Review Paper

Tropical Fruits: Bioactive properties and Health Promoting Benefits in Chronic Disease Prevention and Management

ABSTRACT

Chronic disease conditions such as diabetes, hypertension, cancer, obesity and oxidative stress continue to be a significant concern among nations of the world, which is threatening the economic and social prosperity of the people. This calls for urgent action among relevant stakeholders to explore productive and sustainable ways of addressing the incidence of these life-threatening health conditions. While medicines have been used in the treatment and management of chronic diseases, its adverse side effects over time leave much to be desired. This calls for a novel and safer approach. Tropical fruits contain a rich repository of bioactive compounds. Reports from several studies in literature indeed showed that bioactive compounds present in tropical fruits are capable of not only addressing the prevalence of chronic disease conditions, but they also have minimal to no known side effect. The broad objective of this journal article is to review the bioactive and health-promoting benefits of tropical fruits in chronic disease prevention and management. The valuable knowledge derived from this review will enable food and pharmaceutical companies to explore the production of novel functional foods/neutraceuticals and potent medicines respectively from tropical fruit sources that can be useful in chronic disease prevention and management.

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Keywords: tropical fruits, bioactive compounds, chronic diseases, hypertension, diabetes, oxidative stress

1. INTRODUCTION

The incidence of chronic diseases such as hypertension, diabetes, obesity, cancer, and oxidative stress continue to be a major concern across the world. A report in 2012 revealed that 38 million or 68% of all deaths worldwide were due to chronic diseases [1]. Despite being a well-known health challenge in developed countries, the incidence of chronic diseases is increasing in developing countries. As a matter of fact, in all but the poorest countries, the death and disability from chronic diseases now exceeds that from communicable diseases-comprising 49%, compared with about 40% for communicable disease and 11% for injuries [2]. Not only do chronic diseases threaten the economic and social prosperity of the people, it also leads to a decline in the productive capacity and the quality of life. Health care providers, food scientists, food processors, consumers and other concerned stakeholders have become increasingly interested and are seeking ways by which this major challenge can be addressed. Hippocrates many years ago did say "*Let food be thy medicine and medicine be thy food*". This statement over time has proven to be useful. Today, scientific evidence and a growing awareness of the correlation between diet and health coupled with sedentary lifestyles, an aging population, and an ever-increasing health care costs have driven the interest in healthier foods [3, 4]. It is a common knowledge that tropical fruits have a rich repository of bioactive and health-promoting benefits which can be utilized in chronic disease prevention and management [5-8]. Bioactive compounds are said to be natural constituents of foods that provide health benefits [9] beyond the nutritional properties of the food. They are potential non-toxic therapeutic vehicles that could prevent and manage multiple chronic disease conditions. Bioactive compounds can either act singly or in combination to bring about the much desired therapeutic effects in terms of curbing chronic diseases and other associated health issues. Fruits contain bioactive compounds such as phenolic compounds, anthocyanins, carotenoids, and ascorbic acid [5], among others. This review was borne out of the desire to identify the bioactive compounds and project some of the inherent health-promoting benefits tropical fruits have which can be explored by food and pharmaceutical companies in producing novel health-enhancing food products and potent medicines respectively from tropical fruit sources which can be utilised in the prevention and management of chronic disease conditions that continue to affect the young and the old in our society today.

2. TROPICAL FRUITS, THEIR BIOACTIVE PROPERTIES AND HEALTH PROMOTING BENEFITS

2.1 Avocado

Avocado is a fruit native to the Caribbean, Mexico, South America and Central America [10]. It is regarded as an energetic fruit with a high nutritional value, considered a major tropical fruit, and it is rich in protein and contains fat-soluble vitamins lacking in other fruits, including vitamins A and B, and median levels of vitamin D and E [11]. In other words, the Avocado fruit has a caloric density of 1.7kcal per gram and a half unit (~70g) composed by 114kcal, 4.6g of fibers, 345mg of potassium, 19.5mg of magnesium, 1.39mg of vitamin E and 57mg of phytosterols [12, 13]. It also contains lipids that consist 71% from monounsaturated fatty acids (MUFA), 13% from polyunsaturated fatty acids (PUFA) and 16% from saturated fatty acids (SFA) [14]. The consumption of Avocado is capable of addressing some cardiovascular risk factors. Recent researches have shown that avocado may improve hypercholesterolemia and may be useful in the treatment of hypertension and type 2 diabetes mellitus (T2DM) [15]. Patients with hypercholesterolemia and T2DM supplemented with 300g/day of avocado for 7 days had their total cholesterol (TC) and LDL-cholesterol decreased by 17% and 22% respectively, and their triglycerides (TG) levels reduced by 22%; there was also a slightly increase in HDL-cholesterol when compared to the control group (isocaloric diet, 50% of total calories from fats and without avocado) [16]. The lipid-lowering effect of avocado (also rich in MUFA) occurs mainly due its phytosterol β-sitosterol [17]. In a study, the effect of avocado paste obtained by the fruit oil was evaluated in rats, who consumed a hypercholesterolemic diet added of glucose solution and also the paste of avocado. The study revealed that animals had lower levels of blood sugar, lower values of the Homeostasis Model Assessment-Insulin Resistance Index (HOMA-IR Index) and less accumulation of fat in their liver. In this study, the improvement of the HOMA-IR Index and of the hepatic steatosis was attributed to the phytochemicals components and dietary fibers of the avocado [18]. Avocado has the potential of managing BP values and invariably oxidative stress and inflammation in view of the high amount of potassium and lutein it contains. In addition, diets rich in MUFA may improve systolic and diastolic BP levels when compared to diets with low content of MUFA [19].

2.2 Papaya

The origin of papaya, papaw, or pawpaw fruit (*Carica papaya*) can be traced back to the tropics of the Americas. It is one of the major fruit crops cultivated in tropical and sub-tropical zones which is regarded as a powerhouse of nutrients with rich source of three powerful antioxidant vitamin C, vitamin A and vitamin E as well as minerals, magnesium and potassium, vitamin B pantothenic acid and folate and fiber [20].The folic acid found in papayas is needed for the conversion of homocysteine into amino acids such as cysteine or methionine which if unconverted, homocysteine can directly damage blood vessel walls, is considered a significant risk factor for a heart attack or stroke [21]. In a study reported by Elgadir *et al*. [22] the potential of antioxidant activity of *Carica papaya* juice in a dose of 100 –400 mg/kg/day was determined in a comparison to alpha-tocopherol using Wistar rats. The study revealed that the investigated alpha-tocopherol and the *Carica papaya* juice gave the same effect of the antioxidative stress potential. Papain enzyme from papaya is effective against cancer. Papain breaks down the fibrin cancer cell wall and protein into amino acid form [23]. In animal experiments, organo-sulfur compounds called isothiocyanate found in papaya protects against cancers of the breast, lung, colon, pancreas, and prostate, as well as leukemia, and they have the potential to prevent cancer in humans [24]. Isothiocyanate have shown that they are capable of inhibiting both the formation and development of cancer cells through multiple pathways and mechanisms [24]. The comparative low calories content (32 Kcal / 100 g of ripe fruit) make this a favorite fruit of obese people who are into weight reducing regime and the fermented papaya fruit is a promising nutraceutical as an antioxidant which improves the antioxidant defense in elderly patients even without any overt antioxidant deficiency state at the dose of 9 g/day orally [25]. Pectin is extracted mainly from papaya fruits and it works in a way that it increases viscosity in intestinal tracts, reducing cholesterol absorption from bile or food thus reducing overall blood cholesterol levels [26]. Aqueous extract of *Carica papaya* seeds at doses of 100 – 400 mg/kg/day was investigated for its effects on hypolipidemic, cardioprotective parameters in normal male Wistar rats for 30 days [27]. Three groups of rats were orally administered either with extract of *Carica papaya* seed at doses of 100, 200, and 400 mg/kg/day of the extract or 0.1 mg/kg/day of glibenclamide or 10 ml/kg/day of distilled water (control) for a period of 30 days. The results of studies showed that *Carica papaya* extract significantly ($p<0.05$) lowered the total cholesterol, serum triglyceride, fasting blood glucose and significantly ($p<0.05$) reduced the density of lipoprotein cholesterol in a dose-dependent manner compared to the untreated control rats [22].

2.3 Watermelon

Watermelon (*Citrullus lanatus*) is a popular staple fruit in the world which is consumed equently as a dessert, fruit salad and used in garnishing drinks [28]. Preliminary research indicates that the consumption of watermelon may have antihypertensive effect [29]. *Citrallus lanatus* (water melon) has good amounts of bioactive compounds such as alkaloids, triterpenes, sterols, cucurbitacin, in addition to minerals and vitamins. The seed is used in the treatment of urinary tract infections, bedwetting, dropsy and renal stones, alcohol poisoning, hypertension, diabetic, diarrhea and gonorrhea [29]. *Citrallus lanatus* (water melon) is a fruit of about 93% water, hence the name "*water*" melon while the "*melon*" part came from the fact that the fruit is large and round and has a sweet, pulpy flesh [30]. Every part of the watermelon fruit including the rind and seeds, has nutritional significance. The most preferred way by which watermelon is consumed is by eating the pink or yellow flesh. It can also be consumed as a watermelon cake, watermelon lemonade, watermelon rind pickles and deep fried watermelon. A study was carried out to evaluate the anti-diabetic potential of watermelon (*Citrullus vulgaris Schrad*) *in vivo* [31]. In the study, ICR mice were fed experimental diet containing none, 10% watermelon flesh powder (WM-P) or 1% watermelon rind ethanol extract (WM-E). At the end of 4 weeks, mice were administrated with streptozotocin (40 mg/kg, i.p.) for 5 consecutive days to induce diabetes. Supplementation with WM-E significantly decreased blood glucose level and increased serum insulin levels. Feeding of WM-P also induced moderate changes but those were not statistically significant. Immunohistochemical analysis showed watermelon that effectively protected pancreatic cells death, which suggest that watermelon has a beneficial effect on diabetes. Natural antioxidants such as citruline, ascorbic acid can be found in Watermelon. These functional ingredients act as protection against chronic health problems like cancer insurgence and cardiovascular disorders [32]. Recent investigations have shown that the antioxidant properties of plants could be correlated with oxidative stress defense and different human diseases including cancer, atherosclerosis and the aging process [33]. A recent study has concluded that *Citrullus lanatus* seed extracts possess antioxidant activity and the potency of antioxidant activity depends on the type of extract. The n-hexane extract of *Citrullus lanatus* seeds possess highest anti-oxidant activity in-vitro [34]. This anti-oxidant power depends on total phenolic and flavonoid contents on particular extract [33]. the watermelon-induced increase in plasma antioxidant levels may lend explanation to why an epidemiological study of the Chinese found greater watermelon intake to be associated with a lower risk of cancer [35].A study carried out by Figueroa *et al*., [36] showed that watermelon extract supplementation reduces ankle blood pressure (BP), brachial BP, and carotid wave reflection in obese middle-aged adults with prehypertension or stage 1 hypertension and normal Ankle-brachial index (ABI), which may reflect improved arterial function.

2.4 Banana

Banana is the common name for herbaceous plants of the genus Musa and for the fruit they produce [37]. It is a widely cultivated and consumed fruit in many countries within the tropical and subtropical regions of the world. Banana fruit is a rich source of important phytonutrients, including vitamins and phenolic compounds [38]. It has a rich repository of minerals, such as potassium, calcium, iron, phosphorus, sodium, magnesium, copper, zinc and manganese. Banana utilization as an ingredient in various food formulations has health-enhancing benefits. The incorporation of banana in the recipes of many food products improves the total dietary fiber, resistant starch, total starch and some essential minerals (phosphorus, magnesium, potassium and calcium) [39]. Several researchers have evidenced that bananas are an important source of health-promoting phytochemicals [39-41]. The banana peel is rich in phytochemical compounds than its pulp [42]. The major phytochemicals present in fruits and vegetables remain the phenolics and carotenoids which are health friendly. Bananas contain a rich amount of bioactive compounds, but only the phenolics, carotenoids, flavonoids, biogenic amines and some phytosterols (low amount in banana pulp) have received greater literature attention. Due to these bioactive compounds, bananas have a higher antioxidant capacity than some berries, herbs and vegetables and this capacity increases during fruit maturity [39]. Scientists report that natural compounds in bananas act in a manner similar to antihypertensive drugs with researchers reporting that blood pressure fell by 10% in people who ate two bananas daily for a week [37]. A team studied six popular banana varieties and found that all had ACE inhibiting properties, though the ripened bananas had a stronger action than unripe ones. A study carried out by Ble-Castillo *et al*. [43] was able to demonstrate that Native Banana Starch (NBS) 24 g/day during 4 weeks lowers body weight and increases insulin sensitivity in a group of obese type 2 diabetics. More so, NBS supplementation could be a cheap alternative to reduce body weight and improve glucose homeostasis on subjects with insulin resistance.

2.5 Acai

The açaí fruit (*Euterpe oleracea*) grows on a large palm tree whose origin can be traced to South America. In Brazil, Columbia and Suriname, the natives use it as a major source of food. The 100 g portion of açaí fruit contains water (3.4g), protein (8.1g), fat (32.5g), ash (0.62g), carbohydrates (10.98g), and sugars (10.57g) [10]. Administration of açaí pulp in female Fischer rats fed a hypercholesterolemic diet, dramatically improved the food efficiency and reduced total and non-high-density lipoprotein cholesterol, suggesting a clear hypocholesterolemic effect [44]. In addition, açaí possesses antioxidant and anti-inflammatory properties [10]. Supplementation of açaí to a hypercholesterolemic diet also demonstrated decreased serum levels of end products of oxidative stress i.e. carbonyl proteins, protein sulfhydryl groups, PON-arylesterase and PON-paraoxonase activities, and increased Superoxide Dismutase (SOD) activity. These findings demonstrate that açaí pulp improves the biomarkers of physiological oxidative stress [44]. In an acute (24 hour) human trial of 11 subjects, administration of açaí juice (7mL/ kg) significantly increased plasma antioxidant capacity, and suppressed generation of reactive oxygen species [45].

A nutritional intervention study was conducted with thirty-five healthy women who were asked to consume 200 g/d of açai pulp for 4 weeks [46]. Blood samples were collected, and blood pressure and anthropometric parameters were measured before and after the experimental period. Antioxidant enzymes, superoxide dismutase, catalase, glutathione, production of reactive oxygen species, and total antioxidant capacity were evaluated in polymorphonuclear cells. Serum concentration of protein carbonyl and sulfhydryl groups was also determined. The results show that the açai intake increased catalase activity, total antioxidant capacity, and reduced the production of reactive oxygen species. Furthermore, it reduced serum concentration of protein carbonyl and increased total serum sulfhydryl groups.

2.6 Guava

Psidium guajava L., popularly known as guava, is a small tree belonging to the myrtle family (Myrtaceae) and is native to tropical areas from southern Mexico to northern South America [47]. Guava trees have been grown by many other countries having tropical and subtropical climates, thus allowing production around the world [47]. In recent years, guava leaves tea and some complimentary guava products are available in several shops in Japan as well as on the Internet [48], because guava leaf phenolic compounds have been claimed to be food for specified health use (FOSHU), since they have beneficial health effects related to the modulation of blood–sugar level [49]. Deguchi and Miyazaki [50] reviewed several works regarding the effect of the intake of a commercial guava leaf tea (Bansoureicha®, Yakult Honsha, Tokyo, Japan) on different pathologies of diabetes mellitus illness such as the influence on postprandial blood glucose, on insulin resistance and on hypertriglyceridemia and hypercholesterolemia. The authors concluded that the ingestion of guava leaf tea can ameliorate the symptoms of diabetes mellitus and that it could be used as an alimentotherapy. The guava fruits are believed to overcome various health problems including and a source of antioxidants [51, 52]. Guava fruit contains vitamin C, two times higher than other fruits such as orange; vitamin C is an important compound that has an antioxidant activity [53]. Other compounds in guava fruit are carotenoids such as beta-carotene, lycopene, and beta-cryptoxanthin, and polyphenols [54-56]. Lycopene is associated with the prevention of cardiovascular damage due the LDL oxidation, as the impact of dyslipidemia [57, 58]. In alloxan-treated diabetic mice, intraperitoneal administration of 1g/ kg of guava juice dramatically reduced the blood glucose levels [10]. In STZ-induced diabetic rats, oral administration of guava fruit peel extract actually induced a hyperglycemic effect, suggesting that guava fruit peel should be peeled before eating in diabetic patients [59]. In contrast, another study found that that oral administration of guava fruit peel extract demonstrated significant hypoglycemic and hypolipidemic effects in same model [60]. Hence, it is highly evident that the literature is inconclusive regarding the hypoglycemic and hypolipidemic effects of guava [10].

2.7 Persimmon

Persimmon is fleshy fibrous tropical, deciduous fruit belonging to Ebenaceae family which is commonly cultivated in warm regions of the world including China, Korea, Japan, Brazil, Turkey, and Italy [61]. As a result of its unique flavor in addition to its health enhancing potentials, Persimmon appears to be one of the most popular and valuable fruits in markets in these parts of the world. This fruit contains 79% water, 0.7% pectin, 0.4% protein, and crude fiber; it is rich in vitamin A (217 RE) compared to apple (5 RE) with Vitamin C contents vary from 7.5 to 70mg per 100 g of the fruit flesh depending upon the variety [62]. Well over 400 species of persimmon are grown, among these, *Diospyros kaki, Diospyros virginiana, Diospyros oleifera,* and *Diospyros lotus* [63] are of significant importance. It is interesting for the readers that *D. kaki* (Japanese persimmon) is the most promising specie [61, 64]. Palmitic acid, oleic acid, and linoleic acid are the major fatty acids found in persimmon seeds, ranging from 70.4% to 78.3% of total fatty acids [65]. Among the fatty acids, oleic acid plays a vital role in cancer prevention. The effect of oleic acid on the same lines of breast cancer cells was examined and it supported the theory that oleic acid is chemopreventative [66].Moreover, omega-6 fatty acid (linoleic acid) diminishes the risk of cardiovascular diseases [67]. The published literature demonstrates a potent anti-diabetic and anti-obesity capacity of the persimmon fruit [68-70]. Proanthocyanidin is the major component isolated from persimmon peel and has been demonstrated to play a role in obesity and diabetes. Administration of proanthocyanidin from the peel of persimmon in streptozotocin (STZ)-induced diabetic rats decreased the elevation of lipid peroxidation, suppressed generation of reactive oxygen species, decreased serum glucose, glycosylated hemoglobin (HbA1C), serum urea nitrogen, urinary protein, and renal advanced glycation end products under diabetic conditions. This clearly suggests an overall protective effect against oxidative stress-related inflammatory processes and diabetes [68]. In the diet-induced obesity mouse model, feeding of persimmon significantly attenuated the elevation in plasma lipids (total cholesterol, triglyceride, LDL cholesterol) [71]. Polymers from proanthocyanidins of persimmon exhibited a strong inhibitory effect on α-amylase, while oligomers exerted a stronger protective activity against α-glucosidase activity and AGE formation, suggesting that oligomers may have more potential as anti-diabetic agents [72]. Proanthocyanidins from persimmon also attenuated the increased oxidative stress in db/db mice by suppressing lipid peroxidation, ROS, protein expression of iNOS and COX-2, and increasing the reduced glutathione/oxidized ratio [10]. In view of the health-enhancing value that can be associated with Persimmon fruit as a result of its rich bioactive properties (ascorbic acid, tannins, and carotenoids), it can be used in the manufacturing of novel functional foods.

2.8 Passion Fruits

Passion fruit (*Passiflora edulis flavicarpa*) is native to tropical America and Brazil stands out as the world's largest producer producing approximately 920,000 tons of the fruit in 2010 [73]. Passion fruits belonging to the family *Passifloraceae* are grown mostly in tropical and sub-tropical parts of the world [74]. The two species with the most commercial value are *P. edulis fo. edulis* (red passion fruit) and *P. edulis fo. flavicarpa O. Deg.* (yellow), with the yellow species being the most widely cultivated [75]. Passionfruit have some reasonable amounts of iron, potassium, zinc and manganese. An experimental study on albino rats of which 100, 200, 300, 400 mg/kg body weight was administered indicating % reduction of blood glucose was 6.31, 7.14, 6.73 and 6.00 respectively for each dose and it was also found that 200 mg/kg body weight was the most effective in reducing blood glucose levels with a maximum fall rate of 47.25% after 3 hours of glucose administration [74]. The presence of phenols and flavonoids may be responsible for the observed hypoglycemic activity of *Passiflora edulis* [76]. A diet containing 5% flour of passion fruit peel reduces blood glucose by 59% in diabetic rats reaching the normal glycemic amount (112.6mg/dl) [74]. The mechanism is due to the presence of fiber, tannins and phenolic compounds [77] which reduce the digestion and absorption of carbohydrates, increased the sensitivity of muscle and adipose tissue to insulin [78]. Flour prepared from yellow passion fruit peels has also been shown to reduce blood glucose in diabetic people [75]. In a phase I clinical study, passion fruit peel flour was well tolerated in 36 people between ages 20 and 60, of both sexes. They received 10 g of flour three times a day and were told to put it in their choice of juice, soup, or any other food or beverage. There was an average reduction of blood glucose, triacylglycerides, total cholesterol and LDL of 5.2, 15.0, 18.2 and 19.0%, respectively. In phase II studies, flour prepared from yellow passion fruit peels reduced blood glucose, cholesterol, LDL, blood pressure and body weight in diabetic patients. The petroleum ether and chloroform extracts of *Passiflora edulis* leaf on DPPH free radical scavenging assay showed antioxidant activity with IC_{50} of 58.88μg/ml and 56.85μg/ml respectively [74]. Passion fruit seed oil has high contents of polyunsaturated fatty acids that can be and successfully used, for example, in the production of margarine, which are consumed without heat treatment and therefore less susceptible to oxidation [73]. The oil, extracted by Soxhlet, has significant antioxidant quantity and can serve as a source of natural antioxidants preventing the development of diseases or as a food additive, increasing the stability and quality of food products [79]. Among the compounds with antioxidant and anti-inflammatory effects found in passion fruit species are chlorogenic acid, hyperoside, isovitexin, caffeic acid, quercetin, luteolin, *orentin*, rutin, vitexin and others [51]. Researchers at the University of Florida have found that yellow passion fruit extracts can kill cancer cells in vitro and the phytochemicals which are responsible for this anti-cancer effect are carotenoids and polyphenols [80].

2.9 Durian

Durian (*Durio zibenthinus* Linn) belonging to the family Bombacaceae is otherwise known as "king of tropical fruit" owing to its highly nutritious superlative pulp and outer thorny appearance, resembling the thrones of ancient Asian era kings [81]. It is a seasonal tropical fruit of Southeast Asia (Malaysia, Thailand, Philippines and Indonesia) [82]. The importance of durian fruit as a nutraceutically valued source can be correlated to their composition and presence of bioactive antioxidant compounds [83, 84]. Hundred grams of edible portion of Durian contains water (64.99 g), protein (1.47 g), lipids (5.33 g), ash (1.12 g), carbohydrate (27.09 g) and fiber (3.08 g) [10]. Fresh durian pulp is rich in dietary fibre (soluble, insoluble and total dietary fibre) [85]. Oleic and linoleic acids are the major unsaturated fatty acids, whilst capric, myristic, palmitic, arachidic, and stearic acids are the major saturated fatty acids found in durian [84]. In another report, linoleic acid (2.20%), myristic acid (2.52%), oleic acid (4.68%), 10-octadecenoic acid (4.86%), palmitoleic acid (9.50%), palmitic acid (32.91%), and stearic acid (35.93%) have been stated to be major compounds [86]. The flesh and hull of durian have a wide array of bioactive compounds. These bioactive compounds possess high potential to be used as a therapeutic agent. They can be of help to treat patients suffering from diabetes mellitus (help in regulating secretion of insulin) as well as be of use to treat certain cardiovascular diseases (by reducing serum cholesterol) [84, 85, 87-90]. Some of the major bioactive compounds such as anthocyanins, carotenoids, polyphenols, flavonoids, and others are reported to be present in ample amounts in durian fruit. However, different stages of ripening can influence their concentration levels and bioavailability [84, 85, 91]. Only little number of studies has been made to carry out to explore the anti-diabetic and anti-obesity potential of Durian. The progress made from these studies show that Durian can be further explored to detail its anti-diabetic and anti-obese potentials. Durian exhibits potential effects on metabolic parameters in human and animal models [87, 90, 92]. When rats were fed durian in addition to a cholesterol enriched diet (1% cholesterol), it positively influenced the plasma lipid profile, plasma glucose and antioxidant activity. These metabolically beneficial effects of durian might be due to the higher contents of bioactive compounds with various biological activities, such as metabolic enhancer and antioxidant [10]. This suggests that durian consists of few critical bioactive components that can be further evaluated for hypoglycemic and anti-hyperlipidemic effects [87]. Interestingly, in a small clinical trial, durian has been shown to improve glucose homeostasis by altering insulin secretion and its action [90]. After ingestion of durian, the insulin response curve of 10 diabetic patients was significantly improved compared to the ingestion of other fruits (mango, pineapple, banana, rambutan) and control (no fruit). Various durian cultivars have also been shown to possess anti-oxidant capacities due to the relatively high level of total polyphenols [92]. This anti-oxidant property of durian and its components can be useful for prevention of oxidative stress mediated induction of diabetic and obesity complications [10].

2.10 Lemon

Lemon is classified as *Citrus limon* (L.) Burm. f. and it is the third most important *Citrus* species after orange and mandarin [93]. It is a small tree and originated probably from Asia [94]. Lemon fruit [*C. limon* (L.) Burm. f.] contains many important natural chemical components, including phenolic compounds (mainly flavonoids) and other nutrients and non-nutrients (vitamins, minerals, dietary fiber, essential oils and carotenoids) [93]. Their health-promoting effects and properties have been associated with their contents, namely vitamin C and flavonoids, due to their natural antioxidant characteristics [93]. In general, the rich reserve of flavonoids which lemon fruits have make them an important vehicle in preventing degenerative chronic disease conditions such as diabetes, cancer, obesity, blood lipid lowering and cardiovascular diseases. Lemon is an important medicinal plant used mainly for its alkaloids, which are having anticancer activities [95]. The Journal of Clinical Biochemistry and Nutrition published their findings on the effects of polyphenols within lemons on body weight [96]. They put mice on one of three diets: a low-fat diet, a high-fat diet, and a high-fat diet that included lemon polyphenols. They found that lemon polyphenols actually suppressed not only body weight and fat deposits, but also obesity-related disorders such as insulin resistance, hyperlipidemia, and hyperglycemia.

2.11 Kiwi

Kiwi fruit is native to China subcontinent and today the world has embraced the utilization of this fruit as a result of its inherent economic value and health benefits. It is also known as ''*Macaque peach*'', ''*Mihoutau*'' and ''*Chinese gooesberry*''[97]. More than 90% of the fruit is edible, including the seed, except the skin and almost all the ingredients are available in Kiwi fruits compared to other existing fruit crops [98]. Kiwi fruit is rich in vitamin C, vitamin E, potassium, dietary fiber and magnesium [99]. Kiwi has low glycemic index which makes it suitable for the individuals with diabetes and in addition, fibre rich foods, like kiwifruit, are good for keeping the blood sugar levels of diabetic patients under control [97]. The great amount of dietary fiber in kiwi fruit helps in decreasing the probability of colon cancer while the flavonoids present in kiwi fruits protect the cells from oxidative damage and in turn, help in guarding the DNA from mutation and damage [100]. Thus, it can be said that Kiwi's antioxidant properties has the capacity in protecting the body against free radicals. Kiwi is also associated with lower BMI [101].

2.12 Sweet orange

Citrus sinensis (L. Osbeck) or sweet orange originated from south East Asia, but is consumed all over the world as an excellent source of vitamin C, sufficient amount of folacin, calcium, potassium, thiamine, niacin and magnesium, phytochemicals like liminoids, synephrine, hesperidin flavonoid, polyphenols, pectin, and sufficient amount of folacin, calcium, potassium, thiamine, niacin and magnesium are also present [102]. It is well appreciated that biologically active, non-nutrient compounds found in citrus fruits such as phytochemical antioxidants, soluble and insoluble dietary fibers are known to be helpful in reducing the risk for cancers, many chronic diseases like arthritis, obesity and coronary heart diseases [103]. Their peels are also known for their antioxidant properties. Sweet oranges also contain low calories, no saturated fats or cholesterol, but are rich in dietary fibers and pectin which are very effective in people with obesity [103]

3. CONCLUSION

There is no doubt with the fact that tropical fruits possess an excellent reserve of bioactive compounds with health-enhancing potentials for chronic disease prevention and management. These identified bioactive can indeed act synergistically in bringing about their much-desired effect in ameliorating diabetes, hypertension, obesity, cancer and oxidative stress conditions that are becoming prevalent in our world today. The valuable knowledge derived from this review will enable food and pharmaceutical companies to explore the production of novel functional foods/neutraceuticals and potent medicines respectively from tropical fruit sources which can help in bringing about the much needed relief in the prevention/management of these chronic degenerative diseases.

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