



Antimicrobial Ayurveda Crops as Superfoods for Export, Conservation & Farmers' Benefit

Utkarsh Ghate¹, Hema Kulkarni

¹ BAIF Development Research Foundation

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Abstract

Antimicrobial resistance is growing worldwide and presents risks such as a pandemic. It is caused by the overuse or misdirected use of antibiotics. Regulation of antibiotic use can be accompanied by herbal drugs such as turmeric, pepper, & clover, etc., that have been found to be effective for millennia with no emergence of resistance reported, due to their polyphenols and alkaloids or combination, also emerging as “superfoods” due to their inclusion in the regular diet. Combined herbal therapy may be synergistic, preventing the evolution of resistance among the microbes. The cultivation of such superfoods can double farmers' income due to the growing demand and low input costs and save threatened wild herbs from extinction.

Utkarsh Ghate^{1,*}, and Hema Kulkarni²

¹ Ecologist, BAIF, Warje, Pune city, Maharashtra state, India, Email ughaate@gmail.com

² Faculty, Swami Atmanand Govt. Model College, Dhanora, Durg city, Chhattisgarh state, India, PIN 491001.

Email- drhemakulkarni@gmail.com

*Corresponding author.

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Introduction

Health & well-being for all is an emerging global priority, as highlighted by the COVID-19 pandemic^[1]. Noncontagious diseases (NCDs) such as obesity, diabetes, blood pressure, heart disease, & cancer have emerged as new top global health risks, accounting for 71% of global deaths^[2]. Contagious diseases took a back seat until recently but suddenly emerged as a global health risk due to the emergence of resistant bacteria, threatening the efficacy of antibiotics that have saved millions of lives over decades^[3]. Bacterial infections are again a risk worldwide due to the overuse/misuse of antibiotics, as well as no new drug development in the pharmaceutical industry. The World Health Organization (WHO) recognizes antimicrobial resistance (AMR) as one of the 10 major global public health threats, with an estimated 5 million deaths annually associated with bacterial AMR worldwide. AMR could result in up to 10 million deaths a year by 2050^[4]. Moreover, this burden falls disproportionately on low- and middle-income countries, furthering inequality.

Ayurveda, the traditional Indian medicine system, has emerged as a new global hope to manage NCDs in the West^[5]. Some Ayurvedic remedies are emerging as global “superfoods,” e.g., boiled Turmeric milk - famous as “latte” across airports and roads, hotels!

Superfoods are diet ingredients with antioxidant properties^[6]. Polyphenols, aromatic carbon compounds in many superfoods, are phytochemicals promoting health security and well-being due to their preventive, curative, as well as rejuvenating properties^[7]. Such health molecules are antioxidants and are found in common fruits and vegetables, already emerging rapidly as “super-foods,” e.g., Red Onion, Drumstick leaf, Pumpkin seeds.

Drumstick leaves and powder, from the common Indian backyard tree, are a huge global export commodity, termed “Superfood,” i.e., food with extra nutritional and health benefits^[8]. Green tea, Pumpkin seeds, and Turmeric (in milk, called “latte”) are a few other super-foods with rising global sales and recognition. Most superfoods serve as tonics to overcome fatigue, improve metabolism, and reduce the risk of and medicine intake for chronic or “lifestyle” diseases such as diabetes, diabetes, and cardiovascular disease (CVD)^[2].

Oxidative stress is a major cause behind many ailments, and it deteriorates food too. Lipid peroxidation initiates the food degradation process caused by the free radicals, and is responsible for various chronic and degenerative diseases. To counter such health impacts, antioxidants like vitamin A, B, C, E, β -carotene, etc., are sold today heavily as health supplements. There is a growing trend in consuming natural foods, especially fruits and vegetables, due to their healthy phytochemical content as it is better assimilated and has fewer adverse effects, helps immunity, and supports resilient health^[9]. A diet rich in fruit and vegetables often shows a lower risk of cancer, cardiovascular disease, stroke, Alzheimer's disease, cataracts, and aging disorders, serving often as a “preventive treatment.”

Many Ayurvedic herbs have very good anti-oxidant potential (clove, i.e., *Syzygium aromaticum* L., is amongst the top 3, and Turmeric- *Curcuma longa* L., is in the top 10^[5]. Ayurveda can rise globally faster by branding its anti-oxidant value and polyphenol content as Traditional Chinese medicine (TCM) did with the Ginkgo & Ginseng herbs ^[10]. This can multiply Indian exports and benefit the economy, besides improving farmers' income.

Superfoods can bring environmental, farmer, & social benefits as they have larger popularity & demand than typical medicinal plants, with a niche market. We show this here with the example of 4 marginal crops/ wild vegetables in Ayurveda but now emerging superfoods, viz., Kangkag (*Ipomea aquatica*), Water Chestnut (*trapa bispinosa*), Lotus (*Nelumbo nucifera*), and Spinegourd (*Momordia dioica*). These are mainly wild but are now cultivated marginally in farm bunds, riverbeds, forest margins, etc., especially in eastern India by poor farmers. These are routinely consumed in religious fasting, as tonics, & are already exported, such as from Gujarat (Spinegourd). The increasing demand and harvest of many herbs have led to the problem of wild stock depletion and even the extinction of rare species, with over 100 Indian medicinal plants in Ayurveda being at such risk, using the IUCN (International Union for Nature Conservation, ^[11]. Hence, their substitution by species that are cultivated/ weeds/ abundant in the wild can be an effective conservation measure ^[12].

Methodology

The purpose of this min review and limited farming study is to highlight the cultivation and market, livelihood development scope for the farmers in India/ elsewhere. It is not a lab study on microbial evaluation of the selected/ other herbs nor is it exhaustive comparison with many other species or other systems such as traditional Chinese medicine (TCM).

Nature Based Solutions (NBS) are promoted recently for ecological balance but the same can be useful to improve human health also, it's argued here. Agriculture/ crop diversification is an important development pathway and this article presents some new crops to avoid paddy monoculture that only the rainfed, small, poor farmers grow today as its non-remunerative and the lack the capital for irrigation/ machinery. Rural youth is thus shifting away from agriculture and we show few rays of hope for the enterprising youth farmers and policymakers for promotion of superfoods as crops. Many farmers take up medicinal plants/ herbs cultivation such as *Stevia* or *Aloe vera* and find it hard to market, incur loss and other farmers are discouraged. For, these are not regular food crops so cannot be sold in the normal market. We selected here 4 occasional food crop species with higher market scope and health benefits than the normal fruits/ vegetables and considered "medicinal" in the folklore/ Ayurveda in certain ailments. These can be sold as "food crops" also and hence market failure chance is minimized. These are already sold in the market, mostly collected from the wild. This paper shows that their cultivation can be profitable and can replace the rice crop.

The antioxidant potential and health benefits of the 4 selected herbs were compiled from the literature. Their farm economics were also compiled from the literature and from consulting farmers in Chhattisgarh & consulting agri-experts such as those from the National Institute of Rural Development (NIRD), Hyderabad, where the 1st author worked before.

Results

Table 1 displays the key phytochemical characters of the 4 species, such as total phenolic content (TPC). It also shows that the TPC value of spine gourd is higher than that of most fruits & vegetables &, Water Chestnut/ Caltrop is the top in Asia [13]. Many of them are antimicrobial so can be vital due to the growing antimicrobial resistance from the overuse of antibiotics [14].

Table 1. Phytochemicals and uses of potential superfoods

CROP	Water spinach	Spine gourd	Lotus	Water Chestnut
BOTANICAL NAME	<i>Ipomea aquatica</i> Forsk. [15][16]	<i>Momordia dioica</i> Roxb. ex Willd. [17][18]	<i>Nelumbo nucifera</i> Royle. [19][20]	<i>Trapa natans</i> L.= <i>T. Bispinosa</i> Roxb. [21][22]
COMMON NAMES	Karmatta, Nadishak, Kangkong	Khekasi, Kartoli, Spine gourd	Kamal beej/ gatta, Makhana, lotus seed	Singhara, spiny nut
TPC	8	21	8	45
At RISK SPECIES# [11]	<i>Phyllanthus niruri</i> L.	<i>Phyllanthus niruri</i> L.	<i>Saraca asoca</i> L.	<i>Tribulus terrestris</i> L.
ACTIVE INGREDIENT	Myricetin, quercetin, luteolin, apigenin, kaempferol, carotenoids	Triterpenes, alkaloids, flavonoids, glycosides, Thiamine, Riboflavin, Niacin	Nelumbosides A–D, 5 flavonoids, 4 alkaloids	Saponins, phenols, alkaloids, flavonoids

TPC- Total phenol content- mg GAE/ g FW, FW- fresh weight, GAE- Gallic Acid Equivalent #- local extinction risk by overharvest

Table 2 shows the income potential of the proposed Ayurvedic superfoods, which is about Rs. 0.75 to 1 lakh (0.1 Million= \$ 1,250- one thousand two hundred fifty)/ acre/year, and is found to be double or more than that reported for rice or other common crops in the poor central/east India bypassed by the green revolution [23]. Carlson et al [24] provided antioxidant values for most of the food items globally, and the values of 4 species mentioned here match the herbs and spices category in it (Antioxidant content in mmol/100 g), having medicinal importance, while other normal food items only possess an antioxidant value of 0-5 mmol/100 g. Proestos [6] has provided a literature review to say superfoods can preventively benefit health.

Table 2. Farming Income potential of potential superfoods (USD 1= Rs. 83- December 2023)

SPECIES	Yield Quintal/acre	Price Rs./quintal	Gross Income Rs./acre
Lotus seed	20	3,500	70,000
River spinach	22	5,000	110,000
Spine-gourd	40	2,000	80,000
Water chestnut	40	2,000	80,000

Discussion

The 4 superfoods proposed here have antimicrobial properties: Kangkong [16], Spine gourd [18], Lotus [20], Water Chestnut [22]. Many spices & herbs have antimicrobial properties and can reduce antibiotic use when standardised as a decoction/extract [25].

Table 3 presents the literature summary of the antimicrobial effects demonstrated in experiments in Asia.

Table 3. Antimicrobial properties of superfoods proposed here (from literature)

PLANT	PART, METHOD, REF.	MICROBES, cfu/g	KEY INGREDIENTS	REMARKS, REFERENCE
Kangkong (<i>Ipomoea aquatica</i>)	whole, sterile distilled water extract [26]	<i>Strong (0)- Vibrio anguillarum, Escherichia coli, Moderate (2.7-4.6)- Pseudomonas fluorescens, Salmonella typhi, Aeromonas hydrophila</i>	Saponin, Alkaloid (strong), Catechin, Tanin, Antharquinone	Fish pathogenes, Saponins (1.35 µg/mg Dry weight) Alkaloids (4.10)- (1)
	leaves, methanol extract [27]	<i>E. coli, S. typhi</i>		Standard- Ciprofloxacin (5mg/disc), MIC- 40
		Stem, leaves- methanol extract [16]	Strong- <i>E. coli, Staphylococcus aureus</i> , Medium- <i>Pseudomonas aeruginosa</i>	
Lotus (<i>Nelumbo nucifera</i>)	Leaves, ethanol extract [28]	<i>E. Coli, Klebsiella Pneumoniae and P. Aeruginosa</i>		Standard- Streptomycin 15µm/ml (MIC- 18-20), MIC- 20-20 30
	Leaf extract [29]	<i>S Staphylococcus aureus and P. Aeruginosa, Candida albicans, Aspergillus niger</i>		Standard- Cefotaxime, seed extract not useful
	Flowers, hydroethanolic extract [30]	<i>E. coli, K. pneumonia, P. aeruginosa, Bacillus Subtilis, S. aureus</i>	coclaurine, (–)-1(S)-norcoclaurine	anti-HIV activity seen- EC50 values of 0.8 and < 0.8 mg/ml, respectively
Spine Gourd (<i>Momordia dioica</i>)	Whole plant, methanol extract [31]	<i>Alternaria alternaria, A. niger, A. flavus, E. coli, K pneumoniae, P. aeruginosa, Rhizopus stonifer, S. aureus</i>	Multiple	
	Fruit pulp, hexane extract [32]@	<i>S. typhi, Shigella dysenteriae</i>	Steroids, saponin glycosides and triterpenes	
	Leaf, fruit, extracts in chloroform, ethanol, water [33]	<i>E. coli, S. aureus, K. pneumoniae P. aeruginosa</i>	alkaloids, Saponins, cardiac glycolides	MIC- 6.5 to 10.33 mm
Water Chestnut	Fruit pulp, methanolic extract [34]	<i>Citrobactor freundii, K. aerogenes, E. coli, P. vulgaris, P. aeruginosa, S. typhimurium</i>		agar disc diffusion method used, 1,4-dioxan extract strongest
	Aerial? chloroform extract [35]	<i>Bacillus subtilis, Shigella dysenteriae</i>		MIC- moderate- (08 to 12mm), standard@#

Cfu/g- colony forming unit per gram, MIC- minimum inhibitory concentration (mg/ml)

alkaloids, flavonoids, phenols, steroids, saponins, tannins @& also ethyl acetate soluble portion of methanolic extract, separately found effective, @# Piperacillin, Gentamicin, Amphotericin

Traditional Chinese medicine (TCM) leads globally in exports, and many raw drugs such as Ginkgo or Ginseng are from farming, not the wild [36]. But the reverse is the case for Ayurveda/Indian System of Medicines (ISM) [37]. This is threatening many wild species with extinction due to overharvesting and limited production, and hence there is a need to shift to farming for long-term sustainability [38]. The identification and branding as “superfoods” & “natural” can help in this [39] & benefit the farmers too. The People’s Biodiversity Register (PBR) is a documentation tool at the village council level advocated by Indian biodiversity law that can help to scout the superfoods nationwide [40]. Since the Lotus is used for the treatment of Alzheimer’s disease traditionally [41], the possibility of new drug development cannot be ruled out, as the bioactive “Artemisinin,” used to treat Malaria, sprang a surprise a decade ago [42]. Ayurveda has many such time-tested, traditional surprises that await re-discovery & redevelopment to reduce AMR [43][44][45] & novel uses such as fruit juice preservatives to replace preservatives that are considered carcinogenic/immunity compromising [46]. Even Ayurvedic surgery for Benign Prostate Hyperplasia (BPH) is successfully performed without antibiotics on a 83 year old patient at Meerut, India [47].

Asparagus is a common “superfood” crop in Mexico exported to USA helping the Mexican farmers and economy since long, for instance [48].

Conclusions

We demonstrate that some marginalized forest herbs/ crops in the villages can be “superfoods” in future in the urban/ export markets due to their nutrition/ health benefits. Promoting such crops can lead to agri-diversification and farmer’s livelihood development and boost economy. Further research is needed the safety, toxicity and working mechanism of these herbs and the bioactive ingredients for development as nutraceuticals or health/ food supplements like “curcumin”- a premium product in the global market today from the Turmeric spice.

Statements and Declarations

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Authors' contributions

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