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Culinary and herbal resources as nutritional supplements against malnutrition-associated immunity deficiency: the vegetarian review

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Abstract

Background: Malnutrition may be due to undernutrition and/or overnutrition and is responsible for morbidity and mortality. Fulfilling nutrition requirements of all human age groups is necessary for maintenance of health and quality of life. Nutritional supplements, or daily diet, must include a sufficient amount of macronutrient (carbohydrate, protein, and fat), micronutrients (vitamins and minerals), and nonessential dietary components such as fiber.

Main body: There is a bidirectional relationship that exists between nutrition, infection, and immunity; children are dying due to malnutrition that weakens their immunity and makes them more susceptible to pathogen attack. Culinary and herbal resources containing macro- and micronutrients are required to achieve nutritional deficiencies.

Conclusion: In this review, we have documented different culinary herbs that have been used as prime herbal nutritional source and these herbs might be helpful in malnutrition and boosting immunity. The review contains the description of nutritional levels and their distribution to different age group people. This review gives insight to herbal products that boost immunity to fight against infections by restoring micronutrients.

Keywords: Malnutrition, Culinary herbs, Immunity, Nutrition, Phytoconstituents

Background

Malnutrition has become a leading public health problem globally, more in southern Asian and African countries [1]. The prime cause of malnutrition in developing countries is prevalence of bacterial and parasitic diseases [2]. It has been estimated that 300,000 deaths occur annually due to malnutrition and is indirectly related to half of all deaths in young children [3, 4]. Malnutrition, more specifically to protein-energy, and micronutrient deficiencies, are major health burdens in developing countries. It is one of the most important risk factor for illness and death worldwide.

Malnutrition exists in all countries, irrespective of the economic status of the country, where people are lacking nutritious diet [5]. According to Global Nutrition Report 2018, India is a shelter of 46.6 million stunted children as the world's third highest country having malnourished children. The mortality in below 5-year-old children in India is mostly due to undernutrition [6]. India is faced with serious problems of malnutrition that affect socio-economic progress. One-third of the children are malnourished [7].

Deficiencies of protein, carbohydrates, fat, and micronutrients such as iodine, iron, vitamin A, and zinc are nutritional deficiencies [8]. Poverty is the major cause of malnutrition in developing countries. Severity of malnutrition depends on several factors: education level, sanitation, economy, political situation, climate, food

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production, cultural eating traditions, prevalence of infectious diseases, nutrition awareness programs, and quality of health services [9, 10]. Improper breastfeeding of infants and children leads to malnutrition. The first 6 months of life is crucial for proper nutrition [11]. Breastfeeding provides immunity to the infant and protects against infection due to presence antibodies and lymphocytes (T and B), numerous cytokines, and growth factors to stimulate an infant's immune system [12, 13].

Malnutrition occurs due to improper diet and infection that results to energy and nutrient losses through anorexia, vomiting, and diarrhea. Microbial attack causes contamination of the gut that impairs digestion and nutrient uptake and results in sepsis from bacterial translocation to the intestine [14]. The indicative measures of malnutrition are frailty, impairment of organ functions, cognitive impairment, poor performance, stress and depression, etc. [15]. It can be characterized as physical and mental exhaustion, low basal metabolic rate (BMR), small height (wasting), and rigid skin. India has the highest number of malnourished children in comparison to other developing countries and high rate of mortality due to malnutrition each year [16]. One other cause of malnutrition in developing countries is more consumption of Western diet by the people that is also responsible for the deficient nutrition level in their bodies [17].

Deficiency of nutrition in diets requires proper understanding of processes and determinants that are influencing diets. Thus, there is a need for a large intervention including nutrient-rich food, coverage of immunization, supplements distribution, primary care to children, proper checkup of geriatric patients, and proper sanitation in community which are necessary across different sectors. There may be a rational approach to investigate the dietary supplement effects including all nutrients present in the current government recommended dietary allowance. The solution to malnutrition and other forms of hunger needs to be focused on ensuring the sufficient supply of nutritious and high-quality food.

Main text

Status of child nutrition

The United Nations International Children's Emergency Fund (UNICEF) has defined nutrition status among children and investigated roles of food care—health determinants, i.e., quantities of food available at a national level and varieties of food, women's education and equality of gender, and access to safe drinking water and sanitation. One-third of the women in India are malnourished during pregnancy and give birth to malnourished babies [18]. In 2017, the death of malnourished children below 5 years old was accounting for 68.2% in India. A projection for global malnutrition 2030 target was set according to the study of National Nutrition Mission (NNM) conducted in different states of India in 2017. The malnourished data in this study indicated 21.4% low birthweight, 15.7% child wasting, 39.3% child stunting, 59.7% anemia, 32.7% child underweight, and 11.5% child overweight [19].

The influence of income and quality of governance in countries affects nutritional levels. The conceptual framework indicates (Fig. 1) causes of child malnutrition and death [20]; this framework is a hierarchical relationship between immediate, underlying, and basic determinants of child nutritional status. Factors such as dietary intake and health status are immediate determinants that manifest themselves at the level of the individual child. Inadequate dietary intake may lead to enhanced susceptibility to pathogens; disease caused reduced appetite and inhibition of absorption of nutrients present in food [21]. Underlying determinants manifest themselves at household food security (having enough food for living an active healthy life), care for mother and children (care for women that affects children's nutritional wellbeing is care and support during pregnancy and lactation), and home environment and services (children's exposure to pathogens and the use of preventative and curative health care). Basic determinants manifest political, economic, social, environmental, and cultural context in which children's nutritional status is determined [22].

Effects of aging on nutritional level

The maintenance of healthy life for all age groups depends on diet and nutrition. Obtaining proper nutrition has significant effects for wellbeing, decreasing and delaying risk of diseases, maintaining functional independence, and continuing independent living [23]. Aging leads to physiological and pathological changes in the body that makes it difficult to meet the nutritional requirements for the body (Table 1). Cumulative effects of all these changes lead to malnutrition of elderly people. Aging, combined with arthritis, depression, stroke, respiratory disease, renal diseases, and dementia, creates loss of appetite, inability to swallow properly, alteration in food intake, and unbalanced nutrient in the body [24, 25]. Older persons are more prone to malnutrition that causes energy loss, poor wound healing, and vulnerability to infections increasing the risk factor of morbidity and mortality [26, 27].

Malnutrition and infection

Malnutrition and infection operate synergistically (Fig. 2). Infection interferes with substrate utilization, reduces nutrient absorption, and promotes tissue breakdown. Weight loss is an indication of malnutrition [28]. Signs for nutritional deficiency in children are stunting.

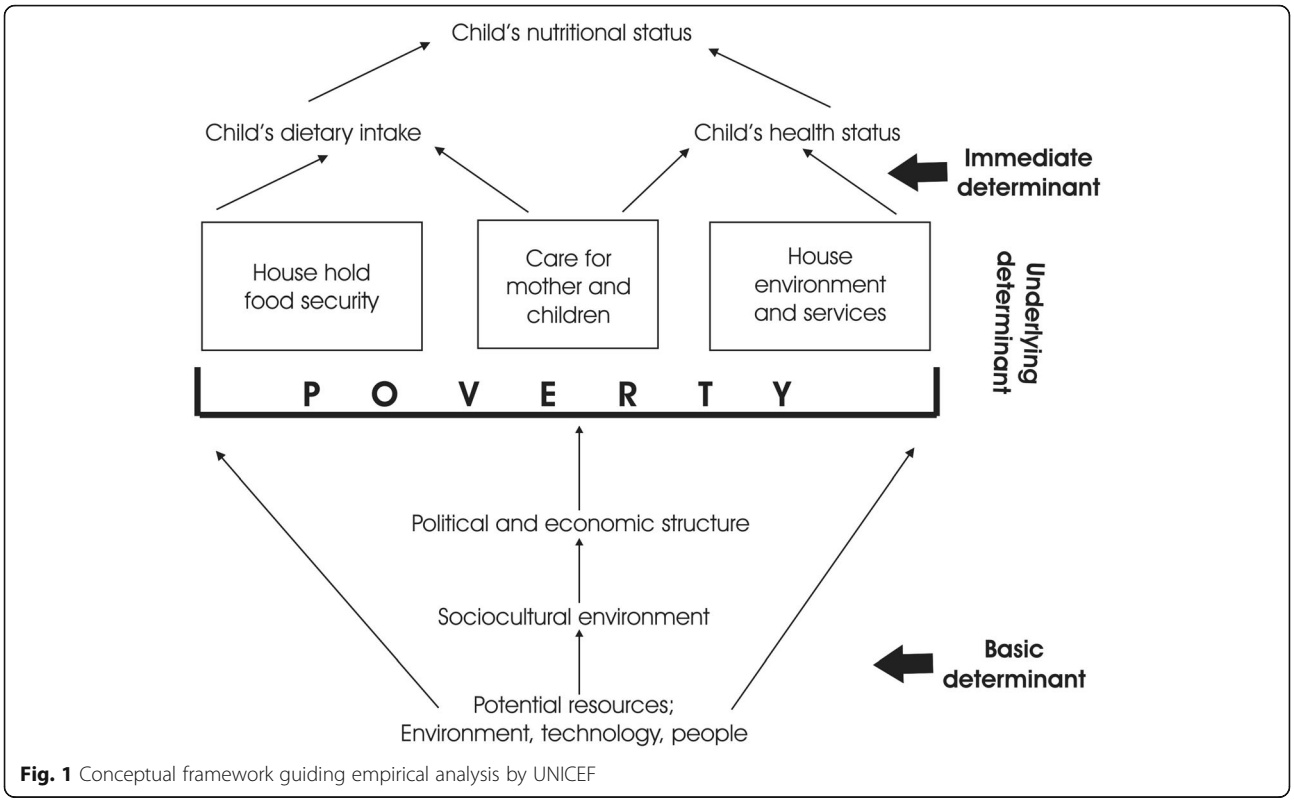

Fig. 1 Conceptual framework guiding empirical analysis by UNICEF

Immune dysfunction as a cause and consequence of malnutrition

Malnutrition leads to suppression of immune and inflammatory systems with weakened responses to infection or injury. Severe acute malnutrition management that fails to consider these complex metabolic and physiological changes results in severe, or fatal, complications [14]. Poor diet, lack of exercise, environmental toxicity, and age progression causes variable effects on the human immune system (Fig. 3). It has been reported that long-term usage of herbal nutrients, or nutraceuticals, may reverse these immune-affecting variables [29].

Table 1 Effects of changes on aging

Change	Effect on older people (age 60 and above)
Decreased sense of taste	Reduced appetite
Decreased sense of smell	Reduced appetite
Loss of vision and hearing	Decreased ability to purchase and prepare food
Oral health/dental problems	Difficulty chewing, inflammation, poor quality diet
Altered energy need	Diet lacking in essential nutrients
Decreased physical activity	Progressive depletion of BMI and loss of appetite
Muscle loss	Decreased functional ability
Social isolation	Decreased appetite
Financial and environmental	Limited access to food, poor quality diet

Culinary herbs

Culinary herbs and spices (dried) include any part of plant (root, leaves, bark, berry, seed, stigma, or flower) that are frequently used while cooking to enhance the aroma or flavor of foods [30]. These herbs contain several nutritional contents along with their flavoring property [31]. They also have been used for several medicinal purposes to diseases including cardiovascular, neurodegenerative, diabetes, cancer, and many more [32]. The use of herbs and spices as functional food extends their importance beyond basic nutrition. Herbs and spices are generally used in the concentration of 0.5–10% in food preparation [33]. Peppermint leaves are most widely used in herbal teas. It is a folk medicine used for dyspepsia, enteritis, gastritis, and intestinal colic. The total phenolic content (TPC) of peppermint leaves is 19–23% along with present of Ca, Mg, Mn, Fe, Zn, Cu, I, Cr, and Se [34]. Several culinary herbs containing rich nutrients are *Melissa officinalis* (Lemon balm leaves), *Hyssopus officinalis* (Hyssop leaves), *Agastache foeniculum* (Anise hyssop), *Capsicum annuum* (Red pepper), *Juniperus communis* (Juniper berries), etc. Table 2 shows the list of culinary herbs and spices used in cooking that are rich in nutritional contents.

Phytoconstituents and biological activity of culinary herbs

Oregano possesses carvacrol, thymol, linalool, *p*-cyeme, and *y*-terpinene as active constituents that gives

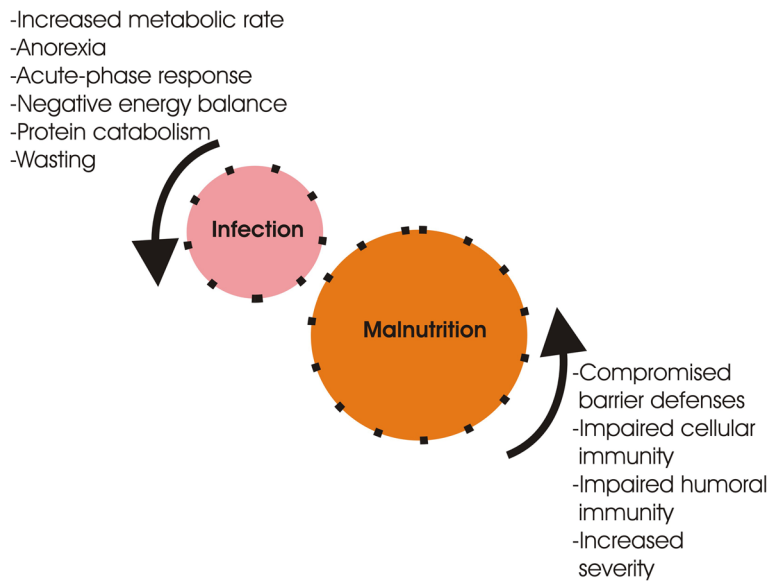

Fig. 2 The vicious cycle of malnutrition and infection

antimicrobial, anti-inflammatory, immunomodulatory, antidiabetic, anticancer, and antioxidant activities; prevents lipid peroxidation; suppress nitric oxide activity; and DNA protection against damage from free radicals [35]. *Salvia officinalis* contains ellagic acid, quercetin, rosmarinic acid, camphor, borneol, cineole, and thujone as phytoconstituents. It helps in cognition enhancement, reduction of throat pain, analgesic, antihyperlipidemic, antinociceptive, anti-inflammatory, and antioxidant activities [65]. *Mentha piperita* contains menthyl acetate, menthone, and menthol as major phytoconstituents. Other active constituents of mentha leaves are methofuran, neomenthol, isomenthone, isorhoifolin, leutolin-7-O-glucoside, and 1,8-cineole. It possesses antioxidant, antimicrobial, insecticidal, and anti-inflammatory activities [66]. *Thymus vulgaris* possess active constituents

Poor diet No exercise Hectic lifestyle Inoculations	PROGRESSIVE IMMUNE DYSFUNCTION				Hypertension Heart attacks Diabetes Cancer Arthritis Asthma
	→	→	→	→	
	Stress	Acute recurrent infection	Allergies	Chronic infections	
Negative thoughts	Stress headaches	Colds	Hay fever	Candida	
Environmental toxicity	Onset of fatigue	Urinary tract infections	Food and chemical allergy	Viral and bacterial infections	Stokes
Age of onset (Approx.)	15-25	10-35	25-45	35-45	45-60

Fig. 3 Factors affecting human immune system

Table 2 Culinary herbs and spices in daily use

Culinary herb	Biological sources	Consumption (mg/day)	Nutritional value	References
Oregano	*Origanum vulgare*	200	One teaspoon of dried oregano contains: energy (5 calories), fiber (0.8 g), calcium (29 mg), iron (0.66 mg), magnesium (5 g), manganese (0.09 mg), potassium (23 mg), vitamin E (0.33 mg), vitamin K (11.2 μg)	[35]
Sage	*Salvia officinalis*	300–600	One teaspoon of dried oregano contains: energy (2 calories), magnesium (3 mg), phosphorous (1 mg), potassium (7 mg), folate (2 μg), beta-carotene (24 μg), vitamin A (41 IU), vitamin K (12 μg)	[36]
Peppermint leaves	*Mentha piperita*	300–600	Two tablespoons of peppermint leaves contain: energy (2 calories), protein (0.12 g), carbohydrate (0.48 g), fat (0.03 g), fiber (0.30 g) and small amount of potassium, magnesium, calcium, phosphorus, vitamin C, iron, and vitamin A	[37]
Garden Thyme	*Thymus vulgaris*	1000–2000	Per 100 g of Garden thyme contains: proteins (5.6 g), energy (101 calories), carbohydrate (24 g), total fat (1.7 g), saturated fat (467 mg), monounsaturated fat (81 mg), polyunsaturated fat (532 mg), Omega-3 fatty acids (447 mg), Omega-6 fatty acids (85 mg), vitamin A (4751 IU), vitamin C (160 mg), thiamin (48 μg), riboflavin (471 μg), niacin (1.8 mg), vitamin B6 (348 μg), folate (45 μg), pantothenic acid (409 μg), calcium (405 mg), iron (17 mg), magnesium (160 mg), phosphorus (106 mg), potassium (609 mg), sodium (9 mg), zinc (1.8 mg), copper (555 μg), manganese (1.7 mg)	[38]
Sweet Marjoram	*Origanum majorana*	1000	Per 100 g of Sweet marjoram contains: energy (271 kcal), carbohydrates (60.56 g), protein (12.66 g), total fat (7.04 g), dietary fiber (40.3 g), folates (274 μg), niacin (0.902 mg), pantothenic acid (0.209 mg), pyridoxine (1.190 mg), riboflavin (0.316 mg), thiamin (0.289 mg), vitamin A (8068 IU), vitamin C (51.4 mg), vitamin E (1.69 mg), vitamin K (621.7 μg), sodium (77 mg), potassium (1522 mg), calcium (1990 mg), copper (1.133 mg), iron (82.71 mg), magnesium (346 mg), manganese (5.433 mg), zinc (3.60 mg), carotene-β (4806 μg), cryptoxanthin-β (70 μg), lutein-zeaxanthin (1895 μg)	[39]
Tansy leaves	*Tanacetum vulgare*	100	The tansy plant contains volatile oils that comprise of 70% of thujone and significant amounts of camphor. It also contains other chemical constituents such as sesquiterpene lactones, bitter glycosides, terpenoids, flavonoids, resin, tannin, oxalic acid, and citric acid. It is a good source of vitamin C and minerals like calcium, magnesium, sodium, manganese, iron, silicon, and sulphur	[40, 41]
Poppy seeds	*Papaver somniferum*	100–150	Per 100 g of poppy seed contains: energy (525 kcal), carbohydrates (28.13 g), sugars (2.99 g), dietary fiber (19.5 g), fat (41.56 g), protein (21.22 g), thiamine (0.854 mg), riboflavin (0.100 mg), niacin (0.896 mg), vitamin B_6 (0.247 mg), folate (82 μg), choline (52.1 mg), vitamin C (1 mg), vitamin E (1.77 mg), calcium (1438 mg), iron (9.76 mg), magnesium (347 mg), manganese (2.285 mg), phosphorus (870 mg), potassium (719 mg), sodium (26 mg), zinc (7.0 mg)	[42, 43]
Cardamom	*Elettaria cardamomum*	250	Per 100 g of cardamom contains: energy (311 kcal), carbohydrates (68.47 g), protein (10.76 g), total fat (6.7 g), dietary fiber (28 g), niacin (1.102 mg), pyridoxine (0.230 mg), riboflavin (0.182 mg), thiamin (0.198 mg), vitamin C (21 mg), sodium (18 mg), potassium (1119 mg), calcium (383 mg), copper (0.383 mg), iron (13.97 mg), magnesium (229 mg), manganese (28 mg), phosphorus (178 mg), zinc (7.47 mg)	[44]
Coriander	*Coriandrum sativum*	600–1200	Per 100 g of coriander contains: choline (12.8 mg), folate (62.00 μg), niacin (1.114 mg), pantothenic acid (0.570 mg), riboflavin (0.162 mg), thiamin (0.067 mg), vitamin A (6748.00 IU), α-carotene (36.00 μg), β-carotene (3930 μg), cryptoxanthin-β (202.00 μg), lutein + zeaxanthin (865.00 μg), vitamin B_6 (0.149 mg), vitamin C (27.0 mg), vitamin E (2.50 mg), tocopherol-α (2.50 mg), vitamin (310.0 μg), calcium (67.00 mg), copper (0.225 mg), iron (1.77 mg), magnesium (26.00 mg), manganese (0.426 mg), phosphorus (48.00 mg), potassium (521.00 mg), selenium (0.9 μg), sodium (46.00 mg), zinc (0.50 mg)	[45]
Garlic	*Allium sativum*	300–900	Per 100 g of garlic contains: choline (23.2 mg), folate (3.0 μg), niacin (0.70 mg), pantothenic acid (0.596 mg), riboflavin (0.110 mg), thiamin (0.20 mg), vitamin A (9.0 IU), β-Carotene (5.0 μg), lutein + zeaxanthin (16.00 μg), vitamin B_6 (1.235 mg), vitamin C (31.2 mg), vitamin E (0.08 mg), α-tocopherol (0.08 mg), vitamin K (1.7 μg), calcium (181.00 mg), copper (0.299 mg), iron (1.70 mg), magnesium (25.00 mg), manganese (1.672 mg), phosphorus (153.00 mg), potassium (401.00 mg), selenium (14.2 μg), sodium (17.00 mg), zinc (1.16 mg), protein (6.36 g), alanine (0.132 g), arginine (0.634 g), aspartic acid (0.489 g),	[46]

Table 2 Culinary herbs and spices in daily use *(Continued)*

Culinary herb	Biological sources	Consumption (mg/day)	Nutritional value	References
			cystine (0.065 g), glutamic acid (0.805 g), glycine (0.200 g), histidine (0.113 g), isoleucine (0.217 g), leucine (0.308 g), lysine (0.273 g), methionine (0.076 g), phenylalanine (0.183 g), proline (0.100 g), serine (0.190 g), threonine (0.157 g),tryptophan (0.066 g), tyrosine (0.081 g), valine (0.291 g)	
Vanilla seed	*Vanilla planifolia*	600–1000	Per 100 g of vanilla contains: niacin (0.425 mg), pantothenic acid (0.035 mg), riboflavin (0.095 mg), thiamin (0.011 mg), vitamin B_6 (0.026 mg), calcium (11.00 mg), copper (0.072 mg), iron (0.12 mg), magnesium (12.00 mg), manganese (0.230 mg), phosphorus (6.00 mg), potassium (148.00 mg), sodium (9.00 mg), zinc (0.11 mg)	[47, 48]
Parsley	*Petroselinum crispum*	6000	Per 100 g of parsley contains: betaine (1.7 mg), choline (97.1 mg), folate (180.00 μg), niacin (9.943 mg), pantothenic acid (1.062 mg), riboflavin (2.383 mg), thiamin (0.196 mg), vitamin A (97.00 μg), α-carotene (17.00 μg), β-carotene (1152.00 μg), cryptoxanthin-β (4.00 μg), lutein + zeaxanthin (2428.00 μg), vitamin B_6 (0.900 mg), vitamin C (125.0 mg), vitamin E (8.96 mg), α-Tocopherol (8.96 mg), β-Tocopherol (0.02 mg), γ-Tocopherol (1.53 mg), vitamin K (1359.5 μg), calcium (1140.00 mg), copper (0.780 mg), iron (22.04 mg), magnesium (400.00 mg), manganese (9.810 mg), phosphorus (436.00 mg), potassium (2683.00 mg), selenium (14.1 μg), sodium (452.00 mg), zinc (5.44 mg), protein (26.63 g), alanine (1.778 g), arginine (1.756 g), aspartic acid (3.169 g), cysteine (0.298 g), glutamic acid (3.688 g), glycine (1.756 g), histidine (0.718 g), isoleucine (1.546 g), leucine (2.794 g), lysine (2.098 g), methionine (0.596 g), phenylalanine (1.712 g), proline (2.010 g), serine (1.159 g), threonine (1.193 g), tryptophan (0.475 g), tyrosine (1.159 g), valine (2.021 g)	[49, 50]
Caraway seed	*Carum carvi*	100–150	Per 100 g of caraway seeds contains: Choline (24.7 mg), folate (10.00 μg), niacin (3.606 mg), riboflavin (0.379 mg), thiamin (0.383 mg), vitamin A (18.00 μg), α-carotene (8.00 μg), β-carotene (206.00 μg), Cryptoxanthin-β (16.00 μg), lutein + zeaxanthin (454.00 μg), lycopene (20.00 μg), vitamin B_6 (0.360 mg), vitamin C (21.0 mg), vitamin E (2.50 mg), α-tocopherol (2.50 mg), calcium (689.00 mg), copper (0.910 mg), iron (16.23 mg), magnesium (258.00 mg), manganese (1.300 mg), phosphorus (568.00 mg), potassium (1351.00 mg), selenium (12.1 μg), sodium (17.00 mg), zinc (5.50 mg), protein (19.77 g), alanine (0.914 g), arginine (1.252 g), aspartic acid (2.084 g), cysteine (0.329 g), glutamic acid (3.169 g), glycine (1.322 g), histidine (0.550 g), isoleucine (0.826 g), leucine (1.218 g), lysine (1.031 g), methionine (0.361 g), phenylalanine (0.867 g), proline (0.917 g), serine (0.946 g), threonine (0.756 g), tryptophan (0.244 g), tyrosine (0.642 g), valine (1.037 g)	[51]
PiriPiri	*Capsicum frutescens*	1000–1200	Per 100 g of piripiri contains: energy (76.3 calories), total fat (6.6 g), sodium (48.3 mg), potassium (119.8 mg)	[52]
Cumin	*Cuminum cyminum*	300–600	Per 100 g of cumin contains: choline (24.7 mg), folate (10.00 μg), niacin (4.579 mg), riboflavin (0.327 mg), thiamin (0.628 mg), vitamin A (64.00 μg), β-carotene (762.00 μg), lutein + zeaxanthin (448.00 μg), vitamin B_6 (0.435 mg), vitamin C (7.7 mg), vitamin E (3.33 mg), α-tocopherol (3.33 mg), vitamin K (5.4 μg), calcium (931.00 mg), copper (0.867 mg), iron (66.36 mg), magnesium (366.00 mg), manganese (3.333 mg), phosphorus (499.00 mg), potassium (1788.00 mg), selenium (5.2 μg), sodium (168.00 mg), zinc (4.80 mg), protein (17.81 g)	[53]
Chives	*Allium schoenoprasum*	1500–2500	Per 100 g of cumin contains: choline (5.2 mg), folate (105.00 μg), niacin (0.647 mg), pantothenic acid (0.324 mg), riboflavin (0.115 mg), thiamin (0.078 mg), vitamin A (218.00 μg), β-carotene (2612.00 μg), lutein + zeaxanthin (323.00 μg), vitamin C (58.1 mg) vitamin E (0.21 mg), α-tocopherol (0.21 mg), vitamin K (212.7 μg), calcium (92.00 mg), copper (0.157 mg), iron (1.60 mg), magnesium (42.00 mg), manganese (0.373 mg), phosphorus (58.00 mg), potassium (296.00 mg), selenium (0.9 μg), sodium (3.00 mg), zinc (0.56 mg), protein (3.27 g), alanine (0.148 g), arginine (0.237 g), aspartic acid (0.303 g), glutamic acid (0.677 g), glycine (0.162 g), histidine (0.057 g), isoleucine (0.139 g), leucine (0.195vg), lysine (0.163 g), methionine (0.036vg), phenylalanine (0.105 g), proline (0.216vg), serine (0.148 g), threonine (0.128 g), tryptophan (0.037 g), tyrosine (0.095 g), valine (0.145 g)	[54, 55]

Table 2 Culinary herbs and spices in daily use *(Continued)*

Culinary herb	Biological sources	Consumption (mg/day)	Nutritional value	References
Mustard	*Brassica nigra*	1500–2000	One table spoon full of mustard contains: total fat (3.2 g), total omega-3 fatty acids (295 mg), total omega-6 fatty acids (285 mg), vitamin A (6.8 IU), vitamin C (0.3 mg), vitamin E (0.3vmg), vitamin K (0.6 μg), thiamin (0.1 mg), niacin (0.9 mg), folate (8.4vμg), choline (13.5vmg), betaine (0.2vmg), calcium (57.3 mg), iron (1.1 mg), magnesium (32.8 mg), phosphorus (92.5 mg), potassium (75.0 mg), sodium (0.6 mg), zinc (0.6 mg), manganese (0.2 mg), selenium (14.7 μg)	
Tumeric	*Curcuma longa*	500–000	Per 100 g of curcuma contains: betaine (9.7 mg), choline (49.2 mg), folate (20.00 μg), niacin (1.350 mg), pantothenic acid (0.542 mg), riboflavin (0.150 mg), thiamin (0.058 mg), vitamin B6 (0.107 mg), vitamin C (0.7 mg), vitamin E (4.43 mg), α-tocopherol (4.43 mg), β-tocopherol (0.01 mg), γ-tocopherol (0.72 mg), α-tocotrienol (0.12 mg), γ-tocotrienol (0.05 mg), vitamin K(13.4 μg), calcium (168.00 mg), copper (1.300 mg), iron (55.00 mg), magnesium (208.00 mg), manganese (19.800 mg), phosphorus (299.00 mg), potassium (2080.00 mg), selenium (6.2 μg), sodium (27.00 mg), zinc (4.50 mg), protein (9.68 g), alanine (0.330 g), arginine (0.540 g), aspartic acid (1.860 g), cysteine (0.150 g), glutamic acid (1.140 g), glycine (0.470 g), histidine (0.150 g), isoleucine (0.470 g), leucine (0.810 g), lysine (0.380 g), methionine (0.140 g), phenylalanine (0.530 g), proline (0.480 g), serine (0.280 g), threonine (0.330 g), tryptophan (0.170 g), tyrosine (0.320 g), valine (0.660 g)	[57]
Nutmeg	*Myristica fragrans*	100–200	Per 100 g of nutmeg contains: choline (8.8 mg), folate (76.00 μg), niacin (1.299 mg), riboflavin (0.057 mg), thiamin (0.346 mg), vitamin A (5.00 μg), β-carotene (28.00 μg), cryptoxanthin-β (66.00 μg), vitamin B_6 (0.160 mg), vitamin C (3.0 mg), γ-tocopherol (0.53 mg), calcium (184.00 mg), copper (1.027 mg), iron (3.04 mg), magnesium (183.00 mg), manganese (2.900 mg), phosphorus (213.00 mg), potassium (350.00 mg), selenium (1.6 μg), sodium (16.00 mg), zinc (2.15 mg), protein (5.84 g)	[58, 59]
Dill	*Anethum graveolens*	100–250	Per 100 g of dill contains: folate (10.00 μg), niacin (2.807 mg), riboflavin (0.284 mg), thiamin (0.418 mg), vitamin A (3.00 μg), vitamin B_6 (0.250 mg), vitamin C (21.0 mg), calcium (1516.00 mg), copper (0.780 mg), iron (16.33 mg), magnesium (256.00 mg), manganese (1.833 mg), phosphorus (277.00 mg), potassium (1186.00 mg), selenium (12.1 μg), sodium (20.00 mg), zinc (5.20 mg), protein (15.98 g), arginine (1.263 g), histidine (0.320 g), isoleucine (0.767 g), leucine (0.925 g), lysine (1.038 g), methionine (0.143 g), phenylalanine (0.670 g), threonine (0.575 g), valine (1.120 g)	[60]
Ginger	*Zingiber officinale*	500–1500	Per 100 g of ginger contains: betaine (3.4 mg), choline (41.2 mg), folate (13.00 μg), niacin (9.620 mg), pantothenic acid (0.477 mg), riboflavin (0.170 mg), thiamin (0.046 mg), vitamin A (2.00 μg), β-carotene (18.00 μg), vitamin B_6 (0.626 mg), vitamin C (0.7 mg), γ-tocopherol (3.01 mg), vitamin K (0.8 μg), calcium (114.00 mg), copper (0.480 mg), iron (19.80 mg), magnesium (214.00 mg), manganese (33.300 mg), phosphorus (168.00 mg), potassium (1320.00 mg), selenium (55.8 μg), sodium (27.00 mg), zinc (3.64 mg), protein (8.98 g), alanine (0.272 g), arginine (0.708 g), aspartic acid (1.387 g), cysteine (0.099 g), glutamic acid (0.790 g), glycine (0.497 g), histidine (0.199 g), isoleucine (0.341 g), leucine (0.513 g), lysine (0.241 g), methionine (0.089 g), phenylalanine (0.311 g), proline (0.334 g), serine (0.250 g), threonine (0.289 g), tryptophan (0.152 g), tyrosine (0.243 g), valine (0.411 g)	[61]
Bayberry leaves	*Myrica pensylvanica*	450–1350	Per 13 g of bayberry contains: energy (6 calories), protein (0.07 g), fat (0.03 g), carbohydrate (1.47 g), vitamin A (0.26 μg), vitamin E (0.04 mg), vitamin B_1 (0.01 mg), niacin (0.04 mg), vitamin B_6 (0.01 mg), folate (3.38 μg), pantothenic acid (0.03 μg), vitamin (0.52 mg), sodium (0.52 mg), potassium (15.6 mg), calcium (0.52 mg), phosphorous (0.65 mg), iron (0.05 mg), zinc (0.01 mg), manganese (0.03 mg)	[62]
Common basil	*Ocimum basilicum*	300–600	Per 42 g of common basil contains: protein (1.3 g), energy (9.8 calories), carbohydrates (1.1 g), dietary fiber (678 mg), sugar (127 mg), fats (271 mg), omega-3 fatty acids (134 mg), omega-6 fatty acids (31 mg), vitamin A (2237 IU), vitamin C (7.6 mg), vitamin E (339 μg), vitamin K (176 μg), thiamin (14 μg), riboflavin (32 μg), niacin (382 μg), vitamin B_6 (66 μg), folate (29 μg), pantothenic acid (89 μg), choline (4.8 mg), betaine (0.17 mg), calcium (75 mg), iron (1.3 mg), magnesium (27 mg), phosphorus (24 mg), potassium (125 mg), sodium (1.7 mg), zinc (343 μg), copper (163 μg), manganese (487 μg), selenium (0.13 μg)	[63, 64]

Table 3 Herbal products containing nutrients for different health benefits

Nutrients	Health benefits	Herb/Herbal product	References
Fat-soluble vitamins			
Vitamin A	Acts as antioxidant, useful for growth, development, and eye sight vision, helps in prevention and treatment of cancers and skin disorders	Aamaranth, spinach, sweet potatoes, carrots, pumpkins, yellow maize, mangoes papayas	[69]
Vitamin D	Useful for bones and teeth development, helps in absorption of calcium from the body	*Solanum lycopersicum*, *S. tuberosum*, *Cucurbita pepo*, *S. glaucophyllum*, *Nicotiana glauca*, *Cestrum diurnum*, *Medicago sativa*, *Trisetum flavescens*, *Capsicum annuum*	[70]
Vitamin E	Acts as antioxidant, helps in formation of blood cells, lungs, muscles and nerve tissue, it also boosts immunity	Nuts, spinach, whole grains, olive oil, sunflower oil, coconut, maize, palm, soybean, wheatgerm	[71]
Vitamin K	Helps in clotting of blood	Kiwifruit, avocado, broccoli, green grapes, and lettuce	[72]
Water-soluble vitamins			
Vitamin C	Acts as antioxidant, maintains healthy bones, teeth and gums, helps in wound healing and cold	Herbal teas and tinctures from rose hips, pine needles, and tree barks	[73]
Vitamin B_1	Helps in conversion of food into energy, useful in neurologic functions	Whole grain cereals (e.g., brown rice and bran), nuts, dried beans, peas, and soybeans	[74]
Vitamin B_3	Helps in conversion of food into energy, useful in brain functions	Peanuts, coffee, beans, barley, wheat, rice, potato, soybean, maize	[75]
Vitamin B_6	Helpful in production of essential proteins and convert protein in to energy	Legumes, nuts, bananas, potatoes	[76]
Vitamin B_{12}	Helps in production of cells genetic material, aids in formation of red blood cells (RBCs), brain functions, and synthesis of amino acids, helps in metabolism of biomolecules	*Boletus* sp., *Macrolepiota procera*, *Pleurotusos treatus*, *Morchella conica*, *Craterellus cornucopioides*, *Cantharellus cibarius*, *Lentinul aedodes*, *Hericium erinaceus*	[77]
Folic acid	Helps in production of cells genetic material, first trimester of pregnancy, helps in formation of RBCs, protects body from heart diseases	Leafy vegetables, legumes, citrus fruits	[76]
Pantothenic acid	Helps in synthesis of cholesterol, acetylcholine steroids and fatty acids	whole grain cereals, broccoli	[76]
Minerals			
Calcium	Helps in strengthening bones and teeth, nerve conduction, functionality of muscle and glands	Orange juice, spinach, soybean, carrots, potato	[78]
Iron	Helps in production of energy production, carrying oxygen to tissues	Cereals, pulses, legumes, fruits, and St John's wort (flowers and leaves), sage (leaves), chamomile (flowers), mint (leaves) and nettle (leaves)	[79, 80]
Magnesium	Helps in nerve conduction and muscle function, formation of bone, prevention of premenstrual syndrome	St John's wort (flowers and leaves), sage (leaves), chamomile (flowers), mint (leaves) and nettle (leaves)	[80]
Phosphorous	Strengthening strong bones and teeth, formation of cells genetic material, production and storage of energy	Margarine oil, corn oil, peanut oil, beans, lentils, rice, maize flour, cornflakes	[81]
Trace elements			
Chromium	Helps in conversion of fats and carbohydrate into energy along with insulin	Aniseed, basil, cinnamon, garlic, laurel, mint, mustard, nutmeg, onion, oregano, parsley, paprika, pepper, pepper, saffron, thyme, vanilla	[82]
Cobalt	Helps in production of vitamin B_{12}	legumes, spinach, cabbage, lettuce, beet greens, and figs.	[83]
Copper	Helps in formation of hemoglobin and production of collagen, maintains heart functions, helps in energy production and iron absorption from body	*Potentilla anserina*, *Mentha arvensis*, *Achillea millefolium*, *Comarum palustre*, *Lysimachia vulgaris*, and *Lycopus europaeus*	[84]
Iodine	Maintains thyroid gland functioning	Fruit, berries, nuts, seeds, potatoes	[85]
Zinc	Aids in reproduction of cells, growth and development in children, helpful in wound healing, generation of	St John's wort (flowers and leaves), sage (leaves), chamomile (flowers), mint (leaves) and nettle (leaves)	[80]

Table 3 Herbal products containing nutrients for different health benefits *(Continued)*

Nutrients	Health benefits	Herb/Herbal product	References
	sperm and testosterone		
Vitamin-like compounds			
Biotin	Regulation of several metabolic functions	Almonds, peanuts, walnuts, pecans, avocado, sweet potatoes and cauliflower	[86]
L-carnitine	Helps in oxidation of fatty acids, excretion of organic acid and help in oxidative phosphorylation	Avocado and asparagus	[87]
Choline	Helps in treatment of fatty liver and disturbed fat metabolism	Wheat germ, bacon, dried soybeans, Mustard seed, tomato	[88]
Vitamin F	Helps in development of various membranes and synthesis of prostaglandins, leukotrienes, and fatty acids	Flaxseed, hemp oil, soya oil, canola oil, chia seeds, pumpkin seeds, sunflower seeds, leafy vegetables, walnuts, sesame seeds, and avocados	[89]
Inositol	Helps in transportation of amino acid, potassium, and sodium	High-bran cereals, fruit, nuts, and beans	[90]

such as cavacrol and thymol [67]. The pharmacological activities of *Thymus vulgaris* include antioxidant, anti-inflammatory, immunostimulatory, and antimicrobial properties. It is also effective against different types of cancer cells such as glioblastoma, glioma, breast, leukemia, mastocytoma, hepatocellular, osteosarcoma, cervical, laryngeal, gastric, and neuroblastoma cells. Other activities of *T. vulgaris* include antihypertensive, antiatherosclerosis, antidiabetic, hepatoprotective, antianxiety, antiepilepsy, antiasthmatic, and antiobesity [68]. *Origanum majorana* contains p-cymene, terpinen-4-ol, sabinene, α-terpineol, and trans-sabinene hydrate. However, thymol and carvacrol is found most prominently. It has reported antioxidant, antianxiety, anticonvulsant, antidiabetic, antigout, anti-mutagenic, antiulcer, antibacterial, antifungal, antiprotozoal, insecticidal, and antiovicidal activities.

Herbs containing nutrients against malnutrition

Herbal products have been used as a valuable source of natural products for medicinal purposes and maintain the healthy human life since a long ago [30]. The lifestyles of human beings are being changing due to the increasing work, industrial age, longer work schedules, improper diets, low physical activity, and various psychological pressures that led to the incidence of obesity, diabetes, various cancers, and vascular diseases. Noticeably, the advancement in nutrition sciences, the herbal products, and medicinal herbs are gaining extensive attention in the public. People started eating more fruits, vegetables, dietary supplements, culinary herbs, phytotherapeutical substances, and other plant foods. The demand for phytonutrients has enhanced over the past few decades and they are being used by people to fulfill their nutrition [29]. Table 3 shows several herbs and herbal products containing different types of nutrition.

Conclusion

Malnutrition is a state of imbalance in a person's intake of energy and/or nutrition. It is a complex interplay between nutrition and socioeconomic status of the country. It has been seen that proper consumption of vitamins and other nutritious food may protect the body from several infections, maintains immunity, and also protects the body from age-related disorders. In certain cases of nutritional deficiencies especially with vitamin B^{12} and vitamin D, it has been assumed that only non-vegetarians have sufficient amount of this vitamin in their body; however, today we came to know that several herbal sources are available for vegetarians through which they can maintain the level of vitamins in their body. Several herbs, microalgae, sea-inhabiting plants, and other photosynthetic organisms are the rich sources of vitamins and nutrients. Thus, it can be used as natural form of nutritious food.

Abbreviations

UNICEF: The United Nations International Children's Emergency Fund; TPC: Total phenolic content; BMR: Basal metabolic rate

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