sesotho), inongwe (isiXhosa)	KwaZulu-Natal (KZN), Gauteng, Eastern Cape, Limpopo, Mpumulanga, Free State, North West, as well as outside South Africa (SA) in Zimbabwe, Mozambique, Lesotho and Swaziland	Benign prostate hypertrophy, vermifuge, laxative, urinary infections, asthma, tuberculosis, gastric and duodenal ulcers, epilepsy, internal cancerous tumours and headaches. Cultural uses: against storms, thunder and lightning and fearful dreams.	Flu, common colds, weakness, psoriasis, hypertension, adult-onset diabetes mellitus, central nervous system disorders, African potato compounds: for benign prostate hypertrophy, phytosterols such as β-sitosterol have been effective. Phytosterols were branded in 1967, as Harzol® and sold in Germany to treat benign prostate hypertrophy. Together with the 'cancer bush' or Sutherlandia frutescens, are considered as two important medicinal plants used to treat patients with HIV/AIDS.	17-19
Moringa oleifera	Moringaceae	Horseradish, drumstick tree, moringa, bean oil tree and peperwortelboom (Afrikaans)	KZN, Free State, Limpopo, Gauteng and Mpumulanga, India, Nigeria, Philippines, Cambodia and the Caribbean Islands	Diarrhoea, malnutrition, headache, gastric ulcers, spleen and liver problems, joint pains, fungal or bacterial skin infections, insect bites and wounds. Also exhibits antispasmodic, antihypertensive, hypoglycaemic, anticancer, diuretic, cholesterol lowering and antitumor properties.	Anti-neoproliferative, neuroprotective, anti-cancer and antioxidant properties, renal dysfunction,	17, 20
Persea americana	Lauraceae	Avocado, butter fruit or Alligator	Native to Central and	Hypoglycaemic, antihypertensive and antiviral	Anti-inflammatory, anticancer agent	16, 21-23

		pear	South America, Mexico and the Caribbean	effects, cardiovascular disease and ulcers, as well as anti-inflammatory and analgesic properties, also as a constituent of dermatological formulations for treatment of dry skin, aging and protects against ultraviolet radiation, gastrointestinal irregularities, diabetes toothaches, anti-dandruff effects, skin eruptions, snakebite, dysentery, contraception		
Psidium guajava	Myrtaceae	Guayaba, guayabo (Spanish); banjiro (Japanese); goyave, guave or goyavier (French); guaiba, aracá-guacá or aracá-goiaba (Brazil); guave, Guayave or Guavenbaum (German); gurfa, Gwaibwa (Nigeria) and poor man's apple, guava (English)	Native to Mexico, other parts of South America, Africa, Asia and Europe	Anti-diarrhoeal, dysentery and gastroenteritis, laxative, astringent, skin infections, wounds and boils, rheumatism, cough, asthma, bronchitis and pulmonary disease, antibiotic, toothache and ulcers, expulsion of the placenta, wounds due to vaginal haemorrhage, fever, skin infections, respiratory disturbances and dehydration, menstruation, premature labour, miscarriages and uterine bleeding, anorexia, laryngitis, cholera, cerebral ailments, epilepsy, scabies, deafness, worms, conjunctivitis, blood cleansing, colic, haemorrhoids, nausea and sprains In South Africa the guava leaves have been used traditionally in folk medicine in the control, management and/or treatment of conditions such as hypertension and diabetes.	Antihypertensive and hypoglycaemic agent, cardiovascular diseases glycation	24-27

potassium are found in the moringa leaves[37], and the leaves also possess a low calorific value that can assist in obesity[38]. Sanchez-Machado *et al.,* (2010) found that in immature moringa pods, there was approximately 20.66% protein content and 46.7% fibre content[39]. Almost 44% of amino acid content was found in the leaves, 31% in flowers and 30% in pods. Immature flowers and pods showed similar oleic, palmitic, linoleic and linolenic acid content[39]. The polyunsaturated fatty acids (PUFA) such as oleic and linoleic acids are important in the control of cholesterol. There is approximately 76% PUFA in the moringa seed oil, and therefore it is an ideal substitute for olive oil[40]. Seasons influence the nutrient content of moringa, such that iron and vitamin C were more abundant in the cool-dry seasons compared to the hot-wet seasons during which vitamin A was more abundant[41].

Currently, reports indicate that its efficacy in DM and CVD effects seems to be most prominent and in both type 1 and 2 diabetes, moringa has been effective as an antidiabetic agent[42]. Streptozotocin-induced type 1 diabetes rats fed moringa seed powder showed a drop in fasting blood glucose levels[43]. Serum antioxidant enzyme levels increased as the rats were treated with approximately 500mg moringa seed powder. The authors concluded that moringa displayed antioxidant activity by reducing the reactive oxygen species in the beta cells[44]. In Thai traditional medicine moringa has been used as a cardiotonic, demonstrating hypocholesterolaemic activity[45]. In rabbits fed a hyper cholesterol diet, a 12-week treatment that included moringa resulted in cholesterol levels decreasing, as well as plaque formation being reduced by almost 80%. Moringa has been compared to the cholesterol-lowering drug Simvastatin[45].

More recently the use of moringa has extended to the extraction of the seeds for Ben oil, an oil which is rich in sterols, oleic acid and tocopherols. Ben oil also serves as a substitute for olive oil in cooking, as well as being used as perfumes or lubricants[34, 40]. In the prevention of malnutrition and deficiency of nutrients, moringa has been used to fortify foods. Moringa seed flour mixed with maize flour was used to make cookies and some cereals have also been fortified with the moringa leaves[46]. As a fortificant moringa has been used in the production of butter and cream crackers, providing a better protein content, as well as serving as a cheaper substitute for the more expensive ground nut cake and soybean meal[47].

Moringa oleifera also possesses water purification properties due to its containing water soluble proteins that function as coagulants[35]. When added to contaminated water, moringa effectively precipitated mineral particulates. As other coagulants are rare and expensive such as ferric chloride, alum and activated carbon, moringa contains a cationic protein that clarifies turbid water[48]. Heavy metals such as cadmium, chromium, arsenic and lead are eliminated from water using the moringa seed extract[49].

While moringa has shown considerable anticancer and antidiabetic properties more research is required to understand the mechanism of action. Further identification of the proteins and/or enzymes of moringa are needed for antidiabetic and anticancer activity that may ultimately lead to novel compound discovery. Moringa also needs to be further researched as a bio-coagulant that may be a potential alternative in water purification. In the food industry the demand for nutritious snacks is high. Therefore, fortification of foods with moringa may be a significant role player in the eradication of malnutrition[35].

***Persea Americana* (Avocado)**

Persea Americana, commonly referred to as avocado, butter fruit or Alligator pear, is a tropical drupe or fruit belonging to the Lauraceae family[16,22]. *Persea americana* is considered as one of the fruits with the most significant oil content[22]. The fleshy edible part of the avocado is most nutritious as part of a fruit and vegetable salad, eaten raw, with a tortilla, on bread, as a sandwich filling and as pureed pulp known as guacamole[50]. The majority of the avocado consumed globally is the Haas avocado[51]. Avocado has various bioactive compounds such as vitamin E, ascorbic acid, phenolics, carotenoids and flavonoids. Lutein is the most predominant carotenoid, with smaller quantities of carotenoids such as neoxanthin, violaxanthin, zeaxanthin, α-carotene and β-carotene[52]. The lipophilic carotenoids have been reported to possess potential anti-carcinogenic properties. Avocado extracts that contained carotenoids and

tocopherols were also reported to display growth inhibition of in vitro prostrate cell lines[53]. The bioactive compound persin, present in avocado leaves, was utilised in apoptosis induction in human breast cancer cells[54]. The phenolics and flavonoids have been reported to display hepatoprotective function[55], as well as scavenging and reducing free radical formation[56]. Avocado essential oils also demonstrated antimicrobial activity[57], while other studies identified more classes of bioactive compounds with antioxidant properties, that are beneficial to metabolism in humans having mineral constituents such as potassium, magnesium and phosphorus, and lipo and hydro soluble vitamins such as provitamin A or β-carotene, vitamins B, C and E[58]. While the avocado seeds, which form 12-16% of total fruit weight, are considered waste products, studies have indicated that the seeds are rich in secondary metabolites such as alkaloids, monounsaturated fatty acids, polyphenols and essential nutrients. The seeds have indicated potential beneficial effects such as cholesterol lowering, anti-inflammatory, anticancer and antimicrobial agents[22,59].

More recent findings over the last decade for avocado have indicated its effectiveness in chronic diseases such as diabetes and hypertension in in vitro and in vivo models. Sodium chloride (NaCl) induced, hypertensive rats displayed reduced blood pressures and plasma low density lipoprotein (LDL), triglyceride (TG) and total cholesterol (TC) levels, when fed an aqueous seed extract over four weeks[60]. Additionally, in a dose dependent study using NaCl hypertensive rats fed an aqueous seed extract, sodium, blood pressure, glucose, cholesterol and urea levels were reduced after five weeks[61]. The mean arterial pressure was reduced in acetylcholine induced hypertensive rats by 39-44% and heart rate by 9-20% after being fed an aqueous seed extract over 10 days[62]. Avocado seed extract was shown to ameliorate diabetes by reducing blood glucose levels by 47-55% in alloxan-induced diabetic rats over 14 days' treatment and pancreatic islet cells were protected by the seed extract[63]. In another 21-day treatment regimen with the seed extract in a similar model, using 300 and 600mg/kg plasma glucose levels were reduced by 73% and 78%, respectively. In non-diabetic rats glucose levels were reduced by 35-39% indicating efficacy in non-disease states[64]. As a cholesterol lowering agent, dried avocado seed flour given to mice showed reduced LDL and TC levels after a six-day period[65]. In a dose dependent study, a reduction in LDL, very low-density lipoprotein (VLDL), TC and TG levels in mice was found after a 10-day treatment with methanolic seed extract[66]. Similar effects were observed in rabbits over a two-month period using the seed extract[67].

Avocado has gained global recognition as a healthy food, with certification from the Heart Foundation in Australia, as well as the American Heart Association and American Dietetic Association both including publications on avocado and its health promoting properties[68]. The non-edible components of avocado such as the seeds, peel and the pulp have been exploited in recent years as these form an important part of reduction in waste production and some non-edible fruit parts may potentially possess important bioactive compounds that may function as antioxidants[68]. In humans, avocado oil has been beneficial and included as part of the diet. In the pharmaceutical industry avocado and its oils are used as a cosmetic application in topical creams for the treatment of medical conditions[69]. Currently dieticians may recommend avocado consumption together with the vegetable and fruit daily intake. Incorporating avocado into most adult diets may be beneficial for individuals with increased metabolic disease risk factors[59].

***Psidium Guajava* (Guava)**

Psidium guajava is commonly known as poor man's apple or guava, belonging to the Myrtaceae family[25,27]. Various compounds are found in guava such as flavonoids, phenolics, tannins, vitamins, triterpenoid acids, essential oils and sesquiterpene alcohols[70]. Some studies have also identified high levels of vitamin C, polyphenols and carotenoids such as lycopene and β-carotene in the guava pulp[71]. While vitamin C displayed significant antioxidant properties, a correlation between cardiovascular damage and lycopene emerged due to lycopene effects on dyslipidaemia[72]. Previous studies have indicated that catechins found in guava leaves provide preventative treatment in obesity and diabetes, while quercetin has been associated with decreased mortality rates due to heart disease. Effective in the inhibition of triglyceride accumulation

in adipocytes is the compound rutin[73]. Terpenoids found in leaf extract such as lupeol and betulinic acid have been reported in cardiovascular disease, atherosclerosis, diabetes and obesity treatment[74].

In myocardial injury, guava aqueous leaf extract significantly reduced malon-dialdehyde and high energy phosphates in the reperfused hearts[75]. Cardioprotective effects were displayed by the aqueous leaf extract against myocardial ischemia-injury in rat hearts[76] due to the endogenous antioxidant augmentation. In the genetic antihypertensive Dahl salt sensitive rat model, the leaf extract displayed hypotensive effects when administered intravenously. Systemic arterial blood pressure and heart rate were reduced dose dependently[77]. From studies mentioned above and other studies (Olatunji *et al.,* 2007), as the traditional uses of the guava leaf extract in hypertension has been well established, the extract may also be beneficial in cardiovascular disease prevention[25].

Guava has been reported as an important anti-LDL glycative agent, whereby its potential therapeutic uses include neurodegenerative and cardiovascular diseases glycation[78]. In another study using aqueous decoctions to investigate anti-LDL glycative agents, the guava fruit displayed antiglycation properties. Guava fruit antiglycation activities were related directly to the polyphenol content. However, Gutierrez *et al.,* (2008) identified that guava fruit may also possess a different and specific scavenging ability of free radicals[25].

In clinical trials, evidence has indicated that the addition of guava to the diet in moderate amounts, may lead to reduced blood pressure and lipoprotein metabolism[79]. In another trial of hypertensive patients, the diet included potassium and fibre with guava included daily. Both diastolic and systolic blood pressures were reduced after four weeks, as well as reduced serum TG and TC levels, with a small increase in high-density lipoprotein (HDL)/ TC ratio[80]. In a nine-week trial the lipid profile and antioxidant status were studied based on a daily guava fruit consumption. Results included reduced blood cholesterol and oxidative stress[81].

In diabetes management, to evaluate guava efficacy a multicentric controlled trial was conducted. Diabetic patients were administered with oral capsules of aqueous leaf extract and this displayed hypoglycaemic effects that were less potent in comparison to metformin and chlorpropamide. The authors suggested that guava can be utilised in prevention and/or improvement of diabetes[82]. In another diabetic study, guava fruit capsules were orally administered to both diabetic and control group patients. Results identified reduced blood glucose levels in the diabetic group as the weeks progressed (weeks 3-5) compared to the diabetic control group[83].

Guava has a host of traditional uses that have been validated from scientific research. The fruit and leaf have been used in animal and human studies, and studied extensively for its pharmacological actions, making guava a significant anti-diarrhoeal, antioxidant, hypoglycaemic and antihypertensive agent. In human trials there is promise of activity of various bioactive [27]. Guava usage as decoctions, tinctures and infusions have been accepted traditionally, and using more recent scientific methods has displayed amelioration properties for multiple diseases. The pharmacological properties and phytochemistry of guava extract have only been assayed using laboratory animal models in vitro and therefore some results may not be applicable to humans. There are gaps and the medicinal potential of *Psidium guajava* still needs to be further explored as it is a fruit with widespread usage that suggests potential benefits for the future[25].

Conclusion Over the years the use of plants in traditional medicine has been well documented[15,16]. South Africa has rich botanical resources that need to be further explored, without the threat of overexploitation and extinction to the various species. In addressing disease states and the metabolic syndrome, the interest in medicinal plants continues to grow with the possibility of novel compounds and/or new drug discovery. The focus on medicinal plants needs to extend beyond the screening phase in order to identify the bioactive compounds that that may serve as potential therapeutic agents. The four fruits and vegetables discussed in this review paper have uses that extend beyond traditional medicine and include usage in food preparation, beverages, as part of fragrances, culinary flavouring, as well as cosmetic use, but more importantly prove

potential in contributing to the amelioration of the deleterious effects of diseases/health conditions. While the marketing of some herbal products is ongoing, such as rooibos tea and the hoodia appetite suppressants, clinical evidence of many plants' therapeutic benefits is still lacking[16]. Thus, there is a need for new products to be developed, to contribute to the reduction of CVD and DM, reduce the epidemic of chronic diseases and build local capacity. However, the processes involved are not that simple and require innovation, financial and time investment, skills and strategies to achieve sustainability. Alternative, affordable ways to sustain large scale harvesting of medicinal plants is also required. Therefore, future studies need to include the metabolic and genetic diversity, taxonomy, socio-cultural context and the identification and specificity of the bioactive compounds that can pave the way to using edible/medicinal plants as future therapeutics, that can also benefit the South African and other developing countries' economies.

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Conflict of interest
The authors declare that they have no competing interests.

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