

Profiling Bioactive Compounds and Key Nutrients in Pacific Island Crops and Marine Resources



Promoting Nutritious Food Systems
in the Pacific Islands





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Leveraging the Development of Local Food Crops and Fisheries Value Chains for Improved Nutrition and Sustainable Food Systems in the Pacific Islands with a focus on Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu.

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Executive summary

Traditionally, Pacific Islanders depended on crop production and fishing to sustain their daily diets and livelihoods. In recent years, Pacific consumers have become increasingly reliant on non-traditional and processed foods; which are often nutritionally poor, and high in fats, salts and sugars, which negatively impact Food and Nutrition Security (FNS). There is a rich biodiversity of terrestrial and marine organisms in the Pacific Island countries (PICs), many of which are yet to be fully studied and utilised for the bioactive compounds and health or nutritional value. Traditional local food crops and seafood that can contribute towards improving the health and nutrition situation and provide new income generation opportunities for local communities are underutilised.

This report gives insights into the current status of knowledge on composition of key nutrients and bioactive compounds, known or associated with traditional crops and seafood consumed in seven Pacific Island countries, namely Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu. Information was initially gathered through guided interviews with traditional knowledge experts. Based on their responses and a systematic literature review of 433 scientific articles, a total of 75 crops and marine resources were identified as commonly consumed and/or having health and nutrition benefits or foods which could be better used in the daily diets. Traditional leaders also gave reasons for declining consumption and limited utilisation of traditional foods. These included loss of traditional varieties, e.g. breadfruit and yam; loss of traditional knowledge on edible plants and seaweed from the wild, and lack of awareness on nutritional value and health benefits.

Breadfruit is a traditional nutrient-dense staple food in the Pacific. It is high in complex carbohydrate (fibre), low in fat and cholesterol and is gluten free. In order to increase availability when not in season, it can be processed (e.g. flour, slices (dried/baked/frozen)) to provide new income generation opportunities for local communities.



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For the fisheries and seafood sector there is scope for more sustainable management of resources, as stocks e.g. of sea cucumbers (*bêche-de-mer*) are dwindling due to overexploitation and climate change. Seaweeds are a relatively inexpensive source of protein, vitamins and minerals and contain bioactive compounds. However, more research is needed on the bioactive principles and associated health benefits of Pacific seaweed varieties and protocols should be developed for value added products for local consumption and for export markets. Some species e.g. sea cucumbers and shellfish could also be better targeted for development through aquaculture.

Leguminous food crops and green leafy vegetables such as drumstick leaves, water spinach, and leaves of some root crops e.g. cassava and taro leaves, as well as fruits such as soursop and star fruit are nutritious and contain a number of bioactive compounds but remain underutilised and not part of a diversified diet of the Pacific Islanders. There is scope for further research on optimum production and postharvest handling systems to retain the health benefit (bioactive properties) and nutritional value and to enhance the agribusiness and market potential.

Traditional knowledge of Pacific Islanders needs to be better harnessed and integrated with modern scientific knowledge to address the nutritional and health problems. The academic and research community need to provide the scientific evidence to validate the health and nutritional benefits and support Pacific communities in making more informed decisions. The consumption of local green leafy vegetables, fruits and leguminous crops as well as seaweeds and sea cucumbers need to be better promoted and their use encouraged. Affordability and consistent supply of these foods, which were identified as barriers to their uptake, could be improved.

Overall, there is a need for greater collaborative research between governmental (Ministries of Agriculture, Ministries of Health), non-governmental and research and academic organisations, and local communities in Pacific Island countries to further develop crops and marine resources which are nutritious and also have bioactive compounds with health benefits e.g. anticancer, antidiabetic and cholesterol lowering.

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Introduction

The Pacific covers a total land area of just over 10 000 square kilometres with hundreds of small islands and archipelagos, surrounded by the vast Pacific Ocean [1]. The Pacific islands can be categorised into three major island groups: Polynesia, Melanesia, and Micronesia. Polynesia consists of American Samoa, Cook Islands, Easter Island, French Polynesia, Niue, Norfolk Island, Pitcairn Island, Samoa, Tokelau, Tonga, Tuvalu, Wallis and Futuna; Melanesia consists of Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu; and Micronesia consists of Federated States of Micronesia, Guam, Kiribati, Marshall Islands, Nauru, Northern Mariana Islands, Palau [2]. Although small in total land area, these islands are large ocean states, rich in biodiversity (both terrestrial and marine) and have diverse cultures and traditions [3, 4].

Traditionally, Pacific Islanders depended on crop production and fishing to sustain their daily diets and livelihoods. Traditional food crops widely consumed in the Pacific Islands include: taro (*Colocasia esculenta*), giant taro (*Alocasia macrorrhiza*), swamp taro (*Cyrtosperma chamissonis*), yam (*Dioscorea spp.*), sweet potato (*Ipomoea batatas*), arrowroot (*Tacca leotopetaloides*), breadfruit (*Artocarpus altilis*), coconut (*Cocos nucifera*), sago (*Metroxylon spp.*), banana (*Musa spp.*), pandanus (*Pandanus tectorius*), kava (*Piper methysticum*), mountain apple (*Melanesia syzigium*) and a range of other crops. In addition to crops, traditional diets also include a variety of seafood including fish, shellfish (Mollusca), sea cucumbers and sea urchins (Echinoderms) and edible seaweed (Algae).

In recent years, Pacific Islanders have become increasingly reliant on non-traditional and processed foods, which are often nutritionally poor, and high in fats, salts and sugars [5]. As a result, the Food and Nutrition Security (FNS) of many Pacific Islanders is threatened [6, 7]. Many of the small developing Pacific Island Countries have very high rates of non-communicable diseases (NCDs) with increasing number of health problems such as obesity, diabetes and high-blood pressure among its people [5, 8]. The FNS of Pacific Islanders is further exacerbated by declining agricultural productivity and declining marine resources, which makes it challenging for many low income households to afford nutritionally balanced diets [9]. Over 20% of Pacific Islanders are living in hardship and are unable to meet basic needs [10].

One of the strategies for addressing FNS in the Pacific is to identify locally available food crops and marine resources, which have high nutritional value. Globally, eating healthy foods offers a practical approach to meeting the nutritional requirements and at the same time reducing the risk factors for diseases [11-14]. Although the concept is gaining popularity recently, traditionally there have always been strong links between food and human health [15, 16]. Globally there is increasing recognition of the importance of local indigenous crops in meeting the nutritional needs of people [17]. Functional foods can have nutritional value (directly providing macro and micronutrients needed by human body) or offer health benefits due to presence of bioactive compounds [18, 19]. Traditionally, Pacific Islanders have used a number of plant and marine sources as medicine [20, 21]. However, their role as functional foods is poorly documented and few studies have been carried out on the nutritional value or availability of bioactive compounds in food and marine resources from the Pacific Islands [22-25].



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Local green leafy vegetables like taro leaves are nutritious and contain a number of bioactive compounds that have associated health benefits such as preventing or managing some non-communicable diseases e.g. diabetes but Pacific Islanders are not eating enough vegetables. There is scope for further research to quantify and validate the bioactive composition and develop optimum production and postharvest handling systems to retain the health and nutritional properties to enhance the agribusiness and market potential.

Traditional local food crops and seafood are potential sources of bioactive compounds and nutrients that can contribute towards improving the health and nutrition situation in the Pacific and also provide new income generation opportunities for locals. For example, the widely consumed breadfruit (*Artocarpus altilis*) is rich in carotenoids which protects against NCDs [26]. Similarly, kava (*Piper methysticum*) has a range of bioactive compounds used in antidepressant medication [27]. Marine resources such as echinoderms, fish, algae and sponges also have a range of bioactive compounds with benefits to human health and applications in the cosmetic, food and pharmaceutical/nutraceutical industries [28-30]. For instance, peptides and polysaccharides isolated from fish and algae are reported to have anticancer, anticoagulant, and anti-hypercholesterolemic activities. Health beneficial bioactive compounds (antioxidants) and omega-3 fatty acids are also reported from seaweeds, fish and shellfish [31-35].

This report investigates the current status of knowledge and information on nutritional composition and bioactive compounds, known or associated with traditional crops and seafood consumed in seven Pacific Island countries, namely Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu. The objectives were to determine potential traditional crops and seafood which could be targeted for addressing the FNS challenges and to identify opportunities for development of agri-business to support local communities.

03

Methods

Nutritive substances include primary metabolites such as carbohydrates, amino acids, proteins and lipids, necessary for the growth and development of an organism, while bioactive compounds include secondary metabolites which help an organism to survive and adapt to local conditions, improving growth and development or reducing risk factors to diseases [36]. For the purposes of this study, bioactive compounds are defined as “substances that are ‘extra-nutritional’ or ‘extra-non-nutritional’ components of living organisms including plants and marine organisms that have a beneficial effect on health” [37]. Nutritive value is defined as the contribution of essential macronutrients (carbohydrates, protein, fats) and micronutrients (vitamins and minerals) from a food to the nutrient content of the diet. The nutritive value depends on the quantity of a food which is digested and absorbed and the amounts of the essential nutrients it contains [38]. The nutritive value of foods can be affected by soil and growing conditions, handling and storage, processing and cooking methods [23, 39, 40]. While important, this aspect is beyond the scope of this investigation.

Interviews and surveys with traditional leaders

An integrated approach combining traditional and scientific knowledge [41] was used to gather information on traditional crops and seafood consumed in the project target countries Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu. In the Pacific, much of the traditional knowledge on foods with nutritional and/or medicinal value is passed on orally and there are few published reports on such traditional knowledge. Although traditional knowledge experts may not know the active ingredients or the bioactive compounds present in traditional foods, the nutritional benefits or medicinal values are well known and such information has been gathered over a long period of time spanning several generations.

Information on nutritional value of traditional crops and seafood was gathered through guided interviews using a standard questionnaire (Appendix 1) sent to three traditional knowledge experts from each of the seven countries: 21 in total (Appendix 2). A definition for traditional crops was applied and includes locally grown introduced crops, which form part of the traditional diets in these countries. Interpreters proficient in English and local languages were used to elicit information from the traditional knowledge experts with limited proficiency in English language. The responses in local languages were translated back to English and recorded. Information on common name(s), scientific name and utilisation of crops and seafood were also recorded. Additionally, information on the utilisation and reasons for lack of utilisation of Pacific Island foods were gathered from the survey.

Bioactive compounds and nutritional value of Pacific crops and seafood

Based on the information gathered from the traditional knowledge experts, a systematic literature review was carried out to determine scientific knowledge on the nutritional value and bioactive compounds from the identified Pacific crops and seafood.



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Wild sea cucumber or Bêche-de-mer (French) has a wide range of health benefits including anticancer, antioxidant and anti-inflammatory properties, but stocks are declining due to overexploitation. They can be eaten raw or smoked, cooked or boiled. There is interest in developing an aquaculture industry for producing sea cucumber to increase affordability and consistency in supply.

Google Scholar was used to search for the identified crop or seafood (using both common and scientific names) and the terms “bioactive” and “nutrient content” or “nutritive value” were used to search for relevant publications. Information on the bioactive compounds known from the crop or seafood was recorded.

Given the food and nutrition challenges and the opportunities for improving production, consumption, processing and marketing of traditional Pacific foods, data gathered was further analysed. The commodities were grouped into (i) regularly consumed commodities – high in nutritive value and containing bioactive compounds with known health and other benefits; (ii) commodities not/less regularly consumed but also of high nutritive value and containing bioactive compounds; (iii) commodities that are of high nutritive value and containing bioactive compounds but for which little scientific information exists or is under threat.

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Results

Traditional leaders from the seven target countries (Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu) were interviewed and a total of 75 crops and marine resources (Table 1) were identified as commonly consumed and or having health benefits or foods which could be better used in the daily diets. Further information gleaned from 433 scientific articles on the health benefits and bioactive compounds in these 75 crops and marine resources is presented in Table 1 under the categories root crops, fruits and vegetables, seaweed, fish and shellfish.

Table 1: Bioactive compounds and nutritional value of traditionally consumed and used Pacific crops and seafood

NO.	SCIENTIFIC NAME	COMMON NAMES	USES	BIOACTIVE COMPOUNDS	NUTRITIONAL VALUE
ROOT CROPS					
1.	<i>Alocasia macrorrhiza</i>	Giant taro	Corm (bulbo-tuber) consumed in most Pacific Island Countries (PICs), similar to taro, boiled or baked.	Antihyperglycemic, antioxidant anti-inflammation, antimicrobial, anticancer, analgesic, hepatoprotective, hepatorenal, antioxidant and antifungal and cytotoxic activities [42, 43].	CHO, fibre, protein, Fe, Mn, Cu, K, thiamine, and riboflavin, flavonoids, alocasin, oxalic acid, cyanogenic glycosides, alocasin, cholesterol, amino acids, gallic acid, malic acid, ascorbic acid, succinic acid, glucose, fructose, sucrose and beta-lectins [44].
2.	<i>Colocasia esculenta</i>	Taro	Taro leaves and stalk are also consumed widely in the Pacific. Corm is a staple in the Pacific diets and of cultural significance.	Contains flavonoids, β -sitosterol, steroids, alkaloids, saponins, tannins, anthocyanins. Used as laxative, diuretic, anti-inflammatory, anticancer, anti-diabetic, antihepatotoxic, anti-helminthic [45-48].	CHO, fibre, amino acids, Ca, P, vitamin C [49].
3.	<i>Cyrtosperma merkusii</i>	Giant swamp taro	Important food in atoll islands, such as Kiribati and Marshall Islands where it is a food of cultural significance. Also grown elsewhere in the Pacific. Corm consumed cooked by boiling or baking.	Antioxidants, carotenoids, and mucilage [50]. Little known about medicinal properties and uses.	CHO, fibre, Ca, P, Zn, Fe, thiamine, riboflavin, niacin, glucuronic acid, rhamnose [50, 51].
4.	<i>Dioscorea spp.¹</i>	Yam	Widely consumed root crop in Fiji, Solomon Islands, Vanuatu, Samoa and Tonga. Can be stored and has cultural significance as food.	Antioxidant, antidiabetic, cholesterol lowering, estrogenic properties [52-54], contains polyphenols, carotenoids.	CHO, protein, fat, fibre, Ca, Na, Mg, P, K, Fe, Zn, Cu, vitamin C, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine [55].
5.	<i>Ipomoea batatas</i>	Sweet potato	Tubers are consumed in Fiji, Solomon Islands, Vanuatu, Tonga, Samoa, Kiribati and Marshall Islands. Leaves are also edible but hardly utilised.	Has anti-mutagenic, anticancer, anti-diabetes and antibacterial properties. Contains antioxidants, polyphenols, anthocyanin, carotenoids, flavonoids [56-58].	CHO, fibre, Ca, Na, P, Zn, K, Mn, Fe, β -Carotene, vitamins A, C, [59].

6.	<i>Manihot esculenta</i>	Cassava	Widely consumed in Fiji, Kiribati, Tonga, Solomon Islands, and Vanuatu. Less popular in Marshall Islands and Samoa. Cooked by boiling or baking. Flour is also used. Leaves are nutritious but seldom used. Roots are rich in starch but poor in nutrients.	Antioxidant, anticarcinogenic, antibacterial, anti-helminthic and anti-diarrheal activity [60-62]. Carotenoids, nitrate, polyphenols, oxalate, and saponins [63-65]. Some varieties are toxic due to high levels of cyanide [66].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, vitamin C, E thiamine, riboflavin, niacin, [63, 67].
FRUITS AND VEGETABLES					
7.	<i>Abelmoschus esculentus</i>	Okra	Tender green fruits cooked and consumed along with seeds. Used in soups. Widely consumed in Fiji, less popular in other PICs.	Antioxidant, antidiabetic, hepatoprotective, antitumor, antimicrobial, pectin, mucilage, starch, palmitic acid, stearic acid, oleic acid, linoleic acid [68-71].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, thiamine, riboflavin, niacin, vitamins A, C, E, K [72, 73].
8.	<i>Abelmoschus manihot</i>	Island cabbage, Bele	Consumed as leafy green vegetable, used in soups or consumed steamed.	Pectin, mucilage, flavanoids, hyperoside, antiviral, hepatoprotective, antidepressant activity, protects against osteoporosis, kidney disease [74-78].	CHO, fibre, proteins, Na, Mg, K, Ca, Fe, Zn, vitamins A, C, E, riboflavin, niacin [24].
9.	<i>Amaranthus viridis</i>	Slender amaranth	Consumed as leafy green vegetable, used in soups or consumed steamed. Utilised in Fiji, less popular in other PICs.	Antioxidant, sterols, flavonoids, rutin, and quercetin, antimicrobial, antioxidant, antipyretic, antiviral, anti-inflammatory, analgesic, anthelmintic, cardioprotective, anti-diabetic, hypolipidemic, and wound healing properties [79-82].	CHO, fibre, proteins, fatty and amino acids lysine, arginine, histidine, cystine, phenylalanine, tyrosine, and tryptophan. Ca, Fe, P, K, Zn, Cu, Mn [83, 84].
10.	<i>Ananas comosus</i>	Pineapple	Fruit is commonly consumed, and locally available in PICs. Leaves also have medicinal properties.	Contains phenols, alkaloids, flavonoids, tannins, phytosterols, glycosides, bromelain. Has antihelminthic, antidiabetic, antioedematous, anti-inflammatory, antithrombotic, antiarthritic, antitumoral and fibrinolytic properties [85, 86].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, thiamine, riboflavin, niacin, vitamin C, E [87].
11.	<i>Annona muricata</i>	Soursop	Fruit and leaves used. Fruits consumed when ripe and leaves are used as herbal medicine for making tea.	Antioxidant, anticancer, anti-inflammatory, antibacterial, anti-arthritis, antiparasitic, antimalarial, hepatoprotective and antidiabetic activities. Protects against high blood pressure, heart disease [88, 89].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, thiamine, riboflavin, niacin, vitamins A, C, [90, 91].

12.	<i>Artocarpus altilis</i>	Breadfruit	Widely consumed in all PICs. Cooked by boiling or baking. Also preserved and kept for food during emergencies. Leaves and bark also known for medicinal uses.	Contains phenols, β -sitosterol and flavonoids, carotenoids. Has antioxidant, antidiabetic, antihypertensive, anticancer properties [92-98].	CHO, fibre, protein, fat, amylose, amylopectin, Na, Mg, K, Ca, Fe, Zn, β -Carotene, vitamins A, C, E, thiamine, riboflavin, niacin, [26, 99, 100].
13.	<i>Artocarpus heterophyllus</i>	Jackfruit	Fruit widely consumed in Fiji, cooked when green or as snack when ripe.	Contains alkaloids, tannins, phenolic compounds, flavonoids, saponins, sugars, essential oils, proteins, and carotenoids. Has anti-inflammatory, antibacterial, antioxidant, antidiabetic, anti-tumour and hepatoprotective properties [101-104].	CHO, fibre, sugars, Na, Mg, K, Ca, Fe, Zn, B carotene, vitamins A, C, E, thiamine, riboflavin, niacin [105].
14.	<i>Averrhoa carambola</i>	Carambola, starfruit	Consumed raw when ripe, made into pickles or used in salads. Plant parts such as leaves and roots are known for traditional medicine uses [106].	Phenolics, flavonols, flavonoids, antioxidant properties, potential antidiabetic and anti-inflammatory activity [107-113].	Vitamins A, C, E, β -carotene, oleic acid, α -linolenic acid, unsaturated fatty acids [106, 114].
15.	<i>Carica papaya</i>	Pawpaw	Pawpaw are widely consumed in all PICs as ripe fruits. The green fruits are also cooked and consumed. Leaves and roots are used in traditional medicine.	Phenolic, chymopapain, papain, mallic acid, pectin, citrates. Has hypotensive, hepatoprotective, nephroprotective, anti-inflammatory, anticengue, anticancer, anthelmintic, antidiarrhea properties [115-119].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, thiamine, riboflavin, niacin, vitamins A, C, E [120].
16.	<i>Citrullus lanatus</i>	Watermelon	Commonly consumed fruit in Fiji, Tonga, Solomon Islands, Vanuatu and Samoa, Kiribati and Marshall Islands.	Contains carbohydrates, proteins, amino acids, steroids, glycosides, flavonoids, tannins and polyphenols, citrullin, lycopin, carotin, linoleic acid, oleic acid and palmitic acid. Has antioxidant, antidiabetic, antimicrobial, antihypertensive, anti-inflammatory, anti-ulcer and laxative properties [121, 122].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, thiamine, riboflavin, niacin, vitamins A, C, E [123].
17.	<i>Citrus limon</i> ⁱⁱ	Lemon	Widely used in all PICs, in salad dressings, consumed raw or as juice. Has wide applications as a traditional medicine.	Phenolic compounds, antioxidant, flavonoids, phenolics, coumarins, limonoids. Anticancer properties, used to treat fevers, headaches, Skin diseases, anaemia. Improves blood circulation, protects from atherosclerosis [124-126].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, b-Carotene, thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, and folate, vitamins A, B, C, E [127].

18.	<i>Cocos nucifera</i>	Coconut	Widely consumed in all PICs. Cooked with various dishes with coconut cream. Oils are also widely used. One of the most important crops in the Pacific and all parts of the plant have some use.	Antioxidant, polyphenols, flavonols, carotenoids, terpenoids, alkaloids, resins, glycosides and steroids, triglycerides, lauric acid, myristic acid, ketones, lecithin, phytosterin, globulin [59]. Has anti-helminthic, anti-tumour, antimicrobial, wound healing [128-130].	CHO, proteins, sugar, fibre, vitamins A, B, C, E, K; nonyl alcohol; Ca, Cu, Fe, Mg, Mn, P, K, Zn [131].
19.	<i>Cucurbita pepo</i>	Pumpkin	Fleshy part consumed after cooking, boiling or baking. Seeds as food are hardly utilised.	Phenolics, fatty acids, tocopherols, phytosterols and squalene from oil extracted from seeds [132-135]. Alkaloids, flavonoids, palmitic, oleic and linoleic acids, carotenoids, lutein, beta-carotene and lycopene antioxidant properties [136-139]. Antioxidant, anticancer, antimicrobial, anti-inflammatory, antidiabetic, and antiulcer activities [140-142].	CHO, protein, fat, and fibre, amino acid and arginine, polysaccharides [143].
20.	<i>Diplazium esculentum</i>	Vegetable fern	Edible fern, cooked by blanching and combined with coconut milk.	Antioxidant, antimicrobial, antifungal, anthelmintic, and antidiabetic effects [144-146]. Contains anthraquinones, anthranol glycosides, cyanidins, phenols, saponins, proteins, leucoanthocyanins, phytosterols, diterpenes, triterpenes, phenolic, and gallic acid.	CHO, fibre, Na, Mg, Ca, Fe, K, P, Zn, β -Carotene, riboflavin, niacin, vitamins B, C, E [147].
21.	Fabaceae	Legumes ⁱⁱⁱ	Consumed raw or cooked. Have a variety of uses and seeds can be easily stored. Some such as bean sprouts are used in salads. Legumes are not part of a traditional Pacific Island diet.	Phenolics, flavonoids phytosterols, tocopherols, polyphenols, triterpenic acids, glycosides, tannins, saponins, alkaloids antioxidants. Protects against cardiovascular diseases, obesity, and diabetes [148-155].	CHO, fibre, protein, lipids, Na, Mg, K, Ca, Fe, Zn, thiamine, riboflavin, niacin, vitamins C, E [150, 156].
22.	<i>Inocarpus fagifer</i>	Polynesian chestnut, Ivi	The fruit is boiled/baked/roasted and consumed in Fiji, Solomon Islands, Vanuatu, Tonga and Samoa.	Not much is known in literature about bioactive compounds and medicinal uses. Few known uses include treatment of insect bites, burns and urinary infections [157].	CHO, fibre, Ca, Na, Fe, K, Mg, Mn, Zn, Cu [158].
23.	<i>Ipomoea aquatica</i>	Water spinach	Consumed as leafy green vegetable, can be used in salads, soups or consumed steamed.	Antidiabetic, antioxidant, diuretic, antimicrobial, hepatoprotective anti-cancer properties [159-161].	CHO, fibre, protein, Glycoglycerolipids, Ca, Na, K, Fe, Mg, Mn, P, Zn, vitamins A, B, C, E, folate [59, 162-164].
24.	<i>Mangifera indica</i>	Mango	Fruit consumed widely in the PICs when ripe or as pickles or chutney when green. Available in abundance during season.	Polyphenolic compounds, anthocyanins and carotenoids, antioxidants, protects against heart diseases and cancer [165, 166].	CHO, fibre, Na, Mg, K, Ca, Fe, β -Carotene, vitamins A, C, E, thiamine, riboflavin, niacin [167, 168].

25.	<i>Momordica charantia</i>	Bitter melon	The vegetable is underutilised as indigenous communities in PICs have not developed taste preferences.	Contains phenolics, alkaloids, glycosides, aglycone, tannin, sterol, phenol and proteins. Has antidiabetic, antioxidant, antirheumatic, antihelminthic, antimicrobial, anti-inflammatory, antifungal, anti-gout properties [169-172].	Amino acids – aspartic acid, serine, glutamic acid, threonine, glutamine, threonine, alanine, g-amino butyric acid and pipercolic acid, luteolin, fatty acids – lauric, myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic acid [173].
26.	<i>Morinda citrifolia</i>	Nonu, Noni, Kura	Has a wide variety of traditional medicinal uses and is arguably one of the best known traditional medicinal plant from PICs. Fruits and leaves are widely used.	Contains aligns, saccharides, alkaloids, triglycerides, octanoic acid, cyclopropyl, hexanoic acid, n-decanoic acid, allantoin, sorbitol, mannitol, glycerine, tocopherols. Has antibacterial, antitumor, anthelmintic, analgesic, anti-inflammatory, immunostimulant, useful against gastritis, skin diseases, osteoarthritis, respiratory infections, menstrual and urinary tract disorders, fever, diabetes and venereal diseases [174-178].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, vitamins A, C, E, thiamine, riboflavin [179, 180].
27.	<i>Moringa oleifera</i>	Drumstick	Leaves are used in soups or cooked and consumed. Fruits and seeds are also used but less commonly. The vegetable is underutilised as communities in PICs have not developed taste preferences.	Antioxidant, anticancer, anti-inflammatory, antidiabetic and antimicrobial, anti-obesity, tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, glucosinolates, isothiocyanates, glycoside [181-184].	CHO, fibre, Na, Mg, Ca, K, Mg, Fe, Mn, Cu, Zn, β -Carotene, thiamine, riboflavin, niacin, vitamins A, B, C, D, E, folate, pyridoxine, nicotinic acid [22, 59, 181, 185, 186].
28.	<i>Musa</i> spp. ^{iv}	Banana	Consumed ripe as fruits or steamed or baked when green. The peel and green banana flour are also a source of bioactive compounds.	Amines, antioxidants, phenolics, carotenoids, biogenic amines and phytosterols, riboflavin [107, 187-193] resistant starch from unripe banana can be used in food for diabetics [194] and for gluten free foods [195] protect against infectious diseases [193].	CHO, dietary fibre, resistant starch, fructans, soluble sugars, Na, Mg, K, Ca, Fe, Zn, and vitamins A, C, E, β -carotene [107, 196-198].
29.	<i>Nephelium lappaceum</i>	Rambutan	Seasonal fruit consumed when ripe, found in Fiji, Vanuatu, Tonga, Samoa, and Solomon Islands.	Contains phenols, saponins, fatty acids (oleic arachidic), and triacylglycerol's. Has antioxidant, antibacterial, antidiabetic, antihyperlipidemic, anti-inflammatory, hepatoprotective properties [199-201].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, thiamine, riboflavin, niacin, vitamins C, E [202].

30.	<i>Pandanus tectorius</i>	Pandanus	Fruits and flour made from fruits consumed in Kiribati, Marshall Islands, Samoa and Tonga. Fruits can be made into juice. Roots and leaves used for making traditional herbal medicine.	Phenolics, flavonoids, terpenoid, steroids, saponins aldehydes and glycosides [203, 204]. Protects against cardiovascular diseases, antioxidant and antibacterial properties [203, 205, 206]. Isopentenyl and dimethylallyl acetates and cinnamate isolated from fruit essential oil [207]. Caffeoylquinic acids – may protect against diabetes [208, 209].	CHO, fibre, Ca, Fe, thiamine, riboflavin, niacin, rich in beta-carotene, vitamin A [210].
31.	<i>Persea americana</i>	Avocado	Consumed as a fruit, used in salads. Seed and pulp are not utilised.	Anti-cancer, antioxidant and antihemolytic, protects against heart disease, high blood pressure, intestinal disorders [211, 212].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, B carotene, vitamins A, C, E, thiamine, riboflavin, niacin, panthothenic acid (vitamin B5), K, mono- and poly-unsaturated fats, taurine, caffeic acid [213, 214].
32.	<i>Piper methysticum</i>	Kava	Is a popular beverage in PICs and has cultural significance. Also used as herbal medicine.	Contains kavalactones, dihydrokavain, yangonin, demethoxyangonin, dihydrokawain, kawain, dihydromethysticin, methysticin phenolics, used to treat sleep disorders, anxiety, and menopausal symptoms, stomach ache, sore muscles [215, 216].	CHO, Na, Mg, K, Ca, Fe, Zn [24].
33.	<i>Psidium guajava</i>	Guava	Consumed as a fruit. Leaves are also used. Has a range of traditional medicine uses.	Phenolics, isoflavonoids, gallic acid, catechin, epicatechin, rutin, naringenin, kaempferol, antioxidants, hepatoprotection, antioxidant, anti-inflammatory, antispasmodic, anticancer, antimicrobial, anti-hyperglycaemic, analgesic, endothelial progenitor cells, anti-stomach ache and anti-diarrhoea, anti-allergic properties [217-223].	CHO, fibre, vitamins A, C, E, alkaloids, carotenoids, humulene, thiamine, riboflavin, niacin, Ca, Na, Mg, K, Fe, Zn [223].
34.	<i>Pometia pinnata</i>	Oceanic Iychee	Traditional medicine used to treat various diseases: ulcers, burns, chicken pox, flu, stomach pain.	Phenolics, antimicrobial and antioxidant, potential hepatoprotective effect [224, 225].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, vitamins A, C, E, riboflavin, niacin, alkaloids and saponins [226].
35.	<i>Solanum lycopersicum</i>	Tomato	Fruit widely consumed, either raw in salads, sandwich or cooked with other dishes.	Contains lycopene, β -carotene, lutein, phenols, and flavonoids. Has strong antioxidant activity, protects against cardiovascular disease, obesity, hyperglycemia, hypercholesterolemia prostate cancer [227-230].	CHO, fibre, protein; fat, Na, K, Ca, Mg, Fe, Cu, Mn, P, S, Cl, vitamins A, B, C, E, nicotinic acid, pantothenic acid, malic acid, citric acid, oxalic acid [231].

36.	<i>Solanum melongena</i>	Eggplant	Fruit cooked and consumed in Fiji, Samoa, Tonga, Vanuatu and Solomon Islands.	Contains phenolics, flavonoids, and saponins. Has antioxidant, anti-inflammatory, hypercholesterolemic activity [232-234].	CHO, fibre, protein, fat, Ca, Fe, Mg, Mn, P, K, Zn, vitamins C, E, K; thiamine, riboflavin, niacin, panthothenic acid [235].
37.	<i>Spondias dulcis</i>	Golden apple, Vi	Seasonal fruit, consumed raw when ripe. Can be made in to juice, jam and pickles.	Contains phenols, flavonoid, has antioxidant, anti-inflammatory, cytotoxic and thrombolytic activity [236-238].	CHO, fibre, Na, Mg, K, Ca, Fe, Zn, β -Carotene, thiamine, riboflavin, pectin, vitamins A, C [24].
38.	<i>Theobroma cacao</i>	Cocoa	Commonly used in PICs except for Kiribati and Marshall Islands. Seeds are extracted roasted and ground into a paste and prepared as a beverage. Also cooked with other dishes and used in baking. The ripe seed pulp maybe consumed raw.	Antioxidants, proanthocyanidins, phenolics and flavanol protects against heart disease, diabetes, anti-inflammatory, antidepressant, used for skin care [239-244].	CHO, fibre, lipids, fatty acids, theobromine, riboflavin, Mg, K, Cr, Fe, P, Zn, vitamins A, B, C, E [244, 245].
39.	<i>Zingiber officinale</i>	Ginger	Widely used spice in PICs. Edible raw or when added to cooked dishes. It is known for a wide range of traditional medicinal uses.	Contains phenolics, terpenoids, flavonoids, alkaloids, and tannins, zingerone, shogaol. Antigout, antidiabetic, anti-inflammatory, lowers cholesterol, relieves allergies, asthma, arthritis, colds, nausea, protects against gallstones, digestive tract, liver; cerebral vascular and cardiovascular diseases [169, 246-248].	CHO, fibre, Na, Fe, K, Mg, P, Zn, vitamins B, C, folate, riboflavin, niacin [249].
SEAWEED (ALGAE)					
40.	<i>Acanthophora</i>	Kirokiro (Vanuatu) lumi karokaro or lumi karo (Fiji)	Edible fresh as salad or cooked with soups or pudding.	Contains flavonoids. Lowers blood cholesterol and prevents blood clots. Potential anticancer activity [250, 251].	Protein, Ca, Fe, agar and carrageenan [252]. Nutritional composition not well known.
41.	<i>Asparagopsis</i>	Supreme limu	Edible cooked or raw.	Helps prevent goitre. Has antioxidant and antibacterial properties [253-256].	CHO, proteins, amino acids, lipids, Iodine [252].
42.	<i>Callophycus</i>	Large wire weed	Edible cooked. Can be dried and stored.	Contains bromophycolides which have anticancer and antimalarial activity [257, 258]. Has laxative effect [252].	CHO, proteins, amino acids, lipids, agar [252].
43.	<i>Caulerpa</i>	Sea grapes and green sea feathers	Edible raw or cooked.	Contains phenolics, triacylglycerols, and polyunsaturated fatty acids. Has antioxidant, anti-tumour activities. Reduces high blood pressure, and rheumatism [259-263].	CHO, proteins, amino acids, lipids, fibre, folic acid; Na, K, P, Ca, Mg, Fe, Zn, Mn, Cu and vitamins A, B and C [252, 264, 265].

44.	<i>Chaetomorpha</i>	Curly fishing line	Edible raw.	Contains phenolic and flavonoid, antioxidant, antibacterial properties [266, 267].	CHO, proteins, amino acids, lipids, vitamins C and A [252, 268].
45.	<i>Cladosiphon</i>	Tangau (Tonga)	Edible raw or in salads.	Contains fucoidan, triacylglycerols, and polyunsaturated fatty acids. Has antioxidant, anti-inflammatory, anti-allergic, anti-tumour, anti-obesity, anticoagulant, antiviral, anti-hepatopathy, anti-uropathy, and antirenalpathy properties. Protects against heart disease. [262, 269, 270].	CHO, proteins, amino acids, lipids, algin [252].
46.	<i>Codium</i>	Totoyava, sagati (Fiji)	Edible raw or cooked.	Anti-tumour, anti-helminthic, antidiabetic, antiviral properties [271, 272].	CHO, proteins, amino acids, lipids, vitamin A [273].
47.	<i>Colpomenia</i>	Papery sea bubble	Edible raw or cooked.	Contains phenols, protects against heart disease. Has anti-tumour, antifungal properties [274, 275].	Proteins, algin, laminarin and folic acid; Na, K, Ca, Fe, Ni, Mn, Cu, Co [276].
48.	<i>Dictyota</i>	Brown ribbon weed vutua (Fiji)	Edible raw, or dried and used as seasoning.	Contains terpenes. Has antibacterial antifungal, cytotoxic, antibiotic, anti-inflammatory, insecticidal and antiviral properties. Protects against heart disease stroke, and goitre [277, 278].	Proteins, iodine and algin, Na, K, Ca, Fe, Ni, Mn, Cu, Co [276].
49.	<i>Enteromorpha</i>	Lulua, lumi boso (Fiji), nalumlum malekesa (Vanuatu)	Edible raw, dried or cooked.	Has antioxidant, anti-tumour, antimicrobial activity [279-281].	Protein, fibre, β -Carotene, vitamins A, B, C, E and Mg, Ca, Fe, Zn, K and Se [280].
50.	<i>Gelidiella</i>	Little wire weed	Edible cooked (often) or raw.	Contains phytol. Has antioxidant, antibacterial, anticancer, anticholinesterase and neuroprotective activity [282-285].	Protein, fibre, agar, Ca, K, Na, Fe, Mg, Zn, Cu, As, Cd, Cr [286].
51.	<i>Gracilaria</i>	Sea moss, lumi wawa, lumi yara (Fiji), limu aau (Samoa),	Edible raw in salads or blanched, added to soups, referred to as sea noodles.	Contains phenolic compounds. Has antioxidant, anticancer, antimicrobial, antifungal, laxative properties [279, 287-291].	CHO, Agar, Na, K, Ca, Fe and Mg, lipids, protein, vitamins C, A, B2, E and other micronutrients [287, 292].
52.	<i>Halymenia</i>	Red sea lettuce, limu lepe 'ula'ula (Hawai'i), akiro matua (Vanuatu), a'au (Samoa)	Edible raw or cooked with other seafood dishes such as fish and soups.	Contains anticancer compounds, has antidiabetic, antimalarial, anticoagulant properties [293-295].	Proteins, K, vitamin B2, jelly-like substance not agar or carrageenan [296].

53.	<i>Hydroclathrus</i>	South sea colander	Edible raw in salads or cooked with other dishes.	Contains iodine, mannitol, algin, fucoidan, laminarin and folic acid. Protects against heart, liver, kidney disease; diabetes, cancer and good food for pregnant women [252, 297, 298].	CHO, lipids, protein, Ca, Fe [299].
54.	<i>Hypnea</i>	Maidenhair, limu luna (Hawai'i), lumt cevata, lumi tabia, lumi vakalolo (Fiji).	Edible raw in salads or cooked with other dishes.	Contains saturated, monounsaturated, polyunsaturated fatty acids; sterols, and carrageenan. Protects against heart disease, lowers cholesterol, anti-diarrhoea, antitumour, antioxidant and antibacterial properties [300-302].	CHO, proteins, vitamins A, E, C, Ca, Mg, Na, K, Fe [303].
55.	<i>Kappaphycus</i>	Thorn grass, elkhorn (Eucheuma), brown liquorice algae, tambalang	Edible seaweed, commercially cultivated, has a range of health benefits and is also used in commercial food and cosmetics products.	Phenolic compounds with antioxidant, radical-scavenging, carrageenan, agar, and antibacterial properties. Protects against cardiovascular disease, diabetes, bronchitis, ulcers, cold, flu, stomach problems; helps remove shellfish toxins. Vitamin C, total carotenoid, beta carotene, quinones [304-309].	CHO, protein, gums, mucilage, and starch [305, 306, 310].
56.	<i>Laurencia</i>	Flower limu	Edible raw. Not much is known about medicinal uses.	Contains terpenes, sesquiterpenes. Has anticancer, antimicrobial, antioxidant properties [311-313].	Protein, lipids, fibre, Ca, P, Fe [314].
57.	<i>Meristotheca</i>	Lumu mie'ta (Rotuma)	Edible raw or cooked. Medicinal value unknown.	Contains carrageenan, Iodine and other bioactive compounds. Has immune boosting and antiviral properties [315, 316].	Protein, fibre, Mg, Ca, I, Fe, Cu, Zn; vitamin B12 [317].
58.	<i>Padina</i>	Sea fan	Edible raw in salads or cooked added to soups.	Contains algin, antibacterial, antioxidant, cytotoxic and antiproliferative activities [318, 319].	Essential fatty acids, palmitic and linolenic acid, Na, K, Ca, Fe, Ni, Mn, Cu, Co [276, 320].
59.	<i>Rosewingea</i>	Slippery cushion	Edible raw in salads or added to soups. Can be dried and stored.	Contains chlorinated benzophenone. Has antibacterial activity, protects against heart disease and good food for pregnant women [321].	CHO, proteins, lipids [322].
60.	<i>Sargassum</i>	Sea oak Pacific names: lecau, mokusoi (Fiji), limu vaovao (Samoa), kala (Hawai'i), rimu akau (Maori)	Edible raw or cooked, and has many medicinal properties.	Contains algin, fucoidan and laminarin, iodine; protects against goitre, heart disease, stroke, obesity; removes poisonous metals and dried powder can be used as a dressing for cuts and burns [32, 307, 323].	CHO, proteins, lipids, fibre, K, Na, P, Ca, Fe, Zn, Mn, Cu, Cd [324, 325].

61.	<i>Scinaia</i>	Glassweed	Unknown.	Contains phenols. Has anti-leishmanial, antibacterial and antiprotozoal properties [326, 327].	CHO, protein, lipid, amino acids, Fe, Ni, Zn, Cd, Cu, Cr, Co, Pb, Mn, Mg [328, 329].
62.	<i>Solieria</i>	Tender golden weed, lumi tamana (Fiji)	Unknown.	Contains lipids, polyunsaturated fatty acids, squalene, α -tocopherol, cholest-4-en-3-one and phytosterols. Has antioxidant, radical scavenging, anticancer, antifungal activity [330-334].	CHO, protein, lipid, fibre [335].
63.	<i>Turbinaria</i>	Spiny leaf, limu lautalatala (Samoa), rimu taratara (Maori)	Edible raw or cooked, and has many medicinal properties.	Contains alkaloids, terpenoids, flavonoids, polyphenols and quinones. Has anticancer, antioxidant, anticoagulant, antibacterial and anti-inflammatory hepatoprotective properties [319, 336-341].	CHO, protein, lipid, fibre, Mg, Fe, Al, B, Cr, Cd, Co, CU, Mn, Ni, Pb, Zn [342].
64.	<i>Ulva</i>	Sea lettuce	Edible seaweed This sea vegetable is eaten raw or cooked and has many other uses.	Antibacterial, antioxidant, antihelminthic, antigout antiparasitic properties; speeds healing from burns [289, 318, 323, 343].	CHO, protein, lipids, amino acids, Fe, I, vitamins A, B, C and E [343, 344].

FISH AND SHELLFISH

65.	Anguillidae	Eel	Edible cooked.	Antioxidant properties [345, 346].	CHO, lipids, fatty acids, proteins, Ca, P [347].
66.	Carangidae, Cichlidae, Scombridae & Serranidae.	Tilapia, mackerel, wahoo, tuna and trevally grouper and other reef fish	Edible raw or cooked, smoked, dried.	Protects against cardiovascular disease, enhances brain development, protects against cancers, inflammatory disease, arthritis, mental and cognitive disorders such as Alzheimer's, Attention Deficit Hyperactive Disorder (ADHD), lipid lowering and antioxidative properties, protects against hyperlipidaemia and fatty liver [28, 348-353].	Proteins, fats, Omega 3 fatty acids, polyunsaturated and long-chain fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), ubiquinone, taurine, vitamins A, D, B, E, Ca, Fe, Mg, Zn, Se, I [28, 354, 355].
67.	<i>Corbicula fluminea</i>	Freshwater mussel, Kai	Edible cooked.	Antioxidant and antitumor properties. Protects against hypolipidemia and hypocholesterolaemia [356-358].	Fatty acids (EPA and DHA), proteins, lipids, polysaccharides, Ca, Na, Mg, K, Fe [359].
68.	Echinoida (order)	Sea urchin	Edible raw, roe or gonads.	Antitumor, antiviral, anticoagulant and antimicrobial activity [360-362].	Contains lipids, proteins, sterols, tocopherols, fatty acids (EPA & DHA) [363].

69.	<i>Grapsidae</i>	Crab	Edible raw or cooked.	Antioxidant, antibacterial and anti-inflammatory properties [364-366].	Fatty acids, proteins, lipids, vitamins A, B ₆ , B ₁₂ , C, D, E, K; Ca, K, Na, Cu, Mg, Fe, Zn [364, 365].
70.	<i>Holothuriidae</i>	Bêche-de-mer (French) or Sea cucumber (English)	Edible raw or smoked, cooked or boiled.	Triterpene, glycosides, phenolics, sponins, polysaccharides, sterols, cerberosides, lectins, peptides, glycoprotein, carotenoids and essential fatty acids. Has anticancer, antioxidant, anti-inflammatory, hepatoprotective properties [367-374].	CHO, lipids, fatty acids, proteins, glycogen, Ca, Ma, Na, K, Fe, Mn, Zn, Cr [375, 376].
71.	<i>Loliginidae and Octopodidae</i>	Squid and octopus	Edible raw or cooked.	Cardio protective, antioxidant, antibacterial and anti-inflammatory properties [377-379].	Lipids, fatty acids (poly and monoun-saturated – EPA & DHA), proteins, [380, 381].
72.	<i>Nephropidae</i>	Lobster	Edible raw or cooked.	Antioxidant, atherogenic, thrombogenicity, hypocholesterolemic, hypercholesterolemic properties [382].	CHO, proteins, lipids, fatty acids, vita-mins A, B, F, Ca, Cu, Mg, Zn, P, [28, 382].
73.	<i>Osteridae</i>	Oyster	Edible raw or cooked.	Contains taurine, protects against hyperlipidaemia and fatty liver [383, 384].	Lipids, fatty acids, proteins, glycogen [385, 386].
74.	<i>Penaidae</i>	Prawn	Edible raw or cooked.	Antioxidant, anti-proliferative, anti-mutagenic, and anti-inflammatory properties [382, 387].	Free fatty acids, triglycerides, carotenoids, lipids [388].
75.	<i>Tridacna maxima</i> ^v	Clam	Edible raw or cooked.	Anti-inflammatory, lipid lowering and antioxidative properties [356].	Proteins, amino acids, lipids [389].

ⁱSeveral species of yam are grown and consumed in Pacific Island countries. They include *D. alata*, *D. bulbifera*, *D. pentaphylla*, *D. nummularia*, *D. esculenta*, *D. trifida*.

ⁱⁱThere are several varieties of citrus in the Pacific.

ⁱⁱⁱLegumes consists of various crops from the Fabaceae. Common ones include snake beans, French beans, cowpeas, lentils, mungbeans, chickpeas, green peas, peanuts, tamarind.

^{iv}There are several species and cultivars of banana found in the Pacific Islands.

^vGiant clams are considered as endangered.

The majority of the traditional food consumed in the seven Pacific Island Countries (PICs) is known for at least one or more bioactive compounds or nutrients beneficial to human health. The quantities and number of bioactive compounds and nutrients may vary between the food types. Generally, the nutrient composition of food is relatively better known (see Pacific Islands Food Composition Table [24]) than their bioactive properties. Few of the Pacific crops/foods listed in Table 1 have been evaluated for bioactive properties and data from locally sourced samples is generally lacking. Therefore, the majority of information on the bioactivity properties has been obtained through literature search and are based on samples from outside of the South Pacific. Further research is needed on the presence and quantity of bioactive compounds in Pacific Island foods.

The consumption of foods also differs between the Pacific Island countries. Food in the Pacific is linked to the cultures and as such some of the preferences are based on cultural beliefs. One good example is the consumption of cassava, which is widely consumed in Fiji, Solomon Islands, Tonga and Vanuatu, while it is less popular in Samoa. Some foods such as seaweeds, seafood, legumes, fruits and vegetables are highly nutritious but underutilised in the diets of people in PICs (Table 2).

Table 2: Food commodities categorised based on their consumption, nutritive and bioactive properties

CATEGORY	COMMODITY
Regularly consumed commodities – high in nutritive value and containing bioactive compounds with known health and other benefits.	Root crops: Taro, yam, sweet potato, cassava.
	Fruits and vegetables: Island cabbage, pineapple, breadfruit, pawpaw, watermelon, lemon, coconut, pumpkin, mango, banana, kava, guava, tomato, egg-plant, ginger.
	Seafood: Fish.
Commodities not/less regularly consumed but also of high nutritive value and containing bioactive compounds.	Root crops: Giant taro, giant swamp taro.
	Fruits and vegetables: Okra, slender amaranth, soursop, jackfruit, starfruit, vegetable fern, legumes, Polynesian chestnut, water spinach, bitter melon, noni, drumstick, rambutan, pandanus, avocado, lychee, vi, cocoa.
	Seaweed (Algae): Limu karo, supreme limu, large wire weed, sea grapes, curly fishing line, tangau, totoya sagati, papery sea bubble, lumi boso, sea moss, red sea lettuce, brown liquorice algae, sea fan, sargassum, sea lettuce. Seafood: Eel, kai, sea urchin, crab.
Commodities that are of high nutritive value and containing bioactive compounds but for which little scientific information exists or under threat.	Seaweed (Algae): Brown ribbon weed, little wire weed, south sea colander, lumi vakalolo, flower limu, lumu mie'ta, slippery cushion, glassweed, tender golden weed, spiny leaf. Seafood: Sea cucumber.

“

In order to increase consumption of nutritious local food crops, we need to support more nutrition education and school gardening programmes, cooking demonstrations, income generating activities and capacity building e.g. showing the benefits of added value products like breadfruit or taro flour.

IONE DEBRUM, Mayor Ebon Atoll, Republic of the Marshall Islands (second from left in the picture)



Based on the surveys in this study, there are several reasons provided by the traditional leaders on why some traditional foods are underutilised:

1. There is increased preference for easily available foods such as bread, biscuits, noodles, rice, frozen meats and canned foods which are generally cheaper, take less time to prepare meals and are more appealing. Often decision on what to eat is based on accessibility, affordability and taste, not necessarily on the nutritional value or health benefits.
2. Some foods have become or are becoming scarce and less accessible (either expensive or unavailable) on a regular basis. For example selected species of fish, sea cucumber, the giant clam, and traditional varieties of breadfruit, banana, and yam.
3. Traditional knowledge on edible plants (vegetables and fruits) and seaweeds from the wild is diminishing. The younger generation lacks knowledge of edible wild plants or seaweeds.
4. An increasing number of people are reliant on markets and supermarkets for their supply of root crops, fruits, vegetables and seafood due to urbanisation. For many people living in urban areas there is little time or space to plant their own crops or to gather seafood.
5. Cultural preferences for food: certain foods are not consumed unless there is famine. For example, cassava and sweet potato are not widely consumed in Samoa as they are considered famine food.
6. People have not developed taste preferences for certain fruits, vegetables and seafood because of lack of awareness on their nutritional value and cooking recipes. For example, seaweeds, sea cucumber, bitter melon, drumstick, and amaranth are all highly nutritious but only utilised selectively by people from certain cultural backgrounds.
7. Certain parts of fruits or plants are not utilised even though they are nutritious. They are discarded possibly due to lack of awareness on the nutritional value of different plant parts. For example, pumpkin seeds, sweet potato and cassava leaves are rarely used, although they are of high nutritious value.



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Cassava leaves are of high nutritious value.

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Discussion

Bioactive compounds along with macro and micro nutrients found in crops and seafood play an important role for the health and wellbeing of consumers [28, 32, 390]. Increasingly there is a focus on consuming foods which have health benefits in addition to meeting the nutritional requirements [11, 391, 392]. The presence of bioactive compounds such as phenols, flavonoids, sponins, sterols, carotenoids, alkaloids, fatty acids, lipids, and lactones etc. in foods have shown various health beneficial properties, for example cardio-protective, hepatoprotective, anticancer, antidiabetic, anti-obesity, antimicrobial and anti-inflammatory (Table 1). Foods containing bioactive compounds which have been scientifically validated and quantified when consumed in sufficient amounts on a regular basis provide health benefits and can protect against major diseases affecting people.

In the South Pacific crops, seaweeds and marine animals have been used for generations, and continue to be used, as (traditional) food and medicines. More than 20 species of seaweeds found in the Pacific are edible, and contain a wide variety of bioactive compounds (such as polyphenols, fatty acids, lipids, alkaloids, terpenoids, flavonoids, carotenoids, quinones, etc.) and properties ranging from anticancer, antimicrobial, anti-inflammatory, anti-hypertensive, cardio-protective to hepatoprotective. Seaweeds are a promising source of bioactive compounds and could be sustainably developed in the Pacific to meet the demand for food and industrial applications [393-399]. However, in recent years, the use of seaweeds as a food source has declined in favour of imported foods but with health consequences [7, 8, 400, 401]. More recently, seaweeds are gaining popularity as new super foods in Europe and Americas due to the variety of nutrients and bioactive compounds beneficial to human health [32, 250, 287, 402, 403]. There is increased interest in using seaweeds to isolate bioactive compounds for enriching other food products. For example, seaweeds used as seasoning for brown bread instead of salt has been reported to have a longer shelf life [396] and compounds from seaweeds are used in a range of cosmetic products [264, 404]. Similarly, seaweed can also be used as a spice or seasoning when preparing other traditional dishes [305, 323]. Seaweed aquaculture has a long history in PICs with mixed results over the years [405-409].

Sea cucumber (*Holothuroidea*) is also a good source of health promoting compounds and has several macro and micro nutrients. Sea cucumber is an important part of the traditional Pacific diet and there is scope for better utilisation of the resource. However, several species are slow growing and populations are dwindling due to overexploitation [410-412]. Some of the fish and shellfish resources listed could be better utilised as well. Tilapia fish for example has a range of bioactive compounds and is regarded as a sustainable source of protein in PICs. Tilapia is mostly farmed and aquaculture projects have been successful in a number of PICs including Fiji, Vanuatu and Solomon Islands [413-416]. Similarly, prawns, crabs, eels, and shellfish also have potential health benefits and nutritional value and could be targeted for aquaculture to meet FNS as well as provide income generating opportunities for Pacific Islanders [417-421]. Sustainability is a major challenge facing fisheries resources which are dwindling in the wild due to overexploitation and climate change [422]. Despite the challenges, the fisheries sector has an important role to play in securing FNS of Pacific Islanders.

Plants are an important source of bioactive compounds with medicinal, nutritional and health benefits and continue to offer prospects of new medicinal compounds [423-426]. Fruits, vegetables, legumes and root crops also have an important role to play in FNS and can contribute towards protecting from non-communicable diseases such as hypertension, diabetes, obesity, kidney and liver disease [390, 427,

428]. A good example is the *Morinda citrifolia* plant (commonly known as Noni or Nonu or Kura), which is used all over the Pacific for treating various diseases such as hypertension, diabetes, fever, muscle and joint pains [174, 429] and is gaining popularity worldwide [176]. The *Morinda citrifolia* plant grows abundantly in Pacific Island countries including atolls and is a known good candidate for development of health food products. Currently, there is small to medium scale production of noni juice in Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu. However, the production fluctuates and is dependent on demand from the export markets as demand for these products in the local markets is limited [430]. There is a need for greater awareness on the health and nutritional benefits of noni to increase local consumption.

Leguminous food crops and green leafy vegetables such as drumstick leaves, water spinach, cassava leaves, sweet potato leaves, pumpkin leaves and vegetable fern are very nutritious and contain a number of bioactive compounds but remain underutilised in diets of the Pacific Islanders [25, 59]. Some of these crops are not widely utilised by all cultural groups and there needs to be greater awareness on the uses and health benefits. For example, bitter melon is commonly found (cultivated or wild) in Fiji, Samoa, Tonga, Vanuatu and Solomon Islands, but is not widely utilised possibly due to taste preferences of people. It is important to note that several plants have bioactive compounds in various different parts of the plant. For example, cassava, sweet potato and pumpkin are used, while their leaves (and including seeds in case of pumpkin) – although nutritious – remain underutilised. Many of these vegetables are available in most PICs and could be sustainably grown and used.

Fruits such as soursop, starfruit, oceanic lychee, golden apple, and rambutan are good sources of bioactive compounds and nutrients and could be better utilised in the Pacific diets. While some fruits such as papaya, banana, and mangoes are commercially grown in a number of PICs, there is scope for further research on optimum farming conditions for the production and postharvest handling of some of the abovementioned fruits due to their health and nutritional value and agribusiness potential.

Crops such as breadfruit, banana and taro have long been a part of the traditional diets of Pacific Islanders and continue to be an important part of their diets. In addition to providing the starch requirement of the diet, these foods also contain a number of bioactive compounds, which protect against several diseases (see results table). There are several varieties of breadfruit, banana and taro in PICs and some of these varieties are underutilised as a crop. The availability of bioactive compounds and their biochemical constituents differs between varieties [26, 92, 99, 193]. Some of these crop plant diversity in PICs are also endangered or threatened and further research documenting their uses and bioactive properties is needed [98, 431-433].

There is a rich biodiversity of terrestrial and marine organisms in the Pacific, many of which are yet to be fully studied and utilised for the bioactive compounds and or nutritional value. Traditional knowledge from PICs needs to be harnessed and integrated with modern scientific knowledge to address the nutritional and health problems. The search for nutritious local foods must be given greater emphasis to meet the FNS challenges in the PICs.

06

Recommendations

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Development of value addition of traditional foods is very slow due to inadequate knowledge of appropriate technologies, poor infrastructure, inadequate facilities and lack of incentives and policies to support such activities. Strengthening public-private-producer partnerships, capacity building and prioritising and mainstreaming the development of food value chains in policies is the way forward.

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- The bioactive properties of many crops and foods sourced from PICs need further investigation. And the University of South Pacific and other universities and research organisations in PICs have a role to play. There is a need for greater awareness on bioactive and nutritional properties of locally available foods among Pacific Islanders.
- Seaweeds are a relatively inexpensive source of protein, vitamins and minerals and contain bioactive compounds. More research is needed on seaweed health benefits, agribusiness potential and developing value added products for local consumption and for export markets.
- Sea cucumbers are an important source of bioactive compounds which have medicinal properties. In addition, edible species are also highly priced in the international markets. Sea cucumber stocks in the wild are at risk of overexploitation and the potential for aquaculture in PICs needs to be further investigated.
- Fish and shellfish contain many beneficial bioactive compounds and need to be used sustainably. There is potential for increasing aquaculture farming of fish and shellfish to meet growing demand in local and international markets.
- The health and nutritional benefits of green leafy vegetables, fruits and leguminous crops as well as seaweeds need to be promoted and their use encouraged. Affordability and consistent supply of these foods were identified as barriers to their uptake and could be improved.
- Overall in PICs, there is a need for greater collaborative research between governmental (Ministries of Agriculture, Ministries of Health) non-governmental organisations, and research organisations to identify and further develop crops and marine resources which are nutritious and also have health promoting qualities.
- Traditional knowledge from PICs needs to be harnessed and integrated with modern scientific knowledge to effectively enhance FNS.

07

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Appendix 1: Questionnaire

NAME	COUNTRY & COMMUNITY OR VILLAGE
AGE	GENDER

Questions

Name at least 5 traditional foods and 5 sea food commonly consumed in your communities.

What are some of the foods that have health benefits and do you know their medicinal value?

Do you know some food (including sea food) which are healthy and could be better used in daily diets in your communities?

What are some of the challenges in accessing healthy and nutritious foods in your communities?

Appendix 2: List of traditional knowledge experts surveyed

Fiji

1. Mr. Satish Sharma
2. Mrs. Amaleni
3. Mr. Sakiusa Vosa

Kiribati

1. Mr. Ngarontaake Tione
2. Mrs. Beiaa Teiwaki
3. Mrs. Kaetieti Iotua

Marshall Islands

1. Mrs Rosemary Loeak
2. Mr. Charlie Juano
3. Mrs. Demetria Malachi

Samoa

1. Mr. Falaniko Amosa
2. Mr. Sonny Lameta
3. Mrs. Ruby Vaa

Solomon Islands

1. Mr. Gilbert Tabihau
2. Mrs. Susan Taniro
3. Mr. Luke Mani

Tonga

1. Mr. Metuisela Falesiva
2. Mrs. Meleana Kauvaka
3. Mrs. Mumui Laakulu

Vanuatu

1. Mrs Judy Bule
2. Mr. Andrew Nakawi
3. Mr. Brian Malteria



About the Project

The project “Leveraging the Development of Local Food Crops and Fisheries Value Chains for Improved Nutrition and Sustainable Food Systems in the Pacific Islands with a focus on Fiji, Kiribati, Marshall Islands, Samoa, Solomon Islands, Tonga, and Vanuatu” is co-funded by the International Fund for Agricultural Development (IFAD) and the Technical Centre for Agricultural and Rural Cooperation (CTA) and is implemented in partnership with the Pacific Islands Private Sector Organisation (PIPSO). The goal is to strengthen the capacity of the Pacific Island governments, farmer and private sector organisations, and sub-regional institutions to develop strategies and programs – as well as mobilise financing – that can increase poor rural people’s access to nutritious and healthy food. CTA has overall responsibility for the implementation of the project.

About the Partners

IFAD

The International Fund for Agricultural Development (IFAD), a specialised agency of the United Nations, was established as an international financial institution in 1977 as one of the major outcomes of the 1974 World Food Conference.

PIPSO

The Pacific Islands Private Sector Organization (PIPSO) is the premier private sector representative body in the Pacific Islands region. It was set-up through the mandate of the Forum Economic Ministers in 2005, and legally established in 2007, to be the representative body of the Pacific region’s private sector. In doing so, it focuses its work on 4 key areas: Supporting National Private Sector Organizations (NPSOs) to be strong and responsive organisations; Assisting Pacific businesses to enhance their business competitiveness and growth; Championing the interests of private sector in the appropriate fora; and Ensuring the sustainability of PIPSO’s resource and enhancing its capabilities.

CTA

The Technical Centre for Agricultural and Rural Cooperation (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). CTA operates under the framework of the Cotonou Agreement and is funded by the EU. For more information on CTA, visit www.cta.int

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