

Bitter Foods are Sometimes Better

ADENIYI Paulina O.*

Institute of Agricultural Research and Training, Obafemi Awolowo University, Ibadan, Nigeria
*Corresponding author: doyinadeniyi@yahoo.com

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Abstract The instinct of every human being is naturally inclined towards the consumption of sweet-tasting foods neglecting the fact that foods that taste bitter are better consumed sometimes. The bitter components of some foods are of immense medicinal value; hence, this is a review of some bitter foods, their bitter components and possible medicinal values. HINARI, Scopus and Google scholar were accessed in this study. All the bitter foods compiled are plant foods and they include: cruciferous vegetables; chicory; chard; artichokes, asparagus, lettuce; bitter leaf; coffee; cocoa powder; ginger; bitter melon; cucumber; olives; charyotes and clove basil. The main bitter components of these foods are: glucosinolates; sesquiterpene lactones (lactucin and lactucopicrin); flavonoids (myricetin, naringenin, kaempferol, apigenin, cynarin); furostanol saponin and other phenolic compounds such as chlorogenic acids (hydroxycinnamic acid and quinnic acid); theobromine (methylxanthines); gingerol/ shogaol; cucurbitacin and oleuropein. These have been reported to be bioactive and exert the following effects: anti-parasitic; antimicrobial; antibacterial; antioxidant, anti-inflammatory; anti-diabetic; hypolipidemic; anti-cancer; protect against toxicity; neuro-protective; anti-depression; anti-anxiety; anti-hypertension; anti-obesity, anti-allergy; anti-nausea, anti-arthritis; anti-viral, analgesic; anti-pyretic; anti-ulcer; gastro-protective; sedative and fertility enhancer. Consumption of these bitter foods may therefore be an effective measure towards improving public health globally since prevention is always better than cure.

Keywords: bitter foods, bitter components, disease prevention, public health

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1. Introduction

Organoleptic responses to the sensory properties of food (taste, aroma, texture, appearance, colour, etc) help to determine food preferences/choices and eating habit. Opting for sweet-tasting foods at all times has been observed to be more detrimental than beneficial since this may lead to overweight, obesity and diabetes even in *utero* [1,2]. Once sweet tooth is developed, the individual naturally develops a bad or poor eating habit having cravings only for sweet-tasting foods which may predispose him or her to certain infections [3].

Bitter components of foods vary from one food to another and these may exert medicinal and beneficial effects such as; diuretic, anti-inflammatory, anti-diabetic, antioxidant, anticancer, hypolipidemic just to mention a few [4].

The increasing prevalence of different diseases globally demands a sustainable preventive and combating measures, for instance, in older adults worldwide 6.7million cancer were diagnosed in 2012 and this was projected to increase to 14 million by 2035 [5]. In 2017, 451 million adults within the age 18 to 99 years were living with diabetes globally and this was projected to increase to 693 million by 2045 [6]. Furthermore, the global prevalence of chronic kidney disease increased by 87% between 1990 and 2016 [7]. In another global study, the rate of systolic blood pressure of at least 110 to 115mmHg increased from

73119 to 81373per every 100,000 persons between 1990 and 2015 while that of 140mmHg and above increased from 17307 to 20,526 per every 100,000 persons within the same period of time [8]. Prevalence of peripheral artery disease increased by 28.7% in low-income and middle-income countries and by 13.1% in high-income countries between 2000 and 2010 [9]. These non communicable diseases may be referred to as diseases of comfort or civilization diseases, the prevalence of which is expected to continue to increase with increase in civilization as a result of modernization and technological advancement [10]. Basically, the prevalence of infectious diseases has been experiencing similar trend, for instance, between 1990 and 2013 deaths resulting from viral hepatitis globally increased from 0.89million to 1.45million [11]. Similarly, the global incidence and prevalence of campylobacteriosis has been on the increasing trend between 2005 and 2015 in both developed and developing countries, poultry being the major reservoir of the *Campylobacter spp* and source of transmission to human beings [12].

The prevalence of diseases may be expected to increase with time but the regular inclusion of some bitter foods with marked medicinal value in the diet could likely proffer a cushion effect to combat this increase. This review therefore compiles some bitter foods, their bitter components, culinary application and the possible medicinal effects they exert with a view of encouraging the consumption of these bitter foods.

2. Methodology

HINARI, Scopus and Google scholar were accessed in this study in December, 2018 and January, 2019. The keywords used in this search were; bitter foods, bitter components, medicinal value and culinary uses.

2.1. Cruciferous or Brassica Vegetables

These belong to the family Brassicaceae and the plant foods in this family are: Rocket (e.g. arugula); broccoli; brussel sprouts; cabbage; cauliflower; kale; cress; amongst others. These all contain notable quantity of glucosinolates which exert the bitter flavour common to these plants. It has been established by several scientific reports that glucosinolates are bioactive compounds and exert medicinal value in the body. Cruciferous vegetables may be eaten raw, steamed, boiled or stir-fried and consumed alone or as a side dish or accompaniment as well as garnishes to foods and may be served with sausages, hot dogs, burgers, meat or fish loaf, etc.

They prevent oxidation stress, activate detoxification enzymes, stimulate immune system, reduce cancer risk, and inhibit tumor formation, carcinogenic mutation as well as proliferation of cancer [13]. Specifically, glucosinolates in cruciferous vegetables protect against cancer by targeting multiple pathways such as; adaptive stress response, phase I/II enzyme modulation, pro-growth, pro-survival, pro-inflammatory signalling, angiogenesis and epigenetic modulation [14]. As well as via modulation of microRNAs in the prevention of colorectal cancers [15]. This anti-carcinogenic activity was also channelled through protection of cells from DNA damage, modulation of cell cycle via pro-apoptotic, anti-angiogenesis and anti-metastasis activities [16,17,18,19]. Another possible anti-carcinogenic mechanism was via DNA protection through the reduction of genotoxic metabolites of chemical carcinogens by the inhibition of their generation and/or stimulation their detoxification [20,21]. In fact many scientific reports have established the anti-carcinogenic effect of glucosinolates in cruciferous vegetables [22-28], hence, it is of pertinent importance that this potential be harnessed by consuming these vegetables towards the prevention of all types of cancer.

The ability of glucosinolates and their hydrolytic derivatives to detoxify potent toxicants has also been established. The anti-oxidative efficacy of aqueous broccoli extract containing glucosinolates at different concentrations protected against the toxic effect of triazophos, an organophosphorous pesticide, in female rats [29]. This was channelled via the activation of antioxidant enzymes thus leading to reduced lipid peroxidation and apoptosis as well as improved histo-architecture of the hepatic and renal status [29]. Consumption of broccoli prevented petrol-induced hematotoxicity, oxidative stress and inflammation through preservation of bone marrow integrity [30]. More still, Glucosinolates isolated from cruciferous vegetables protected against doxorubicin-induced genotoxicity and cardio toxicity in Swiss albino mice via its antioxidant activity [31] as well as against multi organ toxicity in rats [32].

2.2. Chicory (*Cichorium intybus*)

Chicory is a woody perennial herbaceous plant belonging to the dandelion family Astereceae. The leaves are consumed as salads and accompaniment to other food or as a side dish, buds and roots are blanched or baked or roasted and ground and used as a coffee substitute or as spice. It is native to the Mediterranean region and curly endive is also referred to as chicory in the United States of America.

The bitter components of chicory are the sesquiterpene lactones, that is, lactucin and lactucopicrin, and these exert varying medicinal effect. The anti malaria and anti parasitic activities of these components in chicory have been documented. Chicory leaf and root methanolic extracts containing varying concentrations of the sesquiterpene lactones exerted strong larvicidal activity on the larvae of *Anopheles stephensi* (malaria vector), *Aedes aegypti* (dengue fever vector) and *Culex quinquefasciatus* (filariasis vector) [33]. The anti parasitic effect of sesquiterpene lactones in chicory on gastrointestinal parasites was also displayed when chicory was added to livestock feed because it gave an appreciable positive result, thus showing effective parasitic activity after chicory consumption [34]. *In-vitro* studies have ascertained the effective anti helminthic activity of sesquiterpene lactones in methanol extract of chicory against free-living and parasitic stages of *Ostertagia ostertagi* in faeces of mono-infected calves [35,36] and in vivo when consumed with feed in experimental cattle [37].

The anti-diabetic effect of the sesquiterpene lactones in chicory has also been reported. Fan et al., [38] observed the potency of sesquiterpene lactones in chicory root extract in the inhibition of α -glucosidase while Shim et al [39] reported that this anti-diabetic effect was via enhancing the secretion of the cytokine, interleukin (IL-1 β) which subsequently improved glucose metabolism in high-fat diet-fed insulin resistant mice.

The anti carcinogenic effect of sesquiterpene lactones in chicory has also shown a positive progress because Ren et al., [40] established the anti-carcinogenic and tumoricidal effect of these compounds from plant-based sources. Generally, the ability of sesquiterpene lactones in inhibiting the transcription factor NF- κ B [41], inhibition of cytokine production, modulation of pro antioxidant contents and regulation of intracellular signalling pathway [42] make them potential anti inflammatory agent and an anti oxidative compounds [43]. In overall, the antioxidant, anti inflammation, sedative, immunological, reproductive enhancing, hypolipidemic, anti cancer, anti protozoa, gastro-protective, anti-diabetic, analgesic, anti helminthic, anti microbial and wound healing effects of chicory have been attributed to its bitter components, sesquiterpene lactones [44]. Chicory consumption should therefore be encouraged since it is a food with diverse medicinal effects.

2.3. Chard (*Beta vulgaris*)

It is also referred to as Swiss chard. It is a green leafy vegetable belonging to the Flavescens group cultivars of plants. It is native to the Mediterranean region. Fresh young chard can be included in salads while mature leaves

and stalks may be stir-fried, sautéed or added to stews, sauces and soups. Chard owes its bitter taste to the flavonoids which it contains. These include; myricetin, naringenin, kaempferol and apigenin [45]. The flavonoids in chard exert hepatoprotective activity against toxicity and hypolipidemic activity [46] as well as protected organs against damage induced by toxicity [47,48]. A strong antioxidant, antibacterial and anticancer effect of these flavonoids was also observed and reported [49] while Trifunovic et al., [50] also established this strong antioxidant activity. It is of interest to note here that the consumption of Swiss chard leaf extract enhanced cognitive development and protected against memory disorder [51,52] and even protected against hypoglycaemic-induced oxidative stress [53].

2.4. Artichokes (*Cynara scolymus*)

Artichokes belong to the species of thistle which are cultivated as food. It is native to the Mediterranean region. The flower buds are commonly consumed as food. It can be boiled or steamed and consumed with hollandaise, vinegar, mayonnaise, lemon juice and other sauces. The softer parts of artichoke can be eaten raw while the flower bud can also be dried and consumed as herbal tea.

The main bitter component in artichoke is cynarin but it also contains apigenin and luteolin [54]. All these are flavonoids. The bioactive chemicals in artichokes especially the flavonoids and sesquiterpene lactones have been observed to exert anti cancer, anti-inflammatory and antioxidant effect [55]. Reports of animal studies have identified artichoke as a potent anti oxidant source because artichoke extract supplementation increased markedly antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase and glutathione in the liver while malondialdehyde reduced considerably in liver and plasma [56]. Aqueous extract of the edible parts of artichokes also exhibited strong free radical scavenging activity owing to the polyphenols it contains especially the bitter components [57] and these were also responsible for its protective activity against toxicity [58]. The blood cholesterol and glucose lowering effects of artichoke extracts have also been documented and these are owed to the bitter polyphenols it contains [59,60].

2.5. Asparagus (*Asparagus officinalis*)

Asparagus is a vegetable crop belonging to the family Asparagaceae. The young shoot is usually consumed as a spring vegetable and the storage roots are also edible. One of the major bitter components in asparagus are the furostanol saponins [61]. Some saponins have been reported to exert medicinal effects amongst which is the furostanol saponin and its activity as an anti cancer agent has been observed and documented [62,63,64] while the medicinal effect of different varieties of asparagus species have been identified as anti oxidants, anti-diabetic, anti allergic, anti-malaria, hepatoprotective, anti arthritic, immune response enhancer, anti inflammatory, anti ulcerogenic, antipyretic, analgesic [65,66] fertility enhancer in men and women, activator of nerve cells thus preventing risks of nervous disorder like depression, anxiety and stress [67].

2.6. Lettuce (*Lactuca sativa*)

Lettuce is an annual plant belonging to the family Asteraceae. It is mainly cultivated as a leafy vegetable but sometimes for its stems and seeds. The leaf is commonly eaten raw as salads, sandwiches, and garnishes or cooked in soups, stews and sauces. The predominating bitter components in lettuce are the sesquiterpene lactones (lactucin and lactucopicrin). In addition to the medicinal benefits of these chemical components under artichoke, extracts from lettuce have also been reported to protect against induced amnesia via cholinergic and antioxidant mechanisms [68], enhanced sleep behaviour [69] and the therapeutic attributes such as anti oxidant, anti inflammatory, anti microbial, analgesic, neuro-protective and sedative activities of lettuce are owed to the bioactive sesquiterpene lactones it contains [70].

2.7. Bitter Leaf (*Vernonia spp*)

Bitter leaf plant is a perennial shrub belonging to the family Asteraceae. The leaves are commonly eaten as food in stews, soups, sauces, side dish an accompaniment mainly in West African countries. The flavonoids which predominate the chemical constituents of bitter leaf are responsible for its bitter taste and its medicinal activity especially its antioxidant capacity which is exhibited by strong free radical scavenging traits as well as activation of antioxidant enzymes [71,72]. The bitter component in bitter leaf have also been reported to alleviate inflammation, pyrexia and nociception [73] and have been observed to exert anti-diabetic effect [74] as well as enhanced fertility in male rats especially when combined with pumpkin leaf [75].

2.8. Coffee (*Coffea spp*)

Coffea belongs to the group of flowering plants in the family Rubiaceae and is native to Southern Africa and Tropical Asia. The phenolic compounds present in ample amount in coffee are mainly responsible for its bitter taste the predominating of which are hydroxycinnamic acids and quinic acid which are collectively referred to as chlorogenic acids. These exert the characteristic bitter taste and flavour. Caffeine contributes only about 15% of the bitterness of coffee that is why even decaffeinated coffee still tastes as bitter as the coffee itself. The matured beans are commonly roasted, ground and then brewed in very hot or boiling water to extract the stimulating beverage known as coffee. It has been established that decaffeinated coffee protects against development of neurodegenerative diseases such as memory disorders, Parkinson disease, neuropathic pain disorders and cerebral ischemia owing to bitter components in coffee other than caffeine [76]. The anti oxidant activity of these phenolic compounds in coffee has also been documented [77] as well as their blood glucose lowering effect via improvement of insulin sensitivity [78].

2.9. Cocoa Powder (*Theobroma cacao*)

Cocoa tree is a perennial evergreen tree belonging to the family Malvaceae. It originated from the tropical

regions of America and is now cultivated globally in areas suitable for its growth. Cocoa owe its bitter flavour to the alkaloids it contains most especially theobromine of which methylxanthines predominate and polyphenols which it contains. Owing to the bitter components in cocoa bean powder cocoa supplementation in diet has been reported to reduce mild cognitive impairment, insulin resistance, lipid peroxidation as well as protected against non communicable diseases such as cardio metabolic diseases, diabetes mellitus, metabolic syndrome, hypertension, atherosclerosis, stroke and cancer [79]. Furthermore, cocoa consumption has been observed to exert antioxidant activity, inhibition of clot formation, improvement of blood circulation and prevention of atherosclerosis via its antioxidant activity which was channelled through the stimulation of nitric oxide thus controlling blood pressure due to the alkaloids and flavonoids characteristic of the bitter taste [80]. The alkaloids also enhanced breathing flow and prevent chronic allergies [81].

2.10. Ginger (*Zingiber officinale*)

Ginger is a herbaceous perennial flowering plant belonging to the family Zingiberaceae. It is native to Island Southeast Asia. The pungent and bitter component in ginger is the phenolic compound called gingerol in fresh ginger rhizome and shogaols in the dried ginger. Ginger can be made into drink, candy, and may be used as spice in both savoury and sweet dishes, in fact its culinary use is versatile. Gingerol was observed to prevent and treat cancer and chronic inflammatory diseases [82,83] while its anti parasitic effect was highly effective in achieving 100% mortality of *Ichthyophthirius multifiliis* which is a ciliate parasite of fresh water fish [84]. Furthermore, owing to the bioactive bitter and pungent component of ginger and its derivatives, ginger consumption reduced menstrual bleeding in women of reproductive age with heavy menstrual flow [85], protected rat foetuses against Gabapention-induced hepatotoxicity [86], improved blood lipid concentration [87] reduced body weight in overweight and obese human subjects [88], prevented nausea and vomiting during pregnancy and chemotherapy [89], exerted antioxidant activity [90] and anti-diabetic effect [91].

2.11. Bitter Melon (*Momordica charantia*)

Bitter melon is a tropical and subtropical plant belonging to the family Cucurbitaceae. It originated from India. It is commonly consumed in cooked form while the young shoot and leaves may be eaten raw in salads. Other names given to bitter melon are; bitter gourd, bitter apple, bitter squash and balsam bear. Alkaloids are the main bitter components of bitter melon though it also contains some functional polypeptides and polysaccharides which make it medicinal [92]. A polypeptide analogue, p-insulin, which mimics insulin action and certain alkaloids in bitter melon exert the bitter taste and have been reported to exert anti-diabetic activity due to their ability to effectively control blood glucose level [93]. These bioactive components are also responsible for the medicinal effect of bitter melon which include; anticancer, protection against abdominal pain, kidney stone, fever and scabies

[93]. In fact, the anticancer, antiulcer, antiviral, anti-diabetic, antibacterial and anti-polio virus activities of bitter melon are owed to the phytochemicals and functional polypeptides it contains [94,95,96,97]. Its antioxidant activity has also been established [98] as well as its tumoricidal effect [99] and anti-arthritis potential [100].

2.12. Cucumber (*Cucumis sativus*)

Just like bitter melon cucumber also belongs to the gourd family, that is, Cucurbitaceae. It is native to South Asia and is cultivated for its pulpy fruit. It is commonly eaten raw in salads and to flavour or enrich drinks. The chemical component which make cucumber bitter is Cucurbitacin C [101] and is also commonly present in the plants belonging to the family Cucurbitaceae, hence, it is present even in bitter melon and its strong anti inflammatory, tumoricidal and other medicinal effects has been reported. Cucumber consumption was observed to protect vital organs in mice against arsenic-induced toxicity via the normalization enzymatic and non-enzymatic activities that enhances the function of liver and kidney [102]. The cucurbitacin C exerts anti inflammatory effect via the inhibition of tumor necrosis factor (TNF- α) and other intermediate factors which mediate inflammation such as nitric oxide synthase-2 and cyclo-oxygenase-2 [103] while its antitumor and anticancer effect was exerted via the inhibition of cancerous and tumour growth as well as induction of cancer cell apoptosis [103]. It also exhibits anti-diabetic effect through the inhibition of nitric oxide generation [104] and anti atherosclerotic activity via inhibition of lipid oxidation products such as malonaldehyde and 4-hydroxynonenal [105].

2.13. Olives (*Olea europaea*)

Olive plant is a small tree belonging to the family of Oleaceae. It is native to the Mediterranean region. Raw or fresh olives are naturally bitter, hence, it is commonly cured and fermented to reduce bitterness and improve palatability. Oleuropein and other phenolic compounds in olive exert the bitter taste and these are of vital medicinal value such as antioxidant, anti inflammatory, anti atherogenic, anti cancer, antimicrobial, anti viral, hypolipidemic and hypoglycaemic activities [106,107]. The cardio and neuro protective efficacy of oleuropein in olive is channelled through the formation of non-covalent complex with the Amyloid β -peptide which is a potent and vital intermediate of several degenerative diseases [108] while its bioavailability and antioxidant effect in humans have also been observed and reported [109].

2.14. Chayotes (*Sechium edule*)

Chayotes, which is also called mirliton squash, is an edible plant of the gourd family that is Cucurbitaceae, hence, its medicinal effect or activity is similar to that of bitter gourd or bitter melon and cucumber. It is native to Mexico and it can be eaten raw in salads and salsas or cooked as it is done in stir fries. Its root, shoot as well as leaves are also consumed as food.

2.15. Clove Basil (*Ocimum gratissimum* L.)

Clove basil, also known as African basil, is a species of *Ocimum* family. It is native to Africa, Madagascar and South Asia. It is used as a culinary herb in many soups, stews, sauces and savoury main dishes especially in West Africa. The antibacterial and anti microbial effect of clove basil leaves have been well documented [110,111] and it has been observed to be effective even against drug-resistant bacteria species [112] as well against intestinal worms [113].

3. Conclusion

Bitter foods reviewed include cruciferous vegetables; chicory; chard; artichokes, asparagus, lettuce; bitter leaf; coffee; cocoa powder; ginger; bitter melon; cucumber; olives; charyotes and clove basil containing the following bitter components: glucosinolates; sesquiterpene lactones (lactucin and lactucopicrin); flavonoids (myricetin, naringenin, kaempferol, apigenin, cynarin); furostanol saponin and other phenolic compounds such as chlorogenic acids (hydroxycinnamic acid and quinnic acid); theobromine (methylxanthines); gingerol/ shogaol; cucurbitacin and oleuropein. These are of diverse medicinal benefits in preventing and treating some diseases such as: cancer; stroke; diabetes; hypertension; obesity; ulcer; arthritis; malaria; allergy; nausea; parasitic infections; viral infections to mention a few. Harnessing this potential by consuming these bitter foods in improving public health globally would be a laudable drive since prevention is always better than cure.

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