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Antidiabetic and Immunomodulatory Trace Elements Available in Leafy Vegetables of West Bengal: A review

S Das[1], *P Saha[1]
[1]Guru Nanak Institute of Pharmaceutical Science and Technology
157/F, Nilgunj Road, Sahid Colony, Panihati, Kolkata, West Bengal 700114
E-mail: prerona.saha@gnipst.ac.in

Abstract:
Trace elements are essential for biological systems, as they regulate vital biochemical processes and play a part in a variety of life-sustaining functions. Trace elements make up a minor but important part of biological tissues.They play significant role in humoral and cellular immunological regulation, nerve transmission, muscular contractions, membrane potential modulation, and mitochondrial activity and enzyme reactions. A diet that is deficient in micronutrients has a negative impact on the body's functioning abilities, as well as its general potential to fight disease. Chromium, cobalt, iodine, iron, selenium and zinc appear to be deficient in type 2 diabetes. It is generally found that the complex, integrated immune system requires a variety of micronutrients, including zinc, iron, copper, and selenium, all of which play significant, often synergistic roles at different phases of the immune response.This review is focused on the trace elements, acting as anti-diabetic and immunomodulatory agent and available in green leafy vegetables in West Bengal.
Key Words: Antidiabetic Agent, Immunomodulatory, Trace Elements, Leafy Vegetables

INTRODUCTION:

Trace elements are part of micronutrients that are essential for normal physiological functioning of our body. Numerous metabolic reactions require trace elements, which act as stabilising elements of enzymes and proteins and serve as cofactors for several enzymes [1].

By attaching to a receptor on the cell membrane, certain trace elements govern vital biological processes while some of them prevent specific molecules from entering the cell or by modifying the shape of the receptor . Micronutrients play a double function: they keep cellular components stable at reasonable amounts, but their deficiency leads to alternate routes, which can lead to illnesses. These important micronutrients have direct links to diabetes mellitus and have substantial physiological ramifications[1].

Trace elements intake must be adequate for the immune system to function properly. Immunity is suppressed by trace element insufficiency, which affects acute, T cell-mediated, and adaptive antibody activities, resulting in a disruption of the appropriate host response. This state makes people more susceptible to infections, which leads to higher morbidity and mortality. In turn, infections exacerbate micronutrient deficits by decreasing food intake, increasing losses, and interfering with usage through changing metabolic pathways. Micronutrient deficiencies are common in people with eating disorders, smokers (both active and passive), long - term alcohol abusers, specific diseases, pregnant and lactating women, and the geriatric[2].

Micronutrients maintain physical boundaries (skin/mucosa), cell - mediated immunity, and immunoglobulin synthesis on three levels, contributing to the body's natural protection. Trace element zinc, help to improve the skin barrier function, as well as iron, zinc, copper, and selenium, work together to promote the immune cells' protective actions.

Although with the exception of iron, all the trace elements are required for antibody synthesis. Unbalanced diet of certain trace elements can result in lowered immunity, which makes people more susceptible to illnesses. Supplementing with these micronutrients can help to strengthen the body's natural defence system to enhance all three stages of immunity [2].

Immune modulation by humoral and cellular mechanisms, nerve conduction, muscular contractions, membrane potential regulation, and mitochondrial function and enzyme activities are just a few of the activities that trace elements play in tissue, cellular, and subcellular functions. Trace elements work together with vitamins and macro elements to increase their impact on the body. They are recognised as vital for human health and have a wide range of metabolic properties and functions [3-4].

Diabetes mellitus (DM) is a significant, chronic, and complex metabolic condition with numerous etiologies that have severe acute and chronic repercussions. This disease affects 25% of the world's population. Its complications impact people in both developing and affluent countries, posing a significant socioeconomic issue [5]. Diabetes causes long-term damage, dysfunction, and failure of multiple organ systems (including the heart, blood vessels, eyes, kidneys, and nerves), resulting in disability and early death [6,7-9].

Some trace elements, including chromium, zinc, and selenium, have been found to enhance insulin's ability to lower blood glucose. Activation of insulin receptor sites, serving as cofactors or components for enzyme systems involved in glucose metabolism, boosting insulin sensitivity and acting as antioxidants are all postulated mechanisms for trace elements enhancing insulin action. T2D is thus said to be affected by various trace elements, and these elements may play unique roles in the disease's pathogenesis and progression [1,3].

These trace elements perform a variety of biochemical functions in the human body, and their disappearance can result in organ damage, as well as the formation of non-communicable conditions such as diabetes, immune system suppression, cardiac disease, and cancer [8]. The present review aims to explore the trace elements content of leafy vegetables of West Bengal and their role in diabetis and immunity.

Leafy green vegetables as an alternative source of anti-diabetic and immunomodulatory agents:

From ancient time Bengal is well known for medicinally rich plants, many of them are part of our regular diet especially different green leafy vegetables. Natural compounds, particularly those of plant sources, are the primary target for identifying viable lead candidates and will play a major role in future drug developmental activities. Plant-based preparations are the main essential player of all current medicines, especially in rural regions, due to their ease of accessibility, low price, and low adverse effects. Furthermore, many plants have a wealth of potent bioactive compounds and long been an excellent source of medications, with many of the currently accessible drugs originating from them wholly or partly [9].

Fig .1 depicts the major leafy green vegetable families, found in Bengal that work as antidiabetic and immunomodulatory agents. Table.1 explores various commonly consumed vegetables of these families along with their traditional and pharmacological uses.

All these plants exhibits the antidiabetic and immunomodulatory activity because of their secondary metabolites and/or micronutrients. Micronutrients are essentially required by human and other organisms in varying amounts throughout life to coordinate various physiological functions to maintain health(Fig.2). Since plants are the main origin of nutrients for humans and other animals, some micronutrients can be in low quantities and deficiencies can occur when there is insufficient dietary intake, as occurs in malnutrition, indicating the need for initiatives to prevent inadequate supply of micronutrient in plant foods [31]. These essential micronutrients have important physiological implications and have been connected to diabetes mellitus and immunity [3-4].

Trace elements:

The trace element is a dietary component that is required for an organism's healthy growth, maturation, and metabolism. Prolonged unmanaged hyperglycemia may cause changes in trace element status, and trace elements insufficiency may suppressed Immunity which affects innate, T-cell-mediated, and adaptive antibody response, resulting in a disruption of the normal host response. This scenario increases infection susceptibility, as well as morbidity and fatality rates [1-3].

Chromium (Cr), Vanadium (V), iron (Fe), molybdenum (Mo), zinc (Zn), cobalt (Co), copper (Cu) examples of trace elements, as are the nonmetals selenium (Se), fluorine (F), and iodine (I). All of these fall into the category of micronutrients, which the human body requires in relatively small amounts (typically less than 100mg per day) [3]. Table. 2 Explores mechanism of action and their concentration in normal physiology.

Fig 3 and 4 outlines the contribution and role of trace elements in diabetes and immune system. In brief zinc shows higher effectivity against diabetes and it also play key role in boost up the immunity. Selenium also show significant role to increase the immunity and manage the blood glucose level, chromium show high effectivity against hyperglycemia, copper and cobalt deficiency cause hyperglycemia. Where as copper and iron boost up the immunity.

Table .3 explores all the quantitative estimation of these trace elements from leafy vegetables of Bengal which are playing major role as antidiabetic and to boost up the immunity.

Table 1: Leafy vegetables found in West Bengal

Sl no.	Scientific name	Common name	Use
Family: Apiaceae			
1	*Centella asiatica* (L.) Parts used: Whole plants	Indian penny wort, Thankuni	• Wound healing property • Memory enhancement • Cardiovascular treatment • Immunomodulatory agent • Antidepressant agent • Antidiabetic agent [10].
2	*Coriandrum sativum* L Parts used: Whole plant except root	Coriander, Dhoney	• Antioxidant activity • Anti-hyperglycemic activity • Hypolipidemic effect • Diuretic activity • Anti-anthelmintic activity • Anti-bacterial activity [11].
Family : Acanthaceae			
3	*Hygrophila auriculata* (Schumach.) Heine Parts used: Whole plants except roots and spine.	Kulekhara	• Treatment of diarrhea,dysentery, blood diseases, gastric diseases inflammation(ethnobotanical use). • Act as antidiabetic, anthelmintic,antibacterial, antimotility,antioxidant agent [12].
4	*Andrographis paniculata*	Green chiretta, Kalmegh	• To treat Diabetes • Dysentery • Enteritis, • Helminthiasis, • Herpes, • Peptic ulcer, • Skin infections (traditional use)

Sl no.	Scientific name	Common name	Use
			• It has Antimicrobial and Antiparasitic property, • Act as Cardiovascular and immunomodulatory,Antihyperlipidemic agent [13].
Family: Convolvulaceae			
5	*Ipomoea aquatic Forssk* Parts used: Leaves	Water spinach, Kalmi shak	• Beneficial for nervous • General debility in females. • Juice is remedy for liver complaints • Used as emetic, purgative [11].
Family: Fabaceae			
6	*Trigonella foenum-graecum* L. Parts used: Whole aerial parts	Greek Hayes , Methi shak	• Treatment of Diabetes, • Cancer therapy, • Antioxidant, antibacterial agent, Gastro protection [14]. • Anti-tumour, anti-fungal and anti-viral activity [11].
Family: Amaranthaceae			
7	*Spinacia oleracea L* Parts used: Whole aerial parts	Spinach, Palong	• Useful in diseases Of blood and brain, asthma, leprosy(traditional use) [15]. • Antioxidant, • Anticancer agent, • Hepatoprotective activity [15]. • Used as laxative, emollient, diuretic, astringent. • Useful against fever and inflammation [11].
8	*Amaranthus viridis*L Parts used: Whole plants except roots	Amaranth, Notey	• Used to eczema, psoriasis and rashes, anti-inflammatory agent of the Urinary tract, diuretic(traditional use) [16] • Used as appetizer and emollient, hallucination, leprosy, bronchitis and piles [11].
9	*Amaranthus tricolor L* Parts used: Whole plants except roots	Lalshak	• Antimicrobial • Antioxidant activity, • Antibacterial activity, • Antioxidant activity [17]. • Effective against dysentery and hemoptysis [11].
10	*Alternanthera sessilis* L. Parts used: Whole plants except roots	Khenchi shak	• Used to treat Diarrhoea, leprosy, skin disease [11].
Family: Scrophulariaceae			
11	*Bacopa monnieri* (L.) Pennel. Parts used: Whole plants except roots	Bramhi shak	• Improve memory capacity • Intellectual Activity • Increasing immunoglobulin Production [18].
Family: Moringaceae			
12	*Moringa oleifera* Lam Parts used: Whole plant	Drumstick tree, Sojina	• Anti-Oxidant • Antiepileptic • Anti-Convulsant, • Antidiabetic, • Antihypertensive, • Antiasthmatic, • Anti-Inflammatory, • Anthelmintic Activity [19].
Family: Meliaceae			
13	*Azadirachta indica* A. Juss Parts used: whole plant	Neem	• Treatment of Malaria, Gum and Skin diseases(traditional use) [20]. • Anti-inflammattory agent [21]. • Useful against leprosy, • Skin disease, • Leucoderma, • Opthalmopathy, • Intestinal worms, • Dyspepsia, • Ulcers, • Tuberculosis, • Eczema • Malarial fever [11].
Family: Marsileaceae			
14	*Marsilea minuta (L.) Mant.* Parts used: Leaves	Sushni shak	• Treatment of Fever, diabetes, leprosy and other skin diseases.(traditional use) • Antidepressant, • Antidiabetic, • Anti-tussive, • Expectorant, • Hepatoprotective • Hypocholesterolemic activity [22].

Sl no.	Scientific name	Common name	Use
Family: Solanaceae			
15	*Solanum tuberosum L* Parts used: Leaves and tuber	Potato, Alu	• Antispasmodic • Aperients, • Diuretic, • Nervous sedative and stimulant in gout [11].
Family: Tiliaceae			
16	*Corchorus capsularis* L. Parts used: Leaves	White jute , Titapat	• Antiinflammatory, • Antipyretic, • Treatment of Headaches, Liver disorders, Dysentery, coughs and phthisis, and Poulticing sores, worms in children [23].
17	*Corchorus olitorius* L. Parts used: Leaves	Jew's mallow, Mithapat	• Treat the Liver disorders, • Chronic cystitis, • Gonorrhea, • Dysuria, • Carminative, • Demulcent, • Laxative, • Stimulant and stomachic [23].
Family: Alliaceae			
18	*Allium Cepa L* Parts used: Scape and bulb	Red Onion, Piyaz	• Used as Stimulant, • Diuretic, • Aphrodisiac. • Effective against dysentery, colic, jaundice, pneumonia, asthma, bronchitis [11].
Family: Basellaceae			
19	*Basella alba* L. Parts used: Whole plants except root.	Malabar spinach, Pui shak	• Antimicrobial • Anti-inflammatory [24].
Family: Chenopodiaceae			
20	*Chenopodium album* (L.) Parts used: Aerial shoot	Bethu or betoshak	• Beneficial for indigestion, intestinal ulcers, piles, eye and throat problems, hepatic disorders, and spleen enlargement[11]. • Anthelmintic, • Cardiotonic, • Carminative, • Digestive, • Diuretic and laxative(traditional use) [25].
Family: Asteraceae			
21	*Enhydra fluctuans* Lour Parts used: Whole aerial parts	Hingcha	• Laxative, and demulcent properties. • Useful for cutaneous and neurologic disorders [11].
Family: Nyctanthaceae			
22	*Nyctanthes arbor-tristis L* Parts used: Leaves	Night Jasmine , Shiuli/ Parijat	• Antioxidant, • Anti-fungal, • Antihistaminic, • Anti-asthmatic, • Wound healing • Immuno-stimulant activity. • Anti-ulcerogenic • Ulcer-healing property, • Analgesic • Anti-inflammatory activity, Anthelminthic activity, • Hypoglycemic and hypolipidemic activity [26].
Family: Brassicaceae			
23	*Brassica juncea* (L.) Parts used: Whole plant except root	Indian Mustard, Sarisha	• Hepatoprotective and antidiabetic property [24] • Effective against dengue, dyspepsia, stomach colic, and worms [11].
Family: Cucurbit aceae			
24	*Cucurbita maxima* Duchesne ex Lam. Parts used: Whole aerial parts	Pumpkin, Kumra	• Effective against inflammations, • Migraine and neuralgia [11].
25	*Lagenaria siceraria* (Mol.) Standley Parts used: Whole aerial parts	Bottle Gourd , lau	• Effective against cough, bronchitis, inflammations, skin disease, leprosy and fever [11].
Family: Asteraceae			
26	*Eclipta alba* (L.) Hassk. Parts used: Whole aerial parts	Keshuth	• Treat Inflammations, gastropathy, skin disease, ulcers, opthalmopathy, hypertension, leprosy, fever, jaundice [11].
Family: Rutaceae			
27	*Murraya koenigii* (L.) Spreng. Parts used: Leaves	Curry leaves tree, Currypata	• Decreased the body weight, plasma total cholesterol (TC) and triglyceride (TG) values [5] • Anti-diabetic, • Antioxidant, • Hepatoprotective [27].

Sl no.	Scientific name	Common name	Use
Family: Oxalidaceae			
28	*Oxalis corniculata* L Parts used: Whole aerial	Yellow sorrel , Amrulshak	• Purification of blood, • treating dizziness, diarrhoea And dysentery [11].
Family: Araceae			
29	*Typhonium trilobatum* Schott Parts used: Leaves and rhizome	Ghetkochu	• Anti-tumor, • Anti-fungal, • Anti-viral properties [11].
Family: Verbenaceae			
30	*Vitex negundo* L. Parts used: Leaves	Three leaved chaste tree , Nishinda	• Anti-inflammatory activity, • Antioxidant, • Anti-microbial, • Anti-diabetic effect [28]. • Also used to treat the Gout And ulcers [11].
Family: Lamiaceae			
31	*Mentha spicata. L* Parts used: Leaves	Mint , Pudina	• Treat the Bronchitis,nausea,flatulence,anorexia, liver complaints(traditional use) [29].
Family: Commelinaceae			
32	*Commelina benghalensis* L. Parts used: Leaves	Kanchara	• Effective against leprosy [11].
Family: Rubiaceae			
33	*Paederia Foetida* L. Parts used: Leaves	Chinese moon creeper , GandhaBhadulia	• Treat the Allergy, in gastralgia, post natal pain and bleeding, diarrhoea and dysentery and abdominal pain [30]. • Effective against bacillary dysentery, urinary lithiasis, dysuria, rheumatism, dyspepsia, gastritis and enteritis [11] .
Family: Portulacaceae			
34	*Portula caoleracea L.* Parts used: Whole aerial parts	Common purslane, Nunia	• Effective against scurvy, • Disease of liver, • Spleen, kidney, bladder, cardio vascular disease, • Dysuria, dysentery and ulceration of mouth [11] .

Fig: 1 Different family of leafy vegetables of West Bengal showing immunomodulatory and antidiabetic activity

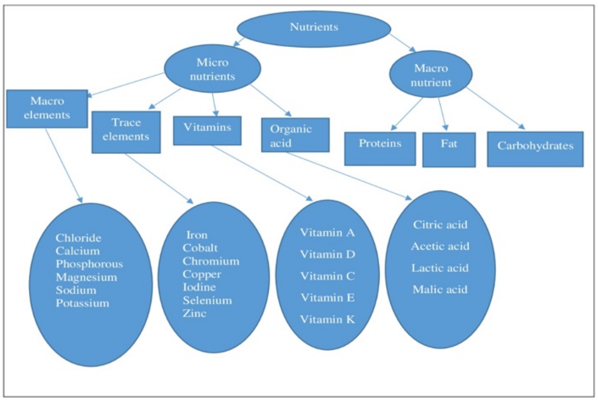

Fig: 2 Classification of micronutrients [3]

Fig: 3 The relationship between various trace elements deficits and the cause of diabetes[73]

Table 2: Mechanism of action of trace elements in type 2 diabetes and immune system

Micronutrients name	Mechanism of action as anti diabetic	Mechanism of action as Immunomodulatory	Concentration in normal physiology
Zinc	• Essential for glucose metabolism. • It aids in the use of glucose by muscle and fat cells. • Necessary as a cofactor for intracellular enzymes involved in protein, lipid, and glucose metabolism. • Play a role in the control of the insulin receptor-initiated signal transduction process and insulin receptor production [3,32-37]	○ Maintains skin and mucosal membrane integrity (for example, as a cofactor for metalloenzymes essential for cell membrane repair) [38]. ○ Maintains or improves the cytotoxic activity of natural killer cells (NK cells) [4,39-40]. ○ Increases peritoneal macrophage phagocytic activity against *E. coli* and *S. aureus* [41]. ○ Enhances phagocytic ability of monocytes[39,42]. ○ Participates in a complementary activity, and involved in the production of IFNγ [43-49].	According to reports, the range for serum/plasma zinc concentration is 84–159 µg/dL [4] .
Selenium	• Antioxidant property of selenium decreases the development of problems in diabetic patients [50-51].	○ Selenoproteins are vital for the antioxidant host defence system, influencing leukocyte and NK cell activity, and playing a role in T cell development and proliferation [52-57]. ○ IFNγ production is increased [43]. ○ Operate as redox regulators and cellular antioxidants, potentially counteracting ROS created during oxidative stress and also assist to maintain antibody levels [39].	Less than 8 µg/dL of selenium is typically present in the serum [4].
Copper	• Deficiency causes glucose intolerance, decreased insulin response, and increased glucose sensitivity. • Linked to hypercholesterolemia and atherosclerosis. • Show insulin-like action and promotes lipogenesis [58-59].	○ Role in macrophage functions (for example, copper accumulates in macrophage phagolysosome to battle specific pathogenic pathogens) [4,60]. ○ A component of copper/zinc superoxide dismutase, a crucial enzyme in ROS defence, maintains intracellular antioxidant equilibrium, implying a role in the inflammatory response [4]. ○ Plays a role in IL2 synthesis and response, as well as T cell differentiation and proliferation [4,52].	Total copper levels in the body should be between 70 and 140 ng/dL [4].
Chromium	• Chromium is an element of the glucose tolerance factor (GTF), • Plays significant part in glucose homeostasis, • Essential for optimal glucose metabolism and as a crucial cofactor for action of insulin [61-66].	*No significant impact in immunomodulation has been reported for chromium.*	Chromium levels in adult serum should range from 0.05 to 0.5 g/L [4].
Cobalt	• Cobalt chloride ($CoCl_2$) reduced glycemia through decreasing systemic glucose synthesis, increasing tissue glucose absorption, or a combination of the two methods. • Increases expression of the glucose transporter 1 (GLUT1) and suppression of gluconeogenesis [67-72] .	*No significant impact in immunomodulation has been reported for cobalt.*	Cobalt levels in normal serum are less than 0.5 g/L [4].
Iodine	• Iodine's involvement is associated with thyroid hormone, • Insulin resistance and β- cell function are inversely correlated with thyroid stimulating hormone, that explained by thyroid hormones' insulin-antagonistic actions combined with an increase in thyroid stimulating hormone (TSH) [3].	*No significant impact in immunomodulation has been reported for iodine.*	Adults typically have iodine levels between 4 and 9.2 µg/dL [4].
Iron	• Elevated iron reserves can cause diabetes by a number of processes, that include oxidative damage to pancreatic βcells, impaired hepatic insulin extraction by the liver, and interference with insulin's capacity to regulate hepatic glucose synthesis [3].	○ Necessary for epithelial tissue development and proliferation [43]. ○ Involved in cytokine generation and activity control ○ Forms highly toxic hydroxyl radicals, which aid in the death of bacteria by neutrophils; a component of enzymes essential for immune cell function (e.g., ribonucleotide reductase, which aids in DNA synthesis); implicated in the regulation of cytokine production and action [43] . ○ Involvement in IFNγ production 43-[44]. ○ T cell differentiation and proliferation are aided by this iron [4]. ○ Necessary for neutrophils to produce pathogen killing ROS during an oxidative burst [4]. ○ Aids in the regulation of the ratio of T helper cells and cytotoxic T cells [43].	Adults typically have iron levels between 60 and 170 g/dL [4].

Table 3: Trace elements content in leafy vegatables

Leafy vegetables	Fe (mg/100gm)	Cu (mg/100gm)	Zn (mg/100gm)	Co (mg/100gm)	Cr (mg/100gm)	Se (mg/100gm)	Reference
(A)Family: Apiaceae							
Centella asiatica (L.)	59.03	1.32	23.74	nr	nr	nr	[74-76]
Coriandrum sativum L.	223.79	74.41	16.99	nr	nr	nr	[77-78]
(B)Family : Acanthaceae							
Hygrophila auriculata (Schumach.) Heine	*7.03*	4.87	56.1	nr	nr	nr	[11-12][79-80]
Andrographis paniculata (Burm.f.) Nees	0.0073	0.0149	0.0191	0.0085	0.0029	nr	[81-83]
(C)Family: Convolvulaceae							
Ipomoea aquatic Forssk	210.30	0.36	2.47	0.02	nr	nr	[84-86]
(D)Family: Convolvulaceae							
Trigonella foenum-graecum L.	0.293	0.0096	0.0496	nf	0.0024	nf	[87-88]
(E)Family: Amaranthaceae							
Spinacea oleracea L	60	nr	5.1	nr	nr	nr	[89]
Amaranthus viridis L.	419	2.87	1.30	0.33	1.53	1.98	[90-91]
Amaranthus tricolor L.	16.2	nr	0.8	nr	0.011	nr	[92-94]
Alternanther asessilis L.	0.14	nr	0.02	nr	nr	nr	[95]
(F)Family: Scrophulariaceae							
Bacopa monnieri (L.) Pennel.	14.19	7.0	4.80	0.15	13.19	nr	[96-97]
(G)Family: Moringaceae							
Moringa oleifera Lam.	14.72	0.825	3.57	0.017	0.48	0.008	[98-99]
(H)Family: Meliaceae							
Azadiracta indica	0.188	0.0011	0.0157	nr	0.0017	nr	[20-21,100]
(I)Family: Marsileaceae							
Marsilea minuta (L.) Mant.	28.10	0.42	4.54	nr	nr	nr	[74]
(M)Family: Basellaceae							
Basella alba L.	4.2	0.04	0.3	nr	nr	nr	[101]
(N)Family: Chenopodiaceae							
Chenopodium album (L.)	0.152	0.0114	0.0486	nf	nf	nf	[25,102-103]
(O)Family: Asteraceae							
Enhydra fluctuans Lour	0.123	1.38	0.043	nf	0.79	nr	[51,104-105]
(P)Family: Nyctanthaceae							
Nyctanthes arbor-tristis L	25.12	1.55	22.36	nr	0.00002	nr	[106-107]
(Q)Family: Brassicaceae							
Brassica juncea	118.50	2.60	7.50	nr	nr	nr	[24,108]
(R)Family: Cucurbitaceae							
Cucurbita maxima	1.0400	0.61	0.59	nr	0.049	nr	[73,108-109]
Lagenaria siceraria (Mol.) Standley Landrace M01	12.17	0.401	4.9	nr	nr	nr	[110]
Lagenaria siceraria (Mol.) Standley Landrace M03	13.92	0.46	4.91	nr	nr	nr	[92]
(S)Family: Asteraceae							
Eclipta alba (L.) Hassk	45.22	2.33	5.82	nr	nr	nr	[111]
(T)Family: Rutaceae							

Leafy vegetables	Fe (mg/100gm)	Cu (mg/100gm)	Zn (mg/100gm)	Co (mg/100gm)	Cr (mg/100gm)	Se (mg/100gm)	Reference
Murraya koenigii (L.) Spreng	0.16	nr	0.04	nr	nr	nr	[27,112-113]
(U)Family: Oxalidaceae							
Oxalis corniculata L	0.1617	0.0343	0.0180	nr	0.002	nr	[114]
(V)Family: Verbenaceae							
Vitex negundo L.	16.48	1.08	5.88	nr	nr	nr	[111,115]
(W)Family: Lamiaceae							
Mentha spicata. L	0.3957	nr	0.0497	nr	nr	nr	[78]
(X)Family: Commelinaceae							
Commelina benghalensis L.	100.10	2.50	2.50	nr	nr	nr	[116]
(Y)Family: Rubiaceae							
Paederia foetida L.	41	0.007	0.013	nr	nr	nr	[117-119]
(Z) Family: Portulacaceae							
Portula caoleracea L.	1.99	0.113	0.17	nr	nr	0.0009	[120]

[a) nr(not reported): these elements may be present in leafy vegetables but their quantative estimation has not been carreid out, b) nf(not found): these trace elements have not found in signifiacant amount among the mentioned plants]

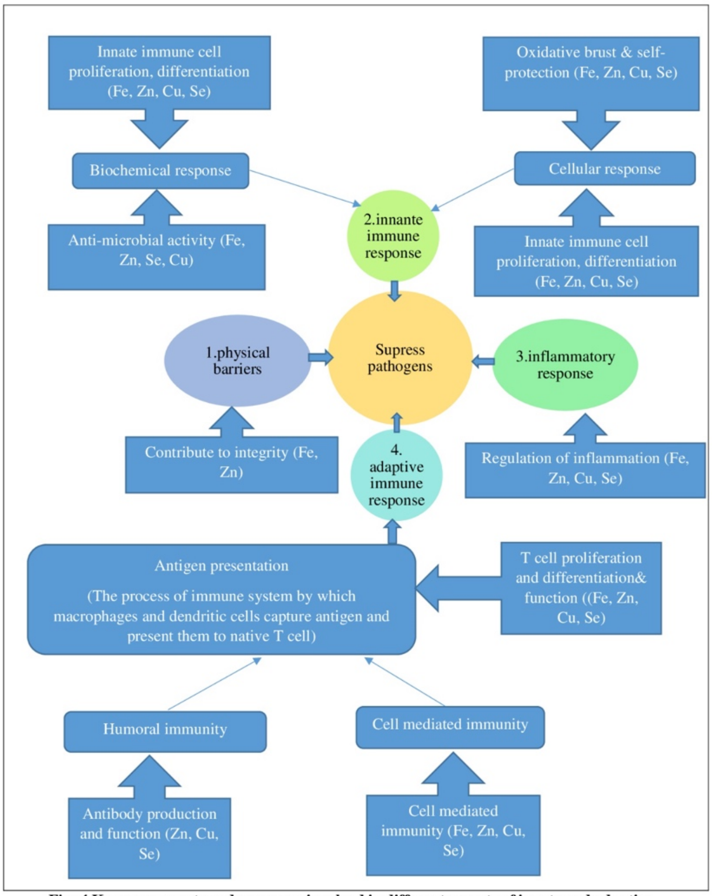

Fig: 4 Key components and processes involved in different aspects of innate and adaptive immune responses and role of trace elements [4]

DISCUSSION:

Inadequate trace element intake can contribute to lower immunity, which makes people more susceptible to illnesses and exacerbates malnutrition. Research has been done that particular micronutrients selectively alter the immune response in humans, that insufficiency and overstock can cause disruption of a coordinated host response to infections, and that shortage can affect the virulence of usually harmless viruses.As a result, for the immune system to operate efficiently, micronutrients must be consumed at the appropriate levels [2].

Worldwide, particularly in developed nations, dietary consumption of several micronutrients is inadequate, which increases the risk of illness. There is a gap between dietary intakes and levels required for good immune function, providing justification for supplementing the diet with micronutrients to assist boost the immune system and minimise the risk of infection [4].

Impact of micronutrient deficiencies and the possible value of supplementation in the prevention and management of type 2 diabetes mellitus is crucial. Since micronutrients play a key role in glucose metabolism, deficiency of micronutrients accelerate the development and progression of diabetes. A well-balanced diet will help diabetis patients to heal up rapidly by providing their necessary micronutrient for recovery [1-3].

According to the information presented in the current review, these edible leafy vegetables can be used as a natural source of micronutrients. These micronutrients aid in diabetes management and immunological modulation. The antioxidant and nutraceutical potential of these plants will aid in the development of nutritional supplements as well as anti-diabetic and immunomodulatory drugs [8].

This review demonstrates the mechanism of action of trace elements as an anti-diabetic and immunomodulatory agent [Table. 2], as well as the leafy vegetables available in Bengal and the trace element content in leafy vegetables [Tables. 1 and 3]. Table. 3 showed concentration of iron in leafy vegetables and the maximum concentration (0.00735 mg/100gm) was found in ***Andrographis paniculata (Burm.f.) Nees*** and minimum concentration was found to be 419 mg/100gm in ***Amaranthus viridisL.*** Copper concentration found to be hieghst in ***Amaranthus viridis L(***74.41mg/100gm) and found to be lowest in ***Azadiracta indica*** (0.0012 mg/100gm). Zinc concentration in leafy vegetables was maximum in ***Hygrophila auriculata (Schumach.) Heine (***56.1mg/100gm) and minimum in ***Paederia foetida L***.(0.013 mg/100gm), levels of Cobalt in leafy vegetables were varied, highest concentration was 0.33 mg/100gm found in ***Amaranthus viridis L*** and lowest contration was 0.008 mg/100gm found in (***Andrographis paniculata (Burm.f.) Nees***), Chromium value ranged from 0.000028 mg/100gm to 13.19 mg/100gm, hieghest concentration found in ***Bacopa monnieri (L.) Pennel.*** and lowest found in ***Nyctanthes arbor-tristis L***, Selenium content was maximum in ***Amaranthus viridisL*** (1.98 mg/100gm) and minimum in ***Portula caoleracea L(*** 0.0009mg/100gm).

Based on the current review study of trace elements for diabetes control and immune boosting, suitable leafy vegetables can be proposed based on the necessity and availability.

CONCLUSION:

The leafy greens are available at very low price and without much difficulty and are very wealthy in relevant micronutrients. Leafy vegetables are ingested on a regular basis by the common people with out proper awareness. Among these leafy vegetables, quantity of Fe, Cu, Zn, were all reported. However trace element profiling with respect to Se, Cr and Co has not yet been completed. It may be concluded from the outcomes of this study that green leafy vegetables, which are frequently disregarded, have a great potential for food value and can serve as easily accessible food resources. Variations in chemical composition can be traced back to differences in species, changing environmental conditions, and plant age.

Many green leafy vegetables are present in this section of the West Bengal in large scale, however further investigation is required to accopmplish their dietary profile with respect to important trace elements. Before those inexperienced leafy vegetation may be exploited industrially, extra studies and awareness are required and these will provide the nutritional suggestion for the common people of the society in future days.

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