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Spices of the Pacific region with special reference to vanilla and ginger production: Challenges and the way forward

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Abstract

The Pacific region (Oceania) is divided into four sub-regions (i) Australasia (Australia and New Zealand), (ii) Melanesia, (iii) Micronesia, and (iv) Polynesia and the population of this region is around 0.5% of the global population. There are 14 independent countries and 12 dependent overseas territories in Oceania. Most of the countries are smaller in size, less developed (except Australia and New Zealand), remotely placed and vulnerable to natural calamities. Spices are mostly introduced crops to this region. Turmeric was the earliest spice introduced to this region. The Missionaries and Europeans who colonized these regions introduced many other spices. British introduced ginger to Australia during 1788. Fiji is an important south pacific country, where Fiji-Indians consume considerable amount of spices. Black pepper and vanilla were introduced during 1880's; ginger before 1890 (Probably from Australia), cardamom, nutmeg and clove during 1930's to Fiji. The FAO statistics provide data on spices production from ten Oceanica countries with a total production of 618, 914 tonnes which translates to 0.3% of the global spices production. The spice crops of the region are chillies, onion, garlic, ginger, turmeric, vanilla, nutmeg and coriander. Other spices like tamarind, mango, (tender mango) cinnamon, curry leaf, herbal spices are produced in small scale and exported within the region. Spice crops like clove, allspice, black pepper, small cardamom are also grown by a few individuals in limited number. There is not much research work on spices except for ginger in Australia and a few on vanilla diseases from the Pacific region. This review provides the status of spices in the Pacific region focusing on ginger and vanilla which helps to understand the status of spices of Oceania. The information complied here may help in designing strategies for enhancing spice production and trade, which can positively influence the economy of the region.

Keywords: Oceania, *Vanilla planifolia, Zingiber officinale*

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Introduction

The Pacific region (Oceania) encompasses vast area (around one third of the Earth's surface area). The region contains approximately 25,000 islands that are home to diverse people and cultures (Pacific People Partnership 2021). Oceania has been divided into Australasia (Australia and New Zealand), Melanesia, Micronesia, and Polynesia (Britannica 2021). There are 14 independent countries and 12 dependent overseas territories in Oceania. The largest sovereign state is Australia, occupying about 86% of the region's total area and the smallest independent country is Nauru (Countries of the world 2021). The common problems are smaller size, remoteness of the nations and natural calamities (UNDP 2021). The Pacific region has around 0.5% of the global population. The countries of this region are surrounded by Pacific Ocean. They have varied terrestrial eco-systems combined with specific environmental problems. There is huge disparity in the development achieved by Australia and New Zealand on one hand and the rest of the countries in this region. Most of them are independent, but few territories are governed by France, USA, New Zealand and United Kingdom. The remote nature of locations, predominance of small and marginal farmers, scattered holdings, undulating topography and occurrence of tropical cyclones, inadequate marketing facilities and non-availability of labour are some of the common problems here. There is no organized cultivation of these crops with established packages of production. Some of the spices like turmeric and cinnamon are harvested from wild. Vinning (1990) reviewed the marketing potential of pacific spices and identified the importance in the order of black pepper, turmeric, chillies, ginger, cassia, cinnamon, cardamoms, vanilla, mace and nutmeg and clove. McGregor (2007) reported that the export of spices from Pacific depends on agronomic conditions, involvement of private sector, marketing and certification.

Spices production in the Pacific

Spices are introduced crops to the Pacific region. Turmeric was first introduced to this region (Ritsuko & Reid 2007). The Missionaries and Europeans who ruled this region introduced many spices. British introduced ginger to Australia during 1788 and later Chinese also brought ginger with them during early 19th century (Ryder 2010). A survey conducted in the pre-colonial Fiji during 1860 by the British recorded five different spices, *viz.*, turmeric (*Curcuma longa* Linn.), *Zingiber zerumbet* Roscoe, Bird's eye pepper (*Capsicum frutescens* Linn.), cinnamon (*Cinnamomum pedatinervium* Meisn) and *Myristica castaneifolia* A. Gray. A mention was also made on tamarind and another aromatic plant *Amomum* sp. (Seemann 1862, 1869). Turmeric is a feral crop in Fiji. Many spice crops such as black pepper and vanilla were introduced in to Fiji during 1880's; ginger before 1890 (Probably from Australia), cardamom, nutmeg and clove during 1930 leading to naturalization of some of them over time (Kaiyanuyanu 1995). Many spices, particularly herbal spices, were introduced during later years, and at present, around 40 different spices are seen in Fiji (Kandiannan *et al*. 2020a). Dr Ronald Gatty, who is considered as "Father of Spice Industry" in Fiji also introduced many spices from other countries (Seeto 2020). Vanilla is one of the important spices in the Pacific region, which was introduced to Tonga during 1827 (Sisifa *et al*. 2019).

Ten countries of the region contribute a total of 6,26,914 tonnes accounting for 0.3% of global spices production (Table 1). The main spice crops of the region are chillies, onion, garlic, ginger, turmeric, vanilla, nutmeg and coriander. The other spices like tamarind, mango (tender mango) cinnamon, curry leaf and herbal spices are produced in small scale and traded within the region. Spices like clove, allspice, black pepper and small cardamom are also grown by a few individuals in very

Table 1. Spices production in the Pacific region (2019) (MT)

Country	Anise, fennel, coriander	Chillies and peppers, green	Chillies and peppers, dry	Garlic	Ginger	Nutmeg, mace and cardamoms	Onions, shallots, green	Onions, dry	Pepper (*Piper* spp)*	Spices (nes)@	Vanilla	Total
Australia	1389	44302			8000**			290840				344531
Cook Islands		1										1
Fiji		262			9398				88			9748
French Polynesia		134					27				30	191
New Zealand		3753		2016			264864					270633
Papua New Guinea			1			100				318	495	914
Samoa									12	103		115
Solomon Islands										219		219
Tonga										255	181	436
Vanuatu										126		126
Total	1389	48452	1	2016	17398	100	264891	290840	100	1021	706	626914

Source: FAOSTAT 2021; * *Piper methysticum* commonly called Kava, which is known by different names in Pacific region. It is not a spice and the roots are used for the preparation of a social drink. @The Spices (nes) includes bay leaves, dill seed, fenugreek seed, saffron, thyme, turmeric as per FAO classification. **Source: australianginger.org.au small scale. Systematic reporting and data collection are absent for most spices. The data on production of nutmeg (*Myristica argentea* Warb.) from Papua New Guinea; ginger from Australia and Fiji and garlic from New Zealand are available. Vanilla is produced from Papua New Guinea, Tonga and French Polynesia and onion/shallot in Australia and New Zealand.

In this paper, the information pertaining to two important spices of this region namely vanilla and ginger are compiled and presented. This document would serve as a reference for those seeking knowledge on these two spices in the Pacific region.

Vanilla

Vanilla is a native of Mexico. Commercially grown vanilla species are *Vanilla planifolia* (syn. *V. fragrans* Salisb. Ames) from Mexico, *V. tahitensis* from Tahiti and *V. pompona* from West Indies and the Caribbean (FAO 2009). The major vanilla species grown in the Pacific region are *Vanilla planifolia* and *V. tahitensis* (McGregor 2007). Vanilla was introduced to Tonga during 1827 (Sisifa *et al*. 2019). Fiji was a major producer of vanilla in the world in 1900. French Polynesia also started vanilla production in the same year and a small market for vanilla began in Tahiti. Arrival of synthetic vanillin in the year 1905 led to the collapse of the Fijian vanilla market. During 1942, Cook Islands introduced Tahiti vanilla (*V. tahitensis*) and Papua New Guinea introduced vanilla from Madagascar during 1965 (Sisifa *et al*. 2019). Tonga produced good quality vanilla in 1970's which was comparable to the Madagascar vanilla. Tahiti has increased the vanilla production from 1997.

Vanilla is cultivated between 20–25° north and south of the equator. Ideal temperature for vanilla is 20 to 30 °C with well distributed annual rainfall of 2,000 to 3,000 mm (Matenga 2017). Pacific region produced 706 tonnes of vanilla during 2019 which accounts for 9.15% of the world production (Table 2). Papua New Guinea, Tonga and French Polynesia are important vanilla producers in this region, whereas the production and supply from other countries is much lower and inconsistent.

Table 2. Vanilla production in Pacific region *vis-a-vis* world during 2019.

Country	Production (tonnes)
Cook Islands	0
Fiji	-
French Polynesia	30
Papua New Guinea	495
Tonga	181
Pacific total	706
World	7715

Source: FAOSTAT 2021

Vanilla is adapted well to South Pacific Region (Menz & Fleming 1988; 1989). The advantages of vanilla in the region include absence of major pests and diseases; good provision for value addition besides processing and storage easiness. About 250 accessions covering 20 cultivars of *V. tahitensis* from French Polynesia and a few *V. planifolia* accessions and hybrids are being conserved in the Pacific (Bory *et al*. 2008). Sisifa *et al*. (2019) reviewed the vanilla production in south-pacific countries and observed the following features.

Fiji: Fiji vanilla is one of the best, however, there is no consistency in production as farmers shift to new crop depending on the market.

Solomon Islands: Farmers show consistent interest in growing organic vanilla aiming for premium quality and market.

Tonga: Vanilla was introduced in Tonga during early 1800s by the French adventurers and at present vanilla production is in revival stage.

Vanuatu: A manual on methods for growing vanilla developed by a private firm is widely followed by vanilla growers.

Papua New Guinea: Agro-climatic conditions in Papua New Guinea (PNG) favors production of good quality vanilla and around 50000 people are involved in the vanilla industry (McGregor, 2004). During 2003, PNG exported 101 tonnes of vanilla with an estimated value of US $ 35 million. Vanilla production is concentrated in East Sepik Province, mostly by small holder producers.

Australia and New Zealand: Though successful vanilla cultivation was reported as early as 1920s in these regions, it failed to gain momentum. Variation in rainfall distribution and humidity, high summer temperatures for an extended dry period are not favorable for vanilla production at Darwin, Australia (Exley 2010). Frenkel & Belanger (2018) have recommended growing vanilla in a protected cultivation using raised beds with mulch and wooden posts and trellis. Protected vanilla cultivation also was successful in New Zealand (Fiona 2009).

Tahiti: The world's largest vanilla production was reported during 1908-1909 from Tahiti and the average export from 1920 to 1950 was 200 tonnes. During 1960's, vanilla export from Tahiti declined due to poor quality (Correll 1953). Christel *et al*. (2017) have reported that Tahitian vanilla production represents less than 1.0% of the world vanilla production; it possesses an unique aura, due to an original anise flavour, highly prized especially in gastronomy and perfumery. A dedicated institute "Vanille de Tahiti" to organize and develop better vanilla sector and to promote Tahitian vanilla was created in 2003 in French Polynesia.

Despite numerous efforts, vanilla in the Pacific has an erratic history (Mudaliar & Ucuboi, 2005). Although some countries like, Tonga and Tahiti have made some spectacular achievements, production is erratic and not sustainable. Reasons for decline are changing world market price, potyvirus diseases in 1980's and strict quality requirement in trade.

In Fiji, Ministry of Agriculture recommend farmers to grow Bourbon vanilla (*V. planifolia*) with a plant population of 1111 plants ha^{-1} at a spacing of 3 m × 3 m. It can be planted all year round with a cutting of 1.5 m long on *Glyricidia* support. Vanilla requires thick mulch (20-30 cm) around base. In general coconut husk, dry leaves and rotten decaying timber are used as mulch. If soil is poor, besides organic mulch, application of 20-30 g of nitrogen and phosphorus, 60-100 g potash per vine per year is recommended. Hand weeding or use of brush cutter at least four times a year is recommended to manage weeds. Destruction of potyvirus infected plants, use of healthy and disease free planting materials, washing hands after handling infected plants and a sanitation time gap are followed to manage the virus diseases. Virus diseases infecting vanilla have been reported by various authors in the Pacific (Grisoni *et al*. 2004, Grisoni *et al*. 2006, Pearson *et al*. 1993 & Wisler *et al*. 1987). Spraying of Sundomil 53 g 16 L^{-1} water is suggested for controlling brown stem rot, anthracnose, root rot, tip rot and black rot. For slugs and snail management, hand picking, use of snail bait and keeping area clean are followed. Spraying the affected vines with a mixture of Diazinon at 64 ml 16 L^{-1} of water with white oil to control scales is recommended. Harvesting starts three years after planting and reaches peak production by 4-5 years. With good management, production can continue for 10 years and yield level is 300-600 kg cured beans ha^{-1} (MoA 2014).

SWOT analysis on vanilla production from the Pacific Island countries - Cook Islands, Niue and Smoa (Sisifa *et al*. 2018)

Strengths	**Weaknesses**
Ideal environment for the crop Government support Availability of farmers skilled in growing vanilla High product value and non-perishable nature Market access	Lack of labour Poor infrastructure Lack of information flow and technology transfer Poor commitment by farmers Weak Market intelligence
Opportunities Research and development Development of certification standards Scope for product diversification Involvement of women	**Threats** Natural calamities Market instability

Ginger

Ginger is grown in all the pacific countries, but area and production data are not available. Ginger was introduced to Australia by the British during 1788 (Ryder 2010). Later it might have spread to other Pacific regions. Australia and Fiji are important ginger producers in the Pacific region. The commercial production of ginger in Australia started during the early 1900s and the first processing facility was built at Buderim during 1941. Queensland and Wide Bay–Burnett regions are important ginger production centers in Australia. During 2008, Sunshine Coast region of Australia with 35 growers cultivating over 420 acres produced 6075 tonnes of ginger which accounted for 75% of Australia's total ginger production (Camacho & Brescia 2009). The Australian Ginger Industry Association (AGIA) assists the farmers to produce best quality ginger (AGIA 2021). Research works in Australian Universities by Hogarth (1999) on 'the growth of the ginger industry in Queensland from 1916 to 1998'; Sanewski (2002) on 'rhizome and fibre development in early harvest ginger' and Ryder (2010) on 'history of ginger focusing ginger growing and use in Australia from 1788 to mid-twentieth century' are noteworthy.

The commercial ginger cultivation in Fiji started as early as 1950 and the produce was exported to New Zealand and USA (Smith *et al*. 2012). Planting season of ginger in Fiji is during September to early November and 70% of the ginger is harvested during January-March for fresh immature rhizomes. The remaining crop is harvested during June-July as matured ginger. Ginger is cultivated in Suva/Nausori/Navua areas of Viti Levu by Fijian small and marginal farmers. Exporters and processors buy ginger from these farmers. Fiji exported ginger valued at 4.0 million FJD (1 FJD = Rs. 34.80) during 2020 which was 207.1% higher than the previous year (MoA 2020).

Crop Improvement

'Queensland' and 'Canton'/'Jumbo' are two commonly grown ginger cultivars in Australia (Smith 2004; Camacho & Brescia 2009). In general, 'Queensland' variety is used by the processing industry and 'Canton' is used for fresh market (AGDA 2015). Fijian cultivars are reported to produce 30% bolder rhizome than 'Queensland' cultivar (Whiley 1990) in Australia. Ginger variety "Queensland Gold" is also grown in Australia (Hall 2019). Stirling (2004) noted that Queensland cultivar was originally introduced from China. It is also grown in Fiji and called as 'red' or 'Queensland pink'. Smith *et al*. (2012) reported that 'Buderim Gold' variety developed in Australia was introduced to Fiji but not grown commercially now. The 'Canton' variety, grown for the fresh market in Fiji is known as 'white' (MoA, 2013). The Fiji Farm Management Budget Manual mentioned these two varieties as "white" and "red" (MoA 2014).

The ginger crop improvement work in Australia was initiated with micro-propagation of cv. Queensland (Smith & Hamill 1996). It took two crop generations to produce normal size rhizome from micro-propagated plants and the same was used for seed as they do not harbor pests and diseases. Subsequently, an autotetraploid variety was developed and they produced bolder rhizome than micropropagated diploid ginger plants, which is preferred by the ginger industry (Smith & Hamill 1997; 1999). This auto tetraploid was released as 'Buderim Gold'. Smith *et al*. (2004) reported that this variety was on par with Queensland cultivar in terms of aroma/flavor, fibre content and yield.

Crop Management

Detailed documentation of ginger cultivation practices in Queensland has been done by Whiley (1974). Season, planting depth and spacing are important for obtaining higher yield. In Australia, September is the right time of planting. When temperature exceeded 32^{o}C it caused sunburn, while low temperatures induced dormancy in ginger. Organic manures like poultry manure or sugar mill mud were used and cover crops were grown before planting ginger. Soil fumigation was done 30 days before planting to control root knot nematode.

Seed size and Planting density

The bold ginger seed produced higher yield and fetched better returns (Whiley 1981). Whiley (1990) compared the plant densities and seed sizes of two ginger cultivars *viz.*, Queensland and Fijian and found that increased plant density reduced the time to harvest and increased rhizome yield but had no significant effect on rhizome size. In Fiji, rhizome pieces weighing 60 to 70 gram with at least two buds are used as seed. Seed rhizomes are air dried under shade for about a week before planting to heal cut ends (Smith *et al*. 2012; MoA 2013). Dipping the air dried seed rhizome in hot water (51°C) for 10 minutes is commonly practiced to eliminate pests and pathogens.

Crop Nutrition

Intensive cultivation of ginger is practiced in Australia for higher yields. Asher & Lee (1975) have documented the nutritional disorders of ginger crop. High nitrogen dose up to 830 kg ha^{-1} is applied, out of which 50% is applied at planting time and 25% is given in the first 16 weeks (Lee & Asher 1981, Whiley 1980). Application of low rates of nitrogen (≤ 300 kg ha^{-1}) in 10 splits as ammonium nitrate also produced higher yield (Lee *et al.* (1981a). Lee and Asher (1981) reported better nitrogen use efficiency even in lower rates when applied in eight splits. Ammonium nitrate, urea, and ammonium sulphate were found equally effective but in terms of cost effectiveness urea is better than ammonium nitrate and ammonium sulphate for nitrogen source. Third leaf from the top is an index leaf for nitrogen estimation in ginger plant (Lee *et al*. 1981b). Camacho & Brescia (2009) noted that application of poultry manure, sawdust, urea, phosphate and potassium nitrate boost the crop growth.

Ideal soil pH for ginger was reported as 6.5 and liming of soil is essential in low pH soils (Whiley 1974). However, Islam *et al*. (1979, 1980) reported that there was no yield advantage due to general liming practice to maintain soil pH at 6.5 as ginger is tolerant to low and high pH. Lee & Asher (1981) obtained good yields even under low soil pH values (< 5.0).

In Fiji, the fertilizer schedule recommended for ginger is application of poultry manure four weeks before planting @ 10 tonnes ha^{-1} along with application of NPK (13:13:21) @ 1000 kg ha^{-1} in two equal splits (first at planting and second at three months after planting) and an additional application of urea @ 300 kg ha^{-1} top dressed in three equal splits (first application at 2-3 leaf stage, second application at 8 weeks after first application and third application at four weeks after second application) (MoA 2014; Kandiannan *et al*. 2020b).

Irrigation, Weed control and Hilling (*earthing up*)

Ginger is grown as rainfed crop where the quantum and distribution of rainfall are good. Ginger cultivation in Australia mostly depends on irrigation (Stirling 2004). It was estimated that ginger needs 10 m^3 of irrigation water per hectare during its growth period. Irrigation is one input that required high capital (Camacho & Brescia 2009). Poor quality of irrigation water affects the growth. Ten mm of irrigation water was applied every alternate day during rapid crop growth phase from mid-January until early March at Queensland. Whiley (1974) reported that intermittent sprinkler irrigation daily from 10 am to 3 pm was essential during late October, November and December to prevent sun scorching. In Fiji, ginger is grown as a rainfed crop and no supplementary irrigation is practiced.

Weeds are one of the important competitors for resources. Good land preparation combined with herbicide prevented the weed growth for about two to three months (McGregor 1988), and subsequently manual weeding is done to control weeds (AGDA 2015). Important weeds such as crows foot (*Eluesine indica*) and thick head (*Crassocephalum crepidoides*) serve as a host to root knot nematode hence need to be removed (Turaganivalu *et al*. 2013).

Crop Protection

Ginger crop is susceptible to rot diseases caused by *Pythium* and *Fusarium* spp. and they spread through seed (AGDA 2015). Crop loss arising from pests and diseases attack can go up to 80% or more. Fusarium yellow rot caused by *Fusarium* spp. affects the planting material. Root-knot nematode and *Pythium* affects the crop at all stages and they attack root and the rhizome. Bacterial rot caused by *Erwinia*, *Armillaria* and big bud are less known. Pests and pathogen spreads through seed and once introduced to new area it becomes difficult to control. Cutworm, *Heliothis* and symphilids are the important insect pests of ginger in Australia (Camacho & Brescia 2009). Farmers of Australia apply pesticides to control the pests and diseases in ginger.

Soft rot caused by *Pythium* damages the ginger crops severely, both in Fiji and Australia. High soil moisture, water stagnation and poor drainage favour pathogen build up (Smith *et al*. 2012). *Pythium myriotylum P. vexans*, *P. graminocola* and *P. zingiberis* are responsible for the root and rhizome rot. Unlike in Australia, the small and marginal farmers of Fiji are not able to use pesticides because of high cost. Nematodes are a serious problem in ginger production (Pegg *et al*. 1974) in this region. Application of soil amendments like poultry manure, sawdust and practicing minimal tillage were effective in managing the pathogens. Use of clean seed, application of organic manures, crop rotation and weed control are important in ginger production to get higher yield (Stirling *et al*. 2009). Vilsoni *et al*. (1976) reported that ginger was infected with *Radopholus similis* when ginger crop was grown after banana in Fiji. Farmers pay less attention to ginger crop when government support was less and market price was low (Gonemaituba 2008).

Crop Rotation

Crop rotation helps to build soil nutrients status and prevents the build up of crop associated pests and pathogens (Camacho & Brescia 2009). Cover crops like oats, barley, sorghum, corn, brassica and pasture grasses are commonly grown in Australia in crop rotation and the period of crop rotation ranges from one to four years. In Fiji, ginger is rotated with taro and cassava, with an additional six months period of fallow (DAWE 2007). Crop rotation with cover crops such as oats (*Avena sativa*), *Brassica* spp., soybean (*Glycine max*), forage sorghum (*Sorghum bicolour* X *S. sudanese*) and pasture ley of Pangola grass (*Digitaria eriantha* subsp. *pentzii*) was reported by Smith *et al*. (2011) at South-eastern Queensland on a red ferrosol that had a long (>60 years) history of ginger farming. Highest rhizome yield of 74.2 t ha^{-1} in the fourth year and minimal (7.0%) losses to pathogens (*Pythium myriotylum* and *Fusarium oxysporum* f. sp. *zingiberi*) were noted in the pasture ley that had been cultivated prior to planting ginger. Furthermore, the minimum tilled cover cropped treatment, also yielded high (62.0 t ha^{-1}), with few losses (5.0%) from rhizome rot (Smith *et al*. 2011).

Harvest, Quality and Value Addition

Ginger harvest time vary with the purpose for which it is used. Ginger harvested during fifth or sixth month after planting is mainly used for vegetable and confectionary purposes and late harvest produce (8 to 10 months) is used for making dry ginger and powder. Hogarth (1999) noted that all types of ginger are processed in Fiji irrespective of its quality, while only good quality ginger is used by the Australian ginger industry. Winterton & Richardson (1965) reported that oleoresin and oil content were maximum at $5^1/_2$ to 6 months harvest while fiber content was highest in ginger harvested at 6-7 months of maturity. High fiber content in ginger affects palatability and hence not preferred in confectionary industry (Whiley 1980). Higher contents (percentage) of neral (21.44 ± 1.63 (19.39 – 26.49) and geranial (36.50 ± 3.26 (31.29 – 44.31) in Australian ginger were reported by Wohlmuth *et al*. (2006). Smith & Robinson (1981) analyzed the quality of Fijian ginger and reported the presence of α-copaene, /β-bourbonene. α-bergamotene, α-selinene, calamenene and cuparene and higher neral (26%) and geranial (40%) content.

A study on optimizing the shelf life of ginger paste indicated that potassium sorbate was the better preservative (AECOM 2016). Globally, there was an increase of 548% in products launched that contain ginger during 2004 to 2014. Seven hundred and forty five ginger based products were launched in Australia during 2004 to 2014, accounting for 3% of the global products (CB 2014).

SWOT of Australian Ginger Industry

Clarke (2017) provided SWOT analysis for Australian ginger production as given below.

Strengths	**Weaknesses**
➢ Scientific 'know-how' ➢ World leader in food safety for ginger ➢ Ginger with an unique and attractive flavor ➢ Australian ginger production is environment friendly ➢ Availability of unique varieties	➢ Diseases and pests ➢ Labour intensive production ➢ Poor quality seed ➢ Irrigation water, expensive land and aging growers
Opportunities	**Threats**
➢ World ginger trade is growing strongly ➢ Opportunities for ginger export ➢ Japan holds potential as a destination for ginger export	➢ Imports of low cost fresh ginger ➢ Exotic pest and disease incursion

Challenges and the Way Forward

The challenges in vanilla production and marketing in Pacific are i) price fluctuations; ii) overplanting of vanilla; iii) inferior-quality beans; iv) harvesting of immature beans; v) bean theft; vi) reliance on small-scale curers; vii) lack of information or misinformation on agro-ecological, agronomic and processing requirements; and viii) lack of export standards (McGregor (2004; 2007). The policies and supporting programmes suggested to assist farmers in better managing their decisions in a highly unstable price environment are: i) market intelligence; ii) information on the quality requirements of the market and how to meet these requirements; iii) Information on the agro-ecological conditions required to successfully grow the crop on a sustainable basis; iv) empowerment of the industry to establish and enforce quality standards; v) adoption of farming systems that minimize risk; and vi) facilitation of rural financial services that encourage savings and investment in order to take advantage of periodic high prices. Food safety certification requirements of importing countries are an important issue to be considered for promotion of sustainable vanilla production.

Production constraints for ginger industry in Australia are - pests and disease, less water and labour availability, lack of good-quality seed, dearth of suitable land, rising production costs, stagnating demand, low prices, advancing age of the growers and foreign competition (Camacho & Brescia 2009). The challenges faced by ginger producers in Fiji are lack of quality planting material, access to water, loss of expertise, soil-borne pathogens like *Pythium* soft rot and nematodes infestation, scale insect infestation, unsatisfactory result of pre-planting hot water dip treatment, land tenure system and market fluctuations (Sharma *et al.* 2021)

Spices are introduced crops in this region and their production constitutes only 0.3% of the global spices production. However, not much research on spices has been carried out. In spite of the common challenges like small size, remote location and vulnerability to natural disasters of Pacific region, there is a great scope for more research on spices and development of spice industry in this region that would help to augment income for small and marginal farmers while boosting the spice trade and economy of the region.

The following future plans may strengthen the spices production and trade in the Pacific region

1. Germplasm exchange between Pacific countries and introduction of new germplasm from outside the Pacific region

2. Identification and mapping of suitable zones for spices production
3. Locating mother plants and establishment of mother gardens
4. Promotion of nurseries and seed production for quality planting material production (QPM) by adopting suitable propagation techniques like cutting, layering, budding, grafting etc.
5. Research on bio-control of pests and diseases and organic production
6. Creation of irrigation facilities to address the climate change
7. Development of package of practices and certification standards
8. Market intelligence and price forecast
9. Demonstrations and extension strategies to promote spices
10. Mechanization and value addition in spices production

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