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PERSPECTIVE OF BIOACTIVE CONSTITUENTS AND MEDICINAL EFFECTS OF SOME BANGLADESHI INDIGENOUS LEAFY VEGETABLES: A REVIEW

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Abstract

Leafy vegetables are an important part of the human diet and natural sources of biologically active substances such as primary and secondary metabolites. Numerous studies have pointed out the pertinence of leafy vegetables in contribution to nutritional and pharmacological activities, especially various preventative and protective roles in relation to human health. Leafy vegetables are the most ubiquitous source of different powerful antioxidant, minerals, and vitamins which are found to be responsible for preventative activities. In this review work, some of the most commonly grown leafy vegetables of Bangladesh such as *Sesbania grandiflora, Beta vulgaris, Lagenaria siceraria, Ipomoea aquatica and Nasturtium officinale* are studied for their biological activities, bioactive constituents and their effects on various in vitro and vivo studies. These leafy vegetables are traditionally regarded as food materials and medicinal plants as well with robust medicinal and healing attributes. Countless medicinal and therapeutic properties include, anti-diabetic, anti-oxidant, anti-microbial, anti-cancer, hepato-protective, anti-inflammatory and enormous cardio-protective properties in relation to health viewpoint. However, a precise accumulation and summarization of different research evidence related to the attributes of these leafy vegetables are yet to be achieved. So, our perspective of this study was to probe the various attributes and scrutinize the substantial health aspects of these leafy vegetables.

Keywords: *Leafy vegetable, medicinal plant, bioactive constituent and biological activity*

1. Introduction

Ever since ancient times, vegetables are used for both dietary component and medical purposes. Due to the higher content of dietary fiber, vitamins, minerals, electrolytes, and broad bioactive constituents; vegetables are included in the quotidian diet and considered as dietary guidance throughout the world [1]. The abundance of high-quality nutrition, biological activities in relation to preventing numerous human health complications, leafy vegetables is widely consumed as both salutary food and medicinal component. Leafy vegetables occupy robust healing power which is especially for their broad range of bioactive constituents and their enormous biological activities. In Bangladesh, production and consumption of vegetables, especially leafy vegetables are decreasing day by day; therefore which intrigued us focusing on leafy vegetables regarding accumulation of current research progress relating to its extreme nutritional and pharmacological attributes. In today's urbanized hectic life people are becoming less prone to go for prolong cooking of food items and are fetching to get habituated with consumption of junk foods which are significantly lower in terms of proper biochemical and medicinal values. Study of biodiversity for vegetable species in Bangladesh estimated approximately 98 species of leafy vegetables widely grown and found throughout Bangladesh but the real number may be more [2]. The five Leafy vegetables species studied namely *S. grandiflora*, *B. vulgaris*, *L. siceraria*, *I. aquatica*, and *N. officinale* from Fabaceae, Amaranthaceae, Cucurbitaceae, Convolvulaceae, and Brassicaceae families respectively are commonly grown in Bangladesh (figure 1) [3]. Leafy vegetables are often regarded as medicinal plants for their different bioactive constituents producing definite physiological action on the human body when consumed. Moreover, Consumption of leafy vegetables is traditional and generally intended for medicinal contrivance; especially for the treatment of many ailments. The approximate biochemical profile of these leafy vegetables have been outlined by many analytical methods and hence found inundated with different macro and micronutrients such as protein, fat, carbohydrate, vitamin A, vitamin C, vitamin B6, calcium, iron, phosphorous, potassium, zinc, and copper etc [3] [4] [5] [6]. According to Food Composition Table of Bangladesh (FCT), 2013 the ranges of approximate biochemical contents of five leafy vegetables are found as protein (1.9g to 8.45g), fat (0.4g to 1.8g), carbohydrate (0.6g to 8.8g) dietary fiber (0.5g to 7.9g), ash (0.8g to 3.1g), vitamin C (30.4mg to 169mg), and vitamin A (198mcg to 1280mcg) per 100 gram for *S. grandiflora*, *B. vulgaris*, *L. siceraria*, *I. aquatica*, and *N. officinale* respectively [3]. Previously many attempts have been made to investigate the ubiquitous appreciation, evaluation, and understanding of the link between dietary leafy vegetable intake and improved human health [7]. The pervasive reports on leafy vegetables including vitro and vivo data and recently published research investigation outspread many profound potentials of reducing risk factors of chronic diseases by various biological activities through their bioactive constituents [7] [8]. Recent work suggests that these five leafy vegetables are accredited with association in improving outcomes related to the cognitive decline of diabetes, weight management, pulmonary functions, and gastrointestinal protection [7] [8]. In addition, numerous researches have moved toward studying bioactive compounds in particular leafy vegetables to gain and expand better understanding of their specific functions in molecular cell lines and the mechanisms involved in the prevention and reduction of disease in humans [8]. The five species possess numerous biological activities including anti-diabetic, anti-cancer, and cardio-protective, free-radical-scavenging, anti-microbial, hepato-protective, anxiolytic, anti-convulsive, wound healing, anti-inflammatory, and anti-arthritic activity along with many more unknown activities [8] [9]. Regular consumption of leafy vegetables is found ameliorating the functional or medicinal improvement in health and can touch the pinnacle of nutritional requirement for a healthy diet. In addition, Bioactive constituents from these leafy vegetables is highly potential for therapeutic and pharmaceuticals industries. Leafy vegetables can be valuable in many ways such as isolation of noble bioactive constituents, nutraceutical formulation, and food fortification (figures 2A). Various biological activates and therapeutic effects in vivo and in vitro experiments of bioactive

constituents from these leafy vegetables are also reviewed and accumulated (figures 2B). Low intakes of leafy vegetables are often associated with the onset of CVD (cardiovascular disease) which comprises 30% of all global deaths [10] [11]. High-fat diets, scant physical activity, increased obesity, sedentary lifestyle and change in food consumption are the predominant factors that escape consumption of vegetables, especially leafy vegetables from meal; therefore contributing to the onset and progression of various chronic diseases such as cardiovascular diseases, blood pressure, hypercholesterolemia, many cancers, and mental health [12] [13]. In Fervency for the upcoming challenge to battle against the outbreak of tremendous disease; it is important to look for alternative therapeutics and pharmacological components. In this concern these leafy vegetables can be a very competent to research with [14].

2. Bioactive Compound Screening of Leafy Vegetables

Bioactive constituents are competent sources for the treatment of different health complications. The bioactive constituents of these five leafy vegetables are studied from different research investigation regarding bioactive constituent screening. According to enormous research works these leafy vegetables deposit variety of known and unknown bioactive constituents including alkaloids, terpenoids, steroids, phenolic compounds, glycosides, and tannins. Traditionally, these bioactive constituents are found effective against many ailments such as ulcer, headache, and neurons protective cough, anti-asthma, and pesticides when consumed or otherwise treated by leafy vegetables [15] [16]. Investigation on *S. grandiflora* (agathi) transpired that it contains phenolic (3, 4, 5-trimethoxyphenol, 3, 5-di-t-butyl phenol), carotenoid (Phytofluene), ester compound (Malonic acid, ethyl 3-hexyl ester), anthraquinone and pholobatannins which are responsible for strong antibacterial, antifungal, anti-inflammatory activities [16] [17]. The literature survey of *S. grandiflora* plant revealed that this plant is plenty with amino acids such as arginine, cysteine, tryptophan, valine, threonine and alanine [18] [19]. *B. vulgaris* (beetroot) is an affluent source of bioactive constituents that includes carotenoids, phenolic acids, flavonoids, and betalains. These compounds and their derivatives are responsible for high antioxidant and anti-inflammatory capabilities in vitro and a variety of in vivo animal model studies [20] [21] [22]. Analysis of *I. aquatica* revealed the presence of high concentrations of alkaloids, reducing sugar, soluble carbohydrate, flavonoids, steroids, glycosides, β-carotene, minerals such as iron, magnesium, phosphate, manganese, and calcium, vitamins such as A, B1, C, and K [23]. Modern bioactive constituents screening methods applied on different parts of *L. siceraria* (bottle gourd) showed that it contains vitamin C, β-carotene, vitamin B-complex, pectin, highest choline level, triterpenoid, fucosterol, and flavone C-glycosides [24] [25]. *L. siceraria* seeds are used in migraine type headache and pain and are reported to contain essential fixed oils and vitamins [26] [27]. Lagenin – a novel ribosome inactivating protein has been isolated from the lyophilized water extract of seeds of *L. siceraria* which is recognized to possess antitumor, antiviral, anti-proliferative, immunosuppressive and anti-HIV activities [28]. The chemical structure illustration of some of the most dynamic and active bioactive constituents isolated from these leafy vegetables are also depicted (figure 3). As for *N. officinale,* it is also rich in many vitamins such as vitamin C, Vitamin A, vitamin E, folate acid, iodine, iron, and calcium. It contains flavonoid bioactive constituents (quercetin and kaempferol) which can act as antioxidants [29] [30] [31]. Because of the excellent source of nutrition, these leafy vegetables have been used for medical treatment since ancient times.

3. Biological Activities

3.1. Anti-Diabetic and Anti-Hyperlipidemic Activities

Diabetes mellitus (DM) is one of the most epidemic burdens of current worldwide which is an endocrine disorder characterized by deflect glucose and lipid metabolism leading to an elevation in blood glucose concentration. Diabetes currently enlisted more than 220 million people worldwide and this will rise to about 552 million by 2030 [32] [33]. DM is associated with hyperglycemia, abdominal obesity, insulin resistance, dyslipidemia, fatty liver and weakness due to disorder in carbohydrate, protein,

and fat metabolism [34] [35]. Hyperlipidemia which is secondary metabolic a disorder associated with diabetes characterized by elevated serum level of triglycerides, LDL, cholesterol; therefore these risk factors consolidate different CVD such as hypertension, atherosclerosis and coronary heart disease, etc [36]. In this concern, numerous Instructive studies found that these five leafy vegetables have decent bioactive constituents with the healing power of reducing blood glucose and lipid concentration to a greater extent. Some of the common isolated bioactive with anti-diabetic and anti-hyperlipidemic activities are studied and presented in (table 1). Research transpired that *S. grandiflora* significantly reduced the level of glucose, cholesterol triglycerides VLDL, LDL, increased HDL mainly due to the increased activity of lecithin which incorporates free cholesterol [37]. Investigation revealed that consumption of the shredded, fresh and edible portion of *I. aquatica* for a week efficiently diminished the fasting blood sugar level of streptozotocin-induced diabetic rats may be due to the activity of tolbutamide, a bioactive constituent previously detected in *I. aquatica* [38] [39]. Another study on *I. aquatica* examined that Treatment of two fractions of *I. aquatica* (IA6-1 and IA9-2) in diabetic rats significantly reduces (51% and 31%) the serum glucose concentration [40]. Investigation on the anti-hyperlipidemic activity of *L. siceraria* fruit assured that bioactive constituents LSN-I, LSN-II, LSN-III isolated from *L. siceraria* reduces the elevated blood cholesterol, triglycerides, LDL, and decreased HDL which are the consequences in hyperlipidemia [41]. The currently six classes of oral anti-hyperglycemic drugs available; sulfonylureas, biguanides, meglitinides, dipeptidyl peptidase IV inhibitors, α-glucosidase inhibitors, and thiazolidinediones have limited use because of objectionable pathological conditions and high rates of organ failure [42]. In this concern *S. grandiflora* can be an effective one to work with. Study indicates that 70% alcoholic extract of *S. grandiflora* flower possesses anti-diabetic activities which can be excellent in treating diabetes with no adverse effect as a natural source [43]. More than 2 months investigation on *N. officinale* confirmed that it possesses the high hypolipidaemic activity and this may be attributed to its anti-oxidative potential [44] [45]. Anti-diabetic and anti-hyperlipidemic activities of leafy vegetables and their associated bioactive constituents are presented in (Table 1). Phytosterols (fucosterol, racemosol, and stigmasterol) isolated from *L. siceraria* showed anti-hyperlipidemic Activity in wistar rats [45]. It is well documented that principal pathogenetic mechanism such as oxidative stress (excessive free radical production and lipid peroxidation) and an aberration in the lipid profile during T2DM are responsible for developing coronary heart disease [53] [54]. In this concern study on *S. grandiflora* revealed that it can attenuate the oxidative stress markers in plasma as well as liver tissue, suggesting its potential antioxidant activity in relation to T2DM [55]. The bioactive constituents make these leafy vegetables useful for treating different ailment while having the potentiality of providing useful drugs for human use.

3.2. Anti Cancer, Anti-Tumor and Chemo-Preventive Activities

Cancer is one of the most skyrocketed public health problems worldwide and one of the leading cause of death which is prescribed as an irregular growth of cells mainly caused by abnormal proliferation of any of the different kinds of cells in the body [56]. Estimation of the worldwide incidence and mortality from 27 major cancers in 2012 anticipated that there were 14.1 million new cases and 8.2 million deaths in 2012 [57] [58]. Over 20 million new cancer cases expected annually as early as 2025 particularly in low and middle-income countries (LMIC) [59]. In recent years, an increasing number of natural products have been reported to revolutionize cancer diagnosis and therapies but the development of therapies for rapidly spreading cancer is not much successful while increasing demand [60] [61].Therefore, numerous attempts have been made to articulate anticancer and related properties of different natural or medicinal plants including leafy vegetables in vitro and in vivo methods [62]. Thus, a novel protein fraction namely SF2 from *S. grandiflora* shows potential anticancer and chemo-preventive efficacy in vitro and in vivo [63]. SF2 inhibited cell proliferation and induced apoptosis as demonstrated by DNA fragmentation and externalization of phosphatidylserine in daltons lymphoma ascites (DLA) and colon cancer cells

(SW-480). SF2 down-regulated phorbol myristate acetate (PMA) induced NF-_B, a transcription factor which controls the expression of genes encoding proteins associated in cell regulation and growth control [63]. Biogenic silver nanoparticles which are potent bio reducer were synthesized using the extract of *S. grandiflora* shown promising anticancer property against human breast cancer (MCF- 7) cell lines [64]. Fraction F2 from *S. grandiflora* triggers pro-oxidant activity and mediates its cytotoxicity in leukemic cells via apoptosis and autophagy [65] [66]. Recent studies on *B. vulgaris* have pointed out the preventive role of beetroot extracts against cancers and their cytotoxic activity on cancer cells [67]. Among many different natural bioactive constituents; these extracts contained betanin and its stereoisomer isobetanin, which belongs to the betalain group of highly bio available antioxidants. The cytotoxicity of this betanin-enriched the extract significantly decreased cancer cell proliferation and viability, particularly in MCF-7-treated cells; the expressions of apoptosis-related proteins (Bad, TRAILR4, FAS, p53) were strongly increased and the mitochondrial membrane potential was altered, demonstrating the involvement of both intrinsic and extrinsic apoptotic pathways [67] [68]. Two types of precious compound namely betanin and betalains from *B. vulgaris* resulted in a 49% and 25% inhibition of HepG2 cell proliferation respectively [68]. The Chemo preventive effect of *L. siceraria* was studied both at anti-initiation/promotion level followed by histopathological study in induced Papillomagenesis. A dose of 2.5% and 5% given in drinking water showed a significant decrease in papilloma number, papilloma incidence, papilloma multiplicity, papilloma latency, papilloma volume, and papilloma size in the different size range [69]. Histopathological study showed chemo-preventive effect by minimizing loss of stratification, a decrease in the number of epithelial layers, reducing dermal infiltration and protection for various cytoplasmic changes [69]. Another study on methanol extract of L. siceraria evaluated that the extract can significantly inhibit the tumor volume, packed cell volume and tumor cell count in EAC tumor-bearing mice [70]. Eleven new resin glycosides, aquaterins isolated from I. aquatica exhibited the most potent activity against HepG2 cells with an IC50 value of 2.4 µM. Cell cycle analysis delineated compound no 4 to inhibit the proliferation of HepG2 cells via G0/G1 arrest and apoptosis induction [71]. Moreover, bioactive constituents 1–4, 7, 9, and 10 were found to elevate Ca2+ in HepG2 cells, which might be involved in the regulation of the cytotoxic activities observed [71] [72]. N. officinale which possess antitumor, chemo-preventative, anticancer and cytotoxic properties against various cancer cell lines because of their broad content of bioactive constituents constituents. Anti-cancer activities of leafy vegetables and their associated bioactive constituents are presented in (Table 2). Bioactive constituents namely glucosinolates, dietary isothiocyanates from *N. officinale* have exhibited chemo protective activity in protocols involving administration of the isothiocyanate either before or during exposure to the carcinogen [89]. Studies suggest that the *N. officinale* is a cruciferous vegetable with a high concentration of bioactive constituents with recognized antitumor activity [90]. The study also demonstrated that the daily intake of an aqueous solution of *N. officinale* both before and after the inoculation of EET (experimental Ehrlich tumor) cells were able to cause suppression of tumor growth. This solution is likely to have chemo preventive and chemo-protective effects and may be related to the main bioactive constituents present in watercress with antitumor properties [90].

3.3. Anti Depressant and Anti Anxiety Properties

Neuropsychiatric disorders are the most ponderous symptoms which have been playing very a significant role in the onset of pathogenesis. Depression, reckless anxiety, apathy, irritability, mania, psychotic disorders, impulse control disorder, cognitive disorders, seizure disorders, movement disorders, traumatic brain injury, learning, and communication disorders are the most prevalent psychiatric disorders throughout the world [80] [91]. According to WHO anticipation, approximately 450 million people are suffering from psychiatric disorders occupying 12.3% of the global burden of disease, and this will be augmented to 15% by 2020 [81]. Among all of the neuropsychiatric disorders Depression and anxiety is the most epidemic, emasculating and life-threatening illness

with a high occurrence [84]. Unfortunately, these disorders are still under diagnosed, undertreated and often disregarded. Available clinically apothecary such as anxiolytics and antidepressants are not efficacious for all patients and submerged by enormous adverse effects, poor patient compliance, and slow onset of actions [91] [92]. Due to the complexity of neuropsychiatric disorders treatment; it is urgent to consider alternative scheme to treat those symptoms. Studies revealed that leafy vegetables such as *B. vulgaris*, *S. grandiflora*, *L. siceraria*, *I. aquatica* possesses phytoconstituents such as betalains, flavonoids, polyphenols, vitamins, and minerals which have robust neuroprotective, hepatoprotective, nephroprotective, wound healing, anti-inflammatory, free radicals scavenging in brain oxidative damage and memory impairments and accompanied with much more tremendous pharmacological peculiarities which can be a very beneficial dietary supplement to combat against various neuropsychiatric disorders [82] [93] [94]. Most importantly the presence of different flavonoids, saponins, and sterols possess high antidepressant and anxiolytics activity having the power of battling against cognitive and mental illnesses [95]. Studies on *B. vulgaris* leaves confirmed that it has decent anti-anxiety- and anti-depressive like Behavior and anti-Oxidative Stress in Mice after Acute Restraint Stress [87] [88] [95] [96] [97] [98] [99] [100] [101]. Research on *S. grandiflora* confirmed that it contains a compound triterpene which exhibits a wide spectrum of anticonvulsant profile and anxiolytic activity [102] [103]. Another study on *S. grandiflora* exhibited a slight increase in locomotor activity and antidepressant Activity through Forced swim test (FST) in Alcohol Withdrawal Syndrome in Rats [97]. Acetone extract of *I. aquatica* leaves possesses anxiolytic activity mainly due to the presence of flavonoids Quercetin [104] [105] [106] [107] [108]. Quercetin acts on $\alpha 1\beta 1\gamma 2s$ GABAA receptors to produce anxiolysis [97]. Several hypotheses have been proposed to establish that *L. siceraria* fruits contain higher level of choline which may have the ability to act on modulating neurotransmitters such as GABA, a monoamines (5-HT, NA, and dopamine) which are inhibitory neurotransmitter having crucial role in depression syndrome; therefore, *L. siceraria* can be effective to suppress depression. Various anti depressant, anxiolytic and relating -antioxidative bioactive constituents isolated from these leafy vegetables are depicted in (Table 3). The presence of opulent bioactive constituents intrigued researchers to propagate the identified and isolated bioactive constituents which are responsible for antidepressant and anti-anxiety activities. Various instructive studies are still required to develop, isolate and modify responsible bioactive constituents to combat against various health complications with a clear understanding of their molecular mechanisms. Oral dietary supplementation during the onset of disorders or treatment during disorders could be significant to alleviate the complexity and extensiveness of symptoms.

4. Conclusions

Overall, our review work indicates that leafy vegetables are a substantial source of many bioactive constituents and significant in protecting different physiological complications such as obesity, cancer, and diabetes. Different extracts of leafy vegetables are associated with the elevation protective response in animal modules and could be effective as an alternative remedy for many ailments treatments.

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Table 1: Anti-diabetic and anti-hyperlipidemic activities of leafy vegetables and their associated bioactive constituents:

Leafy Vegetable Species	Bioactive Compounds	Biological Activities	Parts Used	Methods of Isolation	References
Sesbania grandiflora	SGF60 and SGF90 protein	Anti-hyperglycemic	leaves	GC-MS and HPLC	[44] [45]
Beta vulgaris	quercetin, kaempferol, and epicatechin	Anti-hyperglycemic	roots and stems	LC-MS and HPLC	[20] [30] [45]
Lagenaria siceraria	stigmasterol, and LSN- (I- IV)	Anti-hyperlipidemic, Anti-hyperglycemic	fruits, and leaves	TLC and NMR	[46] [47] [48]
Ipomoea aquatica	tolbutamide, and IA6-1 and IA9-2	Anti-hyperglycemic, Anti-hyperlipidemic	leaves and fractions	TLC,HPLC, and GC-MS	[30] [45] [49]
Nasturtium officinale	stigmasterol, and sitosterol	Anti-hyperglycemic, Anti-hyperlipidemic	leaves	SACC and GLC	[50] [51] [52]

HPLC: High-Performance Liquid Chromatography, LC-MS: Liquid Chromatography–Mass Spectrometry, GC-MS: Gas Chromatography–Mass Spectrometry, TLC: Thin Layer Chromatography, NMR: Nuclear Magnetic Resonance, SACC: Silicic Acid Column Chromatography, GLC: Gas Liquid Chromatography

Table 2: Anti Cancer, Anti-Tumor and Chemo-Preventive Activities of leafy vegetables and their associated bioactive constituents:

Leafy Vegetable Species	Bioactive Compounds	Proliferation Cells	Cell Location	Parts Used	Methods of Isolation	References
Sesbania grandiflora	SF2, Kaempferol and Cyanidin	A549 and H1299 MCF-7 HepG2 U937 and THP1	Lung Breast Liver Leukemia	roots, bark, leaves, flower and fruit	GC-MS	[30], [73] [74] [75] [76] [77] [78]
Beta vulgaris	curcumin, betalain and betaine	MCF-7 and HTB-22 RKO, CaCo-2 T24 A549 Hep3B PC-3	Breast Colon Bladder Lung Liver Human Prostate	roots	GC-MS and HPLC	[30], [79], [80], [81], and [82]
Lagenaria siceraria	Ellagitanins, Isoquercitrin and kaempferol	SK-Hep 1 HaCaT cells	Endothelial Skin	fruits, Stems	(UV-Vis) and NMR	[30], [83], [84] [82]
Ipomoea aquatica	N-cis-Feruloyltyramine, and N-trans-feruloyltyramine	HepG2 and SMMC-7721 MCF-7 MG-63 and U2-OS LNCaP	Hepatoma Breast Osteosarcoma Prostate	Leaves	GC-MS and NMR	[30],[85] [86] [77] [78] [87]
Nasturtium officinale	Isothiocyanates and gluglucosinolates	HL-60, and ML-1 A549 PC-3 cells HF2FF MDA-MB-231	Leukemia Lung Human Prostate Fibroblasts Breast	leaves	GC-MS and HPLC	[30], [82], and [88]

HPLC: High-Performance Liquid Chromatography, GC-MS: Gas Chromatography–Mass Spectrometry, UV-Vis: Ultraviolet and Visible Absorption Spectroscopy and NMR: Nuclear Magnetic Resonance

Table 3: Anti depressant, anxiolytic and relating anti oxidative bioactive constituents of leafy vegetables with activities:

Leafy Vegetable Species	Bioactive Compounds	Biological Activities	Parts Used	Methods of Isolation	References
Sesbania grandiflora	triterpene	anticonvulsant, anxiolytic	leaves	HPLC	[88] [99]
Beta vulgaris	Quercetin	anxiolytic	leaves	GC-MS, and HPLC	[100] [101][102]
Lagenaria siceraria	choline	Anti depressive	fruits	GC-MS, and HPLC	[103] [104][105]
Ipomoea aquatica	apigenin, and vitexin	Anti depressant	fruits, leaves	HPLC	[106] [107] [108]
Nasturtium officinale	Apigenin	antioxidative and anti depressant	stem and leaves	HPLC	

HPLC: High-Performance Liquid Chromatography, GC-MS: Gas Chromatography–Mass Spectrometry

Figures

Figure 1: Photographs of the five leafy vegetables studied are presented as (A) *S. grandiflora,* (B) *B. vulgaris,* (C) *L. siceraria,* (D) *I. aquatica* and (E) *N. officinale*

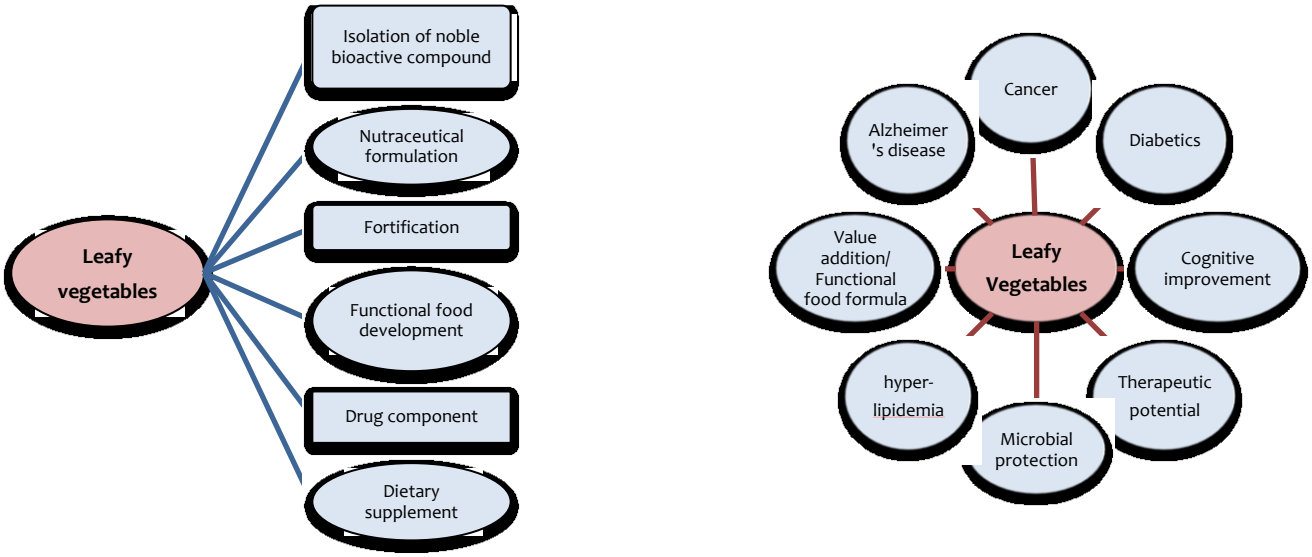

Figure 2: 2(A) Diagrammatic representation depicting the various utilization perspectives, prospects and scopes of the five leafy vegetables studied, **2(B)** Schematic diagram depicting the enormous biological and Medicinal Effects of leafy vegetables

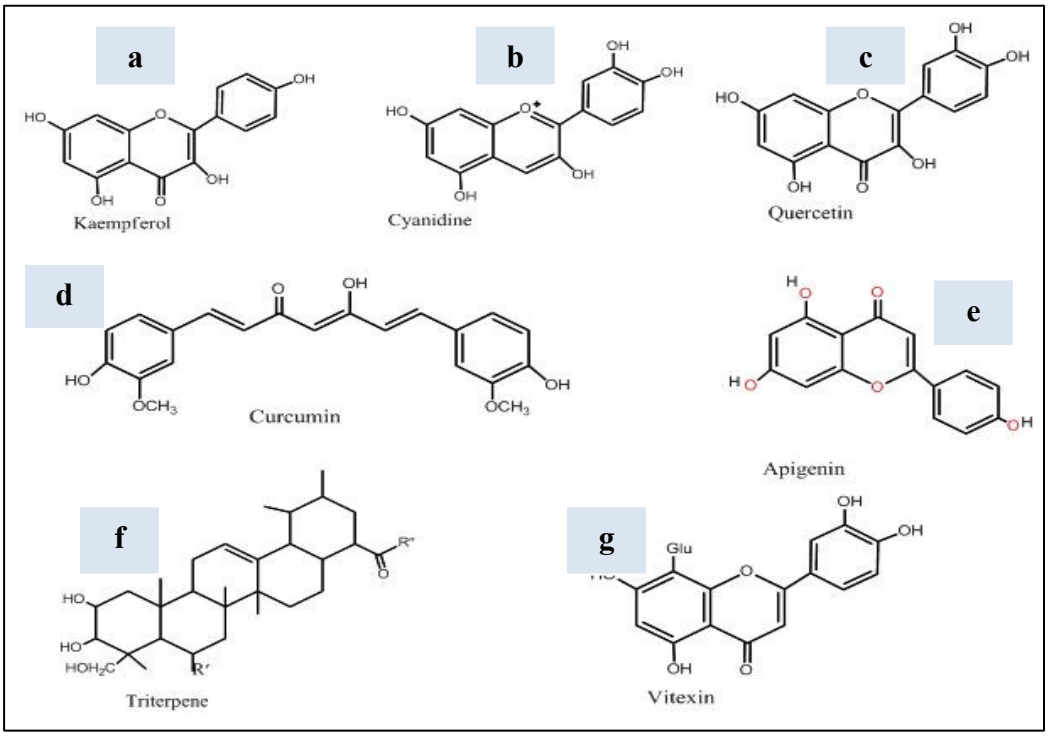

Figure 3: Bioactive constituents isolated from leafy vegetables. Bioactive constituents are presented as (a) Kaempferol (b) Cyanidine (c) Quercetin (d) Curcumin (e) Apigenin (f) Triterpene (g) Vitexin