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Development of a ginger product to add value to the Fijian ginger industry

Technical report 110

Development of a ginger product to add value to the Fijian ginger industry

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Prepared by

AECOM Services Pty Ltd
Level 28, 91 King William Street, Adelaide SA 5000, Australia
T +61 8 7223 5400 F +61 8 7223 5499 www.aecom.com
ABN 46 000 691 690

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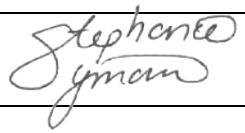
1	16-Nov-2016	FINAL	Stephanie Symon AECOM Project Manger	

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Acknowledgments

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Executive Summary

Ginger is a significant export of Fiji and an important source of income for farming families. While young ginger is processed within Fiji to become value added crystallised ginger, the mature ginger is exported only as the fresh whole root. However, up to 60% of ginger that arrives at processing facilities is below export grade. There is a growing interest in what else can be done with this waste ginger.

Market research was conducted to see what ginger products are currently available. Three areas were focused on: commodity products, retail products and products with Fijian product identity that used Fiji's positive reputation to gain a market advantage. These ideas were then screened to reduce the list to ideas with the greatest potential to be developed and manufactured in Fiji and deliver a profitable return on investment. This was done in three stages, looking at ingredient availability, difficulty of processing, then economic return based on the input of raw ginger.

The final screening was conducted during a cross visit to Fiji via discussion with stakeholders, and refined down to a shortlist of four possible product ideas: ginger wine; ginger oil; dried ginger and crushed ginger paste. An economic analysis was conducted on these four concepts and crushed ginger was identified as the most profitable and selected to be developed further. Ginger paste products already on the market were examined to see what was currently successful.

A shelf life study was conducted to optimise the shelf life of the ginger paste, focusing on the colour change and food safety. A simplified factorial design was used to see what levels of preservatives (potassium sorbate, sodium metabisulphite and salt) were most effective in inhibiting colour change and microbial growth. The results showed that potassium sorbate was most effective in inhibiting bacteria, mould and yeast growth. Colour change across the samples was minimal but was not significantly affected by any of the treatments applied. It is recommended to conduct further shelf life trials examining the effect of different packaging types before the product is launched.

1.0 Introduction

This project is being undertaken for the Pacific Horticultural and Agricultural Market Access (PHAMA) Program. This is an Australian Government initiative, co-funded by the New Zealand Government designed to boost agribusiness in Pacific island countries by better managing of industry and identification of export opportunities. Within Fiji one of the priority areas for PHAMA has been exports of fresh ginger to Australia. Now there is a desire to see what could be done with second grade ginger and what value can be added to the ginger within Fiji to keep expanding and develop other income sources.

Ginger is an effective cash crop for farmers due to its relatively quick growth and high market price, and is an important source of income. Ginger is processed and exported by a small number of companies who work in a cooperative manor, buying from many farmers and exporting larger volumes. It is only at this cleaning and sorting stage that reject ginger is identified, at this point shipping from farm to processor has been paid and shipping must be paid to return the reject ginger to the farm.

2.0 Project scope

2.1 Aim

To produce a commercially viable value adding process, utilizing fresh excess and second grade ginger that can be manufactured in Fiji to develop a new industry supply chain and boost the local economy.

2.2 Objectives

- Conduct a literature review containing current information on ginger growing and processing, and the Fijian cultural land scape and farming practices
- Conduct a market analysis on ginger products currently available
- Generate a shortlist of four possible product concepts via idea generation
- Refine and develop a single concept into a final prototype
- Optimize the product design by conducting a shelf life study
- Conduct a product costing and feasibility analysis
- A field trip to Fiji study the current farming and processing operations and to present concepts and study any relevant issues

2.3 Constraints

- Product must be suitable to be manufactured in Fiji so must utilize the infrastructure, manufacturing sites, and resources locally available
- Product must be made from Fiji grown ginger
- The product concept must be developed to be suitable for second grade ginger and ginger below export quality
- The product concept must be of suitable export quality and meet import requirements for the target market
- Product must be low cost enough to be manufactured in Fiji and make a profit upon export
- Access to knowledge may be impaired as this project is being conducted in New Zealand about Fiji and relies on information being communicated. Communication must be clear to ensure important information is not overlooked or miscommunicated
- Access to resources may limit the project as this project is limited to the resources, skills and equipment available at Massey in the Pilot Plant and PD lab

3.0 Literature review / information summary

3.1 Introduction

The aim of this project is to produce a value add process using Fijian ginger to be manufactured within Fiji. This product must be suitable for manufacture in Fiji and take into account of the available infrastructure and processes. The main areas of knowledge identified for this project are:

- Current ginger industry within Fiji

- Growth conditions of ginger
- Post-harvest processing operations of ginger
- Chemical constitution and active compounds in ginger

Ginger is a spice with a great number of reported health benefits, especially in traditional Chinese and Indian medicine. This review will highlight studies showing health benefits that may occur as a result of ginger consumption. Additionally, the composition of ginger is important to understand how to develop this product into a food item.

There is a great deal of scope within the ginger post-harvest processing, as ginger can be processed in a variety of ways. Data has been collected about the processes for very small producers using traditional methods, as well as for much larger and sophisticated producers and manufacturers. This review will cover the most popularly occurring processing methods and try to present a range of scales and processes, with a focus on scales of production that would suit the size of the Fijian industry.

Currently the majority of the information on the Fijian ginger industry is conducted by international organisations focused on developing trade and most focus on the export of the raw product. While ginger is grown in a large number of sub-tropical countries; Fiji uses traditional farming practices which allow it to stand out on the market. This review will aim to compare the Fijian farming practices with ginger production globally.

3.2 Chemical constitution and active compounds in ginger

There have been multiple studies examining the composition of ginger root. Ginger is classified as a generally recognised as safe (GRAS) product (Al Shabrmi, Aly & Rahmani, 2014, Kubra & Rao, 2012). Ginger is widely consumed as both a food product and as a medicinal product due to the active compounds within that give it its unique characteristics (Kubra & Rao, 2012).

3.2.1 Chemical composition

The chemical composition of ginger is variable, and can change depending on the variety, location its grown, the age of the plant, and weather the ribosomes are fresh or dry (Ali, Blunden, Tanira, Nemmar, 2007; Jolad et al. 2004). The main compounds of interest within ginger are the volatile oils that give ginger its distinctive flavour and are generally present between 1-3% of the total weight (Mojani et al, 2013).

The volatile compounds within ginger have been well characterised in studies by Jolad, Lantz, Solyom, Chen, Bates & Timmermann (2004) using mass spectroscopy and gas chromatography techniques. The most common of these gingerols, (Ali et al. 2007; Jolad et al. 2007) give the distinctive fiery taste of fresh ginger. Gingerol is closely related to the compound capsaicin from chilli, it is a yellow liquid with a low boiling point (Kubra & Rao, 2012). When heated these phenols undergo a dehydration reaction to form Shogaol's, this reaction is pH dependant greatest stability at pH 4 (Jolad et al, 2004). The shogaols, zingerone, gingerone within dried ginger give it its pungency.

There are a wide range of volatile compounds within ginger, many of which are yet to be classified (Kubra & Rao, 2012; Jolad et al. 2004). Some of these, such as Diarylheptanoids are relatively new to scientists and have been found to possess antioxidant, antihepatotoxic, anti-inflammatory, chemopreventive, and antitumor activities (Kubra & Rao, 2012) this has led to more in depth research being done in recent years. While the majority of studies are in agreement regarding the composition of ginger more recent research focuses on defining and characterising lesser known components present in very small amounts.

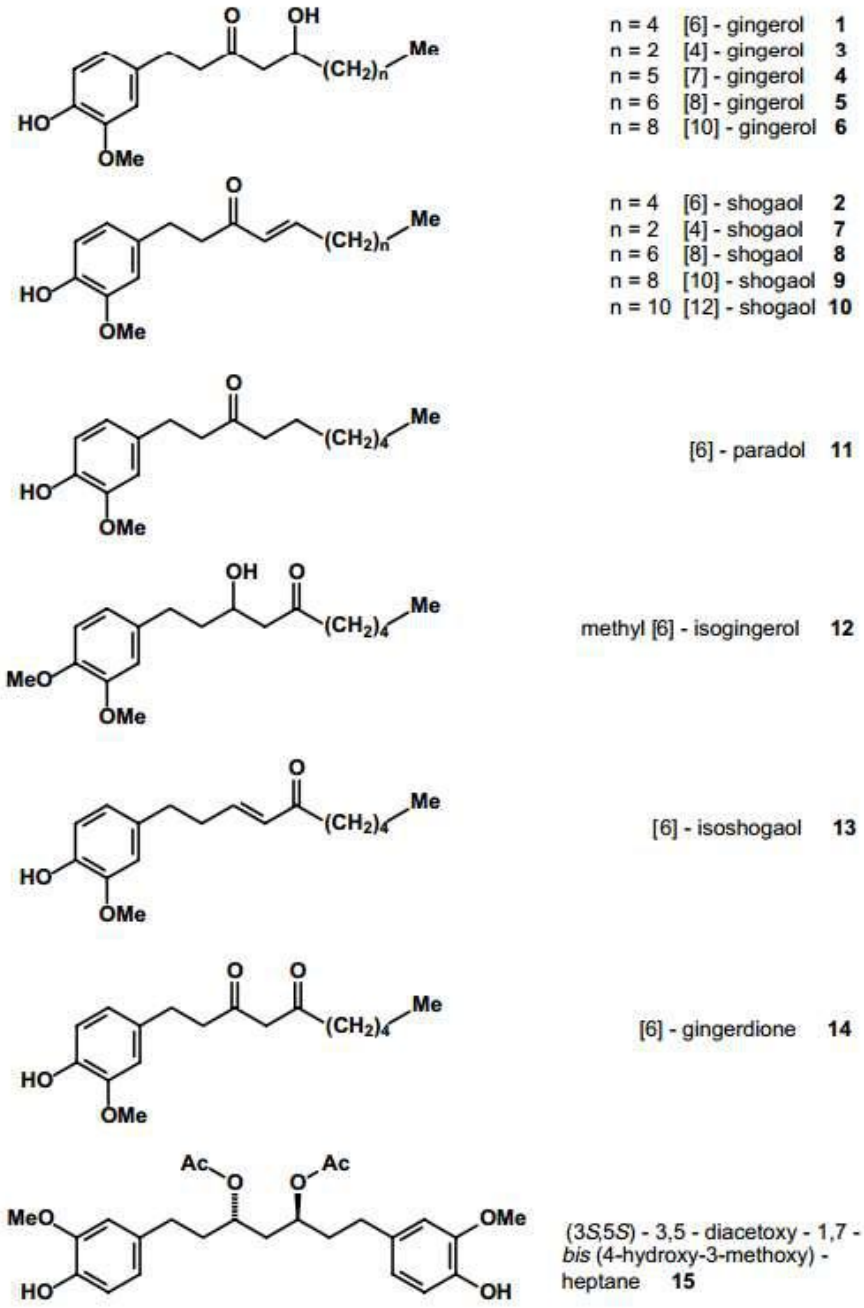


Fig. 1. Major chemical constituents of ginger.

Figure 1. Chemical structure of the active compounds in ginger, the ginger volatiles that give ginger its distinctive properties (Shirin Adel and Prakash, 2010)

3.2.2 Macronutrients

While there is a great deal of information characterising the spice form (Ravindran & Babu, 2004). There is less information available on the composition of the young ginger and fresh mature ginger. The studies of Mojani et al (2013), Latona, Oyeleke & Olayiwola (2012), Mbaeyi-Nwaoha, I. Elizabeth, Okafor, & G. Ifean (2013) and Shirin Adel and Prakash (2010) examined in this review all use similar methodologies, starting from the fresh root the sample is dried then a proximate analysis carried out

using standard techniques. In the below table is the composition of young ginger root and of mature ginger root for comparison.

Table 1. Proximate composition and active compounds of ginger ribosome

Parameter	Fresh Young Malasian ginger (Mojani et al, (2013) (%) DB	Mature Ginger DB (Shirin Adel and Prakash, 2010) (%)	Nigerian Ginger (Latona, Oyeleke & Olayiwola, 2012) (%)	Ginger Peel (Mbaeyi-Nwaoha, Elizabeth, Okafor, & Ifean, 2013) DB (%)
Moisture Content (g/100g WB)	9.10	15.02 ± 0.04	13.75	7.31 ±0.02
Crude Protein (g/100g DB)	7.69	5.98 ± 0.09	39.57	9.42 ± 0.03
Crude Fibre (g/100g DB)	41.76	27.65 ± 0.06	4.66	7.02 ± 0.01
Crude Fat (g/100g DB)	15.38	4.37 ± 0.03	4.66	9.21 ± 0.01
Carbohydrate (g/100g DB)	69.23	38.35 ±0.1		59.58 ± 0.00
Ash (g/100g DB)	7.69	4.53 ± 0.6	8.85	7.46 ± 0.34
Total Flavenoids (water as solvent) (mg/100g DB)	3.66	2.98		
Total Phenolics (water as solvent) (mg/100g DB)	10.22	8.40		
Total gingerols and Shogaols (mg/100g DB)	1.92			

3.2.3 Micronutrients

Ginger like most vegetables also contains a variety of vitamins and minerals. Using standard techniques, the levels within dried ginger were examined by Shirin Adel and Prakash (2010).

Table 2. Vitamin and mineral composition of ginger ribosome

Parameter	Mature ginger root Wet basis (Shirin Adel and Prakash, 2010)	Dry Basis	units
Carbohydrate	38.35±0.1		g/100g
Vitamin C	9.33±0.08	10.97±0.08	mg/100g
Total Carotenoids	79±0.2	9296±0.2	mg/100g
Calcium	88.4±0.97	104.02±0.97	mg/100g
Phosphorous	174±1.2	204.75±1.2	mg/100g
Iron	8.0±0.2	9.41±0.2	mg/100g
Zinc	0.92±0.01	1.08±0.01	mg

Copper	0.545±0.002	0.641±0.002	mg
Manganese	9.13±0.01	10.74±0.01	mg
Chromium	70	83.37	ug

3.2.4 Pharmacological benefits

Both fresh and dried ginger has long been used in traditional Chinese and Indian medicine (Ravindran & Babu, 2004) and contains a number of active compounds with benefits to the health (Ali et al, 2007). Ginger has been used to treat stomach upset, nausea, diarrhoea, colic, arthritis, heart conditions, flu symptoms and menstrual periods (Latona et al. 2012; Jolad et al. 2004).

Ginger is also very high in antioxidants (Shirin et al. 2011) and has a number of active compounds and supposed healing benefits. The antioxidants within ginger are gingerol derivatives as well as other products such as vitamin E (Kubra & Rao, 2012; Ali et al, 2007)

Currently there are a number of anti-nausea ginger products are available in pharmacies. Ernst & Pittler (2000) provide a statistical review of randomised clinical trials on gingers anti-nausea effect. This review selected only double blind, placebo controlled, random clinical trials of pure ginger on nausea and vomiting, and reviewing 6 in total, that were standardised giving greater significance to studies with higher quality of method. This review found that ginger decreases nausea from chemotherapy, seasickness and surgery, though had conflicting data on whether the minimum effective dose was 1g of ginger powder or above.

Ginger is also used as an anti-inflammatory product (Kubra & Rao, 2012) with gingerols and its derivatives being strong inhibitor of platelets which fight infection and cause inflammation within the body.

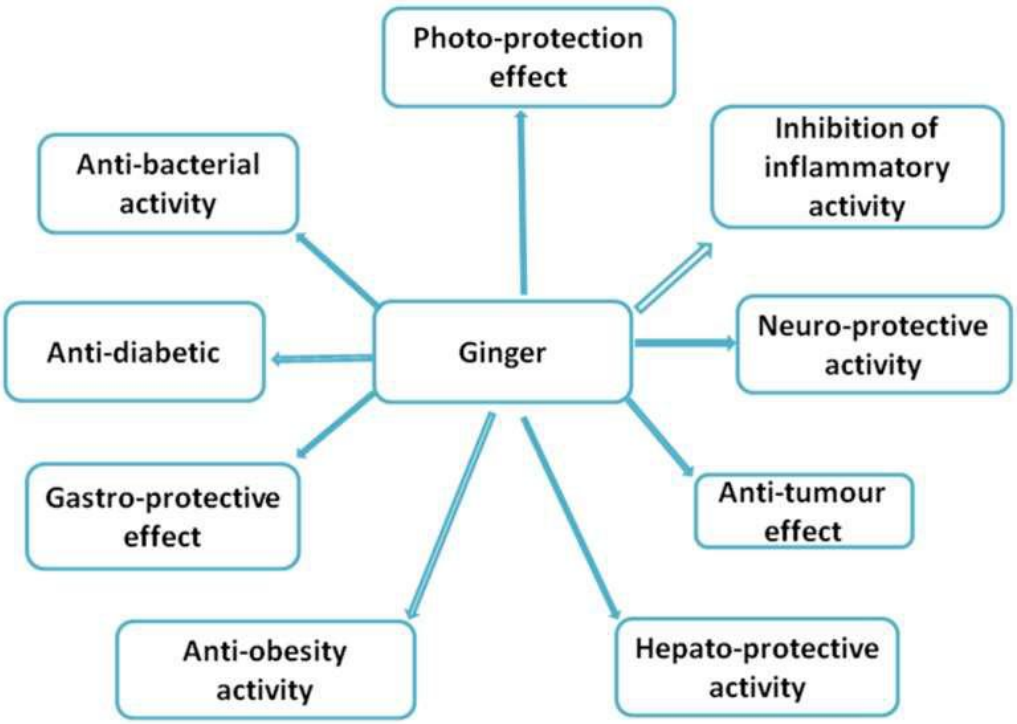


Figure 2. Some proposed pharmacological benefits of ginger

3.3 Post-harvest processing operations of ginger

Ginger can be processed in a number of ways, to create both sweet and savoury products. Below are a number of products commonly with ginger.

Table 3. Processed products derived from ginger

Product	Processes	Applications	Major producers/brands
Dried Ginger	Dried via sun drying or cross flow dryers and ground to a fine powder (Ono, Simonyan & Ndukwu, 2014)	Used as a spice	India, Nigeria
Bleached Ginger	Ginger is soaked in slaked lime, $Ca(OH)^2$ Followed by sun drying (Ono, Simonyan & Ndukwu, 2014)	Pale, and uniformly white in colour. Less susceptible to pests and insects during storage (Ono, Simonyan & Ndukwu, 2014)	India (FAO, 2007)
Candies and preserves	Ginger root is soaked in sugar syrup until the desired sugar content is reached then it is sugar coated and dried	Can be eaten as is or process further with enrobing in chocolate, processing into hard or chewy candies	Australia has large ginger industry largely based on sweet processed ginger products of “superior and consistent quality” (FAO, 2007)
Ginger in Syrup/brine	Ginger is soaked in a sugar syrup or critic acid brine for preservation (FAO, 2002)	Can be further processed into candies and drinks	China has been standard (Ravindran & Babu, 2004)
Ginger syrup	A simple ginger syrup boiled with grated fresh ginger. The residue syrup from ginger candy processing can also be used (Ravindran & Babu, 2004)	Used to flavour drink such as carbonated ginger ales or used on desserts. Can also contain flavours such as lemon or vanilla (Ravindran & Babu, 2004)	
Essential Oil	Volatile oil fraction obtained by steam distillation (FAO, 2007) The heat treatment of gingerol creates degradation products zingerone and shogaols (FAO, 2007)	Essential oils are used in the manufacture of soft drinks, ginger beer, and in food preparation. (FAO, 2007)	Used for its properties as an antiseptic, aphrodisiac, laxative, stimulant and tonic (Ono, Simonyan & Ndukwu, 2014)
Oleoresins	Volatile and soluble oil fractions obtained by solvent extraction (FAO, 2007) Gingerols, (compound responsible for pungency) are found in higher concentration	Within the food industry oils are preferred to dried spices as flavouring, as they are more stable, cleaner, free from contaminations, and can be more easily standardized(Ono, Simonyan & Ndukwu, 2014; FAO, 2007)	Previously operations were performed in import countries but recently it is more commonly used as a value add process in producing countries (FAO, 2007)
Ginger paste	Paste of ground products made up of 50% ginger, 35% garlic, and 15% salt (FAO, 2007)	Used in Indian cuisine ("Ginger Garlic Paste," 2016)	Made largely in India. Was also made experimentally in Hawaii as a value add product (FAO, 2007), was not commercialized beyond 8 weeks
Nutraceuticals	Traditional Indian and Chinese medicine products.		Traditional Chinese and Indian Medicine (Ravindran

	In the west processed into over the counter remedies, for nausea, travel sickness and migraine (FAO, 2007)		& Babu, 2004)
Ginger Ale/Beer	While the terms ale and beer are used interchangeably generally ale is carbonated and flavored with sugar and ginger flavor, whereas beers are yeast fermented with fresh or dried ginger (Ravindran & Babu, 2004) and are alcoholic	Consumed widely across the globe with a range or market positioning from low end budget products to a recent surge in high end gourmet products	
Ginger wine	Fermentation of sugar or raisins with fresh ginger (Ravindran & Babu, 2004)	Warming and spicy alcoholic drink	Stones Ginger Wine
Ginger Tea	Fresh grated ginger or dried powdered ginger infused in hot water Ginger is also the key ingredient in Indian Masala tea (Ravindran & Babu, 2004)	Recognised as a cold and flu remedy this tea is consumed in various forms around the world (Ravindran & Babu, 2004)	
Ginger coffee	Generally dried ginger with a blend of roasted coffee or other spices (Ravindran & Babu, 2004) Variation exist around the world such as Filipino Sakalt coffee	A hot drink with milk and sugar used optionally and recognised as a remedy for cold and flu (Ravindran & Babu, 2004)	

3.3.1 Mature vs young ginger

The processing ginger undergoes depends on the stage of maturity (Azam-Ali, 2007) with young and mature ginger being suitable for different applications, as outlined in the table below:

	Harvested	Properties	Processing	
Young ginger	5-7 months (FAO, 2007; Ravindran & Babu, 2004)	Juicy, tender, relatively sweet, soft skin that does not require peeling (Practical Action, 2008)	Crystallised, glace, preserved in brine or syrup, pickled sushi ginger, fresh products, preserves (FAO, 2007)	 ("Vegtables," 2016)

Mature ginger	8-9 months (FAO, 2007; Ravindran & Babu, 2004)	More fibrous, lower water content, higher oil content, stronger flavour, corky outer skin (Practical Action, 2008)	Drying, oil distillation, crushing	 ("Vegetables," 2016)

3.3.2 Harvest, washing and killing

Immediately after harvesting the ginger is washed of residue, debris, shoots and roots (Ravindran & Babu, 2004). According to FAO (2007) cleaning should be done as soon as possible after harvest and pressure washing is preferred as it is more efficient and lowers the microbial load.

Before processing the ribozyme must be killed, to deactivate enzymatic processes within the root (Ono, Simonyan & Ndukwu, 2014; FAO, 2007). This can be done by peeling or rough scraping of the skin, slicing the ribosome or immersion in boiling water for 10min (FAO, 2007). This heat treatment is also recommended for the killing of the parasitic nematode Radopholus Similis, which is a significant pest that burrows into the roots of ginger.

3.3.3 Drying

The most common use of ginger worldwide is dried ginger (FAO, 2007). This process has been practiced for centuries and so is well documented, with differences in the process coming from variations in scale, equipment and technical ability.

Peeling is recommended for dried ginger as it reduces drying time, thus risk of mould or fermentation, but this also lowers the fibre content and removal of oil constituents that are more concentrated in the peel, reducing pungency (Ono, Simonyan & Ndukwu, 2014; FAO, 2007) The maximum temperature during drying should be 57.2°C, above this the ginger becomes dark in colour (Ono, Simonyan & Ndukwu, 2014).

Small amounts of ginger are processed to bleached ginger, this gives the ginger an even white colour and makes it less susceptible to insect and pests during storage (Ravindran & Babu, 2004).

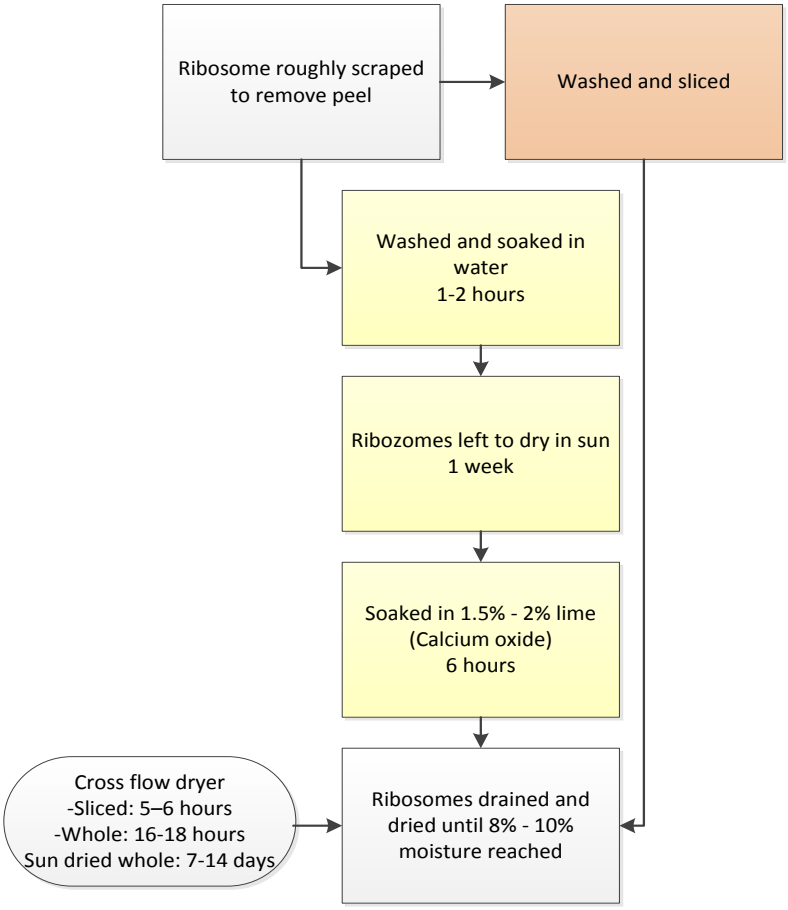


Figure 3. Drying process for whole bleached dried ginger, and sliced dried ginger

Ginger is generally exported whole and ground in the country of origin as not to lose flavour (Practical action, 2008; Ravindran & Babu, 2004). Ginger powder can then be made by pulverising dried ginger though a mesh (Ono, Simonyan & Ndukwu, 2014, Practical action, 2008) or by grinding. This is highly labour intensive and as Ono, Simonyan & Ndukwu, (2014) describe "Traditional method (mortar and pestle) employed in ginger crushing gives low capacity output and is susceptible to increase in microbial load on the crushed ginger, while modern method offers higher capacity output though it requires skilled manpower to operate and maintain" Mechanical pulverisers consist of a rasping unit, that grates and a pulping unit, with blades rotating on a steel shaft (Ono, Simonyan & Ndukwu, 2014).

3.3.4 Oil distillation

Oil can be extracted from either fresh or dried ribosomes (FAO, 2002) however fresh ginger will contain more of the low boiling point volatile oils that have not been removed via heat treatment (Ravindran & Babu, 2004; FAO, 2002). Ginger essential oils are produced via steam distillation, which captures only the volatile fraction, whereas oleoresin capture both soluble and volatile oils so contains both taste and smell compounds (Ono, Simonyan & Ndukwu, 2014; FAO, 2002).

While oil is generally extracted from mature ginger, oil can also be extracted from green ginger or ginger scrapings (Ravindran & Babu, 2004). Oil from green ginger is free of the degradation reactions that occur when heated and so holds the true flavour of the spice and is often used for perfume applications (Natarajan et al, 1970). Oil from ginger scrapings contains the same components as normal ginger oil but is darker in colour and has an earthy heavy odour (Ravindran & Babu, 2004).

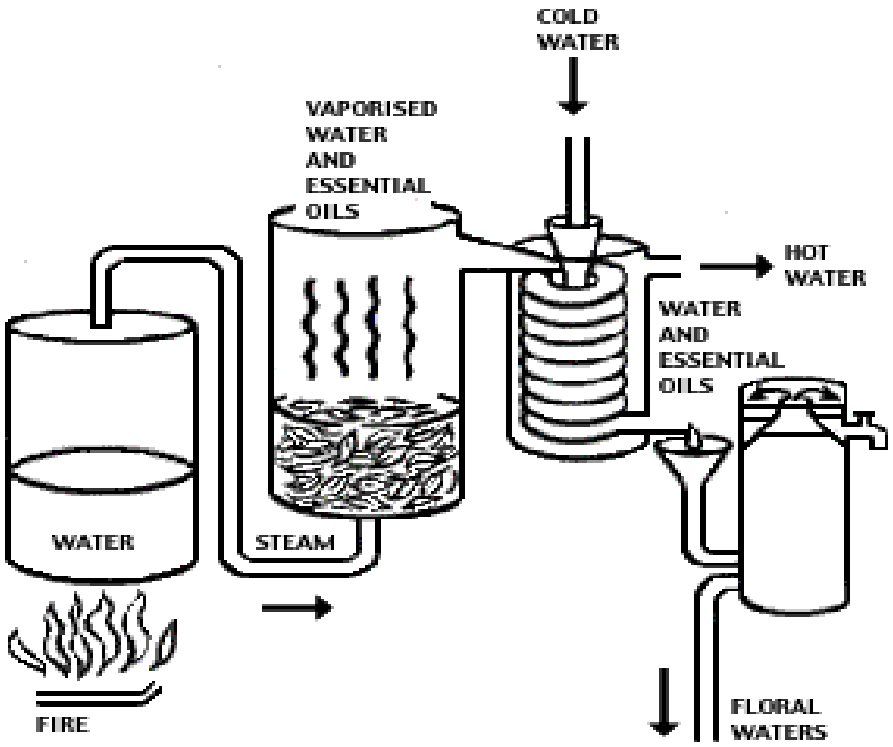


Figure 4. The ginger oil distillation process via steam distillation

3.3.4.1 Essential oils

Essential oils are favoured in the perfume industry (FAO, 2002), currently most production occurs within India (Ravindran & Babu, 2004).

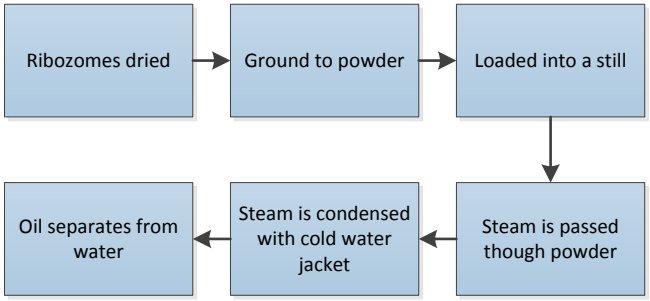


Figure 5. The process of essential oil distillation (FAO, 2002)

3.3.4.2 Oleoresins

Oleoresins contain more of the pungent gingerols that are extracted by solvent extraction (FAO, 2002) and so are more desirable for food applications (Ono, Simonyan & Ndukwu, 2014).

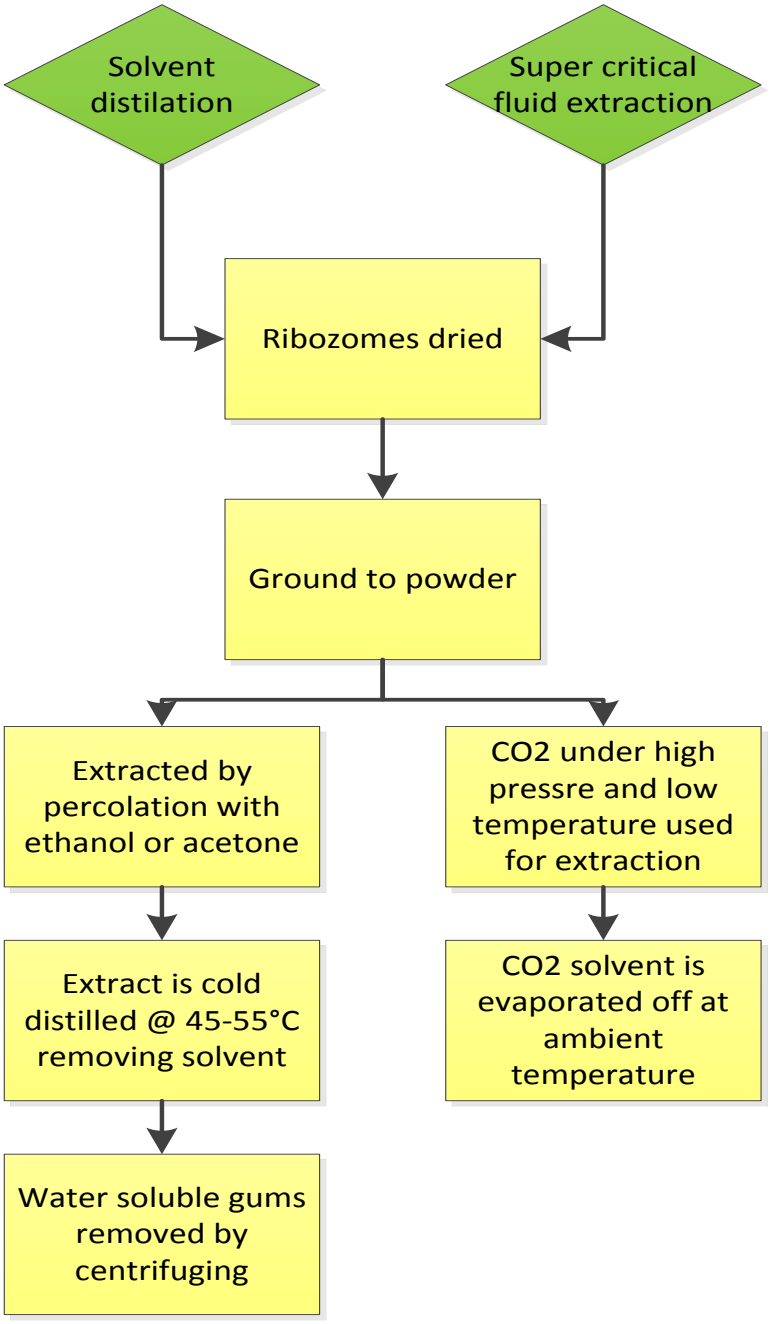


Figure 6. The process for distillation of ginger oleoresin (FAO, 2002)

3.3.5 Candied ginger

The major form of ginger processing in Fiji currently is candied and glace ginger. This ginger must be young and of a low fibre content (Ravindran & Babu, 2004).

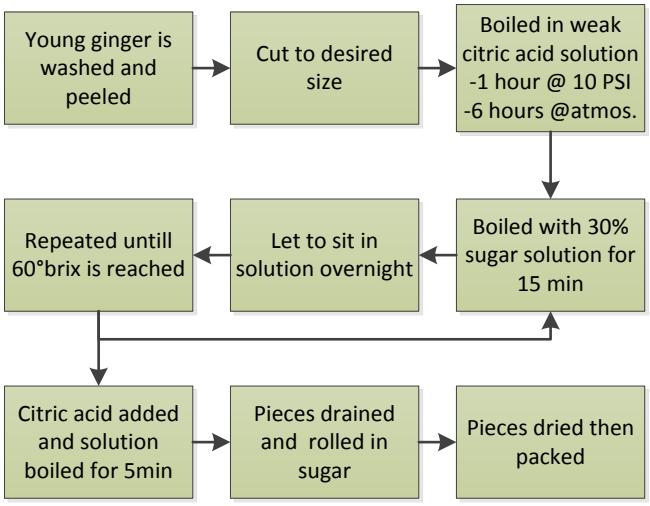


Figure 7. Process for the manufacture of candied ginger ('Ginger and Garlic processing' n.d.)

3.3.6 Evaporated ginger powder

Phoungchandang, Sertwasana, Sanchai & Pasuwan (2009) describe a system for creating high concentration ginger juice powders, comparing the use of traditional pan, natural circulation and vacuum evaporators and the processing methods effect on the resultant product. This is a useful as source as it clearly outlines the process and discusses the differences between different cost levels of processing, allowing it easily applicable to the current Fiji technological landscape.

This process could be used to lower volume for export by removing large amounts of water, this method can also extract gingerol if there is no heat treatment step. The process is as follows:

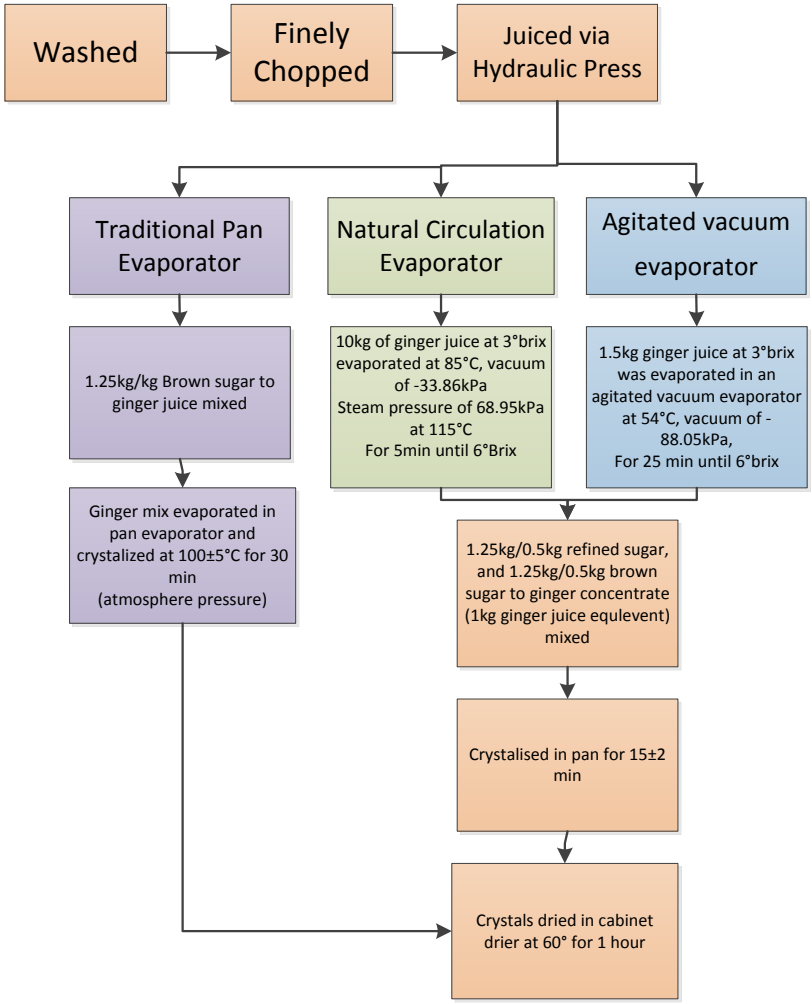


Figure 8. Process for manufacturing evaporated ginger powders (Phounechadang et al, 2009)

The difference in processing of the powders did not create significant differences in terms of water activity, solubility and density. Due to the lower temperature of 54° in the agitated vacuum evaporator there was a much higher concertation of gingerols, as they decompose when heated.

3.3.7 Ginger and garlic paste

Ginger and garlic paste is widely used in Indian cooking and is widely produced in India with most consumed domestically and not exported. (Ravindran & Babu, 2004) it consists of equal amounts of garlic and ginger ground to a fine paste, with vinegar added as a preservative. Green chillies, salt and lime can also be added ("Ginger Garlic Paste," 2016). Figure 9 below shows a description of the process and utilities needed.

Production capacity/annum 9500 Kg.

Production process

The ginger/ garlic received from farm is washed with water jet pressure to clean up any foreign material. The skin of the ginger/ garlic then removed by skin peeling machine. Then the same is put in the fruit mill/ crusher. The output of the fruit mill are put to pulper to further making fine paste. The output is put in the stainless steel tank for mixing the preservative. The same is transferred to the pouch packing machine for packing in custom denomination.

Process flow chart

Machinery & equipment required

- Water jet washer
- Skin peeling machine
- Fruit mill/ crusher
- Pulper
- Stainless Steel tank
- Packing machine

Raw materials/ consumables required

- Ginger/Garlic
- Preservative
- Packing material

Figure 9. Process for manufacture of ginger and garlic paste (Vivid Foundation, 2016)

3.4 Global price of ginger

3.4.1 Dried ginger

According the Nigerian Export Promotional Council (NEPC, 2016) the commodity price for dried split Nigerian ginger is $2850.00 USD per megaton as of February 2016.

Ginger

China: Due to higher 2014/15 production and good coverage with buyers in conjunction with devaluation of Yuan against Dollar, it was anticipated that prices would ease during 2015. However, as can be seen from the chart, prices remained quite stable throughout the year. Only recently we see some easing with price levels going down from $4650 to $4350/ton for pre-cut quality. The new 2015/16 crop will be harvested from December onwards. It is reported that the planted area will increase by some 25%. Weather conditions so far are not ideal, with much rainfall in September. October and November are important for crop development.

India: Fresh ginger is still trading at 5 times higher price than normal due to good domestic demand. Because of this it has become uneconomical for farmers and stockists to convert fresh product to dry ginger. The new crop is getting ready to be harvested High prices have prompted farmers to grow 50% more ginger, but due to unfavourable monsoon rains yield is expected to be lower. Overall expectations are that the harvest will eventually show a 20-25% higher outturn than last year.

Nigeria: Late arrivals of rain have delayed plantings for the 2015/16 crop from April to June. Consequently harvest is not expected until January, which normally should be mid-November. Furthermore because of continuing rainfall the rhizomes will not develop well, which will impact the size of the new crop negatively.

Figure 10. Price fluctuations of dried ginger (NED Spice, 2015)

3.4.2 Ginger oil

Table 5. Ginger oil commodity prices as of March 2016

Product	Origin	Price per Kg (USD)	Source
Ginger oil	Nigeria	$77	(NEPC, 2016)
	Chinese	$72	(International Trade Centre, 2015)
	Indian	$168	(International Trade Centre, 2015)
	Indonesian (Red)	$98	(International Trade Centre, 2015)
Organic ginger Oil	India	$170 (drum lots)	(International Trade Centre, 2015)
	India	$315	(NEPC, 2016)
Ginger Concentrate powder	China	$10-25	Alibaba (17 May 2016)
Pickled Sushi Ginger	China	$1300 – 1400 per ton	Alibaba (17 May 2016)

3.5 Growth conditions of ginger

Ginger, botanically known as Zingiber officially belongs to the family Zingiberaceae and in the order Scitamineae (Ravindran & Babu, 2004) it is an herbaceous perennial plant prized for its aromatic ribosome or root (McGregor, 1989). Worldwide over 25 varieties are grown (Ono, Simonyan & Ndukwu, 2014).

Ginger's botany and growth conditions have been fairly well characterised, and while fairly standard the techniques vary globally with access to technology. The works of Buresova & McGregor, 1990, and McGregor, 1989 were used largely as sources as they refer directly to the Fijian ginger industry. While these sources are not as recent, both being over 20 years old the techniques of farming ginger and resources available within Fiji have remained the same and these studies remain applicable.

3.5.1 Optimal plant growth conditions

Ginger thrives in high rainfall, warm tropical and subtropical climates but requires good drainage (Buresova & McGregor, 1990) due to this, and land shortages; it is often planted on sloped ground (McGregor, 1989). Ginger is planted, tended and harvested by hand (Ravindran & Babu, 2004; Buresova & McGregor, 1990). Ginger requires large amounts of water, in Fiji this is provided by the high rainfall in the eastern districts and irrigation systems in the dryer areas (McGregor, 1989).

3.5.2 Organic farming

Fiji produces organic ginger by merit of its traditional farming practices (McGregor, 1989). Currently the Fijian ginger industry does not use chemical fertilizers, and due to the isolated nature of the island

they have very low heavy metal content in the soil ("Our Products," 2016). This allows Fijian ginger to get a price premium when marketed as organic ginger and aids in producing a high quality product.

3.5.3 Main growing areas / competitors

According to the Food and Agriculture Organization of the United Nations (FAO, 2002) the majority of ginger is both grown in and consumed by Asia, and the Indian subcontinent but consumption of the spice is almost global (Ravindran & Babu, 2004). There are regional differences in quality and taste between producers of the world, and farming practices, while similar, vary globally with differences in scale and access of technology (FAO, 2007).

3.6 Current ginger industry within Fiji

3.6.1 Areas of production

In Fiji historically ginger growing is concentrated on the eastern side of Fiji's main island Viti Levu, within the central district of Naitasiri (Barbour & Terry, 1998) due to the high rainfall in the region (PHAMA, 2016). Most of these farmers were small producers, migrating to the larger islands due to the collapse of the banana industry in the 1950's (Buresova & McGregor, 1990). Ginger cultivation was concentrated in the central district to safeguard the interests of ginger growers (McGregor, 1989).

The soils where ginger is currently grown in the central district are less than ideal, being weathered, strongly leached and ranging in acidity from moderate to very high resulting in low to moderate fertility (McGregor, 1989). When these soils are farmed excessively this can result in problems with erosion of soil due to the steep areas in which ginger is planted.

Currently ginger growing in Fiji is very labour intensive, with most of the land preparation, cultivation, and harvesting taking place by hand. In Fiji ginger is planted in October, the springtime and harvested between late winter in July for young (green) ginger and in early summer in November for mature ginger (McGregor, 1989).

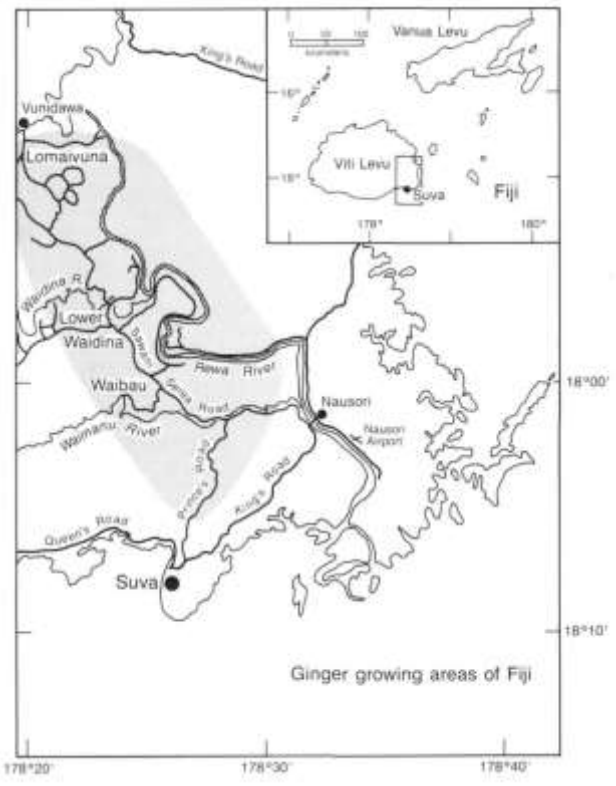


Figure 11. Map of eastern area of Viti Levu showing the main ginger growing area of Naitasiri (McGregor, 1989)

More recently ginger growing has been trailed in the drier western division but production has been slowed by the need for irrigation (PHAMA, 2016). Currently ginger is grown over 550 farms, with 22 registered to meet the export requirements to Australia (PHAMA 2016).

3.6.2 Current processors

Currently there are a small number of processors for ginger within Fiji. According to B. Wiseman (personal communication, 4/4/2016) current exporter from Fiji are as shown in Table 6 below.

The two major processers in Fiji are Kaiming Agro Producers who manufacture crystalized and glace ginger, ginger juice, pickled sushi ginger, and pureed ginger (Zing Fiji Ginger, 2016); and Freshpac Ltd. (PHAMA Communication, 2016) which sells products to Buderim Ginger in Australia. Most of the products produced in Fiji require further value add and are processed into other products, retaining little of the Fijian ginger identity (Personal communication, B. Wiseman, 2016).

3.6.3 Current ginger waste

Currently the mature ginger grown in Fiji is mainly exported as whole mature root or sold on the local market. Due to significant damage from pests such as Radopholus similis there is a large amount of ginger that is not suitable for export or local sale, this is returned to the fields to be used as seed stock for the following years crop or dumped. Often this pest damage can be so great that ginger is left in the fields as farmers know it will be rejected, as can be seen in Figure 11 below.

Figure 12. Ginger rejected due to pest damage left in field after harvest

One ginger processor Sai Yee Foods that exports mature ginger to Australia and New Zealand experiences rejects of between 40% to 60% of the ginger it receives from farmers due to pest damage (Personal communication E. Ofati, 13 July 2016). This is currently shipped back to farmers resulting in high transport costs.

3.6.4 Trade

Currently Fiji exports ginger to Australia, New Zealand, European Union, USA and Canada (Fiji Sun, 2015) which are also Fiji's main trading partners ("Exporting from Fiji," 2016). Due to the cost of shipping and competition from large producers such as Thailand and China Japan and Australia have the most potential for increased trade of ginger (PHAMA communication, 2016)

Due to its nature as an island the Fijian Government encourages trade, lifting many export restrictions and promoting an open economy. Fiji became a member of WHO in 1996. Fiji has a number of regional trade deals, and trade agreements relevant to the trade of ginger as outlined in the table below.

Table 7. Trade deals in operation including Fiji ('Exporting from Fiji' 2016)

Name	Countries involved	Year signed by Fiji	Agreement
Melanesian Spearhead Group Trade Agreement (MSGTA)	Fiji, Papua New Guinea (PNG), Vanuatu and Solomon Islands	1998	Free trade agreement between countries
Pacific Island Countries Trade Agreement (PICTA)	Cook Islands, Fiji, Niue, Samoa, Solomon Islands, Tuvalu and Vanuatu (Kiribati, Nauru, PNG and Tonga working to meet domestic requirements)	2003	Aims to establish a free trade area among the fourteen Forum Island Countries (FICs)
Interim Economic Partnership Agreement (IEPA)	Fiji and Papua New Guinea, and the European Community	2002	Duty free and quota free market access on all products from Fiji except for sugar and rice
South Pacific Regional Trade and Economic Cooperation Agreement (SPARTECA)	FICs: Cook Islands, Fiji, Niue, Samoa, Solomon Islands, Tuvalu, Vanuatu, Kiribati, Nauru, PGN, Tonga, The Federated States of Micronesia (FSM), Republic of Palau, and the Republic of Marshall Islands; and Australia and New Zealand	1980's	Allows FICs to export almost all of their products to Australia and New Zealand duty free. This is a non-reciprocal relationship.
Pacific Agreement on Closer Economic Relations (PACER)	FICs, Australia and New Zealand	2002	Framework agreement for cooperation on trade and economic integration between the fourteen FICs and Australia and New Zealand. Aims towards the development of a single regional market.

In 2013 the Fijian Ministry of Agriculture, Fisheries and Forests is to form a Ginger Task Force. The membership is to include Biosecurity Authority of Fiji, South Pacific Community, PHAMA and selected industry stakeholders (PHAMA, volume 5 February 2013). The aim to provide central coordinating and planning, and advice to Fijian's in how best to deal with challenges in ginger export, such as biosecurity and documentation (PHAMA communication, 2016).

3.7 Conclusion

Ginger has many active compounds that give it a variety of health benefits, with gingerol, the main volatile oil compound having anti-inflammatory, antioxidant, anti-tumour, anti-nausea and lowers blood pressure. While the mechanism of these actions are currently being debated there have been many clinical trials both with animals and humans demonstrating these effects.

Ginger is grown in a wide range of subtropical countries and can be processed into a number of products, both sweet and savoury. Currently Fiji's ginger industry processes mostly young ginger into sweet products such as glace ginger, crystallised ginger, and ginger in syrup or brine.

There are still gaps of information within the area of post-harvest processing. While the most common methods of drying and crystallising are well documented there is little about other forms of processing.

This may be due to manufacturers not wanting to reveal their process but may also be due to the small nature of most ginger processors that still use traditional methods.

The research presented within this review will act as a background for this project and will aid in idea generation and concept development. In order to create a successful product, it must be realistic and fit within the scope of the Fijian and global ginger industries. This review allows for insight into what makes ginger a unique product as well as how it is used and processed worldwide.

4.0 Market research

4.1 Aim

To identify what products utilizing ginger are currently on the market. This information will be used to generate product ideas and gain information on the price and a market size for product types. This will focus on three categories:

- Commodity products
- Products marketed with Fijian identity
- Products available in New Zealand supermarkets

4.2 Methodology

An online search was used to identify suppliers and availability of commodity products, and products marketed as containing Fijian ginger.

Countdown online was used to identify a variety of products containing ginger. Retail price, Ingredients and ginger content were then found from back of packaging analysis at New World Pioneer highway, and Countdown Rangatiki in Palmerston North New Zealand, 8 June 2016.

4.3 Results

(Refer to Appendix A: Market research for a full list of products and prices found)

4.3.1 Ginger commodity products

Commodity products are simplistic goods whose price is determined as a function of the total market price, these can be traded on futures markets as all units are the same. Generally, these are those sold in large quantities (100kg or above) and supplied by multiple international suppliers. As ginger is a seasonal product prices do vary based on availability but due to the large suppliers of processed ginger products like India, Nigeria and China prices are competitive year round (International Trade Centre, 2015).

The main commodity products identified were dried ginger, ginger concentrate, ginger oil and ginger oleoresin. Dried ginger was the most price competitive and shipped in high bulk, resulting in prices of $1-$3 NZD per kg (Nedspice.com, 2016). Within the ginger oils and Oleoresins there was a greater spread of prices, this was mainly due to the difference in price due to the quality of the grades, with India having a premium in this market due to its high quality and well established essential oil industry (Lala's Group, 2016). There was also an increased price for organic oils.

4.3.2 Ginger products with Fijian identity

Products defined as having Fijian identity are those marketed as containing Fijian ginger, generally this is used as a way to gain a premium price. This is significant for the project as it shows a possible marketing strategy to gain a better price, and is beneficial to the ginger industry of Fiji as it boosts its international profile.

Two brands were identified that marketed as products with ginger grown in Fiji; Wakaya, a health and wellness brand supplying high end products, and The Ginger People, an Australian brand that sells a range of ginger based retail and commodity products in New Zealand, Australia the USA and Europe.

Wakaya is a private Island within the Fiji archipelago, it contains a resort and spa sells a number of organic ginger products under the brand Wakaya Perfection. Their products are sold online via their website and on The Copra Center, a US health and wellness supplier. This brand sells organic premium products, capitalizing on the pristine reputation of Fiji. Their main product is dried ginger, and this is then used in tea, nutritional supplements, incense and body wash products.

The Ginger People are a North American company founded in 1984 that specialize in producing a wide range of ginger products and ingredients (The Ginger People, 2016). Currently they supply USA, Canada, Australia, Europe and England. Similarly to Wakaya Perfection, the Ginger People also promote Fiji grown ginger as very high quality, stressing the quality of the growing conditions and traditional farming practices, with their website stating “With one of the most pristine ecosystems in the world, nutrient-rich soil and natural irrigation from tropical rainfall, Fiji produces some of the world’s purest ginger.” The main products supplied are forms of candied ginger, produced from young ginger and processed at their factory within Fiji (The Ginger People, 2016).

4.3.3 New Zealand supermarket products

Products available within New Zealand supermarkets that used ginger were examined to give ideas on what range of concepts could be produced. A large range of products were identified, some using ginger as a main component and others using derived products such as oil or dried ginger.

4.4 Conclusions

There are many products available that utilize ginger, the commodity products available made use of one key processing step that was used to increase the value of the ginger and increase the time it could be stored for, eliminating one of the issues associated with fresh vegetable exports. Many of these products such as dried ginger, and ginger oils are then used as flavouring in other products identified on the market.

Two brands were identified as containing Fijian ginger and both these used this as a unique selling point to promote their product as high quality and gain market access.

5.0 Idea screening

5.1 Aim

Ideas were screened to reduce the list of possible product ideas to those with the greatest potential to be developed and manufactured in Fiji and deliver a profitable return on investment.

5.2 Methodology

Three screening stages were used consecutively to screen ideas.

5.2.1 Initial screening

The initial screening was looking at general feasibility of the product idea taking into account the following screening metrics:

- Availability of ingredients within Fiji
    - Imported products are high cost so using locally available ingredients will result in a higher profit margin
- High return per kg fresh mature ginger
    - Return must be more than the combined price of raw ginger, processing and shipping for final product to make a profit
    - Must have a significant content of mature ginger
- Processing requirements

- To minimize the investment needed processes that make use of industrial equipment is available within Fiji will be selected
- Processes that require large amount of equipment such as retorting, canning, bakery setups will be discarded due to the high capital costs

This screening was conducted on all the initial ideas found in the market research step. All commodity products passed to the second screening due to the high ginger content, simple inputs and large market for these products.

5.2.2 Secondary screening

The secondary screening was based on the price per kg of raw ginger calculated from the total weight of the container, the retail price, and the ginger content of the product. If the ginger content was not known exactly it was estimated based similar products found online.

The concepts with the highest value per kg ginger were then considered onto a shortlist of 6 concepts which had the highest return of profit per kg or ginger, taking into account difficulty and associated costs of processing.

5.2.3 Tertiary screening

The tertiary screening was conducted using feedback from stakeholders and business owners within Fiji. Ideas were presented to them in a casual discussion setting and feedback sought on the ideas and which would be most feasible for them. Options were gathered from the following sources:

- Spices of Fiji
- Sai Yee Foods
- PHAMA

5.3 Results

5.3.1 Initial screening

The initial screening was conducted on all product categories found on the market and all commodity products. The results are shown in 8 below.

Table 8. Screening conducted on ginger products found during market research undergoing an initial screening process with reasons for pass or failure

Product	Pass or Fail	Reason for grading
CRUSHED GINGER	PASS	High ginger content, Minimal processing steps , Availability of ingredients
SUSHI GINGER	FAIL	Made with young ginger, Currently already exported from Fiji
DRIED GINGER POWDER	PASS	High Ginger content, Available ingredients
CRYSTALISED GINGER	FAIL	Made with young ginger, Currently exported from Fiji
SEMI DRIED GINGER	PASS	High ginger content, Simple processing (further research required on processing + market potential)
GINGER JAMS AND MARMALADES	PASS	Medium ginger content, Relatively simple manufacturing, Could market as premium product
MUSLI BARS	FAIL	Low ginger content, Limited availability of ingredients (gains, nuts and seeds are expensive)
GINGER TEA	PASS	High ginger content, Organic price premium (more research required on organic + fair trade requirements

		and premiums)
GINGER CORDIAL/SYRUP	PASS	Medium ginger content, Aligns well with other current business ventures (candied ginger in syrup)
GINGER KOMBUCHA	FAIL	Low ginger content, Ginger requires pre-processing (drying)
GINGER JUICE DRINKS	FAIL	Hard to export fresh juice product, refrigeration required, Low ginger content
GINGER BEER	PASS	Aligns well with other current business ventures (candied ginger in syrup), High packaging cost (bottles would be imported)
GINGER SALAD DRESSING	FAIL	High cost packaging, Low ginger content, Limited access to ingredients (Oils)
GINGER NUTRACUITICALS	PASS	High value product, Could align health and wellness with Fiji (brand and marketing)
GINGER SAUCES	PASS	Medium ginger content, Ginger content could be explored further, Relatively simple product for processing
GINGER FLAVOURED PASTA	FAIL	Access to bakery faculties, Limited ingredients (flour) availability Low ginger content, Refrigerated shipping for fresh product
GINGER FLAVOURED MEATS/ TOFU/ FISH	FAIL	Very low ginger content, Ginger requires pre-processing, Access to meat/fish processing faculties, Limited ingredients (pork/beef) availability Refrigerated shipping for fresh product
GINGER PATE	FAIL	Very low ginger content, Ginger requires pre-processing, Refrigerated shipping required
GINGER BAKED GOODS	FAIL	Low ginger content, Ginger requires pre-processing (drying), Limited access to large scale baking facilities, Difficult product to export internationally
GINGER OIL	PASS	Simple ingredients, High value product, Large consistent market (commodity)
GINGER OLEORESIN	PASS	Simple ingredients, High value product, Large consistent market (commodity)
GINGER CONCETRATE POWDER	PASS	High value product, Large consistent market (commodity)

5.3.2 Secondary screening

The secondary screening was conducted on all concepts that received a pass score. This looked at the return based on the raw ginger input into the product.

Table 9. The results of the secondary screening showing the prodduct type, brand, unit price, price per kg, ginger content, and price per kg of ginger for retail products

PRODUCT TYPE	BRAND	Price (NZD)	Weight (kg)	$/kg (NZD)	Approx. % Raw Ginger	Price per kg/Raw Ginger
Crushed ginger	Gourmet Garden ginger stir in paste	3.49	0.080	43.63	61	26.61
	Masterfoods chopped ginger	3.79	0.160	23.69	95	22.50
	Greggs crushed ginger	3.09	0.145	21.31	95	20.24
Dried ginger	Ms Rogers Eco Pack ginger	2.30	0.030	76.67	100	76.67
	Greggs ground ginger	2.19	0.030	73.00	100	73.00
	Masterfoods ground ginger	3.49	0.025	139.60	100	139.60
Semi dried ginger	Gourmet Garden lightly dried prepacked ginger	4.99	0.012	415.83	100	415.83
Ginger tea	Nerada organic fruit tea, lemon and ginger tea bags	2.89	0.030	96.33	30	28.90
	Twinings herbal tea, Lemon, honey and ginger	3.99	0.035	114.00	37	42.18
	Twinings herbal tea, settling ginger	5.15	0.035	147.14	70	103.00
Ginger wine	Stones ginger wine	18.99	0.750	25.32	5	1.27
Nutraceuticals	Blackmore Nausea relief, travel calm ginger	15.95	0.045	354.44	50	177.22
Ginger sauce	Watties Wok creations stir fry sauce, lemon ginger and sesame	2.30	0.125	18.40	12	2.21
	Maggi stir fry creations, sweet chili ginger and lemongrass	3.69	0.150	24.60	4.3	1.06
Ginger Syrup	Ginger people ginger syrup	4.99	0.237	21.06	5	1.05
	Hakanoa Ginger syrup	16.00	0.330	48.48	5	2.42
Ginger cordial	Shott concentrate, lemon ginger and honey	9.00	0.500	18.00	6	1.08
	Kapiti Kitchen ginger all natural syrup	11.99	0.750	15.99	7.1	1.14

The most profitable product in each product category is highlighted. This was also conducted on the commodity products.

Table 1 The results of the secondary screening showing the product type, brand, unit price, price per kg, ginger content, and price per kg of ginger for commodity products

Product Type	Cost per kg (NZD)	Fresh ginger required (kg)	Cost per kg fresh ginger (NZD)
Ginger oil	110.11	25	4.40
	102.96	25	4.12
	240.24	25	9.61
	464.75	25	18.59
	140.14	25	5.61
Organic ginger Oil	243.10	25	9.72
	450.45	25	18.02
Ginger Oleoresin	171.60	25	6.86
	65.78	25	2.63
	75.79	25	3.03
	300.30	25	12.01
Ginger Concentrate powder	35.75	10	3.58

5.3.3 Tertiary screening

Discussion with Spices of Fiji suggested ginger oil and ginger paste were the two most promising concepts for their business. They had previously investigated producing ginger oil, however due to low yields and a lack of technical knowledge this was not pursued further. Ginger paste was also promising as they recently launched new vanilla paste and cinnamon paste products and this would align well with this new range.

The other business talked with Sai Yee Foods Ltd were most interested in ginger wine and ginger paste, both of these possibilities had been previously investigated but were not pursued due to lack of information regarding equipment and processing parameters needed.

(For further details on the stakeholder feedback refer to Appendix B: Fiji Trip Summary).

5.4 Conclusions

After feedback from stakeholders gained during the field trip to Fiji the shortlist of six concepts were reduced to four that would progress to the economic analysis stage.

- Ginger Oil
- Ginger paste
- Ginger wine
- Dried Ginger

6.0 Product costing

6.1 Aim

To assess the feasibility of the four selected product concepts examining the capital costs and operating expenses to establish which will offer the highest return on investment.

6.2 Methodology

It is estimated that 40%-60% of the current ginger yields that arrive at the processing facility are below export grade and are therefore shipped back to the growers at cost (personal communication with E. Ofati, June 2016). Therefore, it was estimated that 10% of the total current ginger export could then be utilized in this analysis, resulting in an input of 1200kg per year or 1000kg of raw mature ginger root per month.

The following information on each concept was examined:

- Manufacturing process
  - Steps in the process including optional steps
- Equipment needed
  - Costing based on New Zealand supplier of 2nd hand equipment Openshaw Machinery Ltd.
- Ingredient inputs
  - The materials required for the production of these products
- Operation costs
  - The ongoing costs of operation including electricity requirements and labour required
- Expected yields
  - The expected amounts produced from volume of inputs
- Basic economic analysis
  - Based on the above values the expected return on investment after 5 years will be calculated

The following assumptions were made:

- Where machine capacity was not stated it was assumed based on overall machine dimensions -40%
- As ginger is currently a waste product cost was assumed to be zero
- Equipment resale value is 20% at year 5
- Ex works sale cost is 50% of typical retail price for the product produced
- Packaging cost is not included
- Shipping costs not included
- Working capital of $15,000 is borrowed at the start of the 5 years and paid back in full at the end of the period
- Power was priced at $0.15 per kW/h
- Labourer wage was set at $16.50

The Net Present Value (NPV) will be compared to assess the relative merit of the different products. The NPV is a metric used to compare the inflow of profits to expenses over a period of time, in this case 5 years. If positive the revenue is greater than the expenses, if negative the reverse is true and the investment is unprofitable.

This takes into account of the time value of money by comparing it to an alternative rate of return that could be achieved by investing the money at a flat interest rate, in the case of all NPV's presented below this was 5% interest.

6.3 Results

Cash flow tables for the first year are shown below, for full cash flows over the five-year period and further costing details refer to Appendix C: Expanded Costing.

6.3.1 Dried ginger

As the only input ingredient was ginger which was assumed to be zero cost, and the capital and operating costs were low meaning the NPV was highly dependent on the sale price of the product and thus the total income, as shown in Table 11 where a 10 cent different in the selling price resulted in a $70,000 change in the NPV, changing it from negative and unprofitable to positive.

Table 2 Cash flow in the first year for 150g dried ginger at two ex works sale prices

Ex Works selling price	$1.45	$1.55
Type of cost	**Value**	**Value**
Capital cost	-$11,025.00	-$11,025.00
Operating cost	-$12,980.28	-$12,980.28
Ingredient inputs	$-	$-
Labour cost	-$161,700.00	-$161,700.00
Income	$174,000.00	$186,000.00
Cash flow	-$26,705.28	-$14,705.28
NPV	**-$42,105.22**	**$30,803.08**

Income was based on sales within the retail market, however dried ginger is also a commodity product sold by the container load. As the commodity market is extremely price competitive it is recommended to target the retail market where there are higher mark-ups and the Fijian product identity can be communicated more clearly, allowing access to premium markets.

6.3.2 Crushed ginger

The crushed ginger had the lowest capital cost as only a bowl chopper was required; this also resulted in low operating expenses. The largest expense was labour however this was minimal next to the profit that could be returned. At both retail prices examined the NPV was positive meaning the investment offered a profitable return, showing it would be beneficial to produce this product.

Table 3 Cash flow in the first year for 300g of crushed ginger at two ex works sale prices

Ex Works selling price	$1.25	$1.50
Type of cost	**Value**	**Value**
Capital cost	-$6,400.00	-$6,400.00
Operating cost	-$10,500.00	-$10,500.00
Ingredient inputs	-$100,298.26	-$100,298.26
Labour cost	-$444,675.00	-$444,675.00
Income	$592,333.33	$710,800.00
Cash flow	**$15,460.08**	**$133,926.74**
NPV	**$194,317.92**	**$914,084.90**

6.3.3 Ginger oil

The return for the ginger oil was highly dependent on both the selling price and the yield of ginger oil that could be achieved. This costing was conducted on the yield of 1.5% however oil content ranges from 0.5% to 2% depending on ginger type, season and maturity. This would require a higher level on ongoing technical knowledge to adjust processing conditions based on these factors and ensure profitable yields.

Table 4 Cash flow in the first year for 1kg of ginger oil at two ex works sale prices

Ex Works selling price	$115	$125
Type of cost	Value	Value
Capital cost	-$10,000.00	-$10,000.00
Operating cost	-$14,762.63	-$14,762.63
Ingredient inputs	$-	$-
Labour cost	-$121,275.00	-$121,275.00
Income	138000	150000
Cash flow	-23 037	-11 037
NPV	**-$24,201.12**	**$48,707.18**

Ginger oil is highly price dependant however a higher price can be achieved by producing organic oils at premium grades.

6.3.4 Ginger wine

Ginger wine has the most complex processing conditions and operational steps of any of the concepts identified, resulting in the highest capital cost, ingredient costs and operating costs. Due to this the selling price had to be high to justify the cost of production. As the fermentation process has a large impact on the quality of the end product it would need to be monitored throughout the process.

Table 5 Cash flow in the first year for 750g of ginger wine at two ex works sale prices

Ex Works selling price	$8.00	$9.00
Type of cost	Value	Value
Capital cost	-$109,000.00	-$109,000.00
Operating cost	-$155,883.60	-$155,883.60
Ingredient inputs	-$11,867,471.70	-$11,867,471.70
Labour cost	-$202,125.00	-$202,125.00
Income	$10,176,000.00	-$15,000.00
Cash flow	-$2,173,480.30	$11,448,000.00
NPV	**-$12,666,645.70**	**-$4,938,365.39**

The cost of ginger wine could be reduced by lowering ingredient costs, this could be done by finding an alternative source of sugar. Two possible options are the use of unrefined cane sugar or waste sugar syrup from crystallised sugar production.

6.4 Conclusions

The ginger wine and ginger oil are more complex processes, requiring a higher level of ongoing technical knowledge they also have a higher degree of risk. This more complex process also decreases the accuracy of the costing.

The ginger wine was the least profitable, judged by the negative NPV at both prices examined, due to the high cost of input ingredients and operating costs. The most profitable concept was the crushed ginger, with a positive NPV at both prices examined. This is due to its low capital costs, operating costs and labour costs and minimal inputs, as the main ingredient is the current waste product ginger.

Both dried ginger and ginger oil were highly dependent on the selling price as to whether the process was profitable or not. These are both commodity products in a highly competitive market. In order to get a market advantage, it is recommended to use the reputation of Fijian ginger as high quality and organic to target a premium and organic market.

7.0 Commercial ginger paste investigation

7.1 Aim

To examine and compare the pH, total solids, water activity, colour, and texture of five ginger paste products currently available in New Zealand supermarkets in relation to product quality and shelf life. By examining these parameters, a benchmark is able to be set that can aid in making a new ginger paste product that is of high quality and safe to eat.

7.2 Methods and materials

7.2.1 pH testing

The pH probe is calibrated using buffer solutions of pH4 and pH 7 and recalibrated every 12 readings. 5g of ginger paste sample is weighted and diluted with 15ml of distilled water. The probe is immersed in the sample and a reading taken, this setup is shown in **Error! Reference source not found.**. Three replicates will be taken for each of the four products with the probe being washed between tests.

7.2.2 Total solids

Three replicates of 50g of each sample will be weighed into metal dishes. These will be dried in the vacuum oven at 108˚C for 10h or until completely dried and the final dry weight recorded. The total solids will then be calculated with the below equation:

$$Total\ Solids = \frac{Final\ Dry\ Sample\ Weight}{Inital\ Sample\ Weight} * 100$$

7.2.3 Water activity

The water activity will be measured with an Aqua Lab 4TE water activity meter, a sample of approximately 5g will be placed in a plastic container, as shown in Figure 13 three reading will be taken at 20˚C and an average taken.

Figure 13. The experimental setup used to measure water activity

Figure 14. The experimental setup used for measuring pH

7.2.4 Colour

Colour will be measured with a Minolta colorimeter using hunters L*a*b colour space. Ginger paste will be placed 5mm thick into a plastic petri dish 5cm in diameter and placed on a sheet of white paper. Three measurements will be taken and a mean value calculated.

7.2.5 Qualitative assessment of texture

10g of ginger paste will be diluted to 50ml and placed in a glass petri dish. Photos will be taken to compare the relative particle size of the ginger paste.

7.3 Results

The five products tested are shown in Table 6 below.

Table 6 The current market products tested showing the ingredients and nutrition information panel

<table>
<tr><th>Product</th><th>Price (NZD)</th><th>Product Picture</th><th colspan="2">Nutrition panel</th><th></th></tr>
<tr><td rowspan="10">Gourmet Garden</td><td rowspan="10">$4.99 /80g</td><td rowspan="10">  </td><td></td><td>Average Quantity per 100g</td><td rowspan="10">Fresh ginger (61%), dextrose, humectant (glycerol), fructose, sea salt, antioxidant (sodium ascorbate), acidity regulator (citric acid),thickener (xanthan gum)</td></tr>
<tr><td>Energy</td><td>780kJ (186Cal)</td></tr>
<tr><td>Protein</td><td>1.2g</td></tr>
<tr><td>Fat, Total</td><td>0.5g</td></tr>
<tr><td>- Saturated</td><td>0.1g</td></tr>
<tr><td>Carbohydrate</td><td>35.8g</td></tr>
<tr><td>- Sugars</td><td>25.3g</td></tr>
<tr><td>Sodium</td><td>920mg</td></tr>
</table>

<table>
<tr>
<td>Greggs</td>
<td>$3.09
/145g</td>
<td> 

<table>
<tr><th></th><th>Average Quantity per 100g</th></tr>
<tr><td>Energy</td><td>52kJ (12Cal)</td></tr>
<tr><td>Protein</td><td>>1g</td></tr>
<tr><td>Fat, Total</td><td>>1g</td></tr>
<tr><td>- Saturated</td><td>>1g</td></tr>
<tr><td>Carbohydrate</td><td>2.4g</td></tr>
<tr><td>- Sugars</td><td>>1g</td></tr>
<tr><td>Sodium</td><td>420mg</td></tr>
</table></td>
<td>Ginger (84%), water, food acid (260),vegetable gum (415)</td>
</tr>
<tr>
<td>Master foods</td>
<td>$3.49
/160g</td>
<td> 

<table>
<tr><th></th><th>Average Quantity per 100g</th></tr>
<tr><td>Energy</td><td>139kJ (Cal)</td></tr>
<tr><td>Protein</td><td>0.2g</td></tr>
<tr><td>Fat, Total</td><td>2.2g</td></tr>
<tr><td>- Saturated</td><td>0.2g</td></tr>
<tr><td>Carbohydrate</td><td>2.5g</td></tr>
<tr><td>- Sugars</td><td>0.2g</td></tr>
<tr><td>Sodium</td><td>608mg</td></tr>
</table></td>
<td>Ginger puree (79%), water, vegetable oil, salt, food acid (acetic), vegetable gum (xanthan), sugar</td>
</tr>
<tr>
<td>Pams</td>
<td>$2.29
/250g</td>
<td> 

<table>
<tr><th></th><th>Average Quantity per 100g</th></tr>
<tr><td>Energy</td><td>284kJ (12Cal)</td></tr>
<tr><td>Protein</td><td>1.1g</td></tr>
<tr><td>Fat, Total</td><td>0.6g</td></tr>
<tr><td>- Saturated</td><td>0.1g</td></tr>
<tr><td>Carbohydrate</td><td>7.4g</td></tr>
<tr><td>- Sugars</td><td>0.1g</td></tr>
<tr><td>Sodium</td><td>43mg</td></tr>
</table></td>
<td>Ginger (92%), acidity regulator (260), thickener (415), preservative (202, 211)</td>
</tr>
<tr>
<td>Healthy ‘n’ Fresh</td>
<td>$3.79
/380g</td>
<td> 

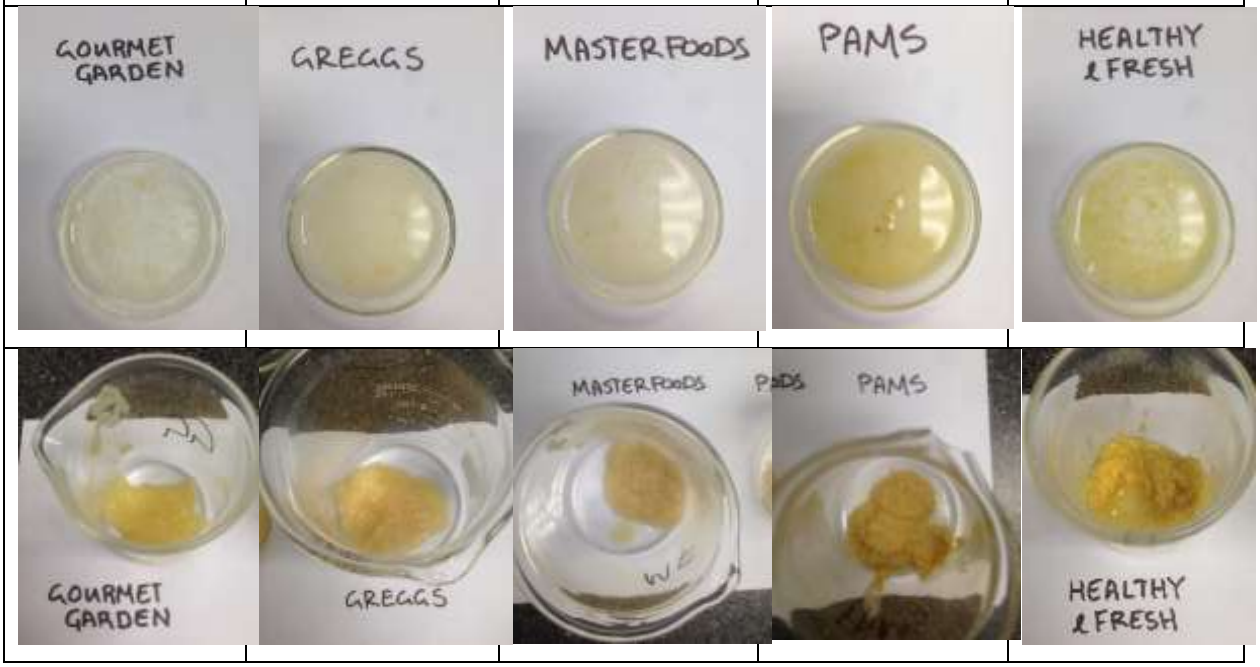
<table>
<tr><th></th><th>Average Quantity per 100g</th></tr>
<tr><td>Energy</td><td>117kJ (12Cal)</td></tr>
<tr><td>Protein</td><td>1g</td></tr>
<tr><td>Fat, Total</td><td>0g</td></tr>
<tr><td>- Saturated</td><td>0g</td></tr>
<tr><td>Carbohydrate</td><td>5.9g</td></tr>
<tr><td>- Sugars</td><td>1.2g</td></tr>
<tr><td>Sodium</td><td>649mg</td></tr>
</table></td>
<td>Fresh ginger (97%), salt, acidity regulator (270), preservative (202)</td>
</tr>
</table>

All products contain an acidity regulator to control and lower the pH. The gourmet garden paste also contains a humectant glycerol, a water absorbing substance that regulates texture and water activity

and inhibits microbial growth. The Pams and Health ‘n’ Fresh products both contain preservatives to inhibit microbial growth; however, the other three products rely on only pH and water activity to control microorganism growth.

The ginger paste products examined all have a shelf life of about a month after opening when stored in the refrigerator, and all but the Gourmet garden paste is shelf stable at ambient temperatures before opening. The Greggs, Masterfoods, and Pams jars all have safety caps on the jar lids, indicating that these products were heat treated and hot filled reducing the microbial load within the product, aiding in extending the shelf life (University of Minnesota Extension. 2016).

Table 7 A qualitative assessment of texture showing the relative particle size of five brands of ginger paste; from left to right brands are Gourmet Garden, Greggs, Master foods, Pams, and Healthy 'n' Fresh

Gourmet Garden	Greggs	Master foods	Pams	Healthy 'n' Fresh
				

The particle size of all products was similar ranging from approximately 0.5mm-2mm in diameter. The most significant difference was in the quantity of particles with the Pams and Healthy 'n' fresh products having many more particles that quickly settled out of solution, whereas the other three products were smoother and more pureed having less large particles that remained suspended within the liquid.

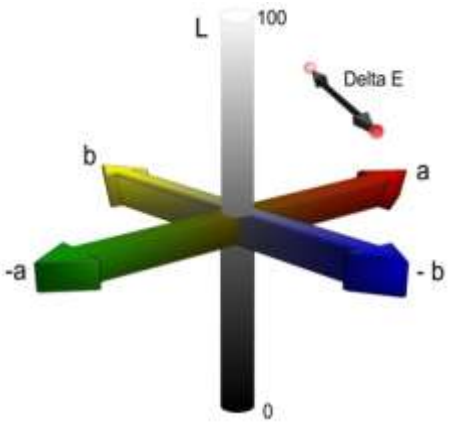


Figure 15. A visual representation of the Hunter L*a*b colour space

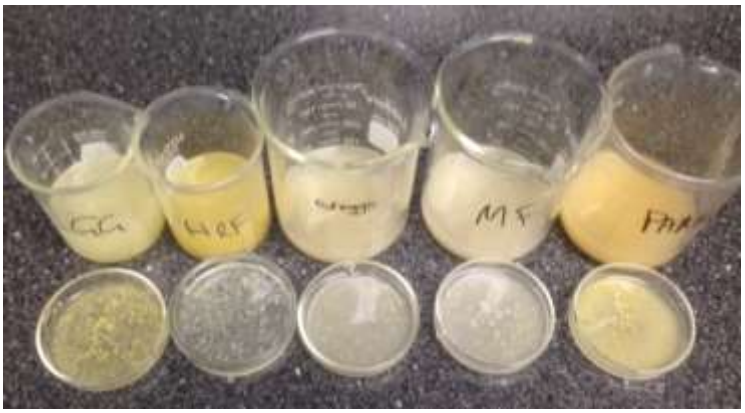


Figure 16. A comparison of texture and particle size of five current market products: Brands from left to right are Gourmet Garden, Healthy 'n' Fresh, Greggs, Master Foods, Pams

When examining the texture of the products two main styles were identified, the Pams and Healthy 'n' Fresh products were small fibrous pieces within a clear liquid, whereas the Greggs, Masterfoods and Gourmet Garden pastes were thick mostly homogenous pastes with smaller lumps. There was a difference in colour between the two groups with the Pams and healthy 'n' Fresh products were a brighter yellow colour where the other three were much paler beige.

This is confirmed by looking at the colour data which indicates that the Pams and Healthy 'n' fresh samples have significantly higher positive b values placing the product in the yellow area, (as can be seen in **Error! Reference source not found.**) above where as Gourmet garden, Greggs and Masterfoods have a and b values close to 0 indicating a low colour saturation that is more brown due to a mixture of colours.

Table 17. Results from quantitative analysis tests showing water activity, pH, total solids and water content

	Water activity	Average pH	Average Solids content (%)	Colour		
				L	a	b
Gourmet Garden	0.9127	3.98	35.51	70.23176	-1.79	-2.04656
Greggs	0.9947	3.40	2.56	94.73384	-0.20	2.09573
Master foods	0.9911	3.84	6.18	94.43516	0.89	1.213612
Pams	0.9848	3.47	10.78	96.34573	1.06	15.53647
Healthy 'n' Fresh	0.9790	3.16	8.09	97.42433	-2.91	21.9468

Ginger paste has high water content putting this product at risk of growth of microbes. Most bacteria can grow above a water activity of 0.91 and mould and yeast growth is only inhibited below a water activity of 0.60 (Decagon Devices Inc., 2016).

The water activity of all the products was relatively high and close to 1, indicating the risk of mould, yeast and bacteria growth. For all products examined the pH was below 4.0, this is most likely a critical control for quality as below pH 4.2 pathogenic bacteria growth is inhibited. The highest pH was the Gourmet Garden at a pH of 3.98, however this also had the lowest water activity and total solids content, due to the added sugars in the product in the forms of fructose and dextrose.

The solids content of all other products was low, ranging between 2.56% and 10.78%. Mature ginger is approximately 15% total solids (Shirin Adel and Prakash, 2010) so the paste's moisture content is consistent with ginger with the addition of water and other products such as oil.

7.4 Conclusions

While there was variation between the ginger pastes samples examined there were two main groupings of products: very smooth puree like pastes that are fairly homogenous that included the Pams, Masterfoods and Greggs products, and more crushed ginger style products with small fibrous pieces of ginger within a clear solution which included the healthy 'n' fresh and Pams products.

All of the samples had a water activity close to one, so used a low pH, below pH 4, and use of preservatives and humectants to control bacteria and mould growth.

8.0 Ginger paste shelf life optimisation

8.1 Aim

To identify the optimal preservative type and level to extend the shelf life of a crushed ginger paste by preventing browning, and keeping mould and bacteria growth within acceptable limits.

8.2 Experimental setup

The shelf life trial ran for 4 weeks, in two blocks of peeled and unpeeled ginger, the experimental set and levels of preservative up for one block is shown in Table 8 below. The paste will be stored at two temperatures, 30˚C and 40˚C.

Table 8. Experimental set up description showing one replication, this will be done for both peeled and unpeeled samples stored at 30° and 40°

Number	Preservative type	Number of samples		Ginger weight (kg)	Sodium Metabisulphite (g)	Potassium Sorbate (g)	Salt (g)
		30°C	40°C		0.02%	1%	1%
1	No preservative (control)	6	6	0.6			
2	Sodium Metabisulphate	6	6	0.6	0.012		
3	Potassium Sorbate	6	6	0.6		0.6	
4	Sodium Metabisulphate * Potassium Sorbate	6	6	0.6	0.012	0.6	
5	Salt	6	6	0.6			60
6	Salt + Sodium Metabisulphate	6	6	0.6	0.012		60
7	Salt + Potassium Sorbate	6	6	0.6		0.6	60
8	Salt + Sodium Metabisulphate * Potassium Sorbate	6	6	0.6	0.012	0.6	60

The following tests will be carried out the pastes each week of the testing and on the initial paste

- pH test
- Colour

The following tests will be carried out on the only the initial and final sample.

- Microbiological tests
- Total solids
- Qualitative assessment texture
- Water activity

8.2.1 Preservative levels

The preservative level was set to be the maximum amount of preservative permitted in a processed vegetable product. This is justified as preservatives are most effective in higher concentrations and ingredients must be declared on the ingredient list no matter the level used in the product, with no benefit from lowered levels of preservative.

To find the maximum permitted levels the Fiji food standards, Codex General Standard on Food Additives and the FSANZ additives standards were examined (refer to appendix D: Maximum allowed preservative levels for further details). As the FSANZ standards had the lowest acceptable limits these were applied.

Table 19. Levels of preservative to be used on maximum permitted levels

Preservative type	E number	Max Level (mg/kg)	Level to be used (g/kg)
Sodium Metabisulphate	E223	20	0.02
Potassium Sorbate	E202	1000	1
Salt		No maximum level	100

8.3 Materials and methods

8.3.1 Materials

- Bowl chopper
- Sodium metabisulphate
- Potassium Sorbate
- Salt
- Citric Acid
- Plastic heat seal pouches
- pH probe
- Knife
- Vegetable peeler
- Chopping board

8.3.2 Ginger paste preparation

1. Ginger ribosome is thoroughly washed to remove any exterior dirt and soil.
2. The ginger root is peeled using a vegetable peeler. Defects such as insect damage or black spots are removed using a knife.
3. The ginger is chopped into pieces 2-5cm in diameter and stored at 0˚C to -4˚C until ready to be made into paste.
4. The chopped ginger is added to the bowl cutter and chopped on slow for 2min until a coarse paste is achieved.
5. The chopper then placed onto high setting for 5 minutes until the paste is more liquid and homogenous in texture.
6. The pH of the chopped ginger was measured, the pH was adjusted by the addition of 10g citric acid until the target pH of 4.00 is achieved, the paste is chopped on high for 2 minutes longer to mix though the acid.
7. Ginger is removed from the chopper and preservatives added dissolved in 10ml hot water, then mixed though by hand.
8. The paste is then packaged into plastic pouches and will be heat sealed closed with minimal air within the package.
9. The process is then repeated with unpeeled ginger.

Figure 17. The bowl chopper showing the peeled ginger paste before acid and preservative addition

Figure 18. The ginger paste samples stored in the 30 incubator

8.3.3 pH testing

The pH probe is calibrated using buffer solutions of pH4 and pH 7 and recalibrated every 12 readings. 5g of ginger paste sample is weighted and diluted with 15ml of distilled water. The probe is immersed in the sample and a reading taken. Three replicates will be taken for each of the four products with the probe being washed between tests.

8.3.4 Total solids

Three replicates of 50g of each sample will be weighed into metal dishes. These will be dried in the vacuum oven at 108˚C for 10h or until completely dried and the final dry weight recorded. The total solids will then be calculated with the below equation:

$$Total\ Solids = \frac{Final\ Dry\ Sample\ Weight}{Inital\ Sample\ Weight} * 100$$

8.3.5 Water activity

The water activity will be measured with an Aqua Lab 4TE water activity meter, a sample of approximately 5g will be placed in a plastic container, three reading will be taken at 20˚C and an average value used.

8.3.6 Microbiological tests

Microbiological testing will be conducted by a Massey University technician. The following tests will be performed:

- Total plate count
- Total coliforms
- Yeasts and moulds

8.3.7 Colour

Colour will be measured with a Minolta colorimeter using hunters L*a*b colour space. The ginger paste will be mixed within the bag then placed on a white tile. Three readings are taken, one from the front of the bag and two from different points on the rear of the bag, and a mean value calculated.

Figure 19. The experimental setup for measuring the colour of the ginger paste

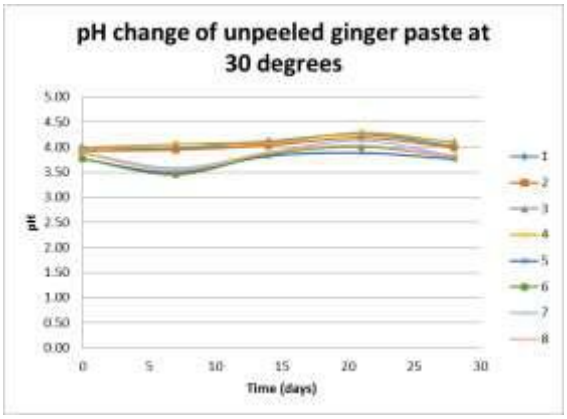
A ΔE value is calculated for every sample at each week, this measures the change in total colour and takes account of the change in L, a and b from the initial reading at time zero, allowing for simple comparison between samples. The equation used is shown below.

$$\Delta E = \sqrt{(L - L_{initial})^2 + (a - a_{initial})^2 + (b - b_{initial})^2}$$

8.4 Results

8.4.1 PH

There was a difference in pH between samples 1-4 with no salt being slightly higher in pH and samples 5-8 with 1% salt. When dissolved in solution NaCl dissociated into Na^+ a strong acid and Cl^- an equally strong base, due to the equal strength of these pairs there should be no difference in pH caused by the addition of salt.



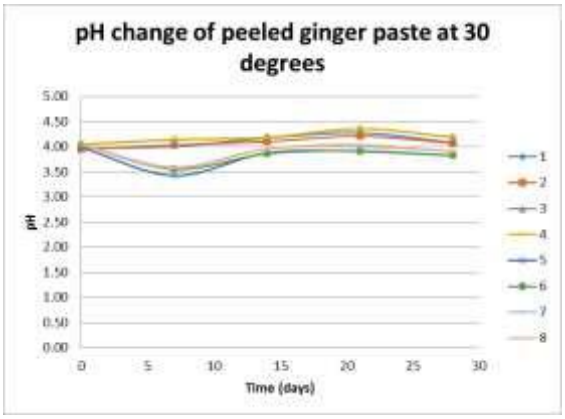


Figure 19. Change in pH in unpeeled ginger paste 30^{0}C over 4 weeks storage

Figure 20. Change in pH in peeled ginger paste 30^{0}C over 4 weeks storage

The change in pH in the pastes stored at 30° was minimal over the experimental period with the pH generally staying consistent for all samples. The main variation was a drop in the pH in samples 5,6,7 and 8 at week 2 to approximately pH 3.50 for both peeled and unpeeled ginger. The pH of in the final week was within ±0.2 of the initial pH reading for all samples. These variations were more significant than the average standard error of 0.02%.

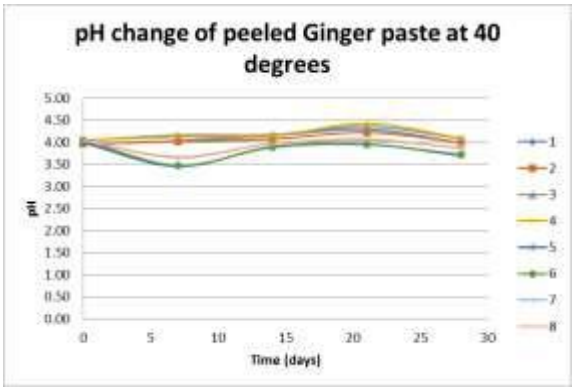


Figure 22. Change in pH in peeled ginger paste 40^{0}C over 4 weeks storage

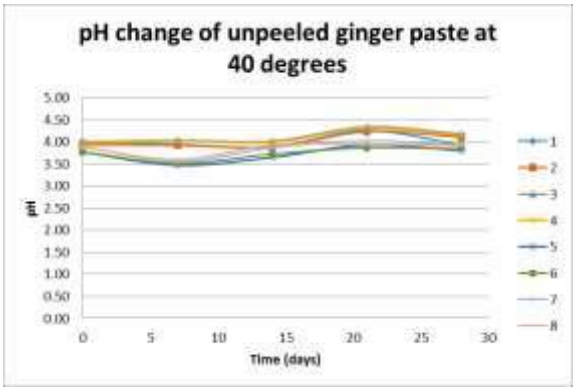


Figure 23. Change in pH in unpeeled ginger paste 40^{0}C over 4 weeks storage

The trends within the data were consistent with the samples at 40°C however there was a more pronounced increase in pH in week 3 of the trial. In the unpeeled samples 1 to 4 there was an increase of 0.3±0.05 and in the peeled ginger samples 1 to 4 this increase was even more noted at an increase of 0.3±0.08. This was the greatest variation noted in any of the samples.

While variation in pH was measured this difference in pH is less than 0.5 therefore would be difficult for taste detection.

8.4.2 Total solids

A change in total solids within the product indicates a moisture loss through the plastic film. This is due to properties of the packaging however may influence other factors if this is a significant change across the duration of the trial.

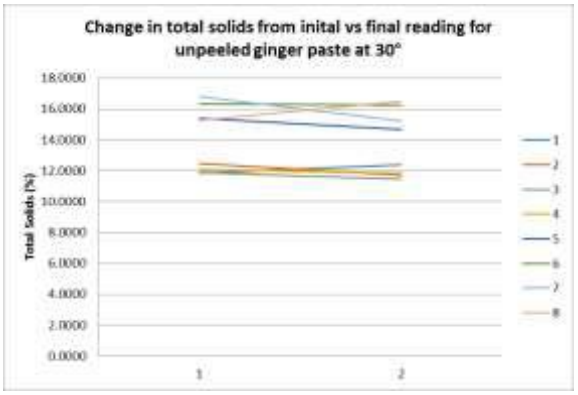


Figure 24. Change in total solids between week 0 and week 4 of the shelf life trial for unpeeled ginger paste stored at 30^{0}C

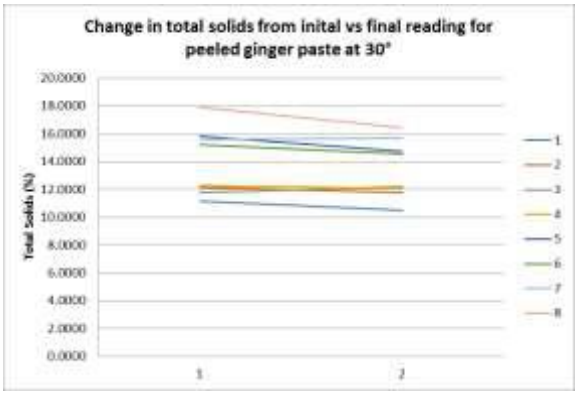


Figure 25. Change in total solids between week 0 and week 4 of the shelf life trial for peeled ginger paste stored at 30°C

Across both peeled and unpeeled samples at both temperatures there was a clear grouping of samples 1, 2, 3 and 4 without salt, having higher total solids content. All the samples stored at 30° had equal or slightly decreased total solids with the average loss being -0.38%, and a range of +0.41% to -1.60%.

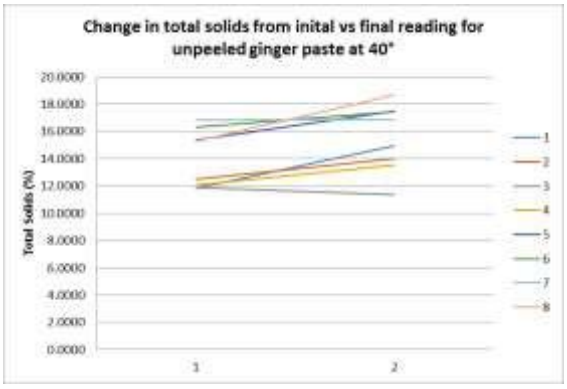


Figure 1 Change in total solids between week 0 and week 4 of the shelf life trial for unpeeled ginger paste stored at 40°C

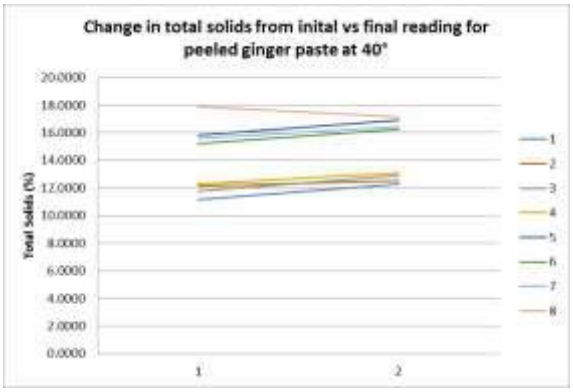


Figure 2 Change in total solids between week 0 and week 4 of the shelf life trial for peeled ginger paste stored at 40°C

The samples stored at 40°C followed a clearer trend with all samples but two increasing in solids content, and thus losing moisture. The two exceptions were peeled sample 8 and the unpeeled sample 3 that decreased over the experimental period by -0.76% and -0.46% respectively.

8.4.3 Water activity

Overall the water activity of all samples decreased between week 0 and week 4 due to moisture migration out of the paste and into environment though the plastic retort pouch. However, this was not true for the unpeeled ginger at 30° which increased in moisture content for almost all samples.

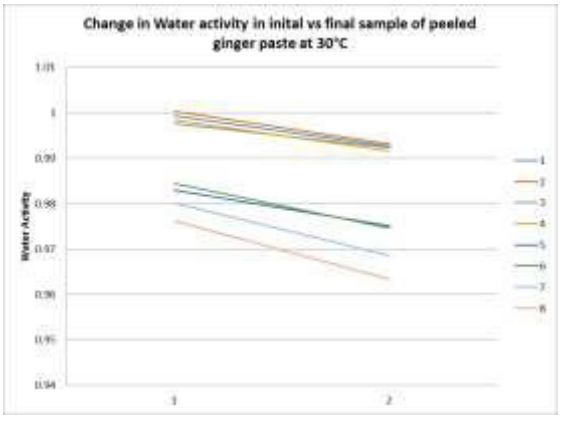


Figure 3 Change in water activity between week 0 and week 4 of the shelf life trial for peeled ginger paste stored at 30°C

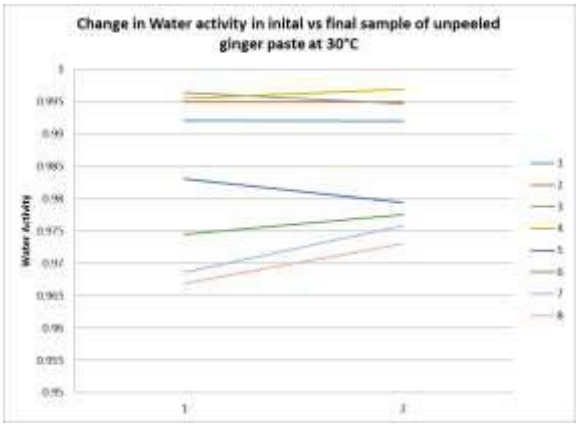


Figure 29. Change in water activity between week 0 and week 4 of the shelf life trial for unpeeled ginger paste stored at 30°C

There was a clear difference in water activities between the salt free samples 1-4 and samples 5-8 with 1% salt. This is as expected due to the addition of a water binding agent such as salt.

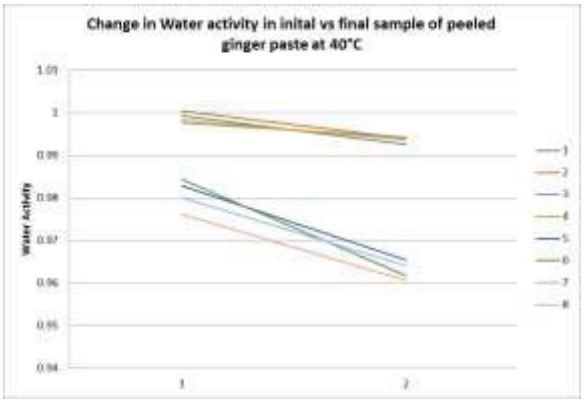


Figure 30. Change in water activity between week 0 and week 4 of the shelf life trial for peeled ginger paste stored at 40^0C

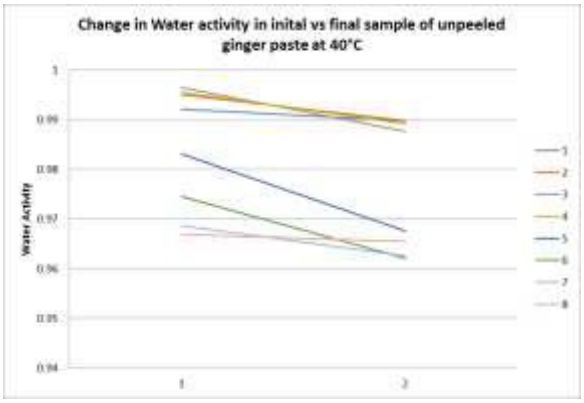


Figure 31. Change in water activity between week 0 and week 4 of the shelf life trial for unpeeled ginger paste stored at 30^0C

8.4.4 Microbiological

The acceptable limits for quality were based on what is set for ready to eat foods by FSANZ. All samples at 40°C were within acceptable limits for total plate count and total coliforms. However, at 30°C samples 1, 2, 5, and 6 in both peeled and unpeeled samples were above the set limits for both total plate count and total coliforms. These samples are without potassium sorbate showing that this preservative was most effective at controlling microbial growth and this is recommended to be used in the final product.

Some components not cooked in manufacturing process (eg sandwiches)

Aerobic plate count at 35°C (/g)	n = 5	c = 2	$m = 10^5$	$M = 5 \times 10^5$
Bacillus cereus (/g)	n = 5	c = 2	$m = 10^2$	$M = 10^3$
Campylobacter (/10 g)	n = 5	c = 0	m = 0	
Clostridium perfringens (/g)	n = 5	c = 2	$m = 10^2$	$M = 10^3$
Coagulase producing staphylococcus (/g)	n = 5	c = 2	$m = 10^2$	$M = 10^3$
Faecal coliform (/g)	n = 5	c = 2	m = 10	$M = 10^2$
**Listeria monocytogenes* (/25 g)	n = 5	c = 0	m = 0	
Salmonella (/25 g)	n = 5	c = 0	m = 0	

* When applying this criteria please refer to Section 4

Figure 32. Figure 4 New Zealand food standards general microbiological reference criteria for food that require no further cooking

(For further details on microbial testing refer to appendix I: Microbial results).

8.4.5 Colour

For the peeled samples there was a significant decrease in the ‘a’ value, as the sample went from red to more green in colour. For both samples the L value that represents lightness increased initially during weeks 1 and 2 then decreased but stayed within ±5 for all values. The largest change was in b, increasing in value to a more saturated yellow.

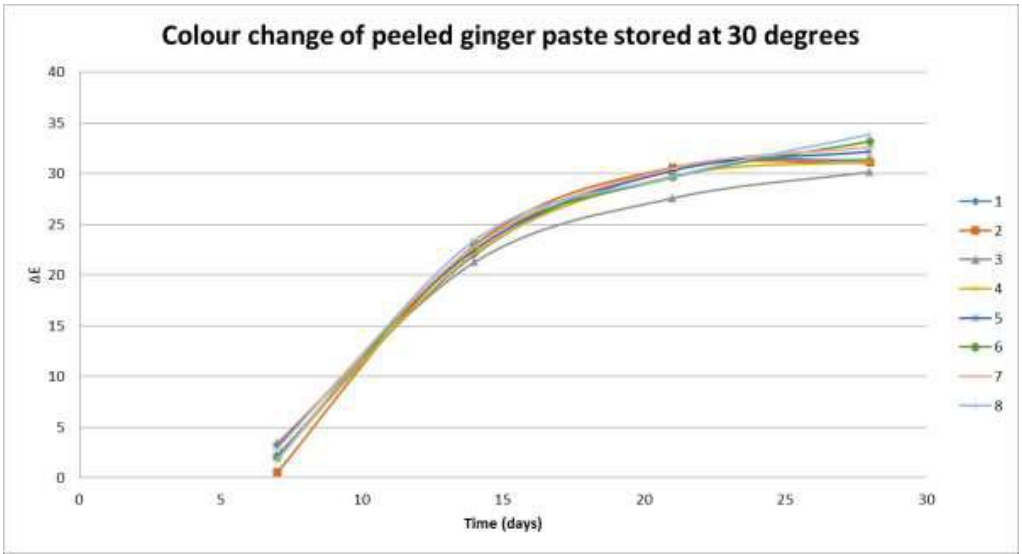


Figure 5 The colour change from the initial colour of peeled ginger paste over four weeks stored at 30˚C

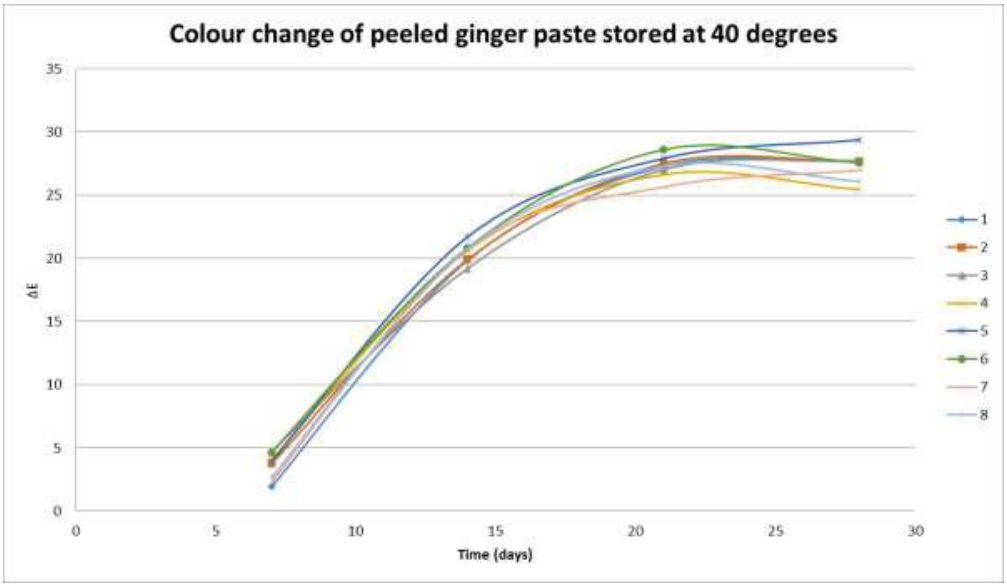


Figure 6 The colour change from the initial colour of peeled ginger paste over four weeks stored at 40˚C

The trend observed was similar for the ginger paste at 30˚C however was more pronounced at the higher temperature of 40˚C with greater variation between treatments.

The unpeeled samples showed a similar trend but more pronounced, especially at the higher temperature of 40˚C. Sample 2, containing only sodium metabisulphate, seemed to show the least colour change however this difference was not significant compared across all trials. In the unpeeled samples there was greater variation noted between samples of different treatments, this is possibly due to the presence of enzymes within the peel that contributed additional enzymatic browning. In the peeled samples there was greater variation in the L value and a more significant variation between the samples at 30˚C and 40˚C.

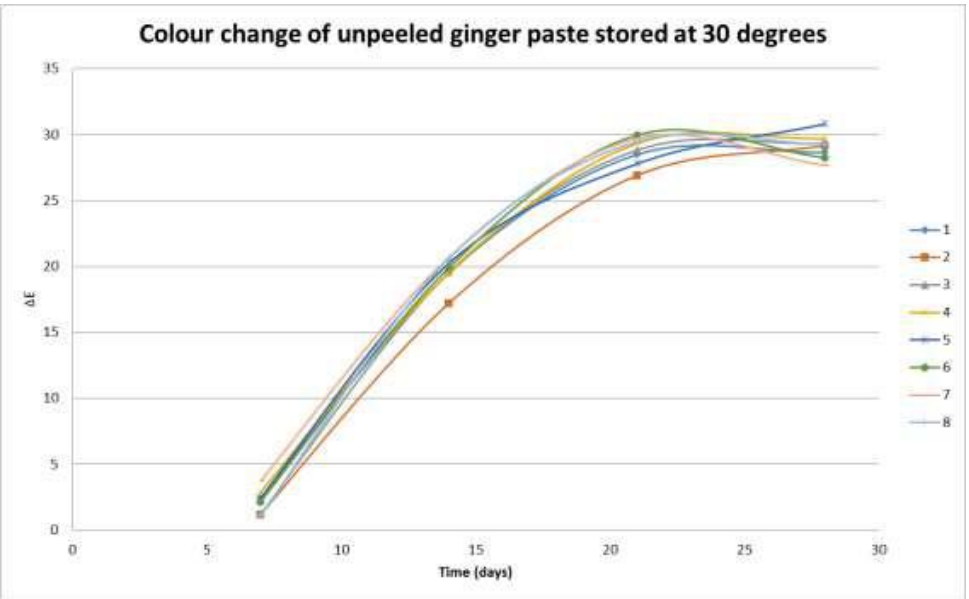


Figure 7 The colour change from the initial colour of unpeeled ginger paste over four weeks stored at 30˚C

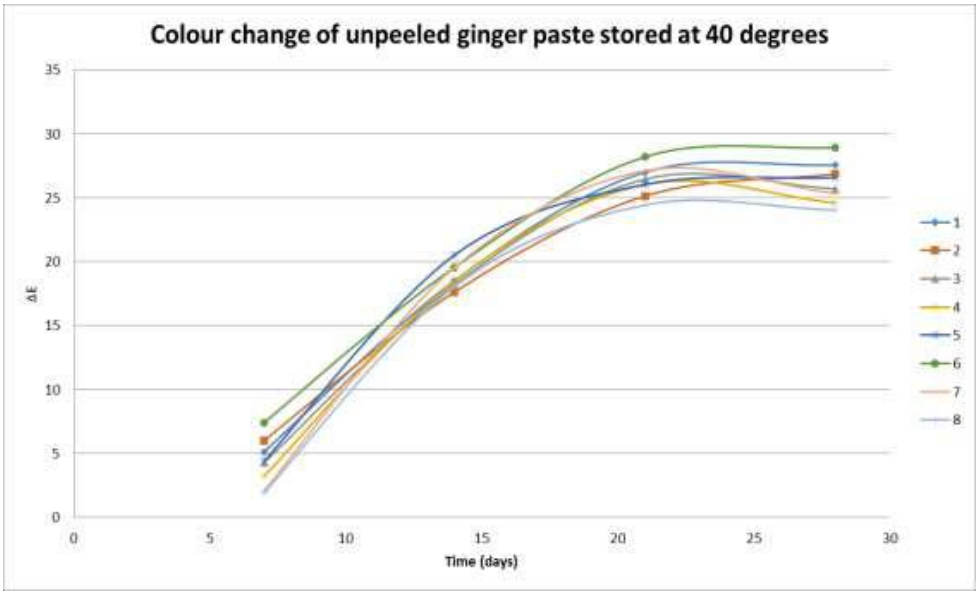


Figure 8 The colour change from the initial colour of unpeeled ginger paste over four weeks stored at 40˚C

8.5 Conclusions

The difference in colour change between samples with different treatments was minimal, and further investigation is required to establish an effective measure to prevent browning. All samples stored at 40˚C were within acceptable microbial limits however samples 1 and 2, and 5 and 6 that were the control, sodium metabisulphate, salt, and salt and metabisulphate all were outside the limits for total plate count and total coliforms. This shows that potassium sorbate is the most effective preservative type at inhibiting bacteria and mould growth.

Further research should be done to investigate in influence of packaging size and material on shelf life, as this will have an impact on the rate of moisture loss and so water activity and shelf life.

9.0 Conclusions and recommendations

While the shelf life trial showed that the ginger paste containing potassium sorbate as a preservative stayed within acceptable limits of quality for both the colour and microbial limits, further work should be done investigating the shelf life and the impact of differing pack sizes and packaging materials on the shelf life. This trial could be extended further to test the maximum possible shelf life that could be achieved.

Ginger wine, ginger oil, and dried ginger could be investigated further. Ginger wine and ginger oil both require higher degrees of ongoing technical knowledge but have the potential to bring high returns. Dried ginger is a product with great potential as it is simplistic and can gain a premium market via the organic and high quality marketing however as a commodity it is very price competitive. It is recommended to investigate the solar drying of ginger by use of simple technologies such as polytarp drying tunnels, as this would lower energy inputs, reduce contamination compared to other solar drying techniques and could be beneficial in gaining access to 'green' markets.

There is a great deal of potential within the Fijian ginger industry to turn the current waste into sustainable and profitable by-products. With a median amount of capital investment and some increased technical knowledge there is great potential for new and innovative products.

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Appendix A

Market research

Appendix A Market research

1 Ginger commodity products

Table 20. Ginger commodity products available

	Product	Origin	Price per Kg (USD)	Source
Ginger Essential oil	Ginger oil	Nigeria	$77	(NEPC, 2016)
		China	$72	(International Trade Centre, 2015)
		India	$168	(International Trade Centre, 2015)
		India	$325	(Lala's Group, 2016)
		Indonesia (Red)	$98	(International Trade Centre, 2015)
	Organic ginger Oil	India	$170 (drum lots)	(International Trade Centre, 2015)
		India	$315	(International Trade Centre, 2015)
Ginger Oleoresin	Ginger Oleoresin	India (oil soluble)	$120	(Lala's Group, 2016)
		India (Green ginger oil soluble)	$46	(Lala's Group, 2016)
		India (Water soluble)	$53	(Lala's Group, 2016)
		India (Green ginger water soluble)	$210	(Lala's Group, 2016)
Ginger Concentrate	Ginger Concentrate powder	China	$10-25	(Alibaba.com, 2016)
Dried ginger	Dried ginger powder	China	$3	(Nedspice.com, 2016)
		Nigeria	$3	(Nedspice.com, 2016)
	Spilt dried ginger ribosomes	India	$2.40	(Nedspice.com, 2016)
Sushi Ginger	Pickled Sushi Ginger	China	$1.5	(Alibaba.com, 2016)

2 Ginger products with Fijian identity

2.1 Wakaya

Table 21. Ginger products produced by Wakaya Perfection, available online at chopra.com May 2015

Picture	Product	Details	Description
	Wakaya Perfection Organic Ginger Tea $17.00	Ingredients: organic ginger root, organic lemon peel, organic crystallized ginger, organic pink Fijian ginger powder, and organic black pepper. Each tin contains 20 organic tea sachets.	Organic Ginger Tea - Blended with Wakaya Perfection: A 100% Organic Pink Fijian Ginger Powder (As used in The Chopra Center's Signature Perfect Health Program) Ginger tea is a warming, spicy, and delicious drink with many detoxifying and healing benefits.
	Wakaya Perfection Organic Ginger Powder $25.00	Ingredients: organic ginger root 6 oz 17g	Adorn your dining table with this, a healthier alternative to salt and pepper that will add zest and depth to your meals. This Uniquely Organic ginger is so versatile you can get the health benefits of it every day! Just add ¼ tsp to your favorite smoothie or a cup of hot water for a refreshing start to your day. Ginger aids digestion, enhances metabolism, reduces inflammation and adds a delicious zing to many of your favourite recipes.
	The Absolute Source Organic Pink Fijian Ginger Tea $27.50	Each tin contains 20 organic tea sachets.	The Absolute Source Organic Pink Fijian ginger tea is made with Wakaya Perfection's rare and proprietary 100% organic pink Fijian seed that has been thoughtfully hand-cultivated in a nutrient enriched pristine virgin volcanic soil on the private island of Wakaya in Fiji. Known as the universal remedy, Ginger has been honoured around the world and across time for its unique medicinal properties
	Ginger Caps Daily Ginger Supplement for Wellbeing $38.00	Ginger 0.6 oz. (45) Vegetarian Gel Caps (380 mg), Serving size: 1 capsule, Suggested use: 2 capsules daily	Enjoy this healing organic ginger as a daily health supplement to help enhance your life. Ginger will help ward off the effects of nausea, soothe common cold symptoms, reduce muscle inflammation and arthritic pain and more. The perfect travel companion for when you are on the go. As essential as your passport, Ginger Caps relieves motion sickness, soothes an upset stomach and eases migraine pain.

	The Absolute Source Organic Pink Fijian Ginger Incense $20.50		With products that celebrate and delight the five senses, The Absolute Source makes healthy choices that benefit body and mind easy and enjoyable. Infused with the delicious fragrance and flavour of perfectly spiced, warm and detoxifying Organic Pink Fijian Ginger, you will delight in every healthy experience. The Absolute Source Organic Pink Fijian Ginger Incense harnesses the distinct, full-bodied aroma of this extremely rare ginger from the island of Wakaya. When burning this exquisite incense creates the perfect atmosphere for timeless experiences. Enjoy this rare Pink Fijian Ginger scent daily as a reminder to celebrate the gift of life.
	Wakaya Perfection Beauty Companion Gift Set $254.00	16.9oz jar A ginger powder 5.8oz jar Pink Fijian Body Scrub. 15.5oz jar Pink Fijian Ginger & Sea Salt Body Soak.	Pink Fijian Body Scrub. This unique blend uses our Pink Fijian Ginger's natural exfoliants, and will help buff away rough skin, giving it a smooth and renewed feeling. Pink Fijian Ginger & Sea Salt Body Soak. A blend of our Pink Fijian Ginger and sea salt, this amazing scrub will help take relaxation to another level. Ideal for the end of a long day, it will soothe sore muscles while also helping to detoxify.
	Wakaya Perfection Organic Pink Fijian Ginger Powder $79.90	5.5 oz. 165g	Spices, Seasonings & Herbs - Pink ginger, a rare hard-to-find spice cultivated by hand from mineral-rich soil delivers the quality and purity that adds unprecedented flavour to beverages and foods. -

	Wakaya Perfection Organic Pink Fijian Ginger Powder, 6.7 Ounce $45.22		Grown in 7-million-year old rich volcanic soil. On the most pristine island on earth. Don't settle for a brand that offers you any less. Only Wakaya's turmeric is so pure and honest it has only one ingredient: turmeric. This is the ultimate organic micro food. A natural anti-inflammatory that soothes the stomach and detoxes the liver. You owe it to your health to buy your ginger from our 2,200-acre paradise. True believers enjoy its powerful effects daily.

2.2 The Ginger People

Table 22. Fijian ginger products available online at gingerpeople.com, May 15 2016

Product	Description	Applications	Appearance
Organic Bare Ginger Item Code #25220 pH: 3.8-4.3 Brix: 72-76% Ingredients: Organic ginger, organic cane sugar Made in Fiji	Bare ginger free from starch/dextrose coating and surface sugar. Dry and smooth to the touch with a soft fiberless texture between candied and crystallized. Certified USDA and EU Organic.	Use in private label re-pack, bulk bins, trail mix/granola, dip in organic dark chocolate or use in baking.	
Ginger Pulp Item Code #21140 pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Course puree of candied ginger. Sticky texture. Sweet, spicy, warm, mellow, candied ginger flavour. Adds body to formulas. Shelf stable, even after opening.	Sauces, salad dressings, chutneys, glazes, ice cream, pastries, pies, fillings, baked goods, creme brulees, cheesecakes.	
Organic Extra Fine Dice 3-7mm Item Code #25240 pH: 4.0-4.3 Brix: 72-76% Ingredients: Organic Ginger, organic cane sugar Made in Fiji	Tender pieces of candied ginger. Sticky texture. Sweet, spicy flavour. Pieces will disperse when mixed, and maintain piece identity when cooked. Shelf stable, even after opening. Certified USDA and EU Organic.	Sauces, salad dressings, chutneys, glazes, pastries, pies, fillings, baked goods, ice cream and other frozen desserts.	
Select Dice Ginger 70-100/500g 12-15mm +10% Syrup Item Code #21275 pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Dices of virtually fiber less candied ginger packed in some syrup.	Chocolate enrobing, hors d'oeuvres, snacking or baking.	
Organic Select Dice Ginger 70-100/500g 12-15mm Item Code #25270 pH: 4.0-4.3 Brix: 72-76% Ingredients: Organic Ginger, organic cane sugar Made in Fiji	Dices of virtually fiberless candied ginger packed in some syrup. Sweet ginger flavour and aroma. Shelf stable, even after opening. Certified USDA and EU Organic.	Chocolate enrobing, hors d'oeuvres, snacking or baking.	

Ginger Slices 25-35mm rounds Item Code #21235 pH: 3.8-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Slices of virtually fibre less candied ginger.	Chocolate enrobing, garnishes.	
Organic Ginger Syrup Item Code #25400 pH: 4.0-4.3 Brix: 72-76% Ingredients: Organic ginger, organic cane sugar Made in Fiji	Sugar syrup naturally infused with the flavour of candied ginger. Certified USDA and EU Organic.	Syrups, beverages.	
Mini Chips 2-5mm Item Code #20144 pH: 3.4-5.0 Brix: 70-78% Ingredients: Ginger, sugar Made in Fiji	Tiny random cut of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibre less ginger. Shelf stable, even after opening.	All baked goods - cookies, muffins, scones, carrot cake, pies, crisps, breads and more. Also used in baking mixes, cereals, snack mixes, and as inclusions in chocolate bars.	
Small Dice 5-8mm Item Code #20145 pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Small random cut of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibre less ginger. Shelf stable, even after opening.	All baked goods - cookies, muffins, scones, carrot cake, pies, etc. Also used in baking mixes, cereals, snack mixes, and as inclusions in chocolate bars.	
Organic Small Dice 5-8mm Item Code #25145 pH: 3.8-4.3 Brix: 72-76% Ingredients: organic ginger, organic cane sugar Made in Fiji	Small random cut of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibreless ginger. Shelf stable, even after opening. Certified USDA and EU Organic.	All baked goods - cookies, muffins, scones, carrot cake, pies, etc. Also used in baking mixes, cereals, snack mixes, and as inclusions in chocolate bars.	
Medium Dice 8-12mm Item Code #20150 pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Irregular cut of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibre less ginger. Shelf stable, even after opening.	Spice bottles, trail mixes and snack mixes.	

Select Dice 15-18mm Item Code #20120 pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Chunks of mild and tender crystallized ginger. Free flowing and dry to the touch on the outside, moist and succulent on the inside. Made from early-harvest fibre less ginger. Shelf stable, even after opening.	Repacking, snacking, enrobing, trail mixes and snack mixes, and hors d'oeuvres.	
Organic Premium Dice 8-16mm Item Code #41120 pH: 3.8-4.3 Brix: 71-74% Ingredients: Organic ginger, organic sugar Made in Fiji	Chunks of tender organic crystallized ginger. Free flowing and dry to the touch on the outside, moist and succulent on the inside. Very hot. Made from early-harvest ginger. Shelf stable, even after opening. Certified USDA and EU Organic.	Repacking, snacking, enrobing, trail mixes and snack mixes	
Select Slices 25-35mm rounds Item Code #20135 Pack: 25.4lb carton pH: 4.0-4.3 Brix: 72-76% Ingredients: Ginger, sugar Made in Fiji	Choice medallions of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibre less ginger. Shelf stable, even after opening.	Repacking, snacking, enrobing, trail mixes and snack mixes and garnishes.	
Organic Select Slices 22-32mm rounds Item Code #25135 Pack: 25.4lb carton pH: 3.8-4.3 Brix: 72-76% Ingredients: organic ginger, organic cane sugar Made in Fiji	Choice medallions of mild crystallized ginger. Free flowing and dry to the touch. Made from tender, fibreless ginger. Shelf stable, even after opening. Certified USDA and EU Organic.	Repacking, snacking, enrobing, trail mixes and snack mixes and garnishes.	

3 New Zealand supermarket products

Product Type	Product	Picture	Price (NZD)	Ingredients	% fresh ginger
FRESH GINGER ROOT	Fresh Produce, loose ginger per kg		$9.99/kg		100
CRUSHED GINGER	Just Ginger, crushed ginger		$2.49/185g	Fresh ginger (97%), acidity regulator (330, 270), salt, preservatives (202)	97
	Gourmet Garden ginger stir in paste		$3.49/80g	Fresh ginger (61%), dextrose, humectant (glycogen), fructose, salt, antioxidant (sodium ascorbate), acidity regulator (citric acid), thickener (xanthan gum)	61
	Masterfoods chopped ginger		$3.79/160g	ginger (96%), sugar, salt, citric acid (330), xanthan gum Contains soy	96

	Greggs crushed ginger		$3.09/145g	ginger (96%), sugar, salt, acidity regulator (330)	95
	Exotic Food Asian minced ginger		$3.19/195g	Ginger (60%), soybean oil, water, sugar, citric acid (330)	60
SUSHI GINGER	Fresh Produce, Pickled ginger		$2.49/150g	Ginger (67%), water, acidity regulator (260), preservative (202), salt, sweetener (954), colour (102, 106)	67
	Mama San Asian sushi ginger		$1.49/50g	Ginger (62%), water, salt, acidity regulator (260, 330), preservative (202), sweeteners (951, 950, 955), colour (163)	90
	Dragon Foods Asian pickled ginger		$2.99/120g	Ginger, water, salt, acidity regulator (acetic acidic, citric acid), preservative (potassium sorbate), MSG, sweeteners (aspartame, acesulfame Potassium, Saccharin, Sucralose), colourings	90

				(Anthocyanin)	
DRIED GINGER POWDER	Greggs ground ginger		$4.39/80g		
	Greggs ground ginger		$2.19/30g		
	Masterfoods ground ginger		$3.49/25g		
	Ms Rogers Eco Pack ginger		$2.30/30g		
CRYSTALISED GINGER	Tasti preserved ginger		$3.29/150g	Ginger (55%), sugar	

	Buderium Mild crystallized ginger		$3.99/125g		
	Buderim Ginger Crystalized		$7.99/250g	Ginger, sugar	
	Bulk value loose crystallized ginger		$24.90/kg		
SEMI DRIED GINGER	Gourmet Garden lightly dried prepacked ginger		$4.99/12g	Ginger (94%), vegetable oil, sea salt, acidity regulator (330)	100%
GINGER JAMS AND MARMALADES	Craigs ginger marmalade		$3.29/375g	Sugar, water, ginger (8%), gelling agent (pectin), citric acid	8

	Roses ginger marmalade		$4.00/500g	Water, sugar, ginger (12%), glucose syrup, gelling agent (pectin), citric acid, mineral salt (calcium chloride)	12
GINGER BAKED GOOD	Griffins Gingernuts		$3.00/250g	Flour, sugar, golden syrup, vegetable fat, [antioxidants (307b)], brown sugar, ginger, raising agent (450), salt, flavors, whey powder, colour (160b)	1
	Homebrand Ginger biscuits		$1.29/250g		
	Rosedale ginger kisses		$3.30/200g		
	Ernest Adams Sweet ginger loaf		$5.50/400g		
	Ernest Adams ginger slice		$4.49/300g		
	Ernest Adams gluten free ginger cookies		$5.49/190g		
	Nairns wheat free stem ginger biscuits		$4.89/200g		

MUSLI BARS	Healtheries real muesli bars, ginger and lemon		$2.20/30g		
GINGER TEA	Read seal fruit tea, lemon and ginger		$3.00/50g		
	Healtheries Lemon and ginger with an apple twist		$3.99/ 44g	Ginger (25%), apple (20%), rosehip, hibiscus, flavours, lemon peel (5%), orange peel, acid, elderberries, licorice root	25
	Chanui herbal green tea, green tea and ginger		$4.89/100g		
	Nerada organic fruit tea, lemon and ginger tea bags		$2.89/30g		

	Bell Zesty green tea and ginger		$6.19/100g	Green tea, natural flavours (lemon, ginger), sweet blackberry leaves, ginger, lemon peel, citric acid (330)	
	Dilmah Ceylon Green tea with ginger		$3.49/ 40g		
	Twinings herbal tea, settling ginger		$5.15/ 35g	Ginger root (70%), liquorice root (15%), cinnamon (10%), cloves (5%) *all our herbs are gently steamed, the process is gentle to protect their delicate taste	70
	Twinings herbal tea, Lemon, honey and ginger		$3.99/ 35g	Ginger (37%), natural lemon and other flavourings (25%), lemongrass, blackberry leaves, lemon peel, sweet fennel, natural ginger and other flavouring (3.5%)	37
	Red seal, red bush lemon and ginger tea		$2.90/ 45g		

GINGER CORDIALS	Hansells cordial honey and ginger		$4.00/ 500ml	Water, acidity regulator (330), natural flavours, natural fruit extract (lemon), sweeteners (952, 954, 955), preservatives (211), natural colour (160a)	
	Shott concentrate, lemon ginger and honey		$9.00/ 500ml	Sugar, water, honey (18%), lemon juice concentrate (11%), ginger (6%), food acid (330), preservatives (220, 223), vegetable gum (412)	6
	Buderim concentrate, ginger refresher cordial		$5.99/ 750ml		
	Barkers fruit syrup, lemon honey and ginger		$7.39/ 710ml	Sugar, lemon juice from concentrate (34%), water, honey (5%), ginger (5%), food acid (citric acid, sodium citrate), vitamin C	5
	Bickford's Ginger beer flavoured cordial		$5.99/ 750ml	Sugar, water, 5% ginger juice, natural flavours, citric acid, vegetable gum (xanthan), preservative (211), colour (150d)	5

	Kapiti Kitchen ginger all natural syrup		$11.99/ 750ml	Water, sugar, fresh ginger infusion (7.1%), tartaric acid, citric acid	7.1
GINGER KOMBUCHA	Kombucha wonder drink, pear and ginger		$5.69/ 414ml		
GINGER JUICE DRINKS	Homegrown Fresh juice, lemon ginger and honey		$4.50/1L		
GINGER BEER	Endeavor Ginger beer		$4.99/(4x 375ml)		
	Schweppes spicy ginger beer		$5.00/(4x 330ml)		

	Mac's ginger beer		$5.00/(4x 330ml)	Carbonated water, sugar, fermented ginger beer base (3.5%)[ginger, water, sugar, lemon juice concentrate, yeast, antioxidant (rosemary extract), flavour, food acid (330)]	
	Bundaberg diet ginger beer		$6.29/(4x 375ml)	Carbonated water, sugar, ginger root, natural flavours, citric acid, yeast, preservatives (202, 211)	
	Stoke ginger beer		$7.50/(4x 330ml)		
	Ranga Alcoholic ginger beer		$19.99/(6x 330ml)		
	Macs ginger brew		$15.00/(6x 330ml)		

GINGER SALAD DRESSING	Urban Appitie Salad dressings ginger and wasabi		$5.49/250ml		
GINGER PATE	Nanric rd fruit paste, pear and ginger		$5.99/130g		
GINGER NUTRACUITICALS	Blackmore Nausea relief, travel calm ginger		$15.95/(45x 1g)		
GINGER SAUCES	Trident chili sauce, ginger and chili		$2.59/285ml	Sugar, pickled red chilli (21%), water, garlic, ginger, vinegar, salt, stabilizer (415)	
			$3.19/280ml	Water, sugar (30%), garlic, ginger (5%), salt, thickener (1422), acidity regulator (acetic acid)	5
	Watties Wok		$2.30g/125g	Oyster sauce	12

	creations stir fry sauce, lemon ginger and sesame			[water, sugar, salt, oyster extracts, flavour enhancer (621),], soy sauce (17%), water, ginger paste (12%) [ginger, sugar, vegetable gum (guar gum), citric acid, preservatives (202, 223)] lemon juice (10%), sugar, garlic, sesame oil (4.7%), red chillis, maize thickener (1422), citric acid, xanthan gum, natural flavour	
	Watties stir fry meal base, honey soy and ginger		$3.15/425g	Water, sugar, vinegar (contains flavour), soy sauce (water, soy, wheat, salt) (6%), oyster sauce, honey (4.5%), ginger paste (3.5%), tapioca thickener (1442), salt, sesame oil, garlic, colour	3.5
	Maggi stir fry creations, sweet chili ginger and lemongrass		$3.69/150g	**Infusion Sauce:** Water, sugar, garlic, canola oil, Lemongrass (8.3%), salt, thickeners (1442, 1422, 1450), Chilli (4.5%), ginger (4.3%), soy sauce, vinegar, coriander, cumin, flavours Finishing Paste:	4.3

				Water, sugar, chilli (5.2%), thickeners (1442, 1422, 1450), salt, spice extract (160c) Contains wheat and soy	
GINGER FLAVOURED PASTA	Pasta pronto fresh filled pasta, pork and ginger		$6.00/400g		
GINGER FLAVOURED MEATS/ TOFU/ FISH	Hellers Sausages sticky beef		$8.49/480g		
	Bean Surpreme marinated tofu, ginger and honey		$5.99/250g	INGREDIENTS: Tofu (60%) (Water, Soy beans, Firming agent (calcium sulphate), Ginger (3%), Spring onion, Garlic, Canola oil)), Honey & Ginger marinade (40%) (Sweet 1 C. chilli sauce (sugar, water, chilli, vinegar, garlic, salty stabiliser (xanthan gum)), Honey (15%), Kecap	

				manis sauce (soy, wheat)), Soy sauce (soy, wheat), Ginger (2.5%)). Contains soy and gluten. May contain traces of sesame, dairy, egg, peanuts and	
	Sealord tuna pockets, Lemon sesame and ginger		$2.59/110g	Tuna (50%), soybean oil, water, ginger (6%), red capsicum, sugar, maltodextrin, lemon peel (2%), coriander (2%), salt, soy sauce powder, sesame seeds (1%), vegetable broth, flavouring, hydrolysed vegetable protein (soy), acidity regulators (330, 262), garlic, sesame seed oil, colours, herb, yeast extract, spice	
	John West tuna chunks, Chilli lime and ginger				

Appendix B

Fiji trip summary

Appendix B Fiji trip summary

1.0 Fiji Trip: Agenda

All days began at the PHAMA office, at SPC Nabua. Work done here consisted of typing up minutes of trip, some research into details of companies seen in Fiji, and discussions of project.

Monday 11/07/16	Travel day
Tuesday 12/07/16	Arrived at PHAMA office, induction and meet the team Overview of Fiji map, ginger growing areas and geographic challenges Visited Spices of Fiji Visited Jemima XXXXXX food science lecturer at University of the South Pacific
Wednesday 13/07/16	Tour of local supermarkets to see retail products Visit to Ken Yee's Lami factory to meet with Elizabeth
Thursday 14/07/16	Typing up work at PHAMA office Early knock off at 2.30pm
Friday 15/07/16	Laboratory work with BAF team at FNU agri research site Nasuri with Mike and Zhang Visit to ginger field

Tuesday 12/07/16

9.00AM Arrived at PHAMA office, induction and meet the team

10.00AM Overview of Fiji map, ginger growing areas and geographic challenges

11.00AM Visited Spices of Fiji -George and Victoria Hazelman

Located 22km out of Suva along Queens road, produce and dry spices for export to Australia and New Zealand. They grow some spices and source from farmers in the surrounding area to export dried turmeric, cardamom, cinnamon, nutmeg, ginger, vanilla beans and are trying to launch a new products cinnamon paste and Vanilla paste.

Spice pastes

- These consist of Cinnamon powder/vanilla beans, water, sugar and seaweed
  - Sugar acts as a preservative
  - Red sea weed is gathered from local islands *assume it is dried and ground* and acts as thickener and stabiliser
    - Another project is underway looking at extracting carrageenan from seaweed to use directly
- Funded by PHAMA to develop this product though Jemima at USP
  - Development took two years to make product + conduct shelf life trials
- Have confirmed buyer for the vanilla products how ever have not been able to supply product
  - The owner of the business Ronald Getty Died in 2014 and the loan for the development of the process and capital for farm operation could not be accessed

        - Cash flow problems mean that some time and energy must be invested into growing plants to sell to a resort in Kadavu for income *not spice plants just decorative*
    - George had received the letter confirming that the money could now be accessed the same week we visited

Current spice processing

- Spices are washed, sun dried and ground to powder (ginger is chopped first by hand)
    - Sun drying takes about 10 days to dry completely
    - dependent on weather and Suva has highest rain fall in Fiji so this is often a problem
    - When it rains spices must quickly be covered or taken inside and a wood burner is used
        - Wood burner takes about 4 days to dry spices, takes a lot of fuel and constant manning, not very practical
        - Have looked at electrical dryers however this is expensive to buy and run
            - Dried ginger must be competitive against ginger from India which can sell for $2000-$3000 per container
            - Looking into solar panels to make power cheaper
            - Are connected to Fiji's power grid
- Sold in local supermarkets in small 50g bags, also exported in 5kg and 10kg plastic bags
- Export about 700kg of each dried spice per year
    - Largest buyer is Ceres organic in NZ
- They grow a range of spices at their farm in Wanadoi but also buy spices from a range of farmers
    - End goal is to be a cooperative business that buys from farmers at a fair price and processes into a final value added product to sell on behalf
    - Most of their farmers work small fields using basic equipment such as a pitchfork, this restricts their ability to expand and break out into larger production
        - Spices of Fiji could purchase equipment such as plow and tractors that could be loaned out to farmers for harvesting ginger
        - Genuine interest in helping the farmers and boosting the community
    - As many farmers are small farms in remote areas shipping to the factory is expensive

Ginger

- This is a popular crop as it is fast and gives good yields (6-10tons per acre)
    - Good cash crop for subsistence or small scale farmers
- Have had interest in fresh ginger exports to overseas but cannot meet the quantity or quality requirements
    - Approached by woman in Wellington NZ making ginger beer
    - Approach from UK asking for 2 container loads per month
    - Approach from UK asking for 500kg per month but of very high quality
        - Ribosomes over 250g, all fingers intact, no broken cut or bruised ribosomes
    - Want more information on how to get their products into the UK and other countries, export requirements, documentation etc

Concepts

- Ginger oil and crushed ginger are the two favourite concepts
- Also thought some kind of drink could be popular a beer/ale/wine
- Ginger oil
    - Have tried to make cinnamon oil from cinnamon leaves using a friends' tea tree oil water still but not very successful
        - Expected yields of 1%-3% but only got 0.5% if even that but not sure why
    - Could then use this to flavour candies, drink and so on

        - *They seemed very excited about the possibilities of what could be done with this after its made*
    - What can you do with the waste?
        - Fibrous waste from wet ginger could be composted and put back onto the fields
        - Could use to make base of a curry paste, add back in removed flavours

What they want from this project:

- What products could be made and how
    - Equipment required,
        - places to source this from (2nd hand from NZ/Australia)
        - cost to buy
        - cost to operate
    - Market information
        - Who will be the buyer
        - What documentation is needed
        - Export/import requirements

What I think may be valuable to them:

- Scale options for processes
    - How does equipment change with scale of production, what inputs are different for different sizes of production
    - Simple drying equipment options
        - As per discussions with Bronwyn

<u>1.00PM Visited Jemima at food science lecturer at University of the South Pacific</u>

Discussed development of cinnamon and vanilla pastes for spices of Fiji

- Used raw seaweed gathered from outlying islands
- The use of local products makes product cheaper and sustainable
- Keeps some Fijian identity within the additive
- Project has taken two years to develop product
    - First year was making product, 2nd year was completing trials
    - Shelf life was tested at 3 months, 6 months, 1 year, 2 years
- Now looking at extracting carrageenan from seaweed
    - Phd student working on this
    - Getting yields of 50%

Discussion of bleached ginger

- Some is currently manufactured in Fiji and exported
- Sodium metabisulphite used to remove colour
    - Then washed off product to a concentration below 10ppm
    - Able to be exported without trouble depending on food additive laws in incoming countries
- Nutritional content and flavour is not affected

Discussed prototype concept ideas

- Crushed ginger
    - This has been done before, not a new product
    - Pacific foods current makes this product to sell locally within Fiji
        - Packaged in retort packaging

        - Brown in appearance-probably due to oxidation and enzyme activity, not such a desirable colour
    - Simple to do
- Ginger syrup
    - Works alongside what is done already for crystallised ginger
- Ginger oil
    - What waste is produced from this?
        - What else can be done with this fibrous waste?
            - Curry paste idea suggested, possible *Jemimia did not seem interested in this idea*
            - *Fibre supplement?*
        - Efficiency of process
            - Will the amounts produced be viable for cost of equipment?
            - Power source?
- Ginger wine
    - Most promising concept
    - Potential for large local market
        - There are no Fiji produced beverages (other than beer) all are imported soft drinks
            - Suggested to have a non-alcoholic version to meet this soft drink niche
    - Can be scaled up easily
    - Simple process and equipment
    - *Offered to go into business, three way split between me, her and Losinali*
- Ginger tea
    - Currently sold as a product locally in the form of spicy masala teas
    - Can't see large opportunity as many people would make their own
- Semi dried ginger
    - Similar product to dried ginger but sells for 4-5x as much
        - Also has higher water content so takes less ginger than dried ginger=better return
    - Would need to connect to a supplier to sell product in NZ
        - No point making a product with no buyer
        - Cannot sell directly into supermarkets
    - Perishability issues due to higher water content?
        - Would need air tight packaging

Key discussion points:

- Deletion of food science course at USP
    - Reason is low course numbers (20-40 students)
    - More politics behind the decision
- Fiji spices progression of project issues
    - They have not fulfilled their section of the agreement by going into production
    - Cannot progress much further without more input on their side
- Sustainability of product must be considered early
    - Environment, waste, ingredient supply must be considered early in the project
    - Sustainability growing issue in Fiji and products should be designed to do future good, not future harm
- Making a new product is easy but connecting the manufacturer to the market is most important
    - Building relationships between suppliers and manufactures
    - Have a company in mind to buy this product if it is specific, or more general that can be bought by many people

3.30PM Discussion with Bronwyn Wiseman regarding project

What information came from today's visits?

Spices of Fiji

- Top concepts were crushed ginger and ginger oil
    - Crushed ginger is essentially ginger in another form, simple process
        - No chemical changes take place (except browning possibly)
        - Packaging can be suited to product, jars or bottles would be imported so plastic would be cheaper, retort/heat sealed bags could be used
        - This could be combined with oil and other spices to make a curry paste
            - Coconut oil manufactured in Fiji, the rest is imported
            - One Fiji company 'taste of India' makes curry ready meals and sauces in retort pouches with screw lids
                - These are complete sauces with cream, onions etc. but contain ginger (>3.5%)
    - Ginger oil is promising
        - What expertise is needed to operate equipment
        - How consistent is the product?
        - Could then be used to flavour products such as drinks, candies etc.
- Main challenges they face are in drying spices as this is done in the sun
    - When it rains they have to drag products inside or cover them
    - The main issue with dryers is the power input needed
        - Research was done in PNG into cocoa dryers using polytarp tunnels with wooden frames
        - This was weather proof so could be used in the rain, kept out contaminants
        - While this did increase heat the effect of weather proofing was most significant
        - Offset peak of roof interrupted convection currents of air creating good air flow
        - Bottom had gap or could be rolled up to ensure precipitation could escape
    - To improve quality, you can upgrade to new equipment for $10000 i.e. mechanical choppers or just can employ and train 20 people, high tech is not always the best solution
        - What is most consistent and viable for infrastructure?
        - What creates most jobs?
        - What expertise is needed to use this equipment? If staff training is needed anyway why not employ and train more staff

Jemima at USP

- Top concept was ginger wine
    - Gap in market for Fijian made drink
    - In Tonga they make a competing soft drink using imported flavoured syrups
        - No innovation, just versions of Fanta, coke, sprite etc. using premade syrups
        - Simple process, water, flavour, carbonation

4.15PM Sit in on meeting with BAF officers regarding Nematode research

Wednesday 13/07/16

11.00AM Tour of local supermarkets to see retail products

Visited three supermarkets

- New World (no relation to the New Zealand brand) Very new development in the sport complex Suva near USP, very similar to a New Zealand supermarket in appearance and represents the highest income bracket in Fiji with many imported New Zealand and Australian brands, high end products and a large dairy section
- New World (no relation to the New Zealand brand) Tamavua in Suva, a relatively wealthy area and but less imported high end products and larger range within products common for Fijians (i.e. tinned meat and fish, instant noodles, rice etc.)
- Shop 'n' Save in Lami, represents the average supermarket in towns. A large range of products with more locally imported products and imports from countries such as Vietnam, Malaysia and Indonesia

Price control items

- Prices of basic items such as oil, flour, grains, pulses, legumes etc. are price capped by the government
- Most (if not all) of these are imported goods
- Aim is to keep staples affordable for all Fijians

Average low wage $20 FJD per day so New World supermarkets don't represent average buyer but it is a growing demographic

- Professional Fijians and those that are university educated are main customers
- Growing demographic of Fijians that travel often and desire luxuries available in Australia and New Zealand
- Many young Fijians aspire to travel to Australia or New Zealand

Expensive dairy but Rewa dairy new local option

- 6 pack yogurt meadow fresh costs $20.50 FJD! Meadow fresh 1L pack costs $17.00 FJD
- Fiji received first fresh milk in 2014
- Make milk, flavoured milks, yogurt, sour cream, and compete with imported products from New Zealand and yogurts made in Nadi licensed under Yoplait
- Quality issues still present in products due to refrigeration issues

Tomato sauce a staple

All potatoes imported

- Some chips are made in Fiji from imported potatoes
- Research going into making chips from dalo, and cassava however due to variation in raw ingredients due to type of plant (more/less sugar/starch etc.) having issues

Curry pastes widely purchased within the large Indian community as well as the general Fijian community

- Range of flavoured pastes available
- Garlic paste was seen (retort pouches produced by Pacific foods) but ginger paste was not in stock

Biscuits very popular in Fiji

- Imported products 2-3 times price but higher quality Fijian brands emerging
- Most products have Fijian equivalent that is slightly lower in quality but comparable
- Biggest Fiji manufacturers Flour Mills Fiji (FMF) and Punjas

Cordials and soft drinks

- Most popular cordials are fruit or powdered (Raro and Vitafresh)
- Ginger cordial seen in the sport complex New World
- Fijian brand of soft drink called Pop, apparently very sweet

2.00PM Visit to Ken Yee's Lami factory to meet with Production Manager Elizabeth Ofati

Ken Yee was in China accompanying first import of Fiji ginger to China so was unavailable. He will be in contact with further questions as he has final say in what the company will do.

Ran though concepts of what can be done

- Ginger wine and ginger paste were identified as most promising
    - Ken had previously mentioned this as promising however lacked information on how to achieve this
- Like what has been done currently
- Want more information on what equipment is needed and the cost of this

Toured the factory

- No production was taking place and currently wrong season for ginger
- Food production area is HACCP approved, standard tiled floors and white aluminum walls
- Strong emphasis on cleaning and good understanding of what is needed to meet quality and safety requirements
- Ginger comes into receiving are for washing (pictured) then is cured in roof space above (pictured) which is a recent addition
    - Washed with water blaster, and by hand. Sorted into crates and cured for 8-10 days
    - Cured in raised roof space, covered only by roof (no sides) with good air circulation
- Then moves into processing area
    - Equipment is basic, stainless steel benches, knives, trays
    - Only mature ginger is processed at this site to be sold as whole ginger root
- Currently ~50% of ginger is below export grade and is sent back after washing
    - This creates a loss on shipping as trucking from highland farms is very expensive and this is paid for by Sai Yee Foods
    - Good yields are 65% pass export grade, bad is about 40% at export grade
    - Reject ginger is used as planting material

This factory is used for processing root crops (dalo, cassava, taro, ginger) for fresh export, and for cleaning, gutting, and freezing fish which is vacuum sealed for frozen export to Australia and New Zealand

- Fish is processed by cleaning, gutting, drying surface then freezing. It is then vacuum packed
    - Frozen by placing in walk in freezer for 1 day/overnight then is vacuum packed when frozen
- Roots are washed, dried and either shipped out whole or further processed
    - Dalo cut into pieces and brined in chemicals to preserve colour and prevent browning
    - For products shipped out whole they go onto the next step where they are inspected and any defects cut out by hand by workers
    - Ginger is washed and dried, moves onto workers who inspect each piece, cut out small defects of Yam scale, or nematode damage or reject the ginger if it is poor quality/too many defects. It is then packed into plastic crates and cured for 7-10 days in roof space

They are also in the process of establishing chocolate manufacturing

- Have purchased 3 pieces of equipment for bean to bar processing

- Cocoa is grown in Fiji and there is one other company who makes artisan chocolate selling for about $15 FJD per small (200-400g) bar
- Have confirmed source of cocoa
- Have been discussing this for a month but needed more expertise, who Ken consulted with is unknown

3.30PM Drove around industrial processing centre of Suva

Thursday 14/07/16

9.00AM Work at PHAMA office

Friday 15/07/16

9.00AM Laboratory work with BAF team at Ministry of agriculture Animal Health and Production site, Nausori

Examining Nematodes within ginger

- Has been difficult to find these nematodes in samples, most farms are well managed and this is not an issue but some areas/farms lack management and are severely affected

Nematodes general

- Nematoda is a phylum
    - Contains very broad range of nematodes
    - Insects are a class (lower in naming order than phylum) so smaller category than nematodes
- Root knot nematode
    - Burrow in to root and block phloem causing blockage and swelling of the root, a knot forms
    - Immobile surface nematodes
    - Lays eggs outside the body
    - Significant pest on tomatoes (also grown in Fiji)
- Cyst Nematode
    - Forms large surface lump on the exterior of the root
    - Stationary immobile nematode
    - Female holds eggs internally
- Radolophilis Similis
    - Female has a flat head, males has more pointed head and thicker body
    - Have a spike on the head called stylet to pierce though cells and suck up matter to digest
    - They eat though root causing cavities
    - Breaking of epidermis allows secondary infections to enter into the root ie fungi, moulds causing further breakdown, waterlogging and rot
    - Reproduces inside root
    - Mobile nematode that can move throughout the root
    - About 1mm in size
    - Eggs are 10-50 microns big

Management of Nematodes

- Crop rotation
    - Planted in a four-year cycle going ginger, dalo, cassava, and a fallow year
        - Dalo is taro in Fijian

        - Fallow year allows for regeneration of the soil
    - These plants are not hosts for radolophis so lower concentration in soil by preventing reproduction of nematode
- Use of chicken manure
    - Ammonia works as a fumigant to deter/kill radolophis
- Clean planting material
    - This is critical! Crop management efforts are wasted if infected material is planted in clean soil
    - Done by segregating one crop from the main area to use as seed crop the following year
        - Many farmers see this high quality product and instead sell this to get a good price, and use lower quality or reject matter as planting stock instead
    - Sai Yee Foods practice of returning reject ginger to farmers to use as seed stock is poor practice and will result in loss of quality in following years
    - Reject matter could also be composted
        - To kill nematode temperature must get above 70°C
        - Must be well managed or improperly treated compost will then inoculate fields with nematode
- This information has been communicated to farmers but many do not follow this
    - Many want a 'silver bullet' one chemical which could solve problem easily
    - Researchers think they do not believe them as they do not come from a commercial point of view

Photos taken of:

- Nematode damage that would mean ginger is rejected
    - Often just left in field to rot
    - Can effect up to 70% of crops (according to Mike)
- Good ginger suitable for export
    - Slightly undersize
- Grub damage to ribosome from eating away at it
    - Come from worms, slugs etc.
- White fungi that is a significant post-harvest pest
    - If not washed and cured quickly after harvest this will rapidly spread
    - If this was left in a bag within 1-2 days, the entire bag would be ruined by these fungi
- Appearance of white scars from previous wounds to ginger
    - Unlike most fresh fruit ginger can be cut or broken and within a week this will be healed over by this white scar tissue
    - Allows for greater ease of shipping as small defects can be removed

<u>3.00PM Visit to ginger field</u>

Ginger field visited in outer Suva city area

Worked by hand

- The only equipment used is metal forks
- Work involves weeding, preparing ground by tilling, planting, harvesting
- Even carrying seed is done by hand

Crop rotation with cassava, dalo (taro in Fijian) could be seen

- Intercropped with vegetation borders of grasses
- Four-year cycle of cassava, dalo, fallow then ginger
- Sometimes fallow stage is skipped. For commercial reasons

Farm was well managed

- This farm weeded by hand, this was done well
    - Some larger farmers use pesticides to control weeds
        - have enough income to afford chemicals
- This particular farm was good in appearance and ginger was well covered by soil
    - Soil is dark red/brown and very good drainage

At this time of year ginger is senescing

- Looks yellow and stalks are bent over which is typical
- Planted in September for harvest in the next month or two
    - This is mature white ginger
        - There is also Fijian pink ginger which is of very high quality

This is a comparatively large ginger farm

- Extra labourers are hired to work the land
- Predominantly Indian and Asian farmers in this area
    - Land is leased native land
        - 3 types of land in Fiji:
            - Native land managed by villages/leased though government department
            - Freehold land that can be bought and sold outright
            - Crown land owned and managed by the government
        - Most leases are long periods, usually 99 years

Road to farm was relatively short but access was poor

- This farm was within greater Suva area and the road quality was quite good more most of the way
    - This was the first farm accessible and last 200m was very rough, hilly, dirt track
        - This was in dry winter season, when wet access is more difficult, and road even worse
- Poor road quality results in bumping of and bruising of ginger root
    - Packed into plastic fertilizer bags and put in back of pickup truck to move to processor

2 Food processing companies in Fiji

Pacific foods	Makes crushed ginger
Spices of Fiji	Export dried spices to NZ and Australia, main buyer is Ceres in NZ. End goal is to set up a cooperative with spice farmers in Fiji
Sai Yee Foods Ltd.	Export fresh fruit, root crops, and vegetables, and fish and ginger to Australia, NZ and expanding into China
FMF	Flour Mills Fiji, one of the largest companies, strong competition with Punjas. Import grain and from this make biscuits, flour, noodles and other bakery products. Export around the pacific, based in Suva
Punjas	One of the largest companies, import grain and make flour, biscuits, wraps, etc. Also import oil, dairy and soaps and under company Punjas and Sons

	imports dried spices, lentils, and other pulses to repack for sale in Fiji. Exports around the pacific, based in LaToya
Paradise Beverages	Manufacture alcoholic drinks, such as Fiji bitter and Fiji gold beer, spirits, and non-alcoholic drinks such as coconut waters and soft drinks. They also import wines from NZ, Australia and USA.
FRIEND	and NGO that manufactures dried spices, high end tea, dried fruit, root flours, jams and chutneys for sale in Fiji and exported around the pacific
Reba Dairy	The only milk and dairy processor in the Pacific, manufactures fresh and UHT milk, yogurt, sour cream and imports cheese and butter from NZ for repackaging and Sale within NZ

Appendix C

Expanded costing

Appendix C Expanded costing

1. Refined concepts

Concept	Process	2nd process	Waste
crushed ginger	chopping/milling	jarring	organic matter
dried ginger	drying	Packaging (Airtight)	Water, peel
ginger wine	fermenting	bottling	peel, strained ginger
ginger oil	distilling	bottling	solvent (none if steam distillation), organic matter

Concepts are ranked approximately in order of complexity of the process. More complex processes also indicate that a higher level of technical knowledge will be required during setup and during manufacturing.

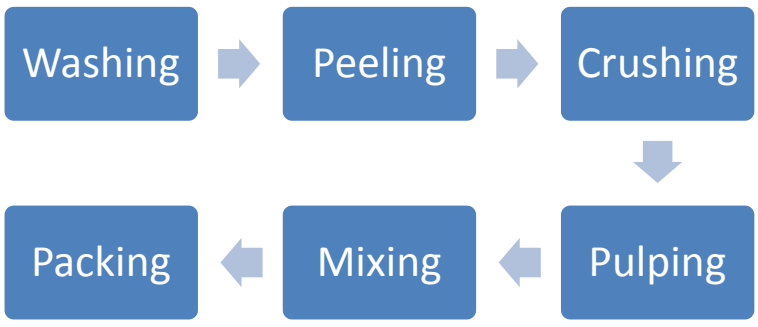
The equipment in this analysis is sized based on an input of 1000kg of raw mature ginger root per month. Machinery costs were sourced from Openshaw Plant Machinery Ltd. (2016)

2. Crushed ginger paste

Crushed ginger is a popular product within New Zealand and many other countries. It has a wide variety of uses, including curries, baking and in Asian style cooking. Some popular variations include additions of oil, salt, sugars, and other spices such as garlic and chili.

Crushed ginger can also be referred to as ginger paste when smoothly ground, salted and seasoned. This differs from the similar product ginger puree, as this is ginger that is peeled, washed, sanitised, cooked briefly and ground.

2.1 Process flow diagram



Washing:

- Ginger is collected and washed of loose soil, roots and debris

Peeling:

- This involves the removal of the fibrous outer skin layer of the ribosome
- While this step produces an end product that is more uniform in colour however is not always necessary and crushed ginger is available from both peeled and unpeeled ginger

Crushing:

- Ginger is put though a mill that forces the ginger between steel plate or blades to produce a coarse textured crushed ginger

Pulping

- This is an optional secondary grinding stage used to refine the coarse ginger paste to a finer and smoother textured product
- This can use a separate pulping machine (as described below) or may be done by running though the mill using a finer aperture

Mixing:

- Preservative and flavours such as salt are thoroughly mixed though the crushed paste

Packing:

- The paste is placed into containers and sealed ready for sale

2.2 Equipment needed

The main equipment required is a chopper or grinder, multiple type of grinder can be used depending on the final product texture desired. For coarser ginger, a bowl chopper could be used or for a finer paste a crusher can be used

Table 23 Equipment required for crushed ginger paste with purchase price, processing capacity and machine dimensions

Equipment Name	Picture	Price (NZD)	Capacity (kg/h)	Dimensions (mm)
Bowl cutter (358sl)		$6400	60L	Length: 1400 Width: 1250 Height: 1250

2.3 Labour costs

The majority of work needed is during the preparation of the paste and filling into containers. Preparation included cutting the ginger into smaller pieces and peeling is desired. It is beneficial to pre-cut the ginger and add over a few stages as not to overload the blades causing them to break (personal communication G. Radford 23 August 2016). This issue becomes less significant the larger the bowl chopper.

Labourers required	Role	hours per day	total cost/day	cost/year
5	Preparing ginger	7	$ 577.50	$ 202,125.00
5	filling containers	7	$ 577.50	$ 202,125.00
1	Bowl chopper operator	7	$ 115.50	$ 40,425.00

SUM				$ 444,675.00

2.4 Ingredient inputs

Other ingredients such as chili, garlic, sugars or thickeners could also be added.

Ingredient inputs	Ingredients (g)	% of total weight	NZ price/kg	Yield (%)	Cost per ingredient /year
Ginger	600	84.41%	0	-20%	$ -
Salt	60	8.44%	1.215		$ 12,307.26
Potassium sorbate	0.8	0.11%	39		$ 5,267.30
Citric acid	50	7.03%	9.8		$ 82,723.69
SUM	710.8				$ 100,298.26

2.5 Income per year

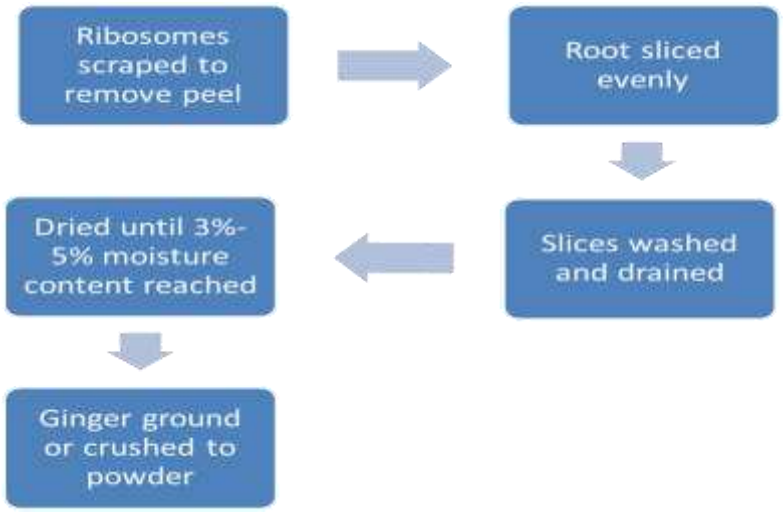
Income was estimated based on a 300g container selling at a retail price of $3.00

Unit size (kg)	Product per year	retail price	Selling price (ex works)	total income
0.3	473,867	$ 3.00	$ 1.50	$ 710,800.00

3 Dried ginger

The most common use of ginger worldwide is dried ginger (FAO, 2007). This process has been practiced for centuries and so is well documented, with differences in the process coming from variations in scale, equipment and technical ability.

3.1 Process flow diagram



Ribozome scraped to remove peel

- If the root is being dried whole this is required to deactivate the enzymes in the root to ‘kill’ it, if the ginger is sliced before drying this is not necessary

Slices washed and drained

- The slices are washed to remove any residues from the surface
- The slices are shaken dry to remove excess moisture from their surface

Dried to a moisture content of 8%-10%

- The ginger can be dried in a variety of ways, in the sun, in a traditional dryer or in a solar dryer
- The moisture content must be below 10% to prevent mould growth during transport

Ginger crushed or ground to powder

- If exported as whole or half ribosomes this is often done in the country of selling to ensure freshness and an aromatic product
- If slices and dried this is generally done by the processor
- When ground the surface area is dramatically increased allowing for faster rates of oxidation and flavour loss in the product, so this step should ideally be done close to when the product is desired to be sold

3.2 Equipment

Table 24 Equipment required for dried ginger with purchase price, processing capacity and machine dimensions

Equipment Name	Picture	Price (NZD)	Capacity (kg/h)	Dimensions (mm)	Power input
Dehydrator/dryer (115ds) http://www.openshaw.co.nz/new-dehydrator-dryer		$1300	Hours to 3 days	Length: 1180 Width: 680 Height: 1800	
Roller Mill/crusher (122mg)		$9725		Length: 1150 Width: 660 Height: 1380	7.5kW

Machines	Cost to	Power	Capacity	Capacity	Capacity	Hours	kW /	Cost /

required	buy (NZD)	required (kW hours)	(m^3)	for ginger (kg)	(kg / hour)	to run / year	year	year
Dehydrator/ dryer	$ 1300	5	0.867	797.26	11.07	10837	54185	$8,127.79
Roller mill/ crusher	$ 9725	25	0.015	13.91	13.91	1293	32349	$4,852.48
SUM	11025							12,980.28

3.3 Labour costs

The majority of labour would be used for the preparation for the ginger for drying in the cleaning, slicing and drying steps. A dryer operator's role would be to monitor the ginger to ensure the target moisture content was reached and to possibly redistribute the ginger to ensure even drying. Both the mill and dryer operator would require further training to ensure safe operation of the machinery.

Labourers required	Role	Hours per day	Total cost	Cost/year
2	Ginger chopping	7	$ 231.00	$ 80,850.00
1	Dryer operator	7	$ 115.50	$ 40,425.00
1	Mill operator	7	$ 115.50	$ 40,425.00
SUM				$ 161,700.00

3.4 Ingredient inputs

No ingredient inputs other than ginger are needed. Bleached dried ginger can also be produced using solutions of slaked lime or sodium metabisulphite.

Ingredient inputs	Ingredients (g)	% of total weight	NZ price/kg	Total input (kg/year)	Yield	Output (kg/year)	cost/year
Ginger	600	100.00%	$ -	120000	15%	18000	$ -

3.5 Income per year

Income was based on sale within the retail market, however dried ginger is also a commodity product sold by the container load. As the commodity market is extremely price competitive it is recommended to target the retail market where there are higher mark-ups and the Fijian product identity can be communicated more clearly, allowing access to premium markets.

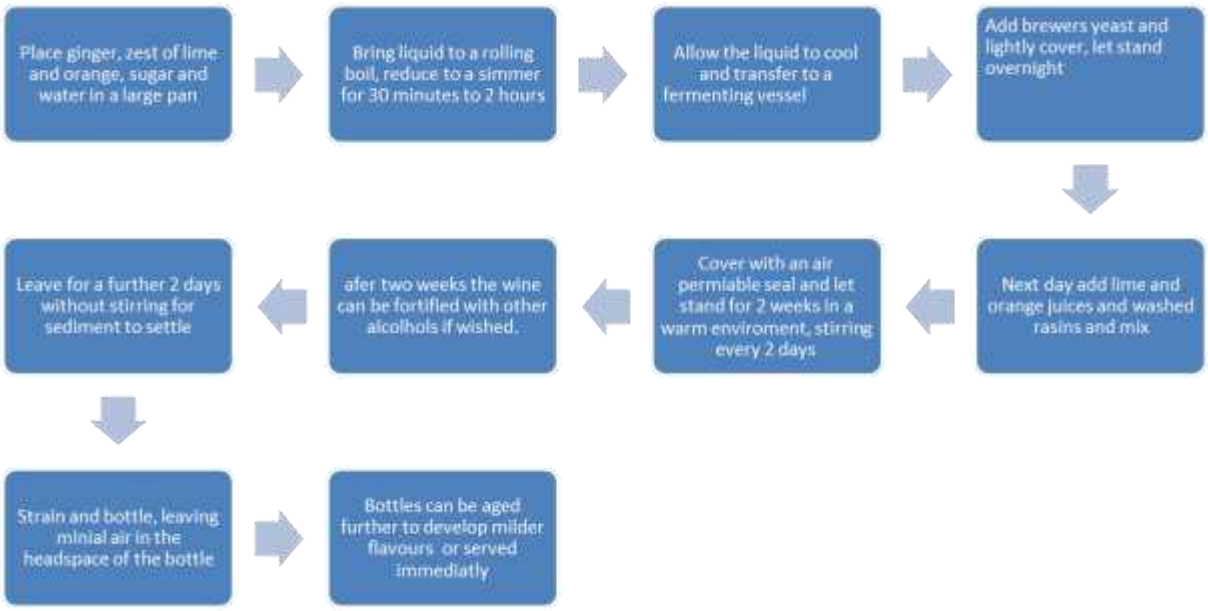
Unit size kg)	Product per year	Retail price	Selling price (ex works)	Total income
0.15	120000	$ 2.90	$ 1.45	$ 174,000.00

4 Ginger wine

Ginger wine is drunk across the world and there are a variety of recipes and methods of preparation. Some are similar to traditional wine making, juicing the ginger then fermenting this with sugar and yeast. Some used chopped up ginger and boil this with flavours such as chilli and ginger before fermenting this mix, or in some cases leave it no alcoholic. Still others use little pre-processing other than chopping all ingredients and leaving it to ferment in large vessels, before further bottle aging.

This costing will focus on the method used in Indian and Anglo Indian ginger wines, similar to that of Stones ginger wine that use raisins in the fermentation process.

4.1 Process flow diagram



Place ginger, zest of lime and orange, sugar and water in a large pan

- Heat tolerant flavoured can be added at this point

Bring liquid to a rolling boil, reduce to a simmer for 30 minutes to 2 hours

- Heating time can be lengthened or shortened to increase or decrease the flavour
- Longer heating times result in a thicker syrup therefore more water may need to be added to counter this

Allow the liquid to cool and transfer to a fermenting vessel

- The heated stirred tank may be the same as the fermenting vessel

Add brewer's yeast and lightly cover, let stand overnight

- Yeast should be added after cooling to ensure it is not inactivated by heating

Next day add lime and orange juices and washed raisins and mix

- Non heat tolerant flavours should be added at this point

Cover with an air permeable seal and let stand for 2 weeks in a warm environment, stirring every 2 days

- The fermenting vessel must have a gas outlet for the CO_2 produced
- Fermenting time can be lengthened for a more alcoholic product or decrease to a minimum of 3 days for a non-alcoholic product

After two weeks the wine can be fortified with other alcohols if wished.

- While brandy is traditionally used, clear spirts could be used to increase the alcohol content or other flavours such as rum may give different and interesting flavour profiles

Leave for a further 2 days without stirring for sediment to settle

- Settling of sediment results in easier bottling

Strain and bottle, leaving minimal air in the headspace of the bottle

- Minimal air is required to prevent oxidation and off flavours being produced

Bottles can be aged further to develop milder flavours or served immediately

4.2 Equipment

Table 25. Equipment required for ginger wine with purchase price, processing capacity and machine dimensions

Equipment Name	Picture	Price (NZD)	Capacity (kg/h)	Dimensions (mm)
1000L Stirred tank with pump (1506ta)		$8000	1000L	Length: 1800 Height: 1620 Diameter: 1300

650 Litre tank (1585ta)		$1200 (ex GST)	650L	Length: 920 Height: 1570 Diameter: 880
12 HEAD COUNTER PRESSURE FILLER (320fi)		$15000 (ex GST)	20 Bottles per Minute	Length: 1300 Width: 1200 Height: 1900

Machines required	Cost to buy (NZD)	Power required (kW hours)	Capacity for ginger (kg)	Capacity (kg / hour)	Hours to run / year	kW / year	Cost / year
Stirred heated tank	$ 50,000.00	7.5	3000	7.81	61056	457920	$ 68,688.00
Stirred heated tank	$ 44,000.00	7.5	2500	6.51	73267	549504	$ 82,425.60
12 head filler	$ 15,000.00	30	20 bottles/ min	1200	1060	31800	$ 4,770.00
SUM							$155,883.60

4.3 Labour costs

The ginger must be prepared by cleaning and chopping and this requires the majority of the labour.

Labourers required	Role	Hours per day	Total cost/day	Cost/year
3	Chopping ginger	7	$ 346.50	$ 121,275.00
1	Fermenter operator	7	$ 115.50	$ 40,425.00
1	bottling staff	7	$ 115.50	$ 40,425.00
SUM			$ 577.50	$ 202,125.00

4.4 Ingredient inputs

Ingredient inputs are highly variable with differing levels of sugar and ginger influencing flavour and alcohol content. Other ingredients such as citrus juice, chili, and spices like cinnamon or cloves can be added to achieve different flavours. Raisins are a characterising ingredient for this style of drink.

Ingredient inputs	Ingredients (g)	% of total weight	NZ price/kg (Amalgamated Food Distributors Ltd, 2016)	Cost per ingredient/year
Water	2.25	56.60	0	$ -
Ginger	0.5	12.58	0	$ -
Sugar	0.7	17.61	1.798	$3,799,547.17
Lime juice	0.2	5.03	5	$3,018,867.92
Orange Juice	0.2	5.03	5	$3,018,867.92
Brewer's yeast	0.025	0.63	10.9	$822,641.51
Raisins	0.1	2.52	4 (estimated)	$1,207,547.17
SUM	3.975			$11,867,471.70

4.5 Income per year

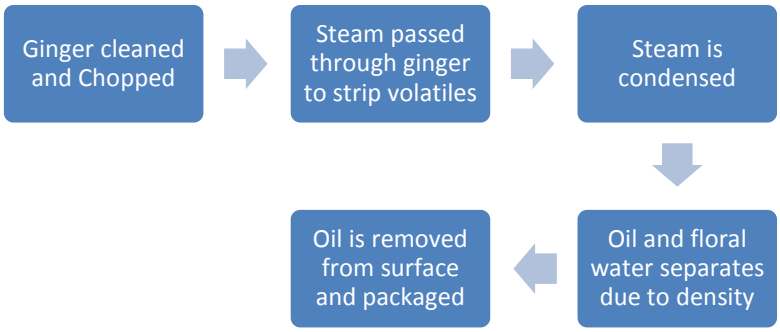
Income per year is based on a 750ml bottle. Due to the high cost of ingredients and operating expenses the retail price for this product would have to be high.

Unit size (kg)	Sales per year	retail price	Selling price (ex works)	total income
0.75	1272000	$ 18.00	$ 9.00	$ 11,448,000.00

5 Ginger oil

Ginger oil is the condensed volatiles from within the ginger, and these are insoluble in water. These can be extracted from dried or fresh ginger. Dried ginger has been heat processed resulting in the hot flavoured gingerols being converted to more mild flavoured zingerones and shogaol, resulting in milder flavoured ginger oil. Oil produced from fresh ginger is less prevalent. Pre drying could be done simply using sun drying to lower the water content or fully dried similarly to dried ginger processing above.

5.1 Process flow diagram



Ginger cleaned and chopped

- Ginger is cleaned of any foreign matter and dirt, any damage to the ribosome is removed
- To increase the speed of the distillation the particle size could be reduced by increased chopping
- This could be done manually or by machine depending on the volume of ginger to be chopped

Steam passed through ginger to strip volatiles

- Depending on the distillation unit used a steam generator may be within the unit or have to be supplied from an external source

Steam is condensed

- Cold or room temperature water can be run through the cool column to cool the steam allowing it to condense

Oil and floral waters separate due to density

- Floral waters are a by-product and contain some flavour aspects of the ginger oil, this can be used in food or skincare products

Oil is removed from surface and packaged

- The oil should require no further purification
- Minimal air should be in the headspace of the bottle to prevent oxidation of the oil

5.2 Equipment

Table 26. Equipment required for ginger oil with purchase price, processing capacity and machine dimensions

Equipment Name	Picture	Price (NZD)	Capacity (kg/h)	Dimensions (mm)	Power input
Electric Still (356ms)		$10,000		Length: 2100 Width: 600 Height: 1950	3 phase power

5.3 Labour costs

As with the other products the main labour cost associated is with the preparation of the ginger as it must be chopped before distillation. The still operator must have a higher degree of training and technical knowledge to monitor the processes as variation in the ginger can result in the need for adjusted processing parameters.

Labourers required	Role	hours per day	total cost/day	cost/year
2	Chopping ginger	7	$ 231.00	$ 80,850.00
1	still operator	7	$ 115.50	$ 40,425.00

5.4 Ingredient inputs

Income was based on a unit size of 1kg, and this would be sold as a commodity product. There was a large range of prices identified for this product with organic Indian essential oils gaining the highest price in the market.

Unit Size (kg)	Product per year	retail price	Selling price (ex works)	total income
1	1200	$ 230.00	$ 115.00	$ 138,000.00

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7 Cash flow diagrams

7.1 Ginger paste

ginger input	120000	year
power cost	0.15	
weeks of production	50	

year	0	1	2	3	4	5
capital cost	-6400					1280
operating cost	-10500	-10500	-10500	-10500	-10500	-10500
ingredient inputs	-100298.2555	-100298.2555	-100298.2555	-100298.2555	-100298.2555	-100298.2555
labour cost	-444675	-444675	-444675	-444675	-444675	-444675
working capital	-15000					15000
Income	710800	710800	710800	710800	710800	710800
cash flow	133926.7445	155326.7445	155326.7445	155326.7445	155326.7445	171606.7445

7.2 Dried ginger

ginger input	120000	year
power cost	0.15	
weeks of production	50	

Year	0	1	2	3	4	5
capital cost	-11025					2205
operating cost	-12980.27501	-12980.27501	-12980.27501	-12980.27501	-12980.27501	-12980.27501
ingredient inputs	0	0	0	0	0	0
Labour cost	-161700	-161700	-161700	-161700	-161700	-161700
working capital	-15000					15000
Income	174000	174000	174000	174000	174000	174000
cash flow	-26705.27501	-680.2750135	-680.2750135	-680.2750135	-680.2750135	16524.72499

7.3 Ginger wine

Ginger input	120000	year
Power cost	0.15	
weeks of production	50	

Year	0	1	2	3	4	5
capital cost	-109000					21800
operating cost	-155883.6	-155883.6	-155883.6	-155883.6	-155883.6	-155883.6
Ingredient inputs	-11867471.7	-11867471.7	-11867471.7	-11867471.7	-11867471.7	-11867471.7
Labour cost	-202125	-202125	-202125	-202125	-202125	-202125
working capital	-15000					15000
Income	11448000	11448000	11448000	11448000	11448000	11448000
cash flow	-901480.2981	-777480.2981	-777480.2981	-777480.2981	-777480.2981	-740680.2981

7.4 Ginger oil

Ginger input	120000	year
Power cost	0.15	
weeks of production	50	

Year	0	1	2	3	4	5
capital cost	-10000					2000
operating cost	-14762.63301	-14762.63301	-14762.63301	-14762.63301	-14762.63301	-14762.63301
Ingredient inputs	0	0	0	0	0	0
Labour cost	-121275	-121275	-121275	-121275	-121275	-121275
working capital	-15000					15000
Income	138000	138000	138000	138000	138000	138000
cash flow	-23037.63301	1962.366992	1962.366992	1962.366992	1962.366992	18962.36699

Appendix D

Maximum allowed preservative levels for ginger pastes

Appendix D Maximum allowed preservative levels for ginger pastes

1 Fiji food standards

18.10 Standard on fruit and vegetable products not covered under other commodity standards

(1) Food additives permitted for use with fruit and vegetable products included under this

standard shall comply with the Codex General Standard on Food Additives.
(Fiji Food Safety Association, 2009)

2 Codex food standard

Food Category No. 04.1.2.8 Fruit preparations, including pulp, purees, fruit toppings and coconut milk

Additive	INS	Step/Yr	Max Level	Comments
BENZOATES	210-213	8 / 2001	1000mg/kg	Note 13
CARAMEL COLOUR, CLASS III	150c	8 / 1999	7500mg/kg	
CARAMEL COLOUR, CLASS IV	150d	8 / 1999	7500mg/kg	
PROPYLENE GLYCOL ESTERS OF FATTY ACIDS			40000mg/kg	

(Codex Alimentarius Commission, 2001)

3 NZ Food code

Food Standards Code—Schedule 15

4.3.6. Fruit and vegetable preparations including pulpMPL (mg/kg)

200 201 202 203	Sorbic acid and sodium, potassium and calcium sorbates	1 000	
210 211 212 213	Benzoic acid and sodium, potassium and calcium benzoates	(a) 3 000 (b) 1 000	Chilli paste Other foods
220 221 222 223 224 225 228	Sulphur dioxide and sodium and potassium	(a) 1 000 sulphites	Fruit and vegetable preparations manufacturing purposes
		(b) 350	Other foods
234	Nisin	GMP	
960	Steviol glycosides	210	

(Food Standards Australia New Zeland, 2014)

4 Bibliography

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Food Standards Australia New Zealand. (2014). *Food Standards Code—Schedule 15*.

Appendix E

Commercial ginger paste investigation raw data

Appendix E Commercial ginger paste investigation raw data

1 Total solids

Total Solids											
	1					2					Average Solids content (%)
Product	Dish weight (g)	Weight of sample (g)	totals after weight (g)	sample after weight (g)	Solids content (%)	Dish weight (g)	Weight of sample (g)	totals after weight (g)	sample after weight (g)	Solids content (%)	
Gourmet Garden	22.6012	10.8918	26.4466	3.8454	35.31	14.044	10.9397	17.95115	3.90715	35.72	35.51
Greggs	31.718	9.6788	31.9637	0.2457	2.54	14.0814	10.1427	14.3424	0.261	2.57	2.56
Masterfoods	20.0062	10.1892	20.636	0.6298	6.18	13.6966	10.3347	14.3345	0.6379	6.17	6.18
Pams	21.0951	10.4195	22.2215	1.1264	10.81	13.9665	10.3029	15.0745	1.108	10.75	10.78
Healthy 'n' Fresh	21.4952	10.4682	22.3436	0.8484	8.10	14.3233	10.306	15.1558	0.8325	8.08	8.09

2 Water activity and pH

	Water activity	pH			
		1st Reading	2nd Reading	3rd Reading	Average pH
Gourmet Garden	0.9127	4.06	3.91	3.97	3.98
Greggs	0.9947	3.19	3.45	3.55	3.40
Masterfoods	0.9911	4.02	3.76	3.75	3.84
Pams	0.9848	3.44	3.51	3.45	3.47
Healthy 'n' Fresh	0.979	3.18	3.14	3.16	3.16

3 Colour

	Average values			XYZ colour space			Hunter Lab		
Product	**Average x**	**Average Y**	**Average y**	**X**	**Y**	**Z**	**L**	**a**	**b**
Gourmet Garden	0.3023	49.3250	0.3129	47.65403484	49.33	60.65919	70.23176	-1.79	-2.04656
Greggs	0.3136	89.7450	0.3203	87.88144262	89.75	102.6077	94.73384	-0.20	2.09573
Masterfoods	0.3135	89.1800	0.3180	87.90399686	89.18	103.3563	94.43516	0.89	1.213612
Pams	0.3408	92.8250	0.3454	91.57532933	92.83	84.34605	96.34573	1.06	15.53647
Healthy 'n' Fresh	0.3486	94.9150	0.3618	91.46473808	94.92	75.99759	97.42433	-2.91	21.9468

Appendix F

pH data

Appendix F pH data

30 DEGREES	DAYS	0	7	14	21	28
Peeled	1	3.97	4.01	4.18	4.28	4.09
	2	3.97	4.04	4.11	4.22	4.07
	3	4.05	4.14	4.19	4.36	4.19
	4	4.05	4.15	4.19	4.36	4.20
	5	3.99	3.43	3.88	3.91	3.83
	6	4.05	3.56	3.87	3.92	3.83
	7	4.05	3.60	3.96	4.01	3.92
	8	4.04	3.58	3.96	4.04	3.91
Unpeeled	1	4.00	3.98	4.12	4.26	4.03
	2	3.93	3.95	4.04	4.19	3.99
	3	3.99	4.06	4.12	4.27	4.11
	4	3.96	4.06	4.07	4.30	4.10
	5	3.77	3.50	3.83	3.89	3.77
	6	3.77	3.46	3.86	4.01	3.81
	7	3.89	3.59	3.90	4.14	3.83
	8	3.88	3.55	3.89	4.04	3.81

40 DEGREES		0	7	14	21	28
Peeled	1	3.97	4.04	**4.15**	4.30	4.00
	2	3.97	4.02	**4.08**	4.23	4.00
	3	4.05	4.17	**4.18**	4.36	4.09
	4	4.05	4.13	**4.15**	4.43	4.10
	5	3.99	3.46	**3.90**	3.96	3.70
	6	4.05	3.48	**3.89**	3.95	3.73
	7	4.05	3.66	**3.97**	4.06	3.88
	8	4.04	3.67	**3.97**	4.08	3.87
Unpeeled	1	4.00	3.94	**3.89**	4.25	3.93
	2	3.93	3.92	**3.88**	4.23	4.10
	3	3.99	4.03	**4.01**	4.34	4.18
	4	3.96	4.02	**3.99**	4.31	4.15
	5	3.77	3.47	**3.65**	3.93	3.80
	6	3.77	3.51	**3.72**	3.87	3.84
	7	3.89	3.55	**3.87**	4.02	3.92
	8	3.88	3.60	**3.93**	3.95	3.91

Appendix G

Total solids data

Appendix G Total solids data

1 Initial (0 weeks)

		Total Solids											
		1st replication						2nd Replication					
		Dish Number	Dish weight (g)	Weight of sample (g)	Totals after weight (g)	Sample after weight (g)	Solids content (%)	**Dish Number**	Dish weight (g)	Weight of sample (g)	Totals after weight (g)	Sample after weight (g)	Solids content (%)
Peeled	1	**67**	14.0819	5.1290	14.6575	0.5756	11.22	**58**	14.4397	5.2156	15.0194	0.5797	11.11
	2	**22**	14.0899	4.8589	14.6464	0.5565	11.45	**92**	14.1949	5.2794	14.8717	0.6768	12.82
	3	**57**	14.0159	5.1358	14.6195	0.6036	11.75	**61**	14.3163	5.1842	14.929	0.6127	11.82
	4	**53**	14.3360	4.9765	14.919	0.5830	11.72	**95**	14.4057	4.7700	15.0211	0.6154	12.90
	5	**39**	13.9449	5.2635	14.7537	0.8088	15.37	**11**	13.1270	5.0906	13.9570	0.8300	16.30
	6	**26**	13.9678	5.2716	14.7487	0.7809	14.81	**43**	14.3254	5.1751	15.1353	0.8099	15.65
	7	**66**	14.1375	4.9385	14.8730	0.7355	14.89	**16**	14.0601	4.6610	14.8205	0.7604	16.31
	8	**88**	14.1170	4.9884	15.1150	0.9980	20.01	**47**	14.0748	5.5181	14.9448	0.8700	15.77
Unpeeled	1	**3**	14.1159	5.1239	14.684	0.5681	11.09	**35**	14.0422	5.2753	14.7061	0.6639	12.59
	2	**44**	14.3200	4.7487	14.8829	0.5629	11.85	**29**	13.6966	4.9048	14.3399	0.6433	13.12
	3	**60**	14.3638	4.4722	14.8712	0.5074	11.35	**102**	13.9370	4.5360	14.4980	0.5610	12.37
	4	**80**	13.8517	4.8048	14.4151	0.5634	11.73	**77**	14.0801	5.0153	14.7041	0.6240	12.44
	5	**82**	13.9650	4.9105	14.7084	0.7434	15.14	**85**	14.253	5.0453	15.0413	0.7883	15.62
	6	**51**	14.4407	4.9283	15.2177	0.7770	15.77	**8**	14.1128	4.9122	14.9418	0.8290	16.88
	7	**9**	14.6742	4.1447	15.3452	0.6710	16.19	**94**	14.2216	4.4674	15.0006	0.7790	17.44
	8	**21**	13.7215	4.3072	14.4132	0.6917	16.06	**73**	14.239	5.2615	15.001	0.7620	14.48

2 Final (4 weeks)

Total Solids

		30°C samples						40°C samples						
		Dish Number	Dish weight (g)	Weight of sample (g)	Totals after weight (g)	Sample after weight (g)	Solids content (%)		Dish Number	Dish weight (g)	Weight of sample (g)	Totals after weight (g)	Sample after weight (g)	Solids content (%)
Peeled	1	**199136**	28.4638	5.4316	29.0349	0.5711	10.51	Peeled	**9020**	30.4735	5.1777	31.1101	0.6366	12.30
	2	**1433185**	26.9332	6.1241	27.6536	0.7204	11.76		**183**	27.3198	5.2450	27.9778	0.6580	12.55
	3	**258**	25.4011	5.2687	26.0435	0.6424	12.19		**248**	26.3815	6.6237	27.2356	0.8541	12.89
	4	**156169**	28.6377	6.1204	29.3755	0.7378	12.05		**45**	29.5871	5.2374	30.2737	0.6866	13.11
	5	**163**	26.7322	5.9972	27.616	0.8838	14.74		**74**	31.1247	5.0113	31.9717	0.8470	16.90
	6	**31**	29.1430	5.6770	29.9708	0.8278	14.58		**146**	27.0614	4.9379	27.8633	0.8019	16.24
	7	**87**	30.2863	5.5599	31.1595	0.8732	15.71		**276213**	25.7454	5.7398	26.6898	0.9444	16.45
	8	**150**	25.0738	5.9531	26.0534	0.9796	16.46		**275**	25.8592	5.6893	26.8338	0.9746	17.13
Unpeeled	1	**148**	27.4883	5.0314	28.1103	0.6220	12.36	Unpeeled	**1696**	30.6489	5.8556	31.5242	0.8753	14.95
	2	**244**	25.9159	5.5854	26.5704	0.6545	11.72		**197**	26.9166	5.3112	27.6587	0.7421	13.97
	3	**207**	28.4789	4.9931	29.0508	0.5719	11.45		**26176**	26.5279	4.8874	27.0835	0.5556	11.37
	4	**255**	25.2759	6.3042	26.0215	0.7456	11.83		**30**	27.6605	6.4877	28.5374	0.8769	13.52
	5	**172**	27.3839	5.8950	28.2481	0.8642	14.66		**179**	27.9648	4.4752	28.7476	0.7828	17.49
	6	**137**	27.1454	5.5387	28.0443	0.8989	16.23		**236**	25.0904	5.3945	26.0307	0.9403	17.43
	7	**238**	30.4236	6.2983	31.3816	0.9580	15.21		**1433**	29.7197	6.8765	30.8786	1.1589	16.85
	8	**187**	28.0331	5.2560	28.8998	0.8667	16.49		**7563**	38.9586	4.7156	39.8382	0.8796	18.65

endix H

activity data

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Appendix H

Water activity data

Water activity @ 20˚C				
		Initial	Final for 30°C samples	Final for 40°C samples
Peeled	1	0.9993	0.9926	0.9925
	2	1.0003	0.993	0.9939
	3	0.9976	0.9923	0.9942
	4	0.9983	0.9916	0.9937
	5	0.9829	0.975	0.9655
	6	0.9844	0.9746	0.9617
	7	0.9801	0.9685	0.9641
	8	0.9761	0.9633	0.9606
Unpeeled	1	0.9921	0.992	0.9897
	2	0.995	0.995	0.9897
	3	0.9964	0.9947	0.9876
	4	0.9955	0.9969	0.9892
	5	0.9831	0.9794	0.9676
	6	0.9745	0.9775	0.962
	7	0.9686	0.9758	0.9625
	8	0.9669	0.9731	0.9655

Appendix I

Microbiological results

Appendix I Microbiological results

1 Aerobic plate count (CFU/G)

Aerobic Plate Count (CFU/g) - Unpeeled paste			
Sample name	**Initial**	**30°C**	**40°C**
UP-1	2.1×10^{4}	2.8×106 (est)	1.65×10^{5}
UP-2	1.95×10^{4}	2.2×10^{6} (est)	6.4×10^{3}
UP-3	3.7×10^{4}	1.3×10^{4}	9.3×10^{2}
UP-4	2.2×10^{4}	5.5×10^{3}	2.1×10^{3}
UP-5	2.7×10^{4}	1.8×10^{6} (est)	4.5×10^{5}
UP-6	1.65×10^{4}	1.44×10^{6} (est)	3.45×10^{5}
UP-7	1.75×10^{4}	5×10^{3}	1.3×10^{2}
UP-8	2.85×10^{4}	1.2×10^{4}	8.5×10^{1}

Aerobic Plate Count (CFU/g) - Peeled paste			
Sample name	**Initial**	**30°C**	**40°C**
P-1	5.2×10^{4}	3.1×10^{6} (est)	2.05×10^{5}
P-2	8.5×10^{3}	3.3×10^{6} (est)	3.2×10^{5}
P-3	7.1×10^{3}	2.5×10^{3}	1.4×10^{2}
P-4	6.2×10^{3}	1×10^{3}	1.6×10^{2}
P-5	8.5×10^{3}	1.9×10^{6} (est)	2.82×10^{5}
P-6	2.7×10^{3}	2.2×10^{6}CFU/g[(e)]	3.48×10^{5}
P-7	3.5×10^{3}	1.12×10^{3}	9×10^{1}
P-8	4×10^{3}	4×10^{3}	7×10^{1}

2 Yeasts and moulds (CFU/G)

Yeast & Moulds (CFU/g) - Unpeeled paste			
Sample name	**Initial**	**30°C**	**40°C**
P-1	2.2×10^{5}	3.26×10^{6}	2.38×10^{5}
P-2	7.4×10^{4}	2.68×10^{6}	3.2×10^{3}
P-3	<100	<100	<100
P-4	100 (est)	<100	<100
P-5	<100	2.7×10^{6}	6.5×10^{5}
P-6	<100	1.83×10^{6}	8.9×10^{5}
P-7	<100	<100	<100
P-8	100 (est)	<100	<100

Yeast & Moulds (CFU/g) - Peeled paste			
Sample name	**Initial**	**30°C**	**40°C**
P-1	1.14×10^{4}	3.08×10^{6}	3.75×10^{5}
P-2	3.7×10^{4}	2.89×10^{6}	7×10^{5}
P-3	<100	<100	<100
P-4	<100	<100	<100
P-5	1.2×10^{3}	1.98×10^{6}	4.8×10^{5}
P-6	100 (est)	2.17×10^{6}	7.4×10^{5}
P-7	<100	<100	<100
P-8	<100	<100	<100

3 Coliforms (MPN/G)

Coliforms (MPN/g) - Peeled paste			
Sample name	**Initial**	**30°C**	**40°C**
P-1	<3	<3	<3
P-2	<3	<3	<3
P-3	<3	<3	<3
P-4	<3	<3	<3
P-5	<3	<3	<3
P-6	<3	<3	<3
P-7	<3	<3	<3
P-8	<3	<3	<3

Coliforms (MPN/g) - Unpeeled paste			
Sample name	**Initial**	**30°C**	**40°C**
P-1	<3	<3	<3
P-2	<3	<3	<3
P-3	<3	<3	<3
P-4	<3	<3	<3
P-5	<3	<3	<3
P-6	<3	<3	<3
P-7	<3	<3	<3
P-8	<3	<3	<3

Appendix J

Colour data for ginger paste shelf life

Appendix J Colour data for ginger paste shelf life

1 L*A*B Hunter colour space of shelf life trials at 30^0

Lab colour space															
		Initial			Week One			Week two			Week three			Week four		
30 Degrees		L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
Peeled	1	65.70008	3.16	18.0144	63.48228	2.78	17.89094	108.9097	-4.34	1.20099	64.91533	-10.32	45.44073	65.84072	-10.82	46.0885
	2	62.53799	2.82	16.55671	62.61789	2.73	17.12071	108.571	-4.66	-0.26104	63.23238	-10.05	44.26266	63.55837	-10.74	44.49086
	3	67.14536	3.07	18.14948	63.73905	3.08	17.56406	109.4044	-3.19	0.684864	60.70695	-8.14	42.49486	65.86856	-8.16	46.10799
	4	65.52099	3.17	17.9418	67.06216	3.42	19.17422	109.4973	-4.07	0.923915	64.32729	-9.04	45.0291	66.80569	-8.69	46.76398
	5	64.64519	3.71	17.76753	67.2483	2.96	19.2862	108.5296	-4.76	0.568038	64.10928	-9.77	44.8765	66.25959	-10.89	46.38171
	6	66.5094	2.94	18.41282	67.92152	2.68	19.86507	111.6766	-5.75	0.841287	64.15866	-10.08	44.91106	69.02898	-11.18	48.32029
	7	64.86524	3.12	17.72848	66.75078	3.06	19.98742	109.0688	-4.74	2.176546	65.03332	-9.44	45.52333	67.81101	-9.91	47.46771
	8	64.77268	3.58	17.23995	64.62971	2.47	18.67125	108.3113	-4.90	2.630585	62.58594	-9.47	43.81016	68.48357	-10.20	47.9385
Unpeeled	1	63.60818	4.90	16.24206	61.22363	4.65	16.29935	100.5452	-0.84	-2.19487	59.68249	-7.10	41.77775	59.84981	-7.29	41.89487
	2	62.79331	3.88	16.28558	61.64144	4.17	16.55401	100.9686	0.26	-6.14607	57.87343	-6.75	40.5114	61.09446	-8.26	42.76612
	3	62.72559	4.41	16.30175	61.58734	4.46	16.71832	103.0162	-0.13	-2.71464	60.78925	-7.34	42.55248	61.86814	-7.04	43.3077
	4	60.63827	3.74	15.29822	62.76942	4.98	16.78264	101.8103	-0.40	-3.64446	60.47038	-7.65	42.32926	61.06827	-7.62	42.74779
	5	62.10475	4.83	15.95766	63.95571	3.82	17.16042	103.3876	-1.52	-4.36875	57.22762	-8.11	40.05933	62.09133	-9.04	43.46393
	6	65.24186	4.34	16.83157	63.19019	4.12	17.47077	102.3654	-2.00	-1.34587	61.83311	-9.32	43.28318	58.55482	-8.70	40.98837
	7	60.34484	4.50	15.88013	63.58983	3.92	17.61786	101.3657	-0.84	-0.43041	60.94807	-8.35	42.66365	58.34952	-7.28	40.84467
	8	61.33514	4.36	16.49461	60.46487	3.77	16.7949	103.2424	-1.87	-1.65858	61.54944	-8.34	43.08461	61.52506	-7.93	43.06754

2 L*A*B Hunter colour space of shelf life trials at 40^0

Lab colour space															
		Initial			Week One			Week two			Week three			Week four		
40 Degrees		L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
Peeled	1	65.70008	3.16	18.0144	64.78683	4.16	19.39572	65.45042	-9.16	33.56063	61.49526	-6.84	43.04668	61.91123	-7.50	43.33786
	2	62.53799	2.82	16.55671	64.42049	4.36	19.4164	63.58571	-8.71	32.77152	60.74811	-6.08	42.52368	61.20185	-5.86	42.8413
	3	67.14536	3.07	18.14948	62.59393	4.12	18.7012	61.45624	-8.54	32.35502	61.41118	-5.92	42.98783	62.85168	-6.01	43.99617
	4	65.52099	3.17	17.9418	61.47357	3.69	18.32753	64.26882	-9.37	34.27136	60.59978	-6.11	42.41985	58.17216	-5.49	40.72051
	5	64.64519	3.71	17.76753	60.72891	3.49	18.06248	65.26533	-9.99	34.60117	61.736	-7.38	43.2152	63.60031	-8.39	44.52022
	6	66.5094	2.94	18.41282	61.84658	3.12	18.64027	65.75842	-10.60	34.22156	63.47178	-8.55	44.43024	62.59393	-7.17	43.76119
	7	64.86524	3.12	17.72848	63.65532	4.28	19.38664	64.83413	-9.33	34.30347	58.67992	-5.54	41.07595	61.44645	-5.66	43.01252
	8	64.77268	3.58	17.23995	63.7469	3.72	19.72315	63.79651	-9.40	33.35813	60.34899	-6.47	42.24429	58.65151	-5.17	41.05606
Unpeeled	1	63.60818	4.90	16.24206	58.55197	5.45	16.97903	61.31981	-7.24	30.02323	57.32074	-5.99	40.12451	58.81893	-5.82	41.17325
	2	62.79331	3.88	16.28558	57.03215	5.54	16.89286	58.01805	-6.96	29.33541	54.87258	-5.01	38.41081	58.84443	-5.36	41.1911
	3	62.72559	4.41	16.30175	58.55766	5.40	16.47232	60.66595	-6.96	30.36416	57.3062	-5.72	40.11434	55.50676	-5.57	38.85473
	4	60.63827	3.74	15.29822	57.81292	4.82	16.43505	59.51333	-7.11	30.20188	56.0803	-5.38	39.25621	52.25578	-5.30	36.57905
	5	62.10475	4.83	15.95766	57.72925	4.25	16.06415	63.44338	-8.59	31.4148	54.568	-6.40	38.1976	55.08478	-7.23	38.56142
	6	65.24186	4.34	16.83157	57.83597	4.34	16.29943	63.21142	-8.57	31.37699	59.66574	-7.56	41.76601	61.4573	-7.36	43.02011
	7	60.34484	4.50	15.88013	60.94533	5.00	17.83235	60.75135	-7.53	31.28511	58.58896	-5.48	41.01227	55.83308	-4.61	39.08316
	8	61.33514	4.36	16.49461	59.61543	4.71	17.36848	49.89721	-6.26	25.57305	53.67805	-5.31	37.57464	53.24785	-4.60	37.27349

3 ∆E colour change from initial colour data in L^*A^*B colour space for samples at 30^0C

30 Degrees		Week one	Week two	Week three	Week four
Peeled	1	2.25309426	22.008527	30.57207249	31.3632843
	2	0.57612145	23.00173	30.55722208	31.0664036
	3	3.45626211	21.292785	27.56601677	30.15842
	4	1.98867972	22.135421	29.73795442	31.1921291
	5	3.10621599	22.507715	30.28091458	32.1638777
	6	2.04217063	22.873114	29.61753659	33.1701019
	7	2.94311099	22.861877	30.50146697	32.6042349
	8	1.81930174	23.451179	29.68451613	33.8557592
Unpeeled	1	2.39846284	19.486123	28.48746938	28.6500565
	2	1.21754629	17.204101	26.90814306	29.181728
	3	1.21317911	19.537825	28.82285242	29.3422784
	4	2.8794965	19.51599	29.33498853	29.7120912
	5	2.42608823	20.235588	27.78658372	30.8045416
	6	2.16040147	19.903596	29.96517379	28.2548355
	7	3.72731416	20.666331	29.71300116	27.6796298
	8	1.08961263	20.619552	29.46508401	29.2783274

4 ∆E colour change from initial colour data in L*A*B colour space for samples at 400C

40 Degrees		Week one	Week two	Week three	Week four
Peeled	1	1.93118372	19.840379	27.28445822	27.7363397
	2	3.75524581	19.92198	27.50717105	27.7105703
	3	4.70279202	19.208358	27.02959739	27.7311733
	4	4.09854857	20.624686	26.63543924	25.4531812
	5	3.93377537	21.712848	27.91331816	29.3825179
	6	4.6718448	20.830081	28.60583414	27.5708976
	7	2.35745353	20.73147	25.65858528	26.9843401
	8	2.69025418	20.720221	27.3088153	26.1020036
Unpeeled	1	5.138484	18.509207	26.9920336	27.5600221
	2	6.02668353	17.625971	25.1259263	26.8563524
	3	4.28767216	18.197768	26.43934032	25.6954473
	4	3.23088506	18.467895	26.03729948	24.5945123
	5	4.41456911	20.517384	26.02799971	26.5636255
	6	7.42497594	19.556958	28.188664	28.9346304
	7	2.10090002	19.549853	27.09867617	25.3348323
	8	1.96179521	18.055382	24.42421158	24.0292499

3 Visual colour change

Time elapsed (days)	Photographs	Comments
0		At 0 days the base line for colour pH, water activity and total solids was established. All samples appeared generally uniform, with the products containing sodium metabisulphate being slighting brighter yellow, and samples 5-8 containing salt appearing slightly pinker in colour.
7		After one week in heated storage there was no visible mould or physical defects within any of the ginger paste samples. The unpeeled samples had appeared to have darkened slightly more than the unpeeled samples. The appeared to be a slight separation of water and solids within the paste, with this being more marked in the peeled ginger. All samples had an acceptable pungent ginger smell and taste, with no 'off' flavours.

		
14		After 14 days of heated storage there was no sign of visible mould or deformities within the ginger paste samples. The samples remained largely unchanged from the previous week however the unpeeled samples had become firmer than the peeled samples All samples had an acceptable pungent ginger smell and taste, with no 'off' flavours.

		
21		At 21 days of storage there was no sign of visible mould or deformities within the ginger paste samples. There was minimal change however there was some white bubbles present next to the headspace of the 40˚C samples, both peeled and unpeeled. All samples had an acceptable ginger smell and taste, with no 'off' flavours.

		
28		At the end of the storage trail, after 28 days the control sample (1) at 30˚C had white mould forming at the top of the product next to the heat seal. This may be due to contamination from human contact during filling and sealing leading to the introduction of microbes. No other samples showed signs of mould growth. An informal sensory of the samples showed that all had an acceptable taste and smell.