ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

https://ajbps.org/

American Journal of Biopharmacy and Pharmaceutical Sciences

Ethnomedicine *Review Article*

Exploration of the Potential of Terrestrial and Marine Biodiversity for the Development of Local Nutraceutical Products: A Case for Mauritius

Hafsah Ramjane[1], Theeshan Bahorun[1,2], Brinda Ramasawmy[3], Deena Ramful-Baboolall[4], Navindra Boodia[3], Okezie I. Aruoma[5], Vidushi S. Neergheen[1]

[1]Biopharmaceutical Unit, Centre for Biomedical and Biomaterials Research, University of Mauritius, Réduit, Mauritius, [2]Department of Biosciences and Ocean Studies, University of Mauritius, Réduit, Mauritius, [3]Department of Agricultural Production and Systems, Faculty of Agriculture, University of Mauritius, Réduit, Mauritius, [4]Department of Food Science and Technology, Faculty of Agriculture, University of Mauritius, Réduit, Mauritius, [5]Department of Chemistry and Biochemistry, California State University Los Angeles, Los Angeles, United States of America.

***Corresponding author:**
Vidushi Neergheen, Biopharmaceutical Unit, Centre for Biomedical and Biomaterials Research, University of Mauritius, Reduit Mauritius, Plaines Wilhems, Mauritius.

vidushin@gmail.com

Received : 08 June 2021
Accepted : 09 July 2021
Published : 08 November 2021

DOI
10.25259/AJBPS_3_2021

Quick Response Code:

ABSTRACT

Nutraceuticals and natural health products globally represent one of the fastest growing sectors of research and development leading to novel products intended for disease risk reduction and human health promotion. The global nutraceutical market is expected to grow at a compound annual growth rate of 8.3% from 2020 to 2027 to reach USD 722.5 billion by 2027. There is a need to respond to this sector by exploring the local resources to target the production of innovative products from plant/marine biofactors with high prospects for commercial ventures. This paper explores the nutraceutical potentials enshrined in biodiversity values in a small island state in view to promote sustainable agricultural development to facilitate available resources for the development of regimen for the management of health and disease and in essence, pharmacotherapy. The reported phytochemical composition and pharmacological activities, of the terrestrial flora and marine organisms with high propensity for development and production of nutraceutical products will be discussed. Bioactive phytochemicals encompassing the immensely diverse groups of phenolic acids, flavonoids, terpenoids, alkaloids, possess therapeutic virtues including anti-diabetic, antihypertensive, anticancer, anti-inflammatory, and immunomodulatory attributes, all of which are highly relevant to the budding nutraceutical industry.

Keywords: Nutraceuticals and functional foods, Natural products biodiversity, Marine biodiversity and agriculture, Dietary supplements, Moringa, Papaya, Noni, Pomegranate, Turmeric rhizome, Pineapple, *Spirulina, Chlorella*, Tea, Ginger, Lemongrass

DEDICATION

"Sir Anerood Jugnauth (GCSK, KCMG, QC), fondly known as SAJ, was a towering figure of Mauritian politics for six decades. He left us on 3rd June 2021. Under his stewardship as both prime minister and president, Mauritius witnessed an unprecedented growth, massive generation of

employment and the diversification of our economic pillars. He was a person of great erudition and intellect, always on the lookout for greater opportunities. SAJ will always be remembered as the father of the Mauritian economic miracle. Indeed, SAJ has left behind him a rich, legacy for the future generations of Mauritians. We have the immense pleasure to dedicate this review article to Sir Anerood Jugnauth, a true crusader for propelling research and innovation in Mauritius through his unflinching support and his long-term vision of transforming Mauritius into a knowledge hub."

INTRODUCTION

The terrestrial and marine ecosystem has phenomenal biodiversity for the development of local nutraceutical products. Mauritius, an isolated oceanic island of volcanic origin, found in the southwest Indian Ocean and part of the Mascarene archipelago consisting of **La** Réunion and Rodrigues islands, harbors a treasure trove of terrestrial and marine biodiversity, which represents a valuable source of unique and structurally diverse bioactive compounds. The south harbors a number of biodiversity hotspots like The Cape Floristic Region, which falls mainly within the Western Cape, South Africa and the Republic of Madagascar.[1,2] There are 691 native flowering plant species in Mauritius, out of which 39.5% are endemic to Mauritius, and 61.2% are endemic to the Mascarene Archipelago.[3] The rich molecular diversity prevailing in Mauritius remains, however, an underexplored resource in terms of its application to health and wellness mainly because its identity and pharmacological properties are poorly disseminated. The richness in terms of primary and secondary bioactive metabolites and associated pharmacological effects has been extensively studied and can propel research for nutraceutical development.[4-17]

Nutraceuticals have become an integral part of the global wellness industry. A nutraceutical may be defined as any substance that is a food, including a fortified food or dietary supplement or a part of a food that is able to induce medical and health benefits and promote wellness, in addition to its basic nutritional properties.[18,19] Escalating global consumer awareness, rising health concerns, heightened interest in natural preventive mechanisms, and growing acceptance of these products have gradually been broadening the size of their market within a global footprint.[20-23] Nutraceuticals are multifunctional and can be utilized to improve or boost our health status, confer protection against chronic diseases, retard the aging process, prolong life expectancy, and among many others.[21,23,24] The rapid infection rate of the severe acute respiratory syndrome coronavirus 2 and elevated morbidity rate stemming from the COVID-19 pandemic has renewed interest in natural botanical supplements to boost immunity and reduce inflammation.[25]

There exists a long-standing history pertaining to the use of natural resources in traditional medicine in Mauritius and in Africa, which advocates for the development of a unique repertoire of health products, including nutraceuticals and functional foods.[26-30] Regarding the nutraceutical sector in Mauritius, it is presently at its nascent stage even though the flora and marine organisms produce a vast array of primary and secondary metabolites. Primary metabolites, including carbohydrates, amino acids, fatty acids, oil, and multiple minerals and vitamins, have well-defined functions in metabolic pathways in the human body, while phytochemicals, the secondary metabolites, encompass phenolic acids, flavonoids, carotenoids, terpenoids, saponins, phytosterols, tannins, and alkaloids that are well-appraised for their multifunctional health properties.[22,23,31,32]

With the steep surge in urbanization and the change in lifestyle worldwide, several lifestyle-related diseases closely linked to stress and malnutrition have emerged, leading to non-communicable diseases (NCDs) such as diabetes, hypertension, cardiovascular diseases, cancer, and obesity.[169] Consumers are now shying away from the use of pharmaceuticals due to the exorbitant pricing and increasing dependence on synthetic drugs, and are instead resorting to alternative natural products, notably nutraceuticals.[22,31] Nutraceuticals such as functional foods, functional beverages and fortified food products have therefore witnessed an unprecedented growth for those consumers seeking preventive health measures to address NCDs and nutritional deficiencies. Consumers are increasingly health-conscious, especially in the post-COVID times, where boosting of immunity and health status is of utmost priority. In view of the emerging nutraceutical sector, it is important to earmark the local natural resources available for nutraceutical product development. The outcome will have relevance to Africa, the Caribbean, and the Asian and Pacific Island Countries.

METHODOLOGY

Literature searches were performed on Google Scholar, ScienceDirect, PubMed, Scopus, ResearchGate, and Web of Science databases to identify all published works related to terrestrial flora and marine organisms that exude potential to be developed into nutraceutical products locally. The search terms used were as follows: Nutraceuticals, functional foods, functional beverages, medicinal plants, ethnomedicinal uses, traditional uses, plant, biodiversity, phytochemical composition, secondary metabolites, biological activities, pharmacological activities, therapeutic activities, health benefits/effects, biochemical, molecular, cellular, pre-clinical and clinical studies, clinical trials, marine extracts, marine nutraceuticals, marine sponges, marine organisms, microalgae, macroalgae, seaweeds, and specific scientific or vernacular names of organisms. All articles in English and French were extracted from 2002 up to April 2020 and assessed critically for data extraction. Local pharmacopeias

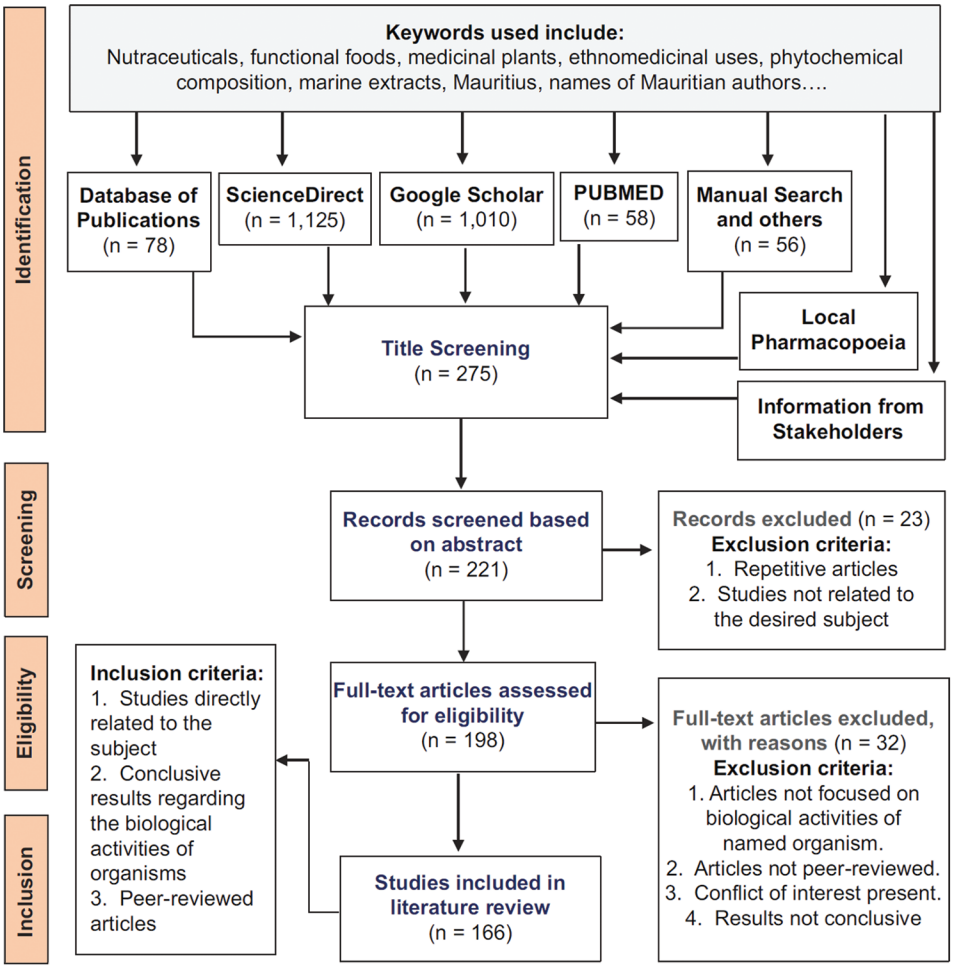

Figure 1: Schematic representation of the methodology used to compile a list of the most apt terrestrial plants and marine organisms to be cultivated for production of nutraceuticals.

were hand searched. The International Plant Names Index (www.ipni.org) (IPNI) and The Plant List (www.plantlist.org) were used for acquiring the authenticity of the botanical names of the plants.

The first search from all the scientific databases generated 2,327 scientific articles. Following this first generalized investigation, the searched articles were subjected to a title screening and then an abstract screening which entailed the elimination of a total of 77 irrelevant articles. Post screening based on abstract reading; the full-text articles were assessed for eligibility [Figure 1]. Eight criteria were used for the curation of the data as follows [Table 1]: (1) Phytochemical composition – The phytochemical constituent of a plant/organism or part of a plant/organism is a crucial factor to take into consideration while evaluating its potential for nutraceutical development; (2) ethnomedicinal uses – The number of reported ethnomedicinal uses of a potential plant/organism remains an essential factor to take into account during plant selection as this provides evidence to its history of usage in Mauritius and other countries; (3) Toxicity – Indeed, evaluating the safety and toxicity profile of a candidate remains the most important criterion for the purpose of plant selection; (4) biological activities – The more consequent the biological activities, the more attractive is the plant/organism or part of the plant/organism as a prospective nutraceutical as it is deemed to have a panoply of physiological benefits for human health; and (4) potential for cultivation in Mauritius – Presently, Mauritius enjoys a mild tropical maritime climate throughout the year. Only plants or organisms which can grow in tropical and subtropical climates can be further evaluated for potency. Expanding this to the African continent can reveal other strategic opportunities; (5) Marketed as nutraceuticals – There are several whole plants, part of plants, marine extracts, plant extracts, powder, and formulations, which are sold as nutraceuticals on the local and international market. Since nutraceuticals sold on international markets must abide by stringent regulations in terms of safety before

Table 1: Score attribution system.

SN	Definition of criteria	Scoring system
1	Phytochemical composition Reported number of major class of phytochemicals	0: No reported phytochemical 1: 1 major class of phytochemical 2: 2 major classes of phytochemicals 3: 3 major classes of phytochemicals 4: 4 major classes of phytochemicals 5: More than 4 major classes of phytochemicals
2	Ethnomedicinal uses Type and number of traditional uses reported	0: None 1: Between 1 to 3 ethnomedicinal uses reported 2: Between 4 to 7 ethnomedicinal uses reported 3: Between 8 to 11 ethnomedicinal uses reported 4: Between 12 to 14 ethnomedicinal uses reported 5: More than 15 ethnomedicinal uses reported
3	Toxicity Reported toxicity of the part of species/ subspecies/ products used	0: Yes 5: No
4	Biological Activities Number of biological activities reported	0: None 1: Between 1 to 3 biological activities reported 2: Between 4 to 7 biological activities reported 3: Between 8 to 11 biological activities reported 4: Between 12 to 14 biological activities reported 5: More than 15 biological activities reported
5	Potential for cultivation in Mauritius	0: Can grow in temperate conditions 3: Can grow in sub-tropical condition 5: Can grow in tropical conditions
6	Marketed as nutraceuticals Either internationally or locally	0: Not marketed as nutraceutical 5: Marketed as nutraceutical
7	Food Application Part of organism used or consumed in food product	0: No 5: Yes
8	Potential use against chronic diseases affecting the Mauritian population Reported use against cancer, diabetes and cardiovascular diseases	0: No use reported against any of the chronic diseases 1: Use reported against one of the chronic diseases 3: Use reported against more than one chronic disease 5: Use reported against major three chronic diseases

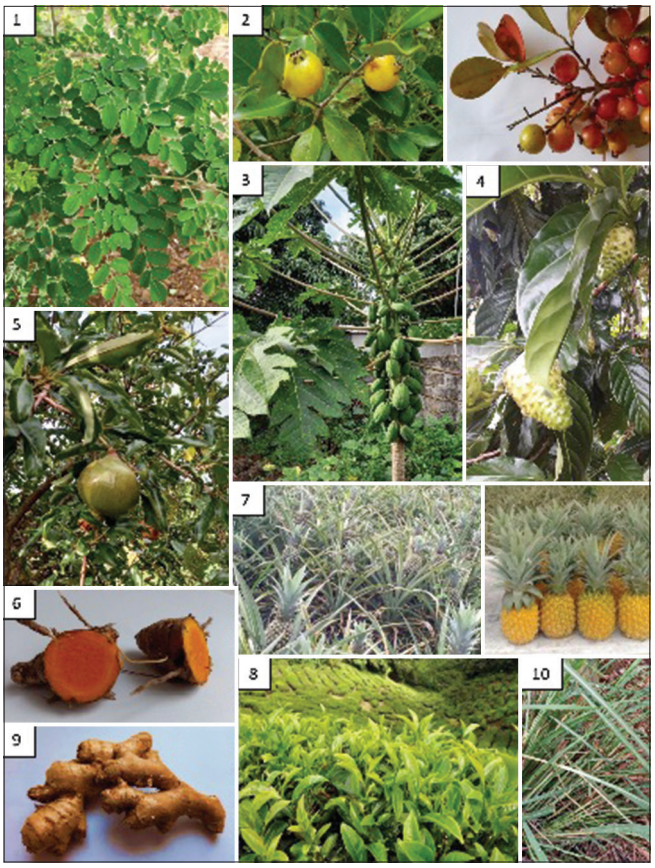

Figure 2: (1) Moringa; (2) Yellow and Red varieties of strawberry guava; (3) Papaya; (4) Noni; (5) Pomegranate; (6) Turmeric rhizome; (7) Pineapple; (8) Tea; (9) Ginger; (10) Lemongrass.

being marketed, this criterion serves to complement the toxicity factor and supplement evidence for safe human consumption; (6) Food application – This criterion also serves to supplement evidence to support the safe use of prospective nutraceuticals for Mauritius; (7) Potential use against chronic diseases affecting the Mauritian population – Cancer, diabetes, cardiovascular diseases, and other NCDs are prevalent within the Mauritian population.

RESULTS AND DISCUSSION

Terrestrial plants, marine flora and fauna: Potential candidates for the development of nutraceuticals

A repertoire of 126 organisms to include 107 terrestrial plants; six and 13 marine flora and fauna that represents potential candidates for the development of nutraceuticals in Mauritius, has been successfully proposed in this process. Post application of the score attribution system to all 126 species, a prioritized list of 45 plants emerged, as depicted in Table 2.

All 45 plants are worth considering for local nutraceutical production. However, the ensuing discussion will focus on the following: (A) Ten terrestrial plants [Figure 2], in

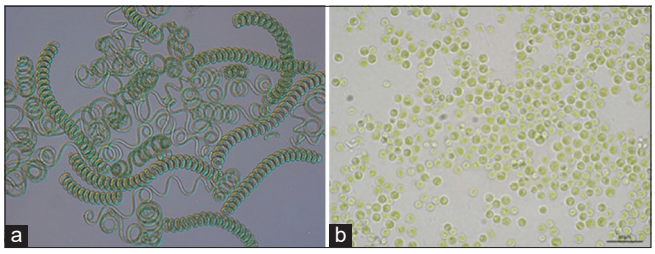

Figure 3: (a) Light microscopy of Arthrospira filaments from natural environment (magnification ×200). (Source: Furmaniak *et al.*,[267]). (b) Light microscopy of Chlorella vulgaris KNUA027 at ×1000 magnification on a Nikon Eclipse E100 Biological Microscope (Japan) (Source. Hong *et al.*,[268]).

particular, moringa, strawberry guava, papaya, pineapple, tea, noni, pomegranate, garlic, lemongrass and turmeric due to the gamut of commercial products that can be derived from them, the numerous pharmacological effects and potential for commercial cultivation in Mauritius and (B) two marine species, namely, *Spirulina* and *Chlorella* on the account of the intensifying consumer interest, growing markets, and countless health-promoting properties [Figure 3a and b].

Moringa: The miracle tree

Moringa oleifera Lam, native to north western India, is a sole genus of Moringaceae family with 13 species widely distributed in the tropical and subtropical regions around the world.[170,171] Commonly known as Moringa, drumstick tree, ben oil tree, miracle tree and "brède Mouroum" in the local vernacular, it is a hardy plant that can withstand both severe drought and mild frost conditions.[172] Almost all parts of the plant are used including leaves, pods, bark, roots, and flowers. In Mauritius, Moringa is traditionally used as an anti-diabetic agent, to alleviate pain in joints and muscles, to treat anemia, and to increase lactation in nursing mothers.[30] In Africa, Moringa is consumed by individuals affected by diabetes, hypertension, or HIV/AIDS.[170] Other traditional uses reported in the literature include in the treatment of diarrhea, dysentery, colitis, sores, skin infections, anemia, cuts, scrapes, rashes, sign of aging, asthma, dental decay, malaria, anxiety, bronchitis, catarrh, chest congestion, cholera, glandular, swelling, fever, headaches, conjunctivitis, cough, pain in joints, pimples, psoriasis, respiratory disorders, and diabetes among others.[170,172] The anti-diabetic, anticancer, antimicrobial, antihypertensive, hypocholesterolemic, antioxidant, anti-atherosclerotic, anti-inflammatory, neuroprotective, and anti-arthritic activities of Moringa are supported by *in vitro* studies.[172] *In vivo* studies involving rat models have validated the use of Moringa as an anti-diabetic agent, a potent neuroprotectant, an anti-ulcer, and an anti-arthritic agent.[173-178] There are numerous commercial applications of Moringa, notably, infusions, powder and capsules from leaves, Ben oil, and infusions with hypocholesterolemic properties from flowers and fortifying moringa in snacks such as cookies, cream, and butter crackers.[172] Locally, Moringa leaves infusions and Moringa powder and capsules are already marketed. Therefore, this represents a great opportunity to further explore local Moringa plants to expand the range of locally manufactured Moringa nutraceuticals.

Strawberry guava: A potent novelty

Strawberry guava (*Psidium cattleianum* Sabine) is an exotic tropical plant native to the temperate zones of Brazil.[131] *P. cattleianum* Sabine belongs to the Myrtaceae family and is commonly known as strawberry guava, Chinese guava, cattley guava, or cherry guava, and locally called "goyaves de chine."[30,127,131] This shrub is highly adaptable and can withstand conditions involving temperature and water extremes.[130,179] Both the leaves and fruits of the plant are used in the traditional medicine system.[128] In Mauritius, a decoction of the immature fruits is used in the treatment of diarrhea and dysentery while the fruits are consumed as a source of Vitamin C to treat scurvy.[30] Around the world, the *Psidium* species is used in folk medicine for antiseptic purposes, for digestive purposes, for antihemorrhagic action, to control blood pressure, as diuretic, and in decoctions for the treatment of diarrhea.[128] *In vitro* studies have provided evidence to the antioxidant, anti-diabetic, anticancer, antimicrobial, and anti-inflammatory properties of strawberry guava.[126-131,180] Moreover, *in vivo* experiments using rat models have substantiated the antioxidant, anti-diabetic, antifungal, and anti-aging activities of *P. cattleianum* Sabine.[131,181,182] Although strawberry guava fruit is widely consumed fresh or used to flavor beverages, ice creams and desserts or in fillings, jams, jellies, sauces, there are currently almost no nutraceutical products derived from the *Psidium* species on the global market.[179,180] The only product that can be found on international websites are fresh strawberry guava leaves for infusion (https://www.movagarden.com/fresh-cattleyguava-leaves). *P. cattleianum* Sabine offers great scope for transformation into innovative health products owing to its assortment of beneficial activities but the invasive nature of the plant remains a sizeable barrier to overcome.[180]

Carica papaya Linn.: A highly promising nutraceutical crop

C. papaya Linn, belonging to the family Caricaceae, is a tropical tree, native to Central America and now widely cultivated in tropical and sub-tropical regions around the world for its fruits and latex.[183-185] Commonly known as papaya or pawpaw, *C. papaya* L. was introduced in Mauritius in the 18th century and now grows in a number of geographic locations in Mauritius, being a resilient crop that adapts well, even on difficult terrain conditions, to the Mauritian agro-climate.[186] Both the green

Table 2: Prioritized list of plants following score attribution system.

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
1. Amaranthaceae							
Amaranthus caudatus L.	Seed/grain amaranth	Betacyanins, Caffeoylglucaric acid 1, Caffeoylglucaric acid 2, Caffeoylglucaric acid 3, Caffeoylglucaric acid 4, Caffeoylglucaric acid 5, Coumaroylglucaric acid 1, Coumaroylglucaric acid 2, Feruloylglucaric acid, Caffeoylquinic acid, Caffeic acid, Coumaroylquinic acid, Feruloylquinic acid, Rutin, Hydroxycinnamic acid derivative, Quercetin glucoside, Kaempferol-3-O-rutinoside, tocopherols, alkaloids, carotenoids, lectin, steroids	Antioxidant, antitumor, antidiabetic, anti-cholesterolemic, antineoplastic activities and stimulates the immune system	The plant is astringent, anthelmintic and diuretic. It is used in the treatment of stranguary and is applied externally to scrofulous sores	Oral and Topical	Seeds, leaves and stem	[33-37]
Amaranthus viridis L.	Locally known as "Bred Malabar"	Tannins, resins, amino acids, reducing sugars, rutin, quercetin, spinosterol (24-ethyl-22 dehydrolathosterol), 24-methyllathosterol 24-ethyllathosterol, 24- methyl-22-dehydrolathosterol, 24-ethyl cholesterol, 24 ethyl- 22-dehydrocholesterol, steroidal component, amasterol (24- methylene-20-hydroxycholesta-5,7-dien-3β ol)	Antioxidant, anti-inflammatory, anti-hyperlipidemia, antidiabetic, antinociceptive, hepatoprotective, antipyretic, analgesic, antimicrobial, cardioprotective activities	Used as analgesic, antiulcer, antirheumatic, antileprotic, and antiemetic agent. It is also believed to treat eye diseases, psoriasis, eczema, asthma, and respiratory problems. In Mauritius, the leaves are used in the treatment of fever and anaemia	Oral	Leaves, stem	[30,34,38-42]
2. Amaryllidaceae							
Allium cepa L.	Onion	Carbohydrates with glucose, fructose, sucrose and a series of fructooligosaccharides as principal components, hydroxycinnamic acids (p-coumaric, caffeic, ferulic, and sinapic acids), hydroxybenzoic acid conjugates (such as protocatechuic acid, gallic acid, and p-hydroxybenzoic acid, flavonoids (particularly flavanols, flavones, such as luteolin and kaempferol and anthocyanin), diglycosides and monoglycosides of quercetin, proanthocyanidin, alkaloids, S-alk(en)yl cysteine sulfoxides, saponins, ascorbic acid	Antioxidant, antimicrobial, anticancer, cardioprotective effects, anti-allergic, hypoglycemic and antihypertensive activities	Skin infection, wound, anti-hair loss agent, Type 1 diabetes, Type 2 diabetes, high level of cholesterol, renal failure, hearing loss, erectile dysfunction, cataract, cough and tonsilitis, mucous discharge, nose infection	Oral and Topical	Bulb	[43-46]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
Allium sativum L.	Garlic	Sulfur-containing compounds such as ajoenes (E-ajoene, Z-ajoene), thiosulfinates (allicin), vinyldithiins (2-vinyl-(4H) -1,3-dithiin, 3-vinyl-(4H)-1,2-dithiin), sulfides (diallyl disulfide, diallyl trisulfide), allistatin I and allistatin II, saponins, bioflavonoids such as quercetin and cyanidin, glycoside, anthraquinones, tannins, alkaloids, terpenoids, polysaccharides (sucrose and glucose), amino acids such as cysteine, glutamine, isoleucine, and methionine	Antihyperlipidemic, cardioprotective, antioxidant, antimicrobial, antidiabetic, anticancer, anti-inflammatory, antibacterial, antifungal, hepatoprotective, digestive system protective, neuroprotective and renal protective activities	Flatulence, sciatica, cardiovascular disorders, convulsions, Type 2 diabetes, cataract, renal failure, wound, ulcer, arthritis, rheumatism, cuts, toxic fish stings and insect bites, asthma, bronchitis, pneumonia and respiratory disorders, cold, hypertension, earache, gastrointestinal disorders	Oral and Topical	Pod	[30,47-51]
3. Anacardiaceae							
Mangifera indica L.	Mango	Hydroxybenzoic acid derivatives (gallic, vanillic, syringic, protocatechuic, and p-hydroxybenzoic acids) and hydroxycinnamic acid derivatives (p-coumaric, chlorogenic, ferulic, and caffeic acids), gallotannins and quercetin derivatives, flavonoids (catechins, glycosides of quercetin, kaempferol, rhamnetin, anthocyanins, and tannic acid), xanthones (mangiferin), tocopherols, carotenoids (particularly β-carotene and lutein), terpenoids (such as monoterpenes, sesquiterpenes), rosmarinic acid	Antioxidant, antibacterial, antiviral, anti-inflammatory, anti-atherosclerotic, antiallergenic, analgesic, antiproliferative activities	Throat pain, dysentery, bronchitis, diarrhea, dysentery, fever, burns, bleeding gums, type 2 diabetes	Oral and Topical	Leaf, bark, flower, fruit	[30,48,52-54]
4. Apiaceae							
Coriandrum sativum L.	Coriander	Polyphenols (including gallic acid, caffeic acid) and flavonoids including catechin, rutin, tannins, diosmin and carotenoids including beta-carotene, sterols, coriandrones, limonene, terpenoids, coumarins, isocoumarins, catechins, alkaloids, fatty acids, sterols, glycosides, reducing sugars	Antioxidant, antidiabetic, hepatoprotective, antibacterial, antimicrobial, antifungal, antiproliferative activities	Bladder disease, flatulence, dyspepsia, intestinal spasms, dyspepsia and intestinal spasm. Whole plant + Magosteen + Cumin: Diarrhea and dysentery	Oral	Seeds, roots and whole plant	[30,55-57]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
Daucus carota L.	Carrot	Phenolic acids, such as p-hydroxybenzoic, caffeic, and hydroxycinnamic acid (mainly chlorogenic acid), flavonoids (anthocyanins), isocoumarins, carotenoids (majorly β-carotene, α-carotene, lutein, β-cryptoxanthin, lycopene, and zeaxanthin), polyacetylenes (falcarinol, falcarindiol, and falcarindiol-3-acetate, (E)-isofalcarinolone, falcarindiol-8-acetate, 1,2-dihydrofalcarindiol-3-acetate, (E)-falcarindiolone-8-acetate, (E)-falcarindiolone-9-acetate, 1,2-dihydrofalcarindiol, (E)-1-methoxy-falcarindiolone-8-acetate, (E)-1-methoxy-falcarindiolone-9-acetate, and panaxydiol), ascorbic acid	Antioxidant, anticancer, immunomodulator, cardioprotective effects, pro-vitamin A, plasma lipid modification activities	Jaundice, pharyngitis, mouth sores, poor eyesight, tonify complexion and give shine to hair, soften skin, diuretic, diuretic, gangrene ulcers and against liver problems. Poultices are used to apply on the breast of feeding mothers to form well on their nipples	Oral and Topical	Roots	[30,58,59]
5. Arecaceae							
Cocos nucifera L.	Coconut	Phenols (catechins, epicatechins), tannins, leucoanthocyanidins, flavonoids, triterpenes, steroids, alkaloids, triterpenes, saponins, tannins	Antihypertensive, analgesia, vasodilation, nephroprotective, cardioprotective, and hepatoprotective, protection against ulcers, anti-inflammatory, antioxidant, anti-osteoporosis, anti-diabetic, antineop lastic, bactericidal, antihelminthic, antimalarial, leishmanicidal, antifungal, and antiviral activities	Chronic hepatitis, diarrhea, worm, gonorrhea, indigestion, stomach-ache, digestive upset from drinking alcohol, diuretic, venereal disease, anthelmintic; as mouthwash for toothache, urinary tract infection, hair oil, cataract, Type 2 diabetes, renal failure, nephritis and bladder infections	Oral	Shell fibre, roots, pulp of coconut, coconut water	[30,60,61]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
6. Brassicaceae							
Brassica oleracea L.	Broccoli	Tannins, phenols, steroids, terpenoids, flavonoids, glucosinolates, carotenoids (beta-carotene, lutein), alkaloids, anthocyanidin	Antioxidant, anticancer, antimicrobial, anti-inflammatory, and antidiabetic activities	Leaves are used against cardiovascular disease, Type 2 diabetes, wounds and cataract	Oral and Topical	Flower and leaves	[30,43,62,63]
Raphanus sativus var. niger (L.) J. Kern	Black Radish	Glucosinolates (glucoraphasatin, glucoraphanin), flavonoids, polyphenols, isothiocyanates (4-(methylthio)-3-butenyl isothiocyanate), polysaccharides	Antioxidant, antilithiatic and hypolipidemic and hepatoprotective activities	Used as a stimulant of bile function, against flatulence, indigestion and the formation of gallstones	Oral	Root	[64-66]
7. Bromeliaceae							
Ananas comosus (L.) Merr	Pineapple	Bromelains, phenolic compounds, flavonoids, carotenoids (gallic acid, ferulic acid, chlorogenic acid, catechin, and epicatechin)	Anti-inflammatory activity, anti-rheumatic, antioxidant, antibacterial, antidiabetic, anticancer activities	The unripe fruit is used for cystitis and is abortive. The ripe fruit is diuretic. The green fruit is abortifacient, anthelmintic and purgative. The juice from the half ripe fruit is employed against bladder problems. A syrup from the fruit is employed against whooping cough in children	Oral	Fruits (both ripe and unripe), leaves and peels	[30,48,67,68]
8. Cactaceae							
Hylocereus undatus (Haw.) Britton & Rose	Dragon fruit, pitaya	Polyphenols, carotenoids including b-carotene, lycopene and tocopherols, triterpenoid, glycosides, alkaloid, flavonoid and saponin, betalain indole pigments	Wound healing, antihyperlipidemic, antidiabetic, antimicrobial, anticancer, antioxidant activities, vascular protection, skin protection (skin antiaging, firming, and humectant properties), antioxidant and antibacterial activities	Treatment of injuries, cough, hyperactivity, tuberculosis, bronchitis, mumps, diabetes, and cervical lymph node tuberculosis	Oral	Fruit, pulp, seeds, peel, flower, leaves	[69-72]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
9. Caesalpinioideae							
Cassia fistula Linn	Golden shower	Anthracene derivatives, sennosides, fistulic acid, tannins derivatives with proanthocyanidin, sterols, beta-sitosterol, flavone glycosides, anthraquinone derivatives	Antipyretic, analgesic, anti-inflammatory, antidiabetic, antibacterial activities; antiperiodic agent. It is also used in the treatment of rheumatism and possesses wound healing properties	Mild laxative suitable for children and pregnant women, purgative and to treat many other intestinal disorders such as healing ulcers	Oral	Leaves, flowers, fruits	[4,48,73,74]
10. Caricaceae							
Carica papaya L	Papaya	Phenolic compounds (5-hydroxy feruloyl quinic acid, acetyl pcoumaryl quinic acid, quercetin-3-O-rhamnoside, syringic acid hexoside, 5-hydroxy caffeic quinic acid, peonidin-3-Oglucoside, sinapic acid-O-hexoside, cyaniding-3-O-glucose and methyl feruloyl glycoside), terpenoids, saponins, steroids, tannins, alkaloids (carposide, xilitol, Carpinine, carpaine, pseudocarpine, choline, carposide), flavonoids (quercetin, myricetin, kaempferol), β-sitosterol, carotenoids (β-carotene, crytoxanthin, violaxanthin, zeaxanthin), monoterpenoids (4-terpineol, linalool, linalool oxide), carbohydrates (Glucose, sucrose, fructose), glucosinolates (benzyl isothiocyanate, benzylthiourea, caricin)	Antioxidant, antidiabetic, antibacterial, antifungal, anthelmintic, wound healing, antisickling, abortifacient, antifertility, antitumor, hypoglycemic and hypolipidemic activities, edema-reducing activities	Diphtheria, eczema, hepatitis. The ripe fruit is used for stomach/peptic ulcer and constipation, anti-pimple, anti-pigmentation, skin moisturizer, hypertension, high cholesterol level. The seeds are used as vermifuge against intestinal worms. The roots are used for pain in joints and muscles and arthritis, while the latex is used as vermifuge	Oral and Topical	Different parts including its leaves, bark, roots, latex, flowers and seeds.	[30,48,75-77]
11. Chlorellaceae							
Chlorella vulgaris	Microalgae	Phenols, flavonoids, alkaloids, terpenoids, glycosides, tannins, triterpenes	Antioxidant, antimicrobial, hepatoprotective, anticancer, antidiabetic, immunomodulatory activities	Not Known	Not Known	Not Known	[78-81]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
12. Convolvulaceae							
Ipomoea pes-caprae (L.) R. Br.	Common beach pantropical creeping vine (Lianes batatrans), railroad vine, beach morning glory	Alkaloid, sugar, glycoside, saponins, steroids, terpenoids and flavonoids	Antihemorrhoidal, anticancer, antioxidant, analgesic, anti-inflammatory, antispasmodic, antinociceptive, antihistaminic, immunostimulant, insulinogenic, hypoglycemic, antimicrobial, antifungal and antibacterial activities	The leaf juice of *I. pes-caprae* is used as a first aid for treatment of jellyfish stings. The plant is astringent, acrid, refrigerant, mucilaginous, somatic, laxative, diuretic and tonic and used in the treatment of skin diseases, boils, swelling, wounds, ulcer, carbuncle, dropsy, menorrhagia, hemorrhoids, colic, flatulence, dyspepsia, cramp, and burning sensation	Oral and Topical	Leaves and stem	[30,82]
13. Cucurbitaceae							
Citrullus lanatus (Thunb.) Matsum. & Nakai	Water-melon	Phenols, saponins, glycoside, tannins, terpenoids, glycosides, steroids, alkaloids, flavonoids, coumarins, quinones, carotenoids (such as lycopene, beta-cryptoxanthin, beta-carotene),	Antibacterial, antifungal, antimicrobial and anti-inflammatory, antiulcer, antioxidant, gastroprotective, analgesic, laxative, antigiardial, hepatoprotective activities. It also demonstrates activities against prostetic hyperplasia and atherosclerosis.	The seeds are used against intestinal parasites including taenia and as a toxic fish poisoning antidote.	Oral	Seeds	[30,48,83,84]
Cucurbita maxima Duchesne	Pumpkin	Alkaloids, flavonoids, phenolic acids, tannins, saponins, reducing sugars, glycosides, triterpenoids, sesquiterpenoids, squalene, tocopherols (αtocopherol is predominant), carotenoids (β-carotene), sterols	Pumpkin seed oil exhibits antihypertensive, antidiabetic and anticancer activities. It also shows antibacterial, antioxidant, and anti-inflammatory properties. The fruit possesses antioxidant and anticancer activities, blood-coagulatory effects and inhibits kidney stone formation	The seeds are used in the treatment of intestinal worms and parasites, constipation, vomiting blood, renal failure and prostatitis. The leaves are used in the treatment of anaemia while the fruits are used in the treatment of urinal disorders, wounds, blood pressure, constipation. Its flowers are used in the treatment of cataract	Topical and Oral	Pulp and Seeds. Different organs (pulp, seeds, flowers, leaves, shoots, roots) are consumed around the world	[85-89]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
14. Lamiaceae							
Ocimum basilicum L.	Sweet Basil	Phenolics, coumarins, glycosides, steroids, sterols, flavones, flavonoids, terpenoids, alkaloids, tannins, saponins, glycosides, ascorbic acid. The main constituents of the O. basilicum essential oil are: estragol, eucalyptol, ocimene, linalool acetate, eugenol, epibicyclosesquiphellandrene, menthol, menthone, cyclohexanol, cyclohexanone, myrcenol and nerol	Antimicrobial, antifungal, anticancer, anticonvulsant, antiviral, antiulcer, anti-inflammatory, cardiac stimulant, hypnotic, and antioxidant activities	Gonorrhoea, nephritis, otitis, treatment of ulcers, stomach ache, indigestion, headache, infected ear, bronchitis, coughs, diarrhea, constipation, warts, worms, kidney malfunction, treatment of acne, loss of smell, insect stings, snake bites and skin infections	Oral and Topical	Seeds and leaves	[30,90,91]
Rosmarinus officinalis L.	Rosemary	Polyphenols (apigenin, diosmin, luteolin, *genkwanina*) and phenolic acids (especially rosmarinic acid, chlorogenic acid and caffeic acid), terpenes such as epirosmanol, carnosol, carnosic acid (tricyclic diterpenes), ursolic acid and oleanolic acid (triterpenes). The main constituents of the rosemary essential oil are: camphor, 1,8-cineole, α-pinene, borneol, camphene, β-pinene and limonene.	Antiproliferative, hepatoprotective, antithrombotic, diuretic, antidiabetic, anti-inflammatory, antioxidant, anti-microbial, anti-cancer, antiangiogenic and neuroprotective, antihypercholesterolemia, antioxidant and relief of physical and mental fatigue	The leaves are used to alleviate heart palpitations, emmenagogue, stress, cardiovascular disease while the stems stimulate slow digestion	Oral	Leaves, stem	[30,92-99]
15. Lauraceae							
Persea americana Mill	Avocado	Carotenoids (predominantly lutein and other carotenoids such as α-carotene, β carotene, zeaxanthin, neoxanthin and violaxanthin)...phytosterols and triterpenes, fatty acids (olefinic, acetylenic bonds, furanoic acid), dimmers of flavanols, oligomeric proanthocyanidins, β-D-glucoside of 8-hydroxyabscisic acid and epi-dihydrophaseic acid β-d-glucoside, phenols, flavonoids, alkaloids, saponins, tannins, unsaturated steroids, triterpenoids (Leucoanthocyanins), isorhamnetin, luteolin, rutin, quercetin, and apigenin	Anticardiovascular, anti-aging, anticancer, antioxidant, anti-inflammatory, antihypercholesterolemia, antihypertensive, antidiabetic, insecticidal, fungicidal, and antimicrobial activities	The plant is used in traditional medicine for the treatment of various ailments, such as monorrhagia, hypertension, stomach ache, bronchitis, diarrhea, and diabetes. The leaves are traditionally used for treatment of hypertension	Oral and Topical	Fruit, Leaves and Seeds	[100-105]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
16. Leguminosae							
Tamarindus indica L.	Tamarin	Phenolic compounds, tannins, fatty acids (such as palmitic acid, oleic acid, linoleic acid, and eicosanoic acid), flavonoids, saponins, alkaloids, proanthocyanidin, glycosides, 2-hydroxy-3', 4'-dihydroxyacetophenone, methy l-3, 4-dihydroxybenzoate, 3, 4-dihydroxyphenylacetate and (-)-epicatechin, arabinose, acetic acid, dihydroxylphenyl acetate	Astringent, antiseptic, laxative, antioxidant activity, antidiabetic activities	The pulp is used as a laxative, anti-asthmatic, astringent agent. The leaves are used as mouth wash, gargle against gingivitis while a bark decoction is used in the treatment of asthma. Infusion of young leaves is used for eye inflammation.	Oral	Pulp and leaves	[30,106-108]
17. Lythraceae							
Punica granatum L.	Pomegranate	Gallic acid, ellagic acid, punicalin, punicalagin, caffeic acid, citric acid, malic acid, succinic acid, tartaric acid, acetic acid, oxalic acid, shikimik acid, maleic acid, furamic acid ellagitannins, pelletierine alkaloids, piperidine alkaloid, isopelletierine, me-thyl-pelletierine, pseudopelletierine, glucoside, granatic acid, luteolin, kaempferol, quercetin, catechin, epigallocatechin gallate, rutin, flavones, flavanones, flavonoid, flavanols, steroids, lignins, fats and oils, glycosides, carbohydrates, anthocyanidins, anthocyanins melatonin, delfinidin 3-O-glucoside, punicacortein A, punicacortein B, pedunculagin, tellimagrandin, glucose, delphinidin, gallagyldilacton, tannins, simple sugars, aliphatic organic acids, quinic acid, amino acids, minerals, ascorbic acids, ursolic acid, triterpenoids, fatty acids, 3,3'-Di-O-methylellagic acid ; 3,3',4'- Tri-O-methyellagic acid, punicic acid, oleic acid, palmitic acid, stearic acid, linoleic acid, sterols, tocopherols, steroids	Antioxidant, anti-inflammatory, antidiabetic, antihypertensive, anticancer, antimutagenic, antimicrobial and anti-atherogenic, memory-enhancing activity, anti-ageing, wound healing, antidiarrheal, hepatoprotective activities	Traditionally used to treat sore throats, coughs, urinary infections, digestive disorders, asthma, cardiovascular disease, high level of cholesterol, diarrhea, dysentery, skin disorders, arthritis, and to expel tapeworms	Oral	Fruit peels and roots; pericarp and mesocarp	[30,109-113]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
18. Malvaceae							
Abelmoschus esculentus (L.) *Moench*	Lalo, ladyfinger, okra	Polyphenolic compounds (mainly oligomeric catechins), flavonoids, flavonol glycosides, polysaccharides, tannins, mucilages, leucoanthocyanins, reducing compounds, sterols and terpenes	Hypoglycemic, antioxidant, anticancer, antidiabetic, antidepressant activities, immunoprotective activities	Traditionally used in the treatment of diabetes, gonorrhea, dysuria, constipation, urinary tract infections, erectile dysfunction, as a diuretic agent	Oral	Fruit and seed	[30,114-116]
19. Microcoleaceae							
Arthrospira platensis	Spirulina	Phenolics, chlorophyll-a, zeaxanthin, diatoxanthin, 3′-hydroxyechinenone, echinenone, beta-carotene, xanthophyll, canthaxanthin, c-phycocyanin, beta-cryptoxanthin, myxoxanthophyll, oscillaxanthin, phycobiliproteins (phycocyanin and allophycocyanin), fatty acids (such as linoleic acid, docosahexaenoic acid, eicosapentaenoic acid, arachidonic acid, and stearidonic acid) and polysaccharides	Antioxidant, anti-inflammatory, antipyretic, antihyperalgesic, antiviral, anticancer, antihypertensive, wound healing, antihypercholesterolemic, antidiabetic activities	Not Known	Not Known	Not Known	[78,79,117-120]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
20. Moringaceae *Moringa oleifera* Lam.	Locally known as "Bred Mouroum" and "Baton Mouroum", drumstick tree	Leaves: n-hexadecanoic acid, tetradecanoic acid, cis-vaccenic acid, octadecanoic acid, palmitoyl chloride, beta-l-rhamnofuranoside, 5-O-acetyl-thio-octyl, gamma-sitosterol, and pregna-7- diene-3-ol-20-one, E-lutein. Plant radicle: 4-(α-l-rhamnopyranosyloxy)-benzylglucosinolate and benzylglucosinolate. Roots: spirochin and anthonine. Peduncle of plant: beta-sitosterone, vanillin, 4-hydroxymellein, β-sitosterol, and octacosanoic acid. Crust: 4-(α-l-rhamnopyranosyloxy)-benzylglucosinolate. Stem: alkaloids (moringine and moringinine), 4-hydroxymellein, octacosanoic acid, and β-sitosterol. Whole gum: l-rhamnose, d-glucuronic acid, l-arabinose, d-mannose, d-xylose, and d-galactose, leucodelphinidin-3-O-B-D-galactopuranosy (1->4)-O-B-D-glucopyranoside. Flower: sucrose, amino acids, alkaloids, and flavonoids, such as rhamnetin, isoquercitrin, and kaempferitrin. Whole pods: isothiocyanate, thiocarbamates, nitrile, O-[2′-hydroxy-3′-(2″-heptenyloxy)]-propyl undecanoate, methyl-p-hydroxybenzoate, and O-ethyl-4-[(α-l-rhamnosyloxy)-benzyl] carbamate. Seeds: benzylglucosinolate, 4-(α-l-rhamnopyranosyloxy)-benzylglucosinolate, 4-(α-l-rhamnosyloxy) benzylisothiocyanate, 4-(α-l-rhamnosyloxy) phenylacetonitrile, and O-ethyl-4-(α-l-rhamnosyloxy) benzyl carbamate	Hypotensive, anticancer, antibacterial, antimicrobial, anti-inflammatory, antiseptic, antihelminthic, antioxidant, hypoglycemic, antiobesity, hypolipidemic, hepatoprotective, cardioprotective, anti-atherosclerotic activities	Used as antidiabetic, antispasmodic, diuretic, purgative, vermifuge, and to manage low blood pressure	Oral	Leaves and pods	[15,121-123]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
21. Musaceae *Musa acuminata* Colla	Wild Banana	Anigorufone, alkaloids, α-tocopherol, apigenin, β sitosterol, chlorogenic acid, 2,3-dihydro-3,5-dihydroxy6-methyl-4H-pyran-4-one, Epi-sesamin, flavonoids, glycosides, kaempferol, lectin, 2-methoxy-9-phenylphenalen-1-one, omega-3, omega-6, phytosterols, quercetin, saponins, sesamin, (S)-(+)-6-methoxy-αmethyl-2-naphthaleneacetic acid, tannins, trans beta carotene	Antioxidant, immunomodulatory, antimicrobial activities, antibacterial, antiviral, anti-inflammatory, antiallergenic, antithrombotic, vasodilatory, cholesterol reduction, cardioprotective, anticancer, anti-HIV activities	The unripe fruit is used to treat diarrhea while the ripe fruit is used to alleviate Type 2 diabetes and gout. The leaves are used to manage fever, lower back ache, joint pain (rheumatism), headache, migraine. The plant is also used in the management of diabetes, high blood pressure, anemia, fever, wounds, allergies, respiratory disorders	Oral and Topical	Fruit, stem, pseudostem, flower, leaf, sap, inner trunk, inner core and root	[30,124,125]
22. Myrtaceae *Psidium cattleianum* Sabine	Red and yellow 'Chinese guava', Araçá or strawberry guava	Ascorbic acid, volatile compounds (including (E)-β-caryophyllene, hexadecanoic acid, (Z)-3-hexenol and α-pinene, β-selinene, neointermedeol), carotenoids (lutein, all-trans-antheraxanthin, all-trans-β-carotene and alltrans-β-cryptoxanthin), phenolic compounds (gallic acid and its derivatives and ellagic acid and its derivatives, epicatechin, chlorogenic acid, quercetin), flavonoids (proanthocyanidins, cyanidins)	Antioxidant, antimicrobial, antifungal and antiproliferative and allelopathic activities	Traditional medicine to combat oral, gastrointestinal, urogenital and intestinal inflammations. A decoction of immature fruits is used against diarrhea and dysentery	Oral	Fruit and Leaves	[30,126-131]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
Psidium guajava L.	White "guava," common guava fruit, goyavier	saponins (combined with oleanolic acid, morin-3-O-α-L-lyxopyranoside and morin-3-O-α-L arabopyranoside), flavonoids (guaijavarin, quercetin, morin-3-O-α-L-lyxopyranosidemorin-3-O-α-L-arabinopyranoside, kæmpferol and luteolin-7-O-glucoside and apigenin-7-O-glucoside), hexanal, (E)-2-hexenal, (E,E)-2,4-hexadienal, (Z)-3-hexenal, (Z)-2-hexenal, (Z)-3-hexenyl acetate and phenol, β-caryophyllene, nerolidol, 3-phenylpropyl acetate and caryophyllene oxide, pentane-2-thiol, cineol, tannins, Guavin B, Guavin A, Isostrictinin, Strictinin, Amritoside or ellagic acid 4-gentiobioside, Pedunculagin and (+)-gallocatechin, menthol, α-pinene, β-bisabolene, β-pinene, β-copanene, limonene, terpenyl acetate, isopropyl alcohol, caryophyllene, longicyclene, cineol, caryophyllene oxide, humulene, farnesene, selinene, curcumene and cardinene, carotene, lycopene, Guavanoic acid, guavacoumaric acid, 2α-hydroxyursolic acid, isoneriucoumaric acid, jacoumaric acid, asiatic acid, ilelatifol D and β-sitosterol-3-O-β-D-glucopyranoside, triterpenoids (such as guavanoic acid, ursolic acid), phenolic compounds	Antioxidant, anti-inflammatory, antipyretic, analgesic, hepatoprotection, anti-allergy, antimicrobial, antigenotoxic, antiplasmodial, cytotoxic, antispasmodic, cardioactive, anticough, antidiabetic, antidiarrheal and antinociceptive activities	Traditionally used in the treatment of dysentery, diarrhea, stomach ache and Type 2 diabetes	Oral	Fruit and Leaves	[30,48,129,132,133]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
23. Piperaceae							
Piper betle L.	Betel	Terpenoids (1,8-cineole, cadinene), camphene, caryophyllene, limonene, pinene, chavicol, allyl pyrocatechol, carvacrol), Phenols (safrole, eugenol, and chavibetol, gallic acid, procatechuic acid, chlorogenic acid, caffeic acid, quercetin, ferulic acid, ellagic acid), luteolin, tannins, steroids, alkaloids, sugar	antioxidant, anticancer, antidiabetic, anti-ulcer, antihistaminic, analgesic, gastroprotective, hepatoprotective, neuroprotective in brain alcohol toxicity, wound-healing, anti-hyperglycemic, antimicrobial activities	Traditionally used to manage cough, fever, type 2 diabetes, high cholesterol, cough, asthma, cold and flu, bronchitis, respiratory disorders, reduce milk flow in breastfeeding mothers and keep gums firm and healthy	Oral	Leaves	[28,30,48,134]
24. Poaceae							
Cymbopogon citratus (DC.) *Stapf*	Citronelle	Hydrocarbon terpenes, alcohols, ketones, citral, esters, tannins, saponins, anthraquinones, alkaloids, triterpenoids, flavonoids (quercetin, kaempferol, apiginin), phenolic compounds (elimicin, catecol, chlorogenic acid, caffeic acid, hydroquinone), luteolin, glycosides	Antibacterial, antidiarrheal, antifungal, anti-inflammatory, antimalarial, antimutagenicity, antinociceptive, antioxidant, hypocholesterolemic, antidiabetic activities	A leaf infusion is used in the treatment of asthma, respiratory disorders, bronchitis, coughs, colds, fever, migraine, grippe, flu, abdominal pain, postpartum pain, abortion while the rhizome decoction is used against cough, bronchitis, asthma, chest problems	Oral	Leaves and rhizomes	[30,135-138]
Triticum aestivum L.	Wheatgrass	Tocopherols, bioflavonoids (such as apigenin, quercetin, luteolin), phenolic acids, saponins, tannins, alkaloids, terpenoids, steroids and glycosides	Anticancer, antiulcer, antioxidant, anti-arthritic activities, and blood building activity in Thalassemia Major. May have cerebroprotective activity as well	Used for digestion improvement, blood pressure reduction, heavy metal detoxification from the bloodstream, immune system modulation, and gout alleviation.	Oral	Leaves	[139-143]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
25. Proteaceae							
(A) *Macadamia integrifolia* Maiden & Betche	Macadamia	Polyphenol compounds, squalene, phytosterols, tocopherols, tocotrienols, carotenoids, proanthocyanidins	Cardioprotective, antihypercholesterolemic, antioxidant, anti-inflammatory, angiogenic, antipyretic, anti-arthritic, chemoprotective and antithrombotic activities	Not Known	Not Known	Fruit - nut	[144-147]
(B) *Macadamia tetraphylla* L.A.S. Johnson		Polyphenol compounds, phytosterols, tocopherols, tocotrienols, squalene, carotenoids, proanthocyanidins	Cardioprotective, antihypercholesterolemic, antioxidant, anti-inflammatory, angiogenic, antipyretic, anti-arthritic, chemoprotective and antithrombotic activities	Not Known	Not Known	Fruit - nut	[144-146]
26. Rubiaceae							
Morinda citrifolia L.	Noni, murier de java, feuille tortue	Phenolic compounds (including damnacanthal, scopoletin, morindone, alizarin, aucubin, nordamnacanthal, rubiadin, rubiadin-1-methyl ether, and anthraquinone glycosides), organic acids, alkaloids, ursolic acids, anthraquinones and their glycosides, caproic acid, caprylic acid, fatty acids and alcohols (C5-9), flavones glycosides, flavonoids, tannins, saponins, steroids, glucose (β-D-glucopyranose), indoles, purines, and β-sitosterol	Antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic, antidiabetic, immune-stimulating and analgesic activity, antimicrobial activities	Ethnomedicinal applications against type 2 diabetes, hypercholesterolemia, hypertension and pain. It is also used for arthritis, headaches, menstrual difficulties, gastric ulcers, poor digestion, and atherosclerosis. Boiled leaves are applied on sprains and swellings while a warm leaf poultice is used to alleviate rheumatism. A leaf decoction is used against toxic fish poisoning	Oral and Topical	Fruits and leaves	[12,30,148-150]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
27. Rutaceae							
Aegle marmelos (L.) Corrêa	Bael	Coumarins, flavonoids, alkaloids, tannins, skimmianine, aeglin, rutin, γ-sitosterole, β-sitosterol, flavone, lupeol, cineol, citral, glycoside, O-isopentenyl, hallordiol, mameline, citronellal, cuuminaldehyde phenylethyle cinnamamides, euginol, marmesinin, aegelin, alkaloids, emodins, ferric chloride, lead acetate, gelatin, phenolics, and volatile oils	Anti-inflammatory, antipyretic, analgesic, antidiabetic, anticancer, antimicrobial, antifungal, cardioprotective, antiulcer, immunomodulatory, hepatoprotective, antihyperlipidemic activities	Used against stomach pains, stomach acidity, palpitations, diarrhea and dysentery; as a laxative. The leaves are astringent and used in treatment of peptic ulcers while dried roots are used in the treatment of earache	Oral	Leaf, fruit (ripe and unripe), roots, pulp of fruit, root bark	[30,48,151,152]
Citrus aurantifolia L.	Lime	Flavonoids (including apigenin, hesperetin, kaempferol, nobiletin, quercetin, and rutin), flavones, flavanones, naringenin, triterpenoid, limonoids, tannins, phenols (chlorogenic acid), carotenoids, saponins, glycosides, alkaloids	Anticancer, antioxidant, antimicrobial, anti-inflammatory, hypocholesterolemic activities	Traditionally used as anti-spasmodic agent, in the treatment of respiratory problems, palpitations, nausea, scurvy. Other traditional uses reported include: antibacterial, antidiabetic, antifungal, antihypertensive, anti-inflammatory, antilipidemic, antioxidant, anti-parasitic, antiplatelet.	Oral	Fruits, leaves	[30,153-156]
Citrus clementina	Clementine	Flavonoids (such as hesperidin, naringin and diosmin), flavones, flavanones, flavanols, isoflavones, anthocyanidins, and flavanols, alkaloids, coumarins, limonoids, carotenoids, phenol acids	Antidiabetic, anticancer, antihypertensive, antioxidant activities	Not Known	Not Known	Not Known	[9,157]
Citrus maxima (Burm.) Merr.	Pamplemousses	Polyphenols, flavones, flavanones, flavanols, isoflavones, anthocyanidins, and flavanols, limonene, saponins, tannins	Antidiabetic, anticancer, antihypertensive, antioxidant activities	Used as an antispasmodic agent, against type 2 diabetes and high cholesterol level	Oral	Fruit and peel	[9,30,157]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
Citrus reticulata	Mandarin/ tangerine	Flavones, flavanones, flavanols, isoflavones, anthocyanidins, and flavanols, alkaloids, coumarins, limonoids, carotenoids, phenol acids.	Antidiabetic, anticancer, antihypertensive, antioxidant activities	Not Known	Not Known	Not Known	[9,157]
Citrus sinensis (L.) Osbeck	Orange	Polyphenols, flavones, flavanones, flavanols, isoflavones, anthocyanidins, and flavanols, limonene, steroids, coumarins, carbohydrates, carotenoids	Antidiabetic, anticancer, antihypertensive, antioxidant, antibacterial, antifungal, antiparasitic, hypocholesterolemic, anti-obesity, cardioprotective, UV protective activities	Traditionally used in the treatment of ailments like constipation, cramps, colic, diarrhea, bronchitis, tuberculosis, cough, cold, obesity, menstrual disorder, angina, hypertension, anxiety, depression and stress	Oral	Fruit	[9,30,157,158]
28. Sapindaceae							
Litchi chinensis Sonn.	Litchi	Flavonoids, phenolic acids, proanthocyanidins, anthocyanins, coumarins, lignans, chromanes, sesquiterpenes, fatty acids (such as palmitic acid, oleic acid, linoleic acid, and cyclopropane fatty acids), sterols, and triterpenes	Antioxidant, anticancer, anti-diabetic, anti-inflammatory, analgesic, antipyretic, antimicrobial, antibacterial, antihyperlipidemic, antiviral, antidiabetic, anti-obesity, hepatoprotective, antithrombotic and immunomodulatory activities.	Traditionally used to treat bilious fever, a violent poison, cough, flatulence, stomach ulcers, diabetes, obesity, testicular swelling, hernia-like conditions, and epigastric and neuralgic pains.	Oral	Fruits and bark	[30,159]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
29. Theaceae							
Camellia sinensis (L.) Kuntze	Mauritian Tea (black and green)	Alkaloids, flavonoids, steroids, terpenoids, carotenoids, benzoic acid, ascorbic acid, tocopherols, folic acid, glycosyl derivatives (i.e., apigenin, myricetin, quercetin, rutin), theaflavins and thearubigins and tannins consisting of catechin (flavonol) and gallic acids	**Black Tea:** Antioxidant, antidiabetic, anticancer, antihypertensive, anti-hypercholesterolemia, anti-inflammatory, osteoporosis protective cardioprotective activities **Green Tea**: antioxidant, antidiabetic, anticancer, antihypertensive, anti-inflammatory, anti-hypercholesterolemia, anti-obesity, osteoporosis protective, cardiovascular protection activities. It also helps in the reduction in diabetic nephropathy	The plant is used as a tonic, stimulant, and astringent. A cold tea infusion is used against conjunctivitis (wash), eye infection and cataract. Strong tea infusion is used to treat diarrhea. Tea bags boiled and cooled are used as anti-dark circles, anti-wrinkle agent, type 2 diabetes, high level of cholesterol	Oral and Topical	Leaves and leaf buds	[7,8,10,14,30,160,161] [11,14,30,161-165]
30. Vitaceae							
Vitis vinifera L.	Common Grape vine, "vigne rouge"	Organic acids, phenolic acids, flavonoids (such as catechin, epicatechin, epicatechin gallate), tannins, procyanidins, anthocyanins, stilbenes	Antioxidant, antimicrobial, antibacterial, antiviral, antifungal, anticancer, cardioprotective, anticholesterolemic, neuroprotective, antidiabetic, anti-inflammatory, hepatoprotective effects	Leaves of *Vitis vinifera* is used in traditional medicine for diarrhea, hepatitis and stomach-aches	Oral	Fruit, seed, leaves	[166,167]

(*Contd...*)

Table 2: (*Continued*).

Scientific Name	Vernacular Name	Major Phytoconstituents	Biological Activities	Ethnomedicinal Uses	Mode of Application	Part(s) used in ethnomedicine	References
31. Zingiberaceae							
Curcuma longa L.	Turmeric, "Safran", "Saffran vert"	Polyphenols, terpenoids, alkaloids, curcuminoids (curcumin, monodesmethoxycurcumin and bisdesmethoxycurcumin), zingiberene, sesquiterpenes	Analgesic, antipyretic, anti-inflammatory, wound healing, antidiabetic, skin care activities, anticancer, antibacterial, antiviral, antioxidant, antiseptic, cardioprotective, hepatoprotective, digestive, antihelmintic, antiseptic, antidepressant, antimalarial, lipid-lowering, anti-arthritic, anti-ageing, antirheumatic, antiulcer activities	Traditionally used in the treatment of cough, cold, eye problems, bronchitis, asthma, pain, fever, ecchymosis, contusions and ecchymoses, wounds, measles, postpartum bleeding and diastasis as bath, cardiovascular disease. The crushed rhizome is used as face cleanser, facemask, and skin moisturizer and as a whitening agent.	Oral and Topical	Rhizome	[28,30,151]
Zingiber officinale Roscoe	Ginger, Gingembre	Essential oils, phenolic compounds, flavonoids, carbohydrates, proteins, alkaloids, glycosides, saponins, steroids, terpenoids, tannin, gingerol, gingerdiones, zingiberene	Antimicrobial, anticancer, antioxidant, antidiabetic, nephroprotective, hepatoprotective, larvicidal, analgesic, anti-inflammatory and immunomodulatory activities	Traditionally used as diuretic, emmenagogue, to speed up digestion and expel intestinal gas, to control high cholesterol level, against blood spitting, dyspepsia or indigestion, pulmonary infection, postpartum bleeding, labor pain, abdominal pain, influenza, cold, nasal congestion, cough, sore throat diarrhea, vomiting, nausea, pulmonary infection	Oral	Rhizome	[30,48,168]

and ripe fruits can be utilized. Indeed, several parts of the *C. papaya* plant are used in traditional medicine in Mauritius: the ripe fruit for stomach/peptic ulcer and constipation, hypertension, high cholesterol level and as anti-pimple, anti-pigmentation and skin moisturizer; the green fruit for stomach and duodenal ulcers; the seeds for intestinal worms; the roots for pain in joints, muscles and arthritis; and the latex as vermifuge.[30] Other reported uses in folk medicine include antibacterial, antifungal, anthelmintic, wound healing, antisickling, abortifacient, antifertility, antitumor, hypoglycemic, and hypolipidemic.[86,183] Studies have reported that papaya exhibits a wide range of biological activities including anti-inflammatory, wound-healing, antihelminthic, anticancer, antidiabetic, anti-hyperglycemic, antifungal, antibacterial, anti-hypertensive, immunomodulatory, gastro-protective, antinociceptive, anti-pyretic, antioxidant, antimalarial, and antihyperlipidemic which can be ascribed to the chemical diversity it possesses.[184,185, 187, 188] Both the ripe and unripe papaya fruit can be consumed in salads, beverages, or in dehydrated, crystallized, canned, pickled form, or fermented into wine.[183,189] Fermented products derived from papaya, for instance, the popular fermented papaya preparation, confers physiological protection against diabetes, cancer, and respiratory diseases.[77,190,191]

Noni: A superfruit gaining popularity

Morinda citrifolia L. commonly known as noni is a tropical plant belonging to the Rubiaceae family, believed to have originated from South Asia and is now found in several countries across the globe where it is cultivated commercially.[149,192] It is a resilient plant that is resistant to severe weather and can withstand different environmental conditions.[149] Noni parts including fruits, seeds, barks, leaves, and flowers are used for their individual nutritional and therapeutic properties but the fruit is deemed to be most valuable in terms of bioactive constituents.[192,193] In Mauritius, noni is used traditionally in the treatment of sprains, swellings, rheumatism, toxic fish poisoning and against type 2 diabetes, hypercholesterolemia and hypertension.[12,30] Other ethnopharmacological uses reported worldwide pertain to the use of noni leaves and fruits as blood purifiers, antihelminthic agents, dietary supplements, against digestive disorders, hypertension, tuberculosis, urinary tract dysfunctions, diabetes, depression, and as appetite stimulator.[12,149,193] Reported *in vitro* biological activities of noni include: wound-healing, antioxidant, anti-microbial, antifungal, antiviral, anti-inflammatory, analgesic, anticarcinogenic, antidiabetic, anti-arthritic, immune stimulating, and analgesic properties.[48,193] *In vivo* studies using rat models have corroborated the anti-diabetic, ulcer healing, memory enhancing, and anticancer activities of noni.[148,149] The anticancer activity has been investigated at the level of clinical trial but no conclusive evidence has been obtained which prompts further experimentation before using *M. citrifolia* in therapeutic anticancer medicine.[194] Products developed from noni fruits and leaves are commonly marketed in the form of pills, tablets, capsules, teas, powders, purees, and juice.[12,149] In the last few decades, *M. citrifolia* has emerged as a popular health product, due to its claimed beneficial physiological effects as a stimulant, anticancer, and anti-inflammatory agent.

Pomegranate: A fruit with myriad virtues

Pomegranate, scientifically known as *Punica granatum* L., belongs to the family of Punicaceae and is native to northern India and to Iran but is widely cultivated in the Asian and African regions including Mauritius.[195,196] Documented use of pomegranate in Mauritian ethnomedicine includes consumption of macerated bark extracts to treat diarrhea, dysentery, asthma, and intestinal worms; consumption of pulp for cardiovascular diseases and to control high cholesterol levels; and usage of the rind in the treatment of diarrhea.[30,195] The use of pomegranate in traditional medicine is deeply entrenched in Ayurveda.[197] The rind of the fruit and the bark of the pomegranate tree is used as a traditional remedy against diarrhea, dysentery and intestinal parasites while the seeds and juice are considered a tonic for the heart, throat, eyes and used for a variety of purposes, such as stopping nose bleeds and gum bleeds, toning skin, firming-up sagging breasts, and treating hemorrhoids.[197] Bhowmik *et al.* reported *in vitro* biological activities of pomegranate include anticancer, antimicrobial, antifungal, antiviral, cardioprotective, anti-diabetic, antioxidant, UV protective, memory enhancing, anti-arthritic, wound healing, anti-obesity, lipid-lowering, antimalarial, antihypertensive, and anti-inflammatory.[111,195-199] Pomegranate has exhibited antiproliferative and anti-invasive effects on different cancer cell lines *in vitro*, *in vivo* and in clinical trials.[109,196,200,201] *In vivo* studies and clinical studies have supported the antioxidant, antihypertensive, anti-obesity, anti-diabetic, anti-hypercholesterolemic, immune stimulating, cardioprotective, and hepatoprotective properties of pomegranate.[109,196,202-208] Nutraceutical and functional food products from *P. granatum* include 100% pomegranate juices, pomegranate-containing beverages, extracts of pomegranate plant parts such as leaves, flowers, seeds and peel, pomegranate seed oil, and skin care products containing pomegranate extracts and/or seed oil as main ingredient.[201,209]

Turmeric: The golden medicine

Curcuma longa L, commonly known as turmeric, is native to tropical South Asia and belongs to the Zingiberaceae family.[210] This extensively grown spice is of huge interest to both the scientific and medical spheres as well as the gastronomical world due to its chemical diversity and its multitude of therapeutic properties. The rhizome is widely

used in Mauritius in traditional medicine to alleviate cough, eye problems, bronchitis, asthma, pain, fever, contusions, wounds, measles, postpartum bleeding, and cardiovascular disease.[30] It is also used as phytocosmetic for face cleanser, facemask, skin moisturizer, and whitening agent.[28] In different regions of India, turmeric is used in traditional medicine in the treatment of cuts, wounds, stomach ache, body pain, joint pain, asthma, itching, bloating, cold, foot rot, intestinal wounds, withering of foot pad, dyspepsia, cancer, fever, malaria, bone fracture, headache, arthritis, neurasthenia, piles, dental caries, skin diseases, rheumatism, sprain, flatulence, diabetes, muscle injury, snake bite, gangrene, cataract, urticaria, ringworm, dry skin, wrinkled skin, prickly heat, measles, psoriasis, pimples on face, breast disorder, and spleen disorder.[28] The characteristic yellow color of turmeric is due to the presence of curcuminoids which is mainly composed of curcumin (75–81%), demethoxycurcumin (15–19%), and bisdemethoxycurcumin (2.2–6.6%).[211] Curcumin, the most prevalent natural polyphenol in turmeric, possesses several biological activities that are supported by *in vitro* studies, including: anti-inflammatory, antibacterial, antiviral, antifungal, antioxidant, photo-protection, neuroprotection, immunomodulatory, nephroprotective, wound healing, and gastroprotective among many others.[211-212] *In vivo* studies using rat models provide evidence for the antioxidant, anti-diabetic, anti-inflammatory, hepatoprotective, cardioprotective, anti-obesity, antitumor, analgesic, anti-pyretic, wound healing, and skin care activities.[210-221] Clinical studies have demonstrated the anti-arthritic effects of curcumin in humans with osteoarthritis and rheumatoid arthritis.[213,222] Curcumin is commonly commercialized in multiple forms including capsules, tablets, ointments, beverages, soaps, skin care products, and cosmetics.[213]

Pineapple: Source of the valuable enzyme, bromelain

Ananas comosus (L.) Merr, popularly known as pineapple, is a plant of the Bromeliaceae family.[223,224] Pineapple is mainly cultivated in the tropical and subtropical regions.[223] In Mauritius, the fruit is traditionally used as an abortifacient, anthelmintic, diuretic, and laxative agent; and used against whooping cough in children.[30] Various parts of the plant pineapple are used in traditional medicine worldwide for treatment of a number of diseases and disorders. The fruits, stems, and leaves of pineapple are used as antimicrobial, vermicide, laxative, abortifacient, anti-edema, and anti-inflammatory agent and in different aspects of wound healing like anti-edema, anti-inflammatory agent in soft tissue injury, osteoarthritis, and as a debriding agent.[68] The fruit contains a proteolytic enzyme namely bromelain which exhibits a wide array of beneficial therapeutic effects.[224] *In vitro* biological activities associated with bromelain pertain to its anti-inflammatory, anti-diabetic, antimicrobial, antioxidant, anti-cancer, anti-metastatic, appetite stimulating, immunomodulatory, and cardioprotective activities.[224-227] *In vivo* and clinical studies have validated the cardioprotective, anti-inflammatory, analgesic, anti-diarrheal, antimicrobial, anticancer, wound-healing, anti-thrombotic, anti-arthritic, and antihypertensive activities of pineapple and confirmed its effectiveness as a fibrinolytic agent.[225,226,228-230] Indeed, bromelain is popular as a nutritional supplement used to promote health, alleviate acute inflammation and treat sport injuries.[230] It is also noteworthy that malic acid in pineapple assists in maintaining oral health, enhancing immunity, and preventing dental plaque formation.[223]

Mauritian tea: A panoply of bioactive constituents

Tea, *Camellia sinensis* (L.) Kuntze, belonging to the family Theaceae, is native to Southeast Asia.[161] Tea made from the leaves of *C. sinensis* is a widely consumed beverage around the world and there are three major varieties of tea - green, black, and oolong.[161,231,232] The difference between the teas lies in their processing; green tea is produced from unfermented leaves, the leaves of oolong tea are partially fermented, while the leaves are fully fermented to prepare black tea.[161,232,233] Locally, ethnopharmacological usage of tea include as tonic, stimulant, astringent, in the treatment of conjunctivitis, eye infection, cataract, diarrhea, type 2 diabetes mellitus, high level of cholesterol, and as anti-dark circles and anti-wrinkle agent.[30] Across the globe, tea is commonly used as a stimulant, diuretic, astringent, cardioprotective agent; to treat flatulence, to regulate body temperature and blood sugar, to assist in digestion, and to enhance mental processes among others.[234,235] Luximon-Ramma *et al.* investigated the polyphenol constituents of Mauritian commercial black tea and reported exceptionally high levels (+)-Catechin ((+)-C), (−)-epicatechin ((−)-EC), (−)-epicatechin 3-gallate ((−)-ECG), (−)-epigallocatechin ((−)-EGC), (−)- epigallocatechin 3-gallate ((−)-EGCG), and gallic acid which reflect an excellent source of polyphenolic constituents with consequent antioxidant activities.[7] A study by Toolsee *et al.* demonstrated the potential of Mauritian green tea in alleviating one of the most severe complications of diabetes, diabetic nephropathy.[164] Clinical trials conducted locally concluded that the consumption of black tea can help to significantly reduce the level of uric acid and C-reactive protein in individuals susceptible to cardiovascular diseases; and demonstrated its hypoglycemic and antioxidant capacities.[8,10] Furthermore, a clinical trial conducted by Ramlagan *et al.* reported the anti-diabetic, cardioprotective and anti-hypercholesterolemic activities of the Mauritian green tea.[14] Indeed, studies performed on the Mauritian tea have highlighted their very high contents in antioxidant active metabolites, compared to teas grown elsewhere, thus providing an originality base for the development of health products. Common nutraceuticals derived from tea include green tea, green tea extracts for consumption and incorporated in cosmeceutical formulations,

green tea capsules, functional food and beverage (e.g. catechin candy, green tea ice cream, and catechin tea bar), herbal teas and tea wine.[233,236,237]

Ginger: A valuable rhizome

Ginger (*Zingiber officinale* Roscoe) belongs to the Zingiberaceae family and is endemic to India.[238,239] It has been commonly consumed as a dietary supplement, condiment and a key ingredient in traditional herbal medicine for a long time.[240] In Mauritius, ginger is traditionally used as diuretic, to help with digestion, to control high cholesterol level, against blood spitting, pulmonary infection, postpartum bleeding, labor pain, abdominal pain, influenza, cold, nasal congestion, cough, sore throat diarrhea, vomiting, nausea, and pulmonary infection among others.[30] The rhizome of the plant is commonly used in decoctions, pastes, and infusions as part of traditional medicine. Around the world, ginger is traditionally used in the treatment of diabetes, high blood pressure and cancer; to aid digestion, reduce nausea, and help fight the flu and common cold among others.[238,241,242] The numerous pharmacological activities of ginger pertain to its antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, cardioprotective, gastroprotective, anti-obesity, antidiabetic, antinausea, anti-emetic properties, and protective effects against respiratory disorders.[238-240,242] All of the aforementioned biological activities of ginger have been substantiated by *in vitro*, *in vivo* experiments, and/or clinical trials.[238-243] The effectiveness of ginger against a number of chronic diseases plaguing the global population renders it a potent ingredient for nutraceuticals. Indeed, ginger supplements, ginger oil, ginger powder, ginger tea, and beverages are common nutraceutical products on the market which are heavily consumed.[244]

Lemongrass: A mighty resource

Cymbopogon citratus (DC.) Stapf, commonly known as lemongrass or citronella, belongs to the Poaceae family and grows in a number of tropical and subtropical regions around the world.[135] In Mauritius, the leaves of the lemongrass plant are commonly used in ethnomedicine. Locally, the common traditional usage includes the treatment and management of asthma, respiratory disorders, bronchitis, coughs, colds, fever, migraine, flu, abdominal pain, postpartum pain, and abortion among others.[26,30] Around the world, the leaves have been traditionally used in tea and decoctions for their anti-inflammatory, antiseptic, anti-fever, antispasmodic, analgesic, anti-hermetic, antibacterial, and diuretic properties.[245,246] Reported pharmacological activities encompass antibacterial, anti-inflammatory, antinociceptive, antifungal, antimalarial, anti-obesity, antihypertensive, antioxidant, anti-HIV, anti-diabetic, anticancer, insecticidal, and dermatotoxicity effects.[246] The antioxidant, anticancer, anti-inflammatory, antidiabetic, antihypertensive, and anti-HIV activities of lemongrass have been validated by *in vivo* trials.[135,245,247-250] A popular nutraceutical derived from this plant is the lemongrass essential oil which is used against flu, colds, nausea, menstrual problems, headaches, muscle cramps, and rheumatisms; and to improve digestion.[138] The essential oil is also used as a stimulating agent, tonic, diuretic, and aroma among others.[138]

Spirulina: A complete food source

Spirulina platensis is a non-toxic cyanobacteria that has gained considerable popularity in the natural health food industry over the years as a complete food source owing to its high protein content (up to 62%) and presence of minerals (including calcium, iron, magnesium, manganese, potassium, zinc and selenium), vitamins (provitamins; Vitamin A Vitamin E, and various B Vitamins), amino acids, essential fatty acids, carotenoids, sulfolipids, glycolipids, and polysaccharides.[251-254] *Spirulina* also acts as a functional food, feeding beneficial intestinal flora, including *Lactobacillus* and *Bifidus*.[255] Ciferri reported pharmacological activities include antioxidant, antihyperlipidemic, anticancer, immunity-boosting, nephroprotective, anti-obesity, antidiabetic, antihypertensive, antiviral, and anti-inflammatory properties.[254] Besides *Spirulina* pills and capsules, *Spirulina* is also added to chocolate bars, cookies, beverages, which are commercialized as health foods.[117]

Chlorella: A source of essential fatty acids

Chlorella vulgaris, a green alga from the Chlorophyceae class, is a renowned food supplement with important antioxidant potential and valuable therapeutic virtues.[256] *C. vulgaris* contains 43–58% protein, essential fatty acids, carbohydrates, lipids, carotenoids, Vitamins A, B, C, and E, and minerals including calcium, potassium, magnesium and zinc.[256] *C. vulgaris* contains a variety of compounds, including antioxidants and a glycoprotein, which may act on different pathways of tumor cell growth and survival.[257] Reported biological activities for *C. vulgaris* encompass antibacterial, antiviral, antitumor, wound healing, antioxidant, anti-Alzheimer, and immunostimulating properties.[256,258,259] One of the most important polysaccharides in *C. vulgaris* is β-1,3-glucan, which is an active immunostimulator, a potent free radical scavenger and an antihyperlipidemic agent.[256] Moreover, the tissue stimulating effects of *C. vulgaris* have enormous potential in cosmetic and skin care products, as it exhibits collagen-forming properties, anti-wrinkling, and anti-aging activities.[258,260]

Drivers for the subsequent development of marine nutraceuticals

A number of metabolites produced by marine organisms are considered as high-value commercial products for both the

phytocosmetic and pharmaceutical industries.[261-263] However, several barriers hinder marine bioprospecting for product development and thus, they need to be addressed to increase the success rate of health products derived from marine sources. At present, only a fraction of the marine diversity prevailing in our oceans are known, which engenders limitations, to the best of our knowledge, and in turn use of these resources.[264] Therefore, sampling techniques need to be honed to allow collection of samples which exhibit promising industrial application but are found in unreachable zones of the oceans.[265] Both the classical and molecular methods including macroscopic examination, microscopy, Fourier transform infrared spectroscopy, thin-layer chromatography, high-pressure liquid chromatography, gas chromatography, involved in determining the taxonomy and classification of a species need to be employed to enhance the process, and improve knowledge on marine species diversity.[266]

The success of a product development program majorly depends on the availability and sustainable supply of the starting material. Therefore, new culturing techniques such as mariculture, land-based aquaculture, and metagenomics are imperative to ensure a continued supply of marine resources.[264] Marine species, which are less vulnerable to environmental fluctuations and can be reproduced under lab-controlled conditions, should be prioritized for product development.[265] Improving extraction techniques by rendering them more productive, sensitive, and robust will enable the screening of small amounts of bioactive constituents' samples with low concentration issues.[264] Furthermore, the structure elucidation process for metabolites derived from marine sources should be enhanced by applying the most appropriate and rigorous techniques before further use.[264]

Drivers for the subsequent development of terrestrial plant-based nutraceuticals

The global market is flooded with nutraceutical products derived from plant sources, which attest to the growing interest in natural botanical products. The biodiversity existing in Mauritius offers countless possibilities in terms of transformation into nutraceuticals. Therefore, it is crucial to address the potent impediments to this mushrooming sector. The financial status of an enterprise is directly proportional to its productive output. Availability of funding for initial capital investment in production of raw materials and processing of raw materials into nutraceuticals will thus serve as a booster. The global spread of these products has raised significant questions about the scientific evidence to back claims associated with them and in the process, has rendered the commercialization procedure stringent. Enabling access to adequate R and D infrastructure and resources to provide support to processors will allow them to successfully validate their product before venturing into marketing. Support mechanisms including incentives and schemes, need to be put in place to motivate wider and more active participation in this sector. There is an ongoing ambiguity related to regulations pertaining to the production, labeling, and commercialization of nutraceuticals, given the absence of legislative measures locally. It is, therefore, imperative to advocate for clear regulations and standards for the local nutraceutical industry and this should apply to products derived from both terrestrial and marine sources.

It is noteworthy that for nutraceuticals derived from terrestrial and marine sources, access to resources and market are key factors impacting on the development process of the product. The Nagoya protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) "provides a transparent legal framework for the effective implementation of one of the three objectives of the Convention on Biological Diversity, namely, the fair and equitable sharing of benefits arising out of the utilization of genetic resources." The nutraceutical industry is dependent on the development and commercialization of products derived from genetic resources, which may fall under the scope of the Nagoya Protocol. Therefore, the implementation and harmonization of the Nagoya Protocol in different countries and regions should be viewed as a priority. Developing a clear access scheme for non-locals will certainly inject finance and boost advances in the nutraceutical development sector.[265] Moreover, market guidelines must be integrated within bioactives discovery and product development programs, early on, to assess the economic viability of the prospective products on the market.[265] Up to date market intelligence to evaluate the trend for nutraceuticals on the global and regional markets to better target the choice of nutraceuticals to be produced locally, should become norm. To secure a higher success rate for locally produced nutraceuticals and products, a close partnership between academics/researchers and the industry/SMEs is highly recommended.[264] This collaboration brings together the expertise of the academics and the market awareness and business sense of the industry/SMEs, all of which contributes to the success of such products on the market.

CONCLUSION

Commercial and large-scale production of nutraceuticals from local terrestrial flora and marine organisms represents a good opportunity for the development of a Mauritian nutraceutical industry, with the same being inextricably applicable to other African countries, the Caribbean, and the Asian and Pacific Island countries. The bioresources that include moringa, yellow and red varieties of strawberry guava, papaya, noni, pomegranate, turmeric rhizome, pineapple, tea, ginger, lemongrass, and a spectrum of tropical plants, have potentials for the nutraceutical industry in the region. The

identified terrestrial flora and marine organisms (including *Spirulina* and *Chlorella*) on the account of their economic and commercial importance, can be exploited in the short and medium terms to produce raw materials for export to countries with already well-established nutraceutical manufacturing plants; and in the long term, theses raw materials can be channeled in the nutraceutical value chain for local production and exportation of finished products. This calls for a sustained, responsible balance of supply to meet demand for the long-term health of these markets.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

OIA is a member of the Scientific Advisory Board for Zurvita, Houston Texas, USA.

TB is Executive Director at Mauritius Research and Innovation Council, Mauritius.

HR, TB, BR, DR-B, NB, OIA, and VSN were consultants for the Mauritius Economic Development Board to assess in 2020, the Development of a nutraceutical framework and industry in Mauritius.

REFERENCES

1. Turpie JK, Heydenrych BJ, Lamberth SJ. Economic value of terrestrial and marine biodiversity in the Cape florist Region: Implications for defining effective and socially optimal conservation strategies. Biol Conserv 2003;112:233-51.
2. Jenkins CN, Van Houtan KS. Global and regional priorities for marine biodiversity protection. Biol Conserv 2016;204:333-9.
3. RoM (Republic of Mauritius). National Biodiversity Strategy and Action Plan (NBSAP) 2017-2025; 2017.
4. Bahorun T, Neergheen VS, Aruoma OI. Phytochemical constituents of *Cassia fistula*. Afr J Biotechnol 2005;4:1530-40.
5. Gurib-Fakim A, Marie D, Narod F. The pharmacological properties of the isolated bioactive compounds from endemic medicinal plants of Mauritius. Acta Horticult 2005;675:133-7.
6. Mahomoodally MF, Fakim AG, Subratty AH. Effects of *Erythroxylum macrocarpum* (*Erythroxylaceae*), an endemic medicinal plant of Mauritius, on the transport of monosaccharide, amino acid and fluid across rat everted intestinal sacs *in vitro*. J Cell Mol Biol 2005;4:93-8.
7. Luximon-Ramma A, Neergheen VS, Bahorun T, Crozier A, Zbarsky V, Datla K, *et al*. Assessment of the polyphenolic composition of the organic extracts of Mauritian black teas: A potential contributor to their antioxidant functions. BioFactors 2006;27:79-91.
8. Bahorun T, Luximon-Ramma A, Gunness TK, Sookar D, Bhoyroo S, Jugessur R, *et al*. Black tea reduces uric acid and C-reactive protein levels in humans susceptible to cardiovascular diseases. Toxicology 2010;278:68-74.
9. Ramful D, Tarnus E, Aruoma OI, Bourdon E, Bahorun T. Polyphenol composition, Vitamin C content and antioxidant capacity of Mauritian citrus fruit pulps. Food Res Int 2011;44:2088-99.
10. Bahorun T, Luximon-Ramma A, Neergheen-Bhujun VS, Gunness TK, Googoolye K, Auger C, *et al*. The effect of black tea on risk factors of cardiovascular disease in a normal population. Prev Med 2012;54:S98-102.
11. Ramsaha S, Aumjaud BE, Neergheen-Bhujun VS, Bahorun T. Polyphenolic rich traditional plants and teas improve lipid stability in food test systems. J Food Sci Technol 2015;52:773-82.
12. Ruhomally Z, Somanah J, Bahorun T, Neergheen-Bhujun VS. *Morinda citrifolia* L. fruit extracts modulate H_2O_2-induced oxidative stress in human liposarcoma SW872 cells. J Tradit Complement Med 2016;6:299-304.
13. Mahomoodally MF, Aumeeruddy MZ. Promising indigenous and endemic medicinal plants from mauritius. In: Medicinal and Aromatic Plants of the World-Africa. Vol. 3. Dordrecht: Springer; 2017. p. 231-48.
14. Ramlagan P, Rondeau P, Planesse C, Neergheen-Bhujun VS, Bourdon E, Bahorun T. Comparative suppressing effects of black and green teas on the formation of advanced glycation end products (AGEs) and AGE-induced oxidative stress. Food Funct 2017b;8:4194-209.
15. Neergheen-Bhujun VS, Ruhomally ZB, Dunneram Y, Boojhawon R, Sun MC. Consumption patterns, determinants and barriers of the underutilised *Moringa oleifera* Lam in Mauritius. S Afr J Bot 2020;129:91-9.
16. Zeb S, Bano S, Rafique I, Batool SS, Rahman A, Jalal S. Pharmaceutical features of herbal remedy *Carica papaya* in life threatening diseases and acceleration of thrombocytes count in dengue fever. Int J Mosquito Res 2020;7:19-25.
17. Rummun N, Rondeau P, Bourdon E, Pires E, McCullagh J, Claridge TD, *et al*. *Terminalia bentztzoe*, a Mascarene endemic plant, inhibits human hepatocellular carcinoma cells growth *in vitro* via G0/G1 phase cell arrest. Pharmaceuticals 2020;13:303.
18. Santini A, Cammarata SM, Capone G, Ianaro A, Tenore GC, Pani L, *et al*. Nutraceuticals: Opening the debate for a regulatory framework. Br J Clin Pharmacol 2018;84:659-72.
19. Thomford NE, Senthebane DA, Rowe A, Muro D, Seele P, Maroyi A, *et al*. Natural products for drug discovery in the 21st century: Innovations for novel drug discovery. Int J Mol Sci 2018;19:1578.
20. Das L, Bhaumik E, Raychaudhuri U, Chakraborty R. Role of nutraceuticals in human health. J Food Sci Technol 2012;49:173-83.
21. Nasri H, Baradaran A, Shirzad H, Rafieian-Kopaei M. New concepts in nutraceuticals as alternative for pharmaceuticals. Int J Prev Med 2014;5:1487-99.
22. Chanda S, Tiwari RK, Kumar A, Singh K. Nutraceuticals inspiring the current therapy for lifestyle diseases. Adv Pharmacol Sci 2019;2019:6908716.
23. Sachdeva V, Roy A, Bharadvaja N. Current prospects of

nutraceuticals: A review. Curr Pharm Biotechnol 2020;21:884-96.
24. Souyoul SA, Saussy KP, Lupo MP. Nutraceuticals: A review. Dermatol Ther 2018;8:5-16.
25. Preuss HG, Aruoma OI. Suggestions for combatting COVID -19 by natural means in the absence of standard medical regimen. J Am Coll Nutr 2021;40:95-7.
26. Mahomoodally MF, Muthoorah LD. An ethnopharmacological survey of natural remedies used by the Chinese community in Mauritius. Asian Pac J Trop Biomed 2014;4(Suppl 1):S387-99.
27. Mootoosamy A, Mahomoodally MF. Ethnomedicinal application of native remedies used against diabetes and related complications in Mauritius. J Ethnopharmacol 2014;151:413-44.
28. Mahomoodally MF, Protab K, Aumeeruddy MZ. Medicinal plants brought by Indian indentured immigrants: A comparative review of ethnopharmacological uses between Mauritius and India. J Ethnopharmacol 2019;234:245-89.
29. Rummun N, Neergheen-Bhujun VS, Pynee KB, Baider C, Bahorun T. The role of endemic plants in Mauritian traditional medicine potential therapeutic benefits or placebo effect? J Ethnopharmacol 2018;213:111-7.
30. Suroowan S, Pynee KB, Mahomoodally MF. A comprehensive review of ethnopharmacologically important medicinal plant species from Mauritius. S Afr J Bot 2019;122:189-213.
31. Gupta C, Prakash D. Phytonutrients as therapeutic agents. J Complement Integr Med 2014;11:151-69.
32. Leitzmann C. Characteristics and health benefits of phytochemicals. Forsch Komplementarmed 2016;23:69-74.
33. Caselato-Sousa VM, Amaya-Farfán J. State of knowledge on Amaranth grain: A comprehensive review. J Food Sci 2012;77:93-104.
34. Girija K, Lakshman K, Udaya C, Sachi GS, Divya T. Anti-diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. Asian Pac J Trop Biomed 2011;1:133-8.
35. Jo HJ, Chung KH, Yoon JA, Lee KJ, Song BC, An JH. Radical scavenging activities of tannin extracted from amaranth (*Amaranthus caudatus* L.). J Microbiol Biotechnol 2015;25: 795-802.
36. Karamać M, Gai F, Longato E, Meineri G, Janiak MA, Amarowicz R, *et al*. Antioxidant activity and phenolic composition of amaranth (*Amaranthus caudatus*) during plant growth. Antioxidants 2019;8:1-14.
37. Peiretti PG, Meineri G, Longato E, Tassone S. Chemical composition, *in vitro* digestibility and fatty acid profile of *Amaranthus caudatus* herbage during its growth cycle. Anim Nutr Feed Technol 2018;18:107-16.
38. Kumar BS, Lakshman K, Swamy VB, Kumar PA, Shekar DS, Manoj B, *et al*. Hepatoprotective and antioxidant activities of *Amaranthus viridis* Linn. Maced J Med Sci 2011;4:125-30.
39. Kumari S, Elancheran R, Devi R. Phytochemical screening, antioxidant, antityrosinase, and antigenotoxic potential of *Amaranthus viridis* extract. Indian J Pharmacol 2018;50:130-8.
40. Salvamani S, Gunasekaran B, Shukor MY, Shaharuddin NA, Sabullah MK, Ahmad SA. Anti-HMG-CoA reductase, antioxidant, and anti-inflammatory activities of *Amaranthus viridis* leaf extract as a potential treatment for hypercholesterolemia. Evid Based Complement Altern Med 2016;2016:8090841.
41. Saravanan G, Ponmurugan P, Sathiyavathi M, Vadivukkarasi S, Sengottuvelu S. Cardioprotective activity of *Amaranthus viridis* Linn: Effect on serum marker enzymes, cardiac troponin and antioxidant system in experimental myocardial infarcted rats. Int J Cardiol 2013;165:494-8.
42. Sarker U, Oba S. Nutrients, minerals, pigments, phytochemicals, and radical scavenging activity in *Amaranthus blitum* leafy vegetables. Sci Rep 2020;10:1-9.
43. Bahorun T, Luximon-Ramma A, Crozier A, Aruoma OI. Total phenol, flavonoid, proanthocyanidin and Vitamin C levels and antioxidant activities of Mauritian vegetables. J Sci Food Agric 2004;84:1553-61.
44. Gomaa EZ. Antimicrobial, antioxidant and antitumor activities of silver nanoparticles synthesized by *Allium cepa* extract: A green approach. J Genet Eng Biotechnol 2017;15:49-57.
45. Sekara A, Pokluda R, Del Vacchio L, Somma S, Caruso G. Interactions among genotype, environment and agronomic practices on production and quality of storage onion (*Allium cepa* L.) a review. Hortic Sci 2017;44:21-42.
46. Vazquez-Armenta FJ, Cruz-Valenzuela MR, Ayala-Zavala JF. Onion (*Allium cepa*) essential oils. In: Essential Oils in Food Preservation, Flavor and Safety. Cambridge, Massachusetts: Academic Press; 2016. p. 617-23.
47. Amarakoon S, Jayasekara D. A review on garlic (*Allium sativum* L.) as a functional food. J Pharmacogn Phytochem 2017;6:1777-80.
48. Gurib-Fakim A. Medicinal Plants of Mauritius and of the World. Mauritius: A. Gurib Fakim; 2007.
49. Martins N, Petropoulos S, Ferreira IC. Chemical composition and bioactive compounds of garlic (*Allium sativum* L.) as affected by pre- and post-harvest conditions: A review. Food Chem 2016;211:41-50.
50. Nurwantoro, Bintoro VP, Legowo AM, Purnomoadi A, Setiani BE. Garlic antioxidant (*Allium sativum* L.) to prevent meat rancidity. Proc Food Sci 2015;3:137-41.
51. Shang A, Cao SY, Xu XY, Gan RY, Tang GY, Corke H, *et al*. Bioactive compounds and biological functions of garlic (*Allium sativum* L.). Foods 2019;8:1-31.
52. Abbasi AM, Liu F, Guo X, Fu X, Li T, Liu RH. Phytochemical composition, cellular antioxidant capacity and antiproliferative activity in mango (*Mangifera indica* L.) pulp and peel. Int J Food Sci Technol 2017;52:817-26.
53. Maldonado-Celis ME, Yahia EM, Bedoya R, Landázuri P, Loango N, Aguillón J, *et al*. Chemical composition of mango (*Mangifera indica* L.) fruit: Nutritional and phytochemical compounds. Front Plant Sci 2019;10:1-21.
54. Reddeman RA, Glávits R, Endres JR, Clewell AE, Hirka G, Vértesi A, *et al*. A Toxicological evaluation of mango leaf extract (*Mangifera indica*) containing 60% Mangiferin. J Toxicol 2019;2019:4763015.
55. Al-Snafi PD. A review on chemical constituents and pharmacological activities of *Coriandrum sativum*. IOSR J Pharm 2016;6:17-42.
56. Asgarpanah J, Kazemivash N. Phytochemistry, pharmacology and medicinal properties of *Coriandrum sativum* L. Afr J Pharm Pharmacol 2012;6:2340-5.
57. Wei JN, Liu ZH, Zhao YP, Zhao LL, Xue TK, Lan QK. Phytochemical and bioactive profile of *Coriandrum sativum* L.

Food Chem 2019;286:260-7.
58. Ahmad T, Cawood M, Iqbal Q, Ariño A, Batool A, Tariq RM, *et al*. Phytochemicals in *Daucus carota* and their health benefits review article. Foods 2019;8:424.
59. Sharma KD, Karki S, Thakur NS, Attri S. Chemical composition, functional properties and processing of carrot a review. J Food Sci Technol 2012;49:22-32.
60. DebMandal M, Mandal S. Coconut (*Cocos nucifera* L.: *Arecaceae*): In health promotion and disease prevention. Asian Pac J Trop Med 2011;4:241-7.
61. Lima EB, Sousa CN, Meneses LN, Ximenes NC, Santos MA Jr., Vasconcelos GS, *et al*. *Cocos nucifera* (L.) (*Aceraceae*): A phytochemical and pharmacological review. Braz J Med Biol Res 2015;48:953-64.
62. Guriya R, Moon A, Talreja K. Phytochemical profiling and characterization of bioactive compounds from *Brassica oleracea*. Int J Pharmacogn Phytochem Res 2015;7:825-31.
63. Le TN, Chiu C, Hsieh P. Bioactive compounds and bioactivities of *Brassica oleracea* L. var. *italica* sprouts and microgreens: An updated overview from a nutraceutical perspective. Plants 2020;9:946.
64. Ahn M, Kim J, Hong S, Kim J, Ko H, Lee NH, *et al*. Black radish (*Raphanus sativus* L. var. *niger*) extract mediates its hepatoprotective effect on carbon tetrachloride-induced hepatic injury by attenuating oxidative stress. J Med Food 2018;21:866-75.
65. Castro-Torres IG, de la O-Arciniega M, Gallegos-Estudillo J, Naranjo-Rodríguez EB, Domínguez-Ortíz MÁ. *Raphanus sativus* L. var *niger* as a source of phytochemicals for the prevention of cholesterol gallstones. Phytother Res 2014;28:167-71.
66. Lugasi A, Blázovics A, Hagymási K, Kocsis I, Kéry Á. Antioxidant effect of squeezed juice from black radish (*Raphanus sativus* L. var *niger*) in alimentary hyperlipidaemia in rats. Phytother Res 2005;19:587-91.
67. Das G, Patra JK, Debnath T, Ansari A, Shin HS. Investigation of antioxidant, antibacterial, antidiabetic, and cytotoxicity potential of silver nanoparticles synthesized using the outer peel extract of *Ananas comosus* (L.). PLoS One 2019;14:1-19.
68. Dutta S, Bhattacharyya D. Enzymatic, antimicrobial and toxicity studies of the aqueous extract of *Ananas comosus* (pineapple) crown leaf. J Ethnopharmacol 2013;150:451-7.
69. Cornara L, Xiao J, Smeriglio A, Trombetta D, Burlando B. Emerging exotic fruits: New functional foods in the European market. EFood 2020;1:126-39.
70. Ibrahim SR, Mohamed GA, Khedr AI, Zayed MF, El-Kholy AA. Genus *Hylocereus*: Beneficial phytochemicals, nutritional importance, and biological relevance a review. J Food Biochem 2018;42:1-29.
71. Ritarwan K, Nerdy N. Antibacterial activity of red dragon fruit leaves extract and white dragon fruit leaves extract against meningitis bacterial. Orient J Chem 2018;34:2534-8.
72. Poolsup N, Suksomboon N, Kurnianta PD, Deawjaroen K. Effect of dragon fruit on glycemic control in prediabetes and Type 2 diabetes: A systematic review and meta-analysis PLoS One 2017;14:1-12.
73. Rahmani AH. *Cassia fistula* Linn: Potential candidate in the health management Pharmacogn Res 2015;7:217-24.
74. Jothy SL, Zakaria Z, Chen Y, Lau YL, Latha LY, Sasidharan S. Acute oral toxicity of methanolic seed extract of *Cassia fistula* in mice. Molecules 2011;16:5268-82.
75. Kaur M, Talniya NC, Sahrawat S, Kumar A, Stashenko EE. Ethnomedicinal uses, phytochemistry and pharmacology of *Carica papaya* plant: A compendious review. Mini Rev Org Chem 2018;16:463-80.
76. Somanah J, Bourdon E, Rondeau P, Bahorun T, Aruoma OI. Relationship between fermented papaya preparation supplementation, erythrocyte integrity and antioxidant status in pre-diabetics. Food Chem Toxicol 2014;65:12-7.
77. Somanah J, Putteeraj M, Aruoma OI, Bahorun T. Discovering the health promoting potential of fermented papaya preparation its future perspectives for the dietary management of oxidative stress during diabetes. Fermentation 2018;4:83.
78. Bhagea R, Bhoyroo V, Puchooa D. Microalgae: The next best alternative to fossil fuels after biomass. A review. Microbiol Res 2019;10:7936.
79. Koyande AK, Chew KW, Rambabu K, Tao Y, Chu DT, Show PL. Microalgae: A potential alternative to health supplementation for humans. Food Sci Hum Wellness 2019;8:16-24.
80. Prabakarana G, Moovendhana M, Arumugam AM, Sampathkumar P. Quantitative analysis of phytochemical profile in marine microalgae *Chlorella vulgaris*. Int J Pharm Biol Sci 2018;2:562-5.
81. Safi C, Zebib B, Merah O, Pontalier PY, Vaca-Garcia C. Morphology, composition, production, processing and applications of *Chlorella vulgaris*: A review. Renew Sustain Energy Rev 2014;35:265-78.
82. Manigauha A, Kharya MD, Ganesh N. *In vivo* antitumor potential of *Ipomoea pes-caprae* on melanoma cancer. Pharmacogn Mag 2015;11:426-33.
83. Adelani-Akande TA, Ajiba LC, Dahunsi SO, Oluyori AP. Antibacterial activity of watermelon (*Citrullus lanatus*) seed against selected microorganisms. Afr J Biotechnol 2015;14:1224-9.
84. Imafidon KE, Abu OD, Obayuwana HO, Okuofu ED. Phytochemical, proximate, and metal content analysis of *Citrullus lanatus* (watermelon) seed. FUDMA J Sci 2018;2:153-6.
85. Kulczynski B, Gramza-Michałowska A. The profile of secondary metabolites and other bioactive compounds in *Cucurbita pepo* L. and *Cucurbita moschata* pumpkin cultivars. Molecules 2019;24:1-22.
86. Montesano D, Blasi F, Simonetti MS, Santini A, Cossignani L. Chemical and nutritional characterization of seed oil from *Cucurbita maxima* L. (Var. *berrettina*) pumpkin. Foods 2018;7:30.
87. Rajasree RS, Sibi PI, Francis F, William H. Phytochemicals of *Cucurbitaceae* family a review. Int J Pharmacogn Phytochem Res 2016;8:113-23.
88. Salehi B, Capanoglu E, Adrar N, Catalkaya G, Shaheen S, Jaffer M, *et al*. Cucurbits plants: A key emphasis to its pharmacological potential. Molecules 2019;24:1854.
89. Yadav M, Jain S, Tomar R, Prasad GB, Yadav H. Medicinal and biological potential of pumpkin: An updated review. Nutr Res Rev 2010;23:184-90.
90. Bilal A, Jahan N, Ahmed A, Bilal SN, Habib S, Hajra S. Phytochemical and pharmacological studies on *Ocimum*

basilicum Linn a review. Int J Curr Res Rev 2012;4:73-83.
91. Ch M, Naz S, Sharif A, Akram M, Saeed M. Biological and pharmacological properties of the sweet basil (*Ocimum basilicum*). Br J Pharm Res 2015;7:330-9.
92. Andrade JM, Faustino C, García C, Ladeiras D, Reis CP, Rijo P. *Rosmarinus officinalis* L.: An update review of its phytochemistry and biological activity. Future Sci 2018;4:FSO283.
93. Borrás-Linares I, Stojanović Z, Quirantes-Piné R, Arráez-Román D, Švarc-Gajić J, Fernández-Gutiérrez A, Segura-Carretero A. *Rosmarinus officinalis* leaves as a natural source of bioactive compounds. Int J Mol Sci2014;15:20585-606.
94. Bozin B, Mimica-Dukic N, Samojlik I, Jovin E. Antimicrobial and antioxidant properties of rosemary and sage (*Rosmarinus officinalis* L. and *Salvia officinalis* L., *Lamiaceae*) essential oils. J Agric Food Chem 2007;55:7879-85.
95. Mena P, Cirlini M, Tassotti M, Herrlinger KA, Dall'Asta C, Del Rio D. Phytochemical profiling of flavonoids, phenolic acids, terpenoids, and volatile fraction of a rosemary (*Rosmarinus officinalis* L.) extract. Molecules 2016;21:1-15.
96. Moore J, Yousef M, Tsiani E. Anticancer effects of rosemary (*Rosmarinus officinalis* L.) extract and rosemary extract polyphenols. Nutrients 2016;8:731.
97. De Oliveira JR, Camargo SE, De Oliveira LD. *Rosmarinus officinalis* L. (rosemary) as therapeutic and prophylactic agent. J Biomed Sci 2019;26:5.
98. Petiwala SM, Johnson JJ. Diterpenes from rosemary (*Rosmarinus officinalis*): Defining their potential for anti-cancer activity. Cancer Lett 2015;367:93-102.
99. Rosemary SB. Handbook of Herbs and Spices. 2nd ed., Vol. 1.Sawston, United Kingdom:Woodhead Publishing Limited;2012. p. 452-68.
100. Dabas D, Shegog R, Ziegler G, Lambert J. Avocado (*Persea americana*) seed as a source of bioactive phytochemicals. Curr Pharm Des 2013;19:6133-40.
101. Dreher ML, Davenport AJ. Hass avocado composition and potential health effects. Crit Rev Food Sci Nutr 2013;53:738-50.
102. Ngbolua KN. A mini-review on the phytochemistry and pharmacology of the medicinal plant species *Persea americana* Mill. (*Lauraceae*). Discov Phytomed 2019;6:102-11.
103. Padilla-Camberos E, Martínez-Velázquez M, Flores-Fernández JM, Villanueva-Rodríguez S. Acute toxicity and genotoxic activity of avocado seed extract (*Persea americana* Mill., c.v. Hass). Sci World J 2013;2013:18-23.
104. Vo TS, Le Uyen P, Ngo DH. Free radical scavenging and anti-proliferative activities of avocado (*Persea americana* Mill.) seed extract. Asian Pac J Trop Biomed 2019;9:91-7.
105. Yasir M, Das S, Kharya M. The phytochemical and pharmacological profile of *Persea americana* Mill. Pharmacogn Rev 2010;4:77-84.
106. Ahmad A, Ahmad W, Zeenat F, Sajid M. Therapeutic, phytochemistry and pharmacology of *Tamarindus indica*: A review. Int J Unani Integr Med 2018;2:14-9.
107. Escalona-Arranz JC, Garcia-Diaz J, Perez-Rosés R, De La Vega J, Rodríguez-Amado J, Morris-Quevedo HJ. Effect of *Tamarindus indica* L. leaves' fluid extract on human blood cells. Nat Prod Res 2014;28:1485-8.
108. Iskandar I, Setiawan F, Sasongko LD, Adnyana IK. Six-month chronic toxicity study of tamarind pulp (*Tamarindus indica* L.) water extract. Sci Pharm 2017;85:10.
109. Jacinto AM. Review of the phytochemical, pharmacological and toxicological properties of *Punica granatum* L., (*Lythraceae*) Plant. Int J Food Sci Agric 2018;2:45-56.
110. Jahromi SB, Pourshafie MR, Mirabzadeh E, Tavasoli A, Katiraee F, Mostafavi E, *et al*. *Punica granatum* peel extract toxicity in mice. Jundishapur J Nat Pharm Prod 2015;10:e23770.
111. Ramlagan P, Rondeau P, Planesse C, Neergheen-Bhujun VS, Fawdar S, Bourdon E, *et al*. *Punica granatum* L. mesocarp suppresses advanced glycation end products (AGEs) and H_2O_2-induced oxidative stress and pro-inflammatory biomarkers. J Functional Foods 2017a;29:115-26.
112. Singh B, Singh JP, Kaur A, Singh N. Phenolic compounds as beneficial phytochemicals in pomegranate (*Punica granatum* L.) peel: A review. Food Chem 2018;261:75-86.
113. Vidal A, Fallarero A, Peña BR, Medina ME, Gra B, Rivera F, *et al*. Studies on the toxicity of *Punica granatum* L. (*Punicaceae*) whole fruit extracts. J Ethnopharmacol 2003;89:295-300.
114. Bawa SH, Badrie N. Nutrient profile, bioactive components, and functional properties of okra (*Abelmoschus esculentus* (L.) Moench). In: Fruits, Vegetables, and Herbs: Bioactive Foods in Health Promotion. Amsterdam, Netherlands: Elsevier Inc.; 2016.
115. Das S, Nandi G, Gosh LK. Okra and its various applications in drug delivery, food technology, health care and pharmacological aspects a review. J Pharm Sci Res 2019;11:2139-47.
116. Liao Z, Zhang J, Wang J, Yan T, Xu F, Wu B, *et al*. The anti-nephritic activity of a polysaccharide from okra (*Abelmoschus esculentus* (L.) Moench) via modulation of AMPK-Sirt1-PGC-1α signaling axis mediated anti-oxidative in Type 2 diabetes model mice. Int J Biol Macromol 2019;140:568-76.
117. Al-Dhabi NA, Arasu MV. Quantification of Phytochemicals from commercial *Spirulina* products and their antioxidant activities. Evid Based Complement Altern Med 2016;2016:7631864.
118. Finamore A, Palmery M, Bensehaila S, Peluso I. Antioxidant, immunomodulating, and microbial-modulating activities of the sustainable and ecofriendly *Spirulina*. Oxid Med Cell Longev 2017;2017:3247528.
119. Hutadilok-Towatana N, Reanmongkol W, Panichayupakaranant P. Evaluation of the toxicity of *Arthrospira* (*Spirulina*) *platensis* extract. J Appl Phycol 2010;22:599-605.
120. Wollina U, Voicu C, Gianfaldoni S, Lotti T, França K, Tchernev G. *Arthrospira platensis* potential in dermatology and beyond. Open Access Maced J Med Sci 2018;6:176-80.
121. Asare GA, Gyan B, Bugyei K, Adjei S, Mahama R, Addo P, *et al*. Toxicity potentials of the nutraceutical *Moringa oleifera* at supra-supplementation levels. J Ethnopharmacol 2012;139:265-72.
122. Bhattacharya A, Tiwari P, Sahu PK, Kumar S. A review of the phytochemical and pharmacological characteristics of *Moringa oleifera*. J Pharm Bioallied Sci 2018;10:181-91.
123. Oyeyinka AT, Oyeyinka SA. *Moringa oleifera* as a food fortificant: Recent trends and prospects. J Saudi Soc Agric Sci

2018;17:127-36.
124. Mathew NS, Negi PS. Traditional uses, phytochemistry and pharmacology of wild banana (*Musa acuminata* Colla): A review. J Ethnopharmacol 2017;196:124-40.
125. Ortiz L, Dorta E, Lobo MG, González-Mendoza LA, Díaz C, González M. Use of banana (*Musa acuminata* Colla AAA) peel extract as an antioxidant source in orange juices. Plant Foods Hum Nutr 2017;72:60-6.
126. Dacoreggio MV, Moroni LS, Kempka AP. Antioxidant, antimicrobial and allelopathic activities and surface disinfection of the extract of *Psidium cattleianum* sabine leaves. Biocatal Agric Biotechnol 2019;21:101295.
127. Faleiro JH, Gonçalves RC, dos Santos MN, da Silva DP, Naves PL, Malafaia G. The chemical featuring, toxicity, and antimicrobial activity of *Psidium cattleianum* (*Myrtaceae*) leaves. New J Sci 2016a;2016:7538613.
128. Faleiro JH, Gonçalves RC, Naves PL, dos Santos MN, Celestino SM, Malafaia G. Pharmacognostic characterization, bioactive compounds and powder antioxidant action of leaves of Araca (*Psidium cattleianum Myrtaceae*). Gen Med 2016b;4:1-6.
129. Luximon-Ramma A, Bahorun T, Crozier A. Antioxidant actions and phenolic and Vitamin C contents of common Mauritian exotic fruits. J Sci Food Agric 2003;83:496-502.
130. Medina AL, Haas LI, Chaves FC, Salvador M, Zambiazi RC, Da Silva WP, *et al*. Araçá (*Psidium cattleianum* Sabine) fruit extracts with antioxidant and antimicrobial activities and antiproliferative effect on human cancer cells. Food Chem 2011;128:916-22.
131. dos Santos Pereira E, Vinholes J, Franzon RC, Dalmazo G, Vizzotto M, Nora L. *Psidium cattleianum* fruits: A review on its composition and bioactivity. Food Chem 2018;258:95-103.
132. Gutiérrez RM, Mitchell S, Solis RV. *Psidium guajava*: A review of its traditional uses, phytochemistry and pharmacology. J Ethnopharmacol 2008;117:1-27.
133. Ngbolua JP. A review on the phytochemistry and pharmacology of *Psidium guajava* L. (*Myrtaceae*) and future direction. Discov Phytomed 2018;5:7-13.
134. Nagori K, Singh MK, Alexander A, Kumar T, Dewangan D, Badwaik H, *et al*. *Piper betle* L.: A review on its ethnobotany, phytochemistry, pharmacological profile and profiling by new hyphenated technique DART-MS (direct analysis in real time mass spectrometry). J Pharm Res 2011;4:2991-7.
135. Boukhatem MN, Ferhat MA, Kameli A, Saidi F, Kebir HT. Lemon grass (*Cymbopogon citratus*) essential oil as a potent anti-inflammatory and antifungal drugs. Libyan J Med 2014;9:25431.
136. Ekpenyong CE, Akpan E, Nyoh A. Ethnopharmacology, phytochemistry, and biological activities of *Cymbopogon citratus* (DC.) Stapf extracts. Chin J Nat Med 2015;13:321-37
137. Haque AN, Remadevi R, Naebe M. Lemongrass (*Cymbopogon citratus*): A review on its structure, properties, applications and recent developments. Cellulose 2018;25:5455-77.
138. Shah G, Shri R, Panchal V, Sharma N, Singh B, Mann AS. Scientific basis for the therapeutic use of *Cymbopogon citratus*, stapf (Lemon grass). J Adv Pharm Technol Res 2011;2:3-8.
139. Annapurna A, Vishala TC, Bitra VR, Rapaka D, Shaik A. Cerebroprotective actions of *Triticum aestivum* Linn powder and *Bauhinia purpurea* flower powder in surgically induced cerebral infraction in rats. Pharmacogn Mag 2018;13:S737-41.
140. Qamar A, Saeed F, Tahir-Nadeem M, Hussain AI, Niaz B, Khan AU, *et al*. Exploring the phytochemical profile of green grasses with special reference to antioxidant properties. Int J Food Prop 2018;21:2566-77.
141. Runjala S, Murthy YL. Product development with wheat grass and nutrient analysis. Int J Sci Res 2016;5:633-45.
142. Suriyavathana M, Roopavathi I, Vijayan V. Phytochemical characterization of *Triticum aestivum* (Wheat Grass). J Pharmacogn Phytochem 2016;5:283-6.
143. Tsai CC, Lin CR, Tsai HY, Chen CJ, Li WT, Yu HM, *et al*. The immunologically active oligosaccharides isolated from wheatgrass modulate monocytes via toll-like receptor-2 signaling. J Biol Chem 2013;288:17689-97.
144. Bolling BW, Mckay DL, Blumberg JB. The phytochemical composition and antioxidant actions of tree nuts. Asian Pac J Clin Nutr 2016;19:117-23.
145. Garg ML, Blake RJ, Wills RB, Clayton EH. Macadamia nut consumption modulates favourably risk factors for coronary artery disease in hypercholesterolemic subjects. Lipids 2007;42:583-7.
146. Cazzola R, Garziano M, Porta MD, Loreggian L, Cestaro B. First insights of macadamia nut oil as dietary fat potential health benefits. Agro Food Ind Hitech 2018;29:18-20.
147. Rengel A, Pérez E, Piombo G, Ricci J, Servent A, Tapia MS, *et al*. Lipid profile and antioxidant activity of macadamia nuts (*Macadamia integrifolia*) cultivated in Venezuela. Nat Sci 2015;7:535-47.
148. Assi RA, Darwis Y, Abdulbaqi IM, Khan AA, Vuanghao L, Laghari MH. *Morinda citrifolia* (Noni): A comprehensive review on its industrial uses, pharmacological activities, and clinical trials. Arab J Chem 2017;10:691-707.
149. Almeida ÉS, de Oliveira D, Hotza D. Properties and applications of *Morinda citrifolia* (Noni): A review. Compr Rev Food Sci Food Saf 2019;18: 883-909.
150. Jugreet BS, Mahomoodally MF, Sinan KI, Zengin G, Abdallah HH. Chemical variability, pharmacological potential, multivariate and molecular docking analyses of essential oils obtained from four medicinal plants. Ind Crops Prod 2020;150:112394.
151. Veerappan A, Miyazaki S, Kadarkaraisamy M, Ranganathan D. Acute and subacute toxicity studies of *Aegle marmelos* Corr., an Indian medicinal plant. Phytomedicine 2007;14:209-215.
152. Verma S, Bahorun T, Singh RK, Aruoma OI, Kumar A. Effect of *Aegle marmelos* leaf extract on N-methyl N-nitrosourea-induced hepatocarcinogensis in Balb/c mice. Pharm Biol 2013;51:1272-81.
153. Amorim JL, Simas DL, Pinheiro MM, Moreno DS, Alviano CS, Da Silva AJ, *et al*. Anti-inflammatory properties and chemical characterization of the essential oils of four *Citrus* species. PLoS One 2016;11:1-18.
154. Dosoky NS, Setzer WN. Biological activities and safety of *Citrus* spp. Essential oils. Int J Mol Sci 2018;19:1-25.
155. Narang N, Jiraungkoorskul W. Anticancer activity of key lime, *Citrus aurantifolia*. Pharmacogn Rev 2016;10:118-22.
156. Oboh G, Bello FO, Ademosun AO, Akinyemi AJ, Adewuni TM. Antioxidant, hypolipidemic, and anti-angiotensin-1-converting enzyme properties of lemon (*Citrus limon*) and lime (*Citrus*

aurantifolia) juices. Comp Clin Pathol 2015;24:1395-406.
157. Aruoma OI, Landes B, Ramful-Baboolall D, Bourdon E, Neergheen-Bhujun V, Wagner KH, *et al*. Functional benefits of citrus fruits in the management of diabetes. Prev Med 2012;54:S12-6.
158. Favela-Hernández JM, González-Santiago O, Ramírez-Cabrera MA, Esquivel-Ferriño PC, Camacho-Corona MD. Chemistry and pharmacology of *Citrus sinensis*. Molecules 2016;21:247.
159. Ibrahim SR, Mohamed GA. *Litchi chinensis*: Medicinal uses, phytochemistry, and pharmacology. J Ethnopharmacol 2015;174:492-513.
160. Dey A, Gomes A, Dasgupta SC. Black tea (*Camellia sinensis*) extract induced prenatal and postnatal toxicity in experimental albino rats. Pharmacogn Mag 2018;13:S769-74.
161. Sánchez M, González-Burgos E, Iglesias I, Lozano R, Gómez-Serranillos MP. The pharmacological activity of *Camellia sinensis* (L.) Kuntze on metabolic and endocrine disorders: A systematic review. Biomolecules 2020;10:603.
162. Bedrood Z, Rameshrad M, Hosseinzadeh H. Toxicological effects of *Camellia sinensis* (green tea): A review. Phytother Res 2018;32:1163-80.
163. Toolsee NA, Aruoma OI, Gunness TK, Kowlessur S, Dambala V, Murad F, *et al*. Effectiveness of green tea in a randomized human cohort: Relevance to diabetes and its complications. Biomed Res Int 2013;2013:412379.
164. Toolsee N, Aruoma O, Rondeau P, Bourdon E, Bahorun T. Modulatory effects of green tea on HEK-293 cell energy metabolism: implications in diabetic nephropathy. Arch Med Biomed Res 2015;1:156.
165. Vuong QV, Stathopoulos CE, Nguyen MH, Golding JB, Roach PD. Isolation of green tea catechins and their utilization in the food industry. Food Rev Int 2011;27:227-47.
166. Aouey B, Samet AM, Fetoui H, Simmonds MS, Bouaziz M. Anti-oxidant, anti-inflammatory, analgesic and antipyretic activities of grapevine leaf extract (*Vitis vinifera*) in mice and identification of its active constituents by LC-MS/MS analyses. Biomed Pharmacother 2016;84:1088-98.
167. Nassiri-Asl M, Hosseinzadeh H. Review of the pharmacological effects of *Vitis vinifera* (Grape) and its bioactive constituents: An update. Phytother Res 2016;30:1392-403.
168. Kumar G, Karthik L, Rao KV. A review on pharmacological and phytochemical properties of *Zingiber officinale* Roscoe (*Zingiberaceae*). J Pharm Res 2011;4:2963-6.
169. Corzo L, Fernández-Novoa L, Carrera I, Martínez O, Rodríguez S, Alejo R, *et al*. Nutrition, health, and disease: Role of selected marine and vegetal nutraceuticals. Nutrients 2020;12:747.
170. Rani NZ, Husain K, Kumolosasi E. *Moringa* genus: A review of phytochemistry and pharmacology. Front Pharmacol 2018;9:1-26.
171. Senthilkumar A, Karuvantevida N, Rastrelli L, Kurup SS, Cheruth AJ. Traditional uses, pharmacological efficacy, and phytochemistry of *Moringa peregrina* (Forssk.) Fiori. a review. Front Pharmacol 2018;9:1-17.
172. Gopalakrishnan L, Doriya K, Kumar DS. *Moringa oleifera*: A review on nutritive importance and its medicinal application. Food Sci Human Wellness 2016;5:49-56.
173. Baker K, Marcus CB, Huffman K, Kruk H, Malfroy B, Doctrow SR. Synthetic combined superoxide dismutase/catalase mimetics are protective as a delayed treatment in a rat stroke model: A key role for reactive oxygen species in ischemic brain injury. J Pharmacol Exp Ther 1998;284:215-21.
174. Mahajan GS, Mehta AA. Anti-arthritic activity of hydroalcoholic extract of flowers of *Moringa oleifera* Lam. in Wistar rats. J Herb Spices Med Plants 2009;15:149-63.
175. Divi SM, Bellamkonda R, Dasireddy SK. Evaluation of antidiabetic and antihyperlipedemic potential of aqueous extract of *Moringa oleifera* in fructose fed insulin resistant and STZ induced diabetic Wistar rats: A comparative study. Asian J Pharm Clin Res 2012;5:67-72.
176. Choudhary MK, Bodakhe SH, Gupta SK. Assessment of the antiulcer potential of *Moringa oleifera* root-bark extract in rats. J Acupunct Merid Stud 2013;6:214-20.
177. Sutalangka C, Wattanathorn J, Muchimapura S, Thukham-Mee W. *Moringa oleifera* mitigates memory impairment and neurodegeneration in animal model of age-related dementia. Oxid Med Cell Longev 2013;2013:695936.
178. Al-Malki AL, El Rabey HA. The antidiabetic effect of low doses of *Moringa oleifera* Lam. seeds on streptozotocin induced diabetes and diabetic nephropathy in male rats. Biomed Res Int 2015;2015:381040.
179. Hister CA, Boligon AA, Laughinghouse HD, Tedesco SB. Determination of phenolic compounds and assessment of the genotoxic and proliferative potential of *Psidium cattleianum* Sabine (*Myrtaceae*) fruits. Caryologia 2017;70:350-6.
180. Patel S. Exotic tropical plant *Psidium cattleianum*: A review on prospects and threats. Rev Environ Sci Biotechnol 2012;11:243-8.
181. Ramirez MR, Zanchin NI, Henriques AT, Zuanazzi JÂ. Study of the effects of *Psidium cattleyanum* on gene expression from senescent mouse hippocampus. Bol Latin Carib Plant Med Aromat 2012;11:127-37.
182. Castro MR, Victoria FN, Oliveira DH, Jacob RG, Savegnago L, Alves D. Essential oil of *Psidium cattleianum* leaves: Antioxidant and antifungal activity. Pharm Biol 2015;53:242-50.
183. Saran PL, Choudhary R. Drug bioavailability and traditional medicaments of commercially available papaya: A review. Afr J Agric Res 2013;8:3216-23.
184. Gunde MC, Amnerkar ND. Nutritional, medicinal and pharmacological properties of papaya (*Carica papaya* linn.): A review. J Innov Pharm Biol Sci 2016;3:162-9.
185. Gadge S, Game M, Salode V. Marvelous plant *Carica papaya* Linn: A herbal therapeutic option. Phytopathology 2020;9:629-33.
186. Somanah J, Bourdon E, Bahorun T. Extracts of Mauritian *Carica papaya* (var. solo) protect SW872 and HepG2 cells against hydrogen peroxide induced oxidative stress. J Food Sci Technol 2017;54:1917-27.
187. Liyongo CI, Ashande CM, Mawi CF, Wa Mbembo BM, Domondo JA, Matondang MI, *et al*. A mini-review on the phytochemistry and pharmacology of the plant *Carica papaya* L. (*Caricaceae*). Br Int Exact Sci J 2020;2:663-75.
188. Karunamoorthi K, Kim HM, Jegajeevanram K, Xavier J, Vijayalakshmi J. Papaya: A gifted nutraceutical plant a critical review of recent human health research. Tang Hum Med 2014;4:2.1-17.
189. Ikram EH, Stanley R, Netzel M, Fanning K. Phytochemicals of papaya and its traditional health and culinary uses a review. J Food Comp Anal 2015;41:201-11.

190. Aruoma OI, Hayashi Y, Marotta F, Mantello P, Rachmilewitz E, Montagnier L. Applications and bioefficacy of the functional food supplement fermented papaya preparation. Toxicology 2010;278:6-16.
191. Somanah J, Ramsaha S, Verma S, Kumar A, Sharma P, Singh R, *et al*. Fermented papaya preparation modulates the progression of N-methyl-N-nitrosourea induced hepatocellular carcinoma in Balb/c mice. Life Sci 2016;151:330-8.
192. Benatrehina PA, Pan L, Naman CB, Li J, Kinghorn AD. Usage, biological activity, and safety of selected botanical dietary supplements consumed in the United States. J Tradit Complement Med 2018;8:267-77.
193. ThyagaRajan S, Rethinam P, Pratap UP. Pharmacological properties and clinical applications of *Morinda citrifolia* L. Int J Noni Res 2015;10:1-18.
194. Issell BF, Gotay CC, Pagano I, Franke AA. Using quality of life measures in a phase I clinical trial of noni in patients with advanced cancer to select a phase II dose. J Dietary Suppl 2009;6:347-59.
195. Rummun N, Somanah J, Ramsaha S, Bahorun T, Neergheen-Bhujun VS. Bioactivity of nonedible parts of *Punica granatum* L.: A potential source of functional ingredients. Int J Food Sci 2013;2013:602312.
196. Bassiri-Jahromi S. *Punica granatum* (Pomegranate) activity in health promotion and cancer prevention. Oncol Rev 2018;12:1-7.
197. Bhowmik D, Gopinath H, Kumar BP, Duraivel S, Aravind G, Kumar KP. Medicinal uses of *Punica granatum* and its health benefits. J Pharmacogn Phytochem 2013;1:28-35.
198. Thangavelu A, Elavarasu S, Sundaram R, Kumar T, Rajendran D, Prem F. Ancient seed for modern cure pomegranate review of therapeutic applications in periodontics. J Pharm Bioallied Sci 2017;9:S11-4.
199. Sorrenti V, Randazzo CL, Caggia C, Ballistreri G, Romeo FV, Fabroni S, *et al*. Beneficial effects of pomegranate peel extract and probiotics on pre-adipocyte differentiation. Front Microbiol 2019;10:1-11.
200. Syed D, Chamcheu JC, Adhami V, Mukhtar H. Pomegranate extracts and cancer prevention: Molecular and cellular activities. Anti Cancer Agents Med Chem 2013;13:1149-61.
201. Asgary S, Javanmard S, Zarfeshany A. Potent health effects of pomegranate. Adv Biomed Res 2014;3:100.
202. Shema-Didi L, Sela S, Ore L, Shapiro G, Geron R, Moshe G, Kristal B. One year of pomegranate juice intake decreases oxidative stress, inflammation, and incidence of infections in haemodialysis patients: A randomized placebo-controlled trial. Free Radic Biol Med 2012;53:297-304.
203. Park JE, Kim JY, Kim J, Kim YJ, Kim MJ, Kwon SW, Kwon O. Pomegranate vinegar beverage reduces visceral fat accumulation in association with AMPK activation in overweight women: A double-blind, randomized, and placebo-controlled trial. J Funct Foods 2014;8:274-81.
204. Hosseini B, Saedisomeolia A, Wood LG, Yaseri M, Tavasoli S. Effects of pomegranate extract supplementation on inflammation in overweight and obese individuals: A randomized controlled clinical trial. Complement Ther Clin Pract 2016;22:44-50.
205. Sahebkar A, Ferri C, Giorgini P, Bo S, Nachtigal P, Grassi D. Effects of pomegranate juice on blood pressure: A systematic review and meta-analysis of randomized controlled trials. Pharmacol Res 2017;115:149-61.
206. Sohrab G, Ebrahimof S, Sotoudeh G, Neyestani TR, Angoorani P, Hedayati M, Siasi F. Effects of pomegranate juice consumption on oxidative stress in patients with Type 2 diabetes: A single-blind, randomized clinical trial. Int J Food Sci Nutr 2017;68:249-55.
207. Grabež M, Škrbić R, Stojiljković M, Rudić-Grujić V, Šavikin K, Menković N, *et al*. Beneficial effects of pomegranate peel extract treatment on anthropometry and body composition of overweight patients with diabetes mellitus Type-2: A randomised clinical trial. Script Med 2020;51:21-7.
208. Jafari T, Fallah AA, Bahrami M, Lorigooini Z. Effects of pomegranate peel extract and Vitamin E on oxidative stress and antioxidative capacity of haemodialysis patients: A randomized controlled clinical trial. J Funct Foods 2020;72:104069.
209. Johanningsmeier SD, Harris GK. Pomegranate as a functional food and nutraceutical source. Ann Rev Food Sci Technol 2011;2:181-201.
210. Arya N, Prakash O, Pant V. Anti-inflammatory and antipyretic activity of *Curcuma longa* L. collected from Uttarakhand. Int J Dev Res 2015;5:2914-7.
211. Manarin G, Anderson D, Silva JM, da Coppede JS, Roxo-Junior P, Pereira AM, *et al*. *Curcuma longa* L. ameliorates asthma control in children and adolescents: A randomized, double-blind, controlled trial. J Ethnopharmacol 2019;238:111882.
212. Hewlings S, Kalman D. Curcumin: A review of its effects on human health. Foods 2017;6:92.
213. Rahmani A, Alsahli M, Aly S, Khan M, Aldebasi Y. Role of curcumin in disease prevention and treatment. Adv Biomed Res 2018;7:38.
214. Sidhu GS, Singh AK, Thaloor D, Banaudha KK, Patnaik GK, Srimal RC, *et al*. Enhancement of wound healing by curcumin in animals. Wound Repair Regener 1998;6:167-77.
215. Ejaz A, Wu D, Kwan P, Meydani M. Curcumin inhibits adipogenesis in 3T3-L1 adipocytes and angiogenesis and obesity in C57/BL mice. J Nutr 2009;139:919-25.
216. Sumiyoshi M, Kimura Y. Effects of a turmeric extract (*Curcuma longa*) on chronic ultraviolet B irradiation-induced skin damage in melanin-possessing hairless mice. Phytomedicine 2009;16:1137-43.
217. Ye J, Zhang Y. Curcumin protects against intracellular amyloid toxicity in rat primary neurons. Int J Clin Exp Med 2011;5:44-9.
218. Olatunde A, Luca CD, Tijjani H, Obidola SM, Joel EB. Anti-diabetic activity of aqueous extract of *Curcuma longa* (Linn) rhizome in normal and alloxan-induced diabetic rats. Researcher 2014;6:58-65.
219. Jogdand S, Bhattacharjee J. Evaluation of analgesic activity of turmeric (*Curcuma longa* Linn.) in Wister rats. Int J Basic Clin Pharmacol 2017;6:568.
220. Savaringal JP, Lally MS. Anti-inflammatory effect of rhizome of *Curcuma longa*. Linn, in Albino rats by the method of Carrageenin induced paw oedema. Int J Basic Clin Pharmacol 2018;7:229.
221. Karamalakova YD, Nikolova GD, Georgiev TK, Gadjeva VG, Tolekova AN. Hepatoprotective properties of *Curcuma longa*

L. extract in bleomycin-induced chronic hepatotoxicity. Drug Discov Ther 2019;13:9-16.
222. Daily JW, Yang M, Park S. Efficacy of turmeric extracts and curcumin for alleviating the symptoms of joint arthritis: A systematic review and meta-analysis of randomized clinical trials. J Med Food 2016;19:717-29.
223. Zdrojewicz Z, Chorbińska J, Biezyński B, Krajewski P. Health-promoting properties of pineapple. Pediatr Med Rodz 2018;14:133-42.
224. Ali MM, Hashim N, Abd Aziz S, Lasekan O. Pineapple (*Ananas comosus*): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products. Food Res Int 2020;137:109675.
225. Chobotova K, Vernallis AB, Majid FA. Bromelain's activity and potential as an anti-cancer agent: Current evidence and perspectives. Cancer Lett 2010;290:148-56.
226. Rathnavelu V, Alitheen NB, Sohila S, Kanagesan S, Ramesh R. Potential role of bromelain in clinical and therapeutic applications (review). Biomed Rep 2016;5:283-8.
227. Lee JH, Lee JT, Park HR, Kim JB. The potential use of bromelain as a natural oral medicine having anticarcinogenic activities. Food Sci Nutr 2019;7:1656-67.
228. Brien S, Lewith G, Walker A, Hicks SM, Middleton D. Bromelain as a treatment for osteoarthritis: A review of clinical studies. Evid Based Complement Altern Med 2004;1:251-7.
229. Béez R, Lopes MT, Salas CE, Hernández M. *In vivo* antitumoral activity of stem pineapple (*Ananas comosus*) bromelain. Plant Med 2007;73:1377-83.
230. Pavan R, Jain S, Shraddha, Kumar A. Properties and therapeutic application of bromelain: A review. Biotechnol Res Int 2012;2012:976203.
231. Khan N, Mukhtar H. Tea and health: Studies in humans. Curr Pharm Des 2013;19:6141-7.
232. Prasanth MI, Sivamaruthi BS, Chaiyasut C, Tencomnao T. A review of the role of green tea (*Camellia sinensis*) in antiphotoaging, stress resistance, neuroprotection, and autophagy. Nutrients 2019;11:474.
233. Koch W, Zagórska J, Marzec Z, Kukula-Koch W. Applications of tea (*Camellia sinensis*) and its active constituents in cosmetics. Molecules 2019;24:1-28.
234. Chopade VV, Phatak AA, Upaganlawar AB, Tankar AA. Green tea (*Camellia sinensis*): Chemistry, traditional, medicinal uses and its pharmacological activities a review. Pharmacogn Rev 2008;2:157-62.
235. Patel S. Green tea as a nutraceutical: The latest developments. Food Sci Technol Res 2013;19:923-32.
236. Stallings AF, Lupo MP. Practical uses of botanicals in skin care. J Clin Aesthet Dermatol 2009;2:36-40.
237. Gianeti MD, Mercurio DG, Campos PM. The use of green tea extract in cosmetic formulations: Not only an antioxidant active ingredient. Dermatol Ther 2013;26:267-71.
238. Bodagh MN, Maleki I, Hekmatdoost A. Ginger in gastrointestinal disorders: A systematic review of clinical trials. Food Sci Nutr 2019;7:96-108.
239. Mao QQ, Xu XY, Cao SY, Gan RY, Corke H, Beta T, *et al*. Bioactive compounds and bioactivities of ginger (*Zingiber officinale* roscoe). Foods 2019;8:1-21.
240. de Lima RM, dos Reis AC, de Menezes AA, de Santos JV, de Filho JW, Ferreira JR, *et al*. Protective and therapeutic potential of ginger (*Zingiber officinale*) extract and [6]-gingerol in cancer: A comprehensive review. Phytother Res 2018;32:1885-907.
241. Sahardi NF, Makpol S. Ginger (*Zingiber officinale* Roscoe) in the prevention of ageing and degenerative diseases: Review of current evidence. Evid Based Complement Altern Med 2019;2019:5054395.
242. Anh NH, Kim SJ, Long NP, Min JE, Yoon YC, Lee EG, *et al*. Ginger on human health: A comprehensive controlled trials. Nutrients 2020;12:1-28.
243. dos Tramontin NS, Luciano TF, de Marques SO, de Souza CT, Muller AP. Ginger and avocado as nutraceuticals for obesity and its comorbidities. Phytother Res 2020;34:1282-90.
244. Shoaib M, Shehzad A, Butt MS, Saeed M, Raza H, Niazi S, *et al*. An overview: Ginger, a tremendous herb. J Glob Innov Agric Soc Sci 2020;4:172-87.
245. Bidinotto LT, Costa CA, Salvadori DM, Costa M, Rodrigues MA, Barbisan LF. Protective effects of lemongrass (*Cymbopogon citratus* STAPF) essential oil on DNA damage and carcinogenesis in female Balb/C mice. J Appl Toxicol 2011;31:536-44.
246. Oladeji OS, Adelowo FE, Ayodele DT, Odelade KA. Phytochemistry and pharmacological activities of *Cymbopogon citratus*: A review. Sci Afr 2019;6:e00137.
247. Wright SC, Maree JE, Sibanyoni M. Treatment of oral thrush in HIV/AIDS patients with lemon juice and lemon grass (*Cymbopogon citratus*) and gentian violet. Phytomedicine 2009;16:118-24.
248. Devi RC, Sim SM, Ismail R. Effect of *Cymbopogon citratus* and citral on vascular smooth muscle of the isolated thoracic rat aorta. Evid Based Complement Altern Med 2012;2012:539475.
249. Bharti SK, Kumar A, Prakash O, Krishnan S, Gupta AK. Essential oil of *Cymbopogon citratus* against diabetes: Validation by *in vivo* experiments and computational studies. J Bioanal Biomed 2013;5:194-203.
250. Ademuyiwa AJ, Grace OK. The effects of *Cymbopogon citratus* (Lemon grass) on the antioxidant profiles wistar albino rats. Merit Res J Environ Sci Technol 2015;3:51-8.
251. Moorhead K, Capelli B. Spirulina Nature's Superfood. 3rd ed. Kailua-Kona, Hawaii: Cyanotech Corporation; 2011.
252. Saranraj P, Sivasakthi S. *Spirulina platensis* Food for future: A review. Asian J Pharm Sci Technol 2014;4:26-33.
253. Gutiérrez-Salmeán G, Fabila-Castillo L, Chamorro-Cevallos G. Nutritional and toxicological aspects of *Spirulina* (*Arthrospira*). Nutr Hosp 2015;32:34-40.
254. Ghaeni M, Roomiani L. Review for application and medicine effects of *Spirulina*, *Spirulina platensis* Microalgae. J Adv Agric Technol 2016;3:114-7.
255. Kiran BR, Mohan SV. Microalgal cell biofactory-therapeutic, nutraceutical and functional food applications. Plants 2021;10:836.
256. Ciferri O. *Spirulina*, the edible microorganism. Microbiol Rev 1983;47:551-78.
257. Raghavendran HR, Sathivel A, Rekha S. Gastric and hepatic protective effects of algal components. In: Functional Ingredients from Algae for Foods and Nutraceuticals. Sawston, United Kingdom: Woodhead Publishing Limited; 2013.
258. Spolaore P, Joannis-Cassan C, Duran E, Isambert A.

Commercial applications of microalgae. J Biosci Bioeng 2006;101:87-96.
259. Tabarsa M, Shin IS, Lee JH, Surayot U, Park WJ, You SG. An immune-enhancing water-soluble α-glucan from *Chlorella vulgaris* and structural characteristics. Food Sci Biotechnol 2015;24:1933-41.
260. Ariede MB, Candido TM, Jacome AL, Velasco MV, de Carvalho JC, Baby AR. Cosmetic attributes of algae a review. Algal Res 2017;25:483-7.
261. Lordan S, Ross RP, Stanton C. Marine bioactives as functional food ingredients: Potential to reduce the incidence of chronic diseases. Mar Drugs 2011;9:1056-100.
262. Suleria HA, Osborne S, Masci P, Gobe G. Marine-based nutraceuticals: An innovative trend in the food and supplement industries. Mar Drugs 2015;13:6336-51.
263. Šimat V, Elabed N, Kulawik P, Ceylan Z, Jamroz E, Yazgan H, *et al*. Recent advances in marine-based nutraceuticals and their health benefits. Mar Drugs 2020;18:1-40.
264. Lindequist U. Marine-derived pharmaceuticals challenges and opportunities. Biomol Ther 2016;24:561-71.
265. Martins A, Vieira H, Gaspar H, Santos S. Marketed marine natural products in the pharmaceutical and cosmeceutical industries: Tips for success. Mar Drugs 2014;12:1066-101.
266. Mukherjee PK, Harwansh RK, Bahadur S, Duraipandiyan V, Al-Dhabi NA. Factors to Consider in development of nutraceutical and dietary supplements. In Pharmacognosy: Fundamentals, Applications and Strategy. Amsterdam, Netherlands: Elsevier Inc.; 2017.
267. Furmaniak MA, Misztak AE, Franczuk MD, Wilmotte A, Waleron M, Waleron KF. Edible cyanobacterial genus *Arthrospira*: Actual state of the art in cultivation methods, genetics, and application in medicine. Front Microbiol 2017;8:2541.
268. Hong JW, Kim OH, Jo SW, Kim H, Jeong MR, Park KM, Lee KI, *et al*. Biochemical composition of a Korean domestic microalga *Chlorella vulgaris* KNUA027. Microbiol Biotechnol Lett 2016;44:400-7.

How to cite this article: Ramjane H, Bahorun T, Ramasawmy B, Ramful-Baboolall D, Boodia N, Aruoma OI, *et al*. Exploration of the Potential of Terrestrial and Marine Biodiversity for the Development of Local Nutraceutical Products: A Case for Mauritius. Am J Biopharm Pharm Sci 2021;1:3.