Samoa Avocado Oils: Processing into Export Products and Commercialization Opportunities

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Executive Summary

Avocado fruit is one valuable tropical produce which is highly underutilized in Samoa. It is recorded from previous researches that it has positive health claims such as lowering blood cholesterol, controlling weight and providing humans with the essential nutrients and vitamins the body needs. It has a healthy fatty acid composition which is dominated by the good fatty acids that helps lower the bad cholesterol and raise the good cholesterol. However, the qualities of the fruits are determined by various factors like variety, growth conditions and harvesting time.

There is no previous research on local avocado varieties and their compositional changes, hence the need for a research on the nutritional analysis as well as other uses for the local fruit. The fruits are only sold at the local fruit market and side road stalls only to be consumed as ripe fruits by a small number of people and restaurant franchises for salads and chef’s special dishes. Avocado oil has been in the market only in overseas supermarkets and the need to be utilized locally as an end product of such magnitude can be achieved rather slowly and with much thought in its process for the overall benefit of the country.

The variety identified for oil processing was identified to be Fuerte. It’s noted during the survey as one of the most common variety out in the field and bought at the local fruit market. It has the most mineral and fat content in terms of its nutritional analyses. The technology for the avocado oil extraction from local avocado fruits has been identified as the cold press technology and the oil produced has been analyzed and assessed accordingly. The quality of the oil produced from the cold press technology shows superiority when compared to other method of extraction. The mentioned technology is widely used in the industrial level for the avocado oil extraction. The chemical analysis for the oil produced from the identified technology has shown better quality in regards to its lower peroxide value which is a good indication of prolong shelf life, a high free fatty acid content with % oleic fatty acid indicating a high smoking point for the oil. However, local farmers are also given the opportunity to earn revenue from growing and selling the identified variety for the production of the avocado oil.
Introduction

The avocado is a tropical tree which grows well and abundant in Samoa when it is in season. Season availability of the fruit in Samoa only comes into fruition during the months of September to December and January through to early April. The unpopularity of the fruit amongst consumer’s results in a lot of the fruits going to waste which thus creates the need for value adding by using the fruits instead of going to waste but also for the economic benefit of the country.

The avocado comes from the Lauraceae family with its scientific name; *Persea Americana*; it is a native plant of Southern Mexico and Central America (Human, 1987). Interestingly enough, the fruit was originally called *ahuacatl* by the Aztecs of ancient Mexico, the fruit later became known as aguacate by the Spanish in the 16th century and nicknamed the “alligator pear” by English colonists who mistakenly substituted “alligator” for aguacate and added “pear” for the fruit’s shape. The term aguacate eventually evolved into avocado by Americans who could not pronounce the Spanish. The avocado plant grows really well in warm weather with tropical or subtropical climates. The flowers when in bloom are very sensitive to very low temperature and freezing conditions. There are three known varieties; namely the Mexican, Guatemalan and the West Indian types. Each of the three varieties thrives and grows really well under different conditions. The Mexican types flourish in Mediterranean climate and are native to dry subtropical plateaus. The Guatemalan types are native to cool, high altitude tropics while the West Indian variety thrive in humid and tropical climates.

The avocado fruit is a highly nutritious fruit with many studies confirming its positive effects on human health (Bergh, 1992; Eyres et al. 2006). The utmost misperception amongst most people on the healthfulness of the fruit is mainly attributed to its high fat content and so most nutritionist and dieticians either advise against it or to use it “sparingly” (Bergh, 1992). Many studies and research however have proven avocado in particular its fat content to be highly advantageous for human health due to its healthy fat composition. All this goodness of avocado is well preserved in avocado oil and thus presents an excellent alternative for utilization of the fruit. More than 70% of the fat content is monounsaturated fat which is considered a good fat that helps lower the levels of harmful cholesterol known as Low Density Lipoprotein (LDL) but maintains the level of the beneficial High Density Lipoprotein (HDL); the fat content contained also has low levels of polyunsaturated and saturated fat with slight variations according to cultivars and fruit maturity (Arpaia et al. 2006; Bergh, 1992) The change in lifestyle towards healthy living for the people of Samoa; has been a contributing drive in carrying out such research.
Samoa’s local supermarkets do not have avocado oil on its shelves nor is it imported into the country but that of other oils such as vegetable, soya bean, peanut and olive to name a few. Yet, Mediterranean lifestyle and dishes uses a lot of the avocado oil as an essential part of their diet and mainly due to its healthy nutritional content. The only local oil reported to be in local supermarkets is that of virgin cooking coconut oil.

Various options for the utilization of such local produce are covered in this report in terms of its nutritional value, best technology identified to produce good quality oil; products identified for consumer consumption as well as economic benefit for the country in terms of export potential as well as import substitution. Currently all the oil needs for the country are imported and yet we have more than enough supply of avocado produce that is going to waste but can be used to process oil. The food industry is the biggest user of oil and a special niche market for new products of the oil needs to be explored more.
Methodology

The Scientific Research Organisation of Samoa (SROS) has been involved in the accreditation process for certification under the ISO: 17025 through the International Accreditation of New Zealand (IANZ) and a lot of the methods and tests accredited are basically used for the research phase of this project. The tests accredited for the laboratory to use as well as other equipments bought with the research funding such as the Oxitester equipment has the ability of testing for acid value, peroxide value of the oil quality and free fatty acid which is a good indication of how well the quality of the oil is. Other qualitative analyses used were methods from AOCS and AOAC Official methods of Analysis.
Research and Discussion

The avocado fruit with much emphasis on its use for local development into a fruitful and more functional end product; hence the research as presented give a much needed indication on the importance of such findings. With a lot of positive outcomes and end results from previous overseas literature research, SROS has however been very fortunate to have had the opportunity to explore further and report on the viability of such product for Samoa. Expected outcomes for the research as anticipated in the original proposal will be looked at and dealt with specifically in this section of the report.

a. Local Varieties Identification and Analysis

To better understand the varieties available locally, our research team has managed to identify two other varieties, other than the varieties already on site at Nafanua, from the Atele Horticulture Center avocado orchard which are Nabal and Peters. Total varieties looked at during this research was 9. Some common varieties seen out in local farmers after a recent survey are identified namely as Edranol, Fuerte, Buebla and Peters. The area surveyed was at Aleisa to Faleasiu-uta with variety identification using of orchards at both Nafanua and Atele. (Appendix 1 for survey map area) Other ways the research team managed to identify the varieties from outside farmers was leaves comparison; the flush and mature leaves from each tree. The other five varieties, Hass, Pinkerton, Granter, Hazzard and Nabal were collected also for further research reasons. The fruits were bought from local farmers; they were stored in cool room temperature (~4-5°C), placed inside bubble wrap layered cartons until they were ready to be used.

Some areas of consideration for the fruit will be on the postharvest for prolong storage life of the fruit when it’s off season. This is, however, an area that can be considered further with attachments to this research. Listed in Table 1, are the varieties identified for the research phase of this project with basic information as noted. (Refer to Appendix 2 for variety photos)
Table 1. Avocado varieties identified and used for this project.

<table>
<thead>
<tr>
<th>Avocado Variety</th>
<th>Avg Fruit wt (g)</th>
<th>Avg Fruit wt (g)</th>
<th>Avg Fruit Length (cm)</th>
<th>Flesh: Skin+Seed ratio (%)</th>
<th>Skin Texture</th>
<th>Skin Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hass</td>
<td>262.62</td>
<td>NA</td>
<td>7.9</td>
<td>53:46</td>
<td>Thick Pebbly</td>
<td>Green Black</td>
</tr>
<tr>
<td>Pinkerton</td>
<td>318.01</td>
<td>310.00</td>
<td>10.8</td>
<td>78:21</td>
<td>Rough pebbly</td>
<td>Green Green</td>
</tr>
<tr>
<td>Edranol</td>
<td>287.71</td>
<td>294.45</td>
<td>12.5</td>
<td>67:32</td>
<td>Glossy smooth/ waxy</td>
<td>Green Light Green</td>
</tr>
<tr>
<td>Fuerte</td>
<td>431.75</td>
<td>420.42</td>
<td>12.7</td>
<td>72:27</td>
<td>Smooth</td>
<td>Green Green</td>
</tr>
<tr>
<td>Buebla</td>
<td>434.66</td>
<td>390.78</td>
<td>11.8</td>
<td>76:23</td>
<td>Smooth</td>
<td>Green Reddish-green</td>
</tr>
<tr>
<td>Granter</td>
<td>278.84</td>
<td>NA</td>
<td>11.5</td>
<td>69:30</td>
<td>Smooth</td>
<td>Green Green</td>
</tr>
<tr>
<td>Hazzard</td>
<td>396.52</td>
<td>NA</td>
<td>10.7</td>
<td>68:31</td>
<td>Smooth</td>
<td>Green Green</td>
</tr>
<tr>
<td>Nabal</td>
<td>248.24</td>
<td>304.23</td>
<td>8.3</td>
<td>70:29</td>
<td>Glossy smooth</td>
<td>Reddish-green Dark purple</td>
</tr>
<tr>
<td>Peters</td>
<td>328.75</td>
<td>NA</td>
<td>11.8</td>
<td>60:39</td>
<td>Glossy smooth</td>
<td>Green Green</td>
</tr>
</tbody>
</table>

1 = sample size per variety (n=50)
2 = Fruit weights at beginning of season (Sept - Nov)
3 = Reduce sample size (n=30); not enough trees for sample collection
4 = Fruit weights towards end of season (Feb – March)
NA = Fruits not available, out of season

The smallest variety; Nabal variety, as shown in Figure 1, when compared to other larger varieties, had the most flesh yield. The sizes for most of the varieties are taken up by the seed alone which explains the poor pulp or flesh yield. Avocado collection took place twice during the season. The comparison for the first weights and those of second weights during the season indicated a drop in weights for the majority of the varieties. As will be shown later, the decrease in weight fairly relies on the amount of moisture contained inside the fruit and also indicative of the best time for harvesting the fruits due to increase in fat content.
Since the trials were conducted only for two seasons, this can be another area for further research or study and data collection for the local varieties of Samoa. Furthermore, the two most common varieties used overseas, from previous literature research, are Hass and Fuerte variety. Hass variety is mainly used by oil producing companies due to its thick skin which can withstand the transport and handling process and also easy identification when it is ripe for use as it changes colour. Unfortunately, the Hass variety was not located at any of the farms that the research team had surveyed nor seen sold in local fruit markets/stalls. The Nafanua orchards had three trees but are sadly rotting and improperly pruned.

### Table 2. Avocado fruit analysis results for moisture content, fat and ash content.

<table>
<thead>
<tr>
<th>Avocado Variety</th>
<th>Moisture Content (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Moisture Content (%)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Fat Content (%)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Fat Content (%)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Ash Content (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ash Content (%)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ash Content (%)&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hass</td>
<td>78.2</td>
<td>NA</td>
<td>12.18</td>
<td>NA</td>
<td>0.67</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pinkerton</td>
<td>72.1</td>
<td>68.2</td>
<td>11.00</td>
<td>16.23</td>
<td>0.58</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>Edranol</td>
<td>80.4</td>
<td>81.2</td>
<td>7.30</td>
<td>9.20</td>
<td>0.51</td>
<td>0.62</td>
<td>NA</td>
</tr>
<tr>
<td>Fuerte</td>
<td>81.9</td>
<td>72.8</td>
<td>10.29</td>
<td>14.22</td>
<td>0.78</td>
<td>0.75</td>
<td>NA</td>
</tr>
<tr>
<td>Buebla</td>
<td>74.1</td>
<td>70.2</td>
<td>6.66</td>
<td>7.90</td>
<td>0.67</td>
<td>0.62</td>
<td>NA</td>
</tr>
<tr>
<td>Granter</td>
<td>71.2</td>
<td>NA</td>
<td>7.25</td>
<td>NA</td>
<td>0.76</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Hazzard</td>
<td>79.4</td>
<td>NA</td>
<td>9.42</td>
<td>NA</td>
<td>0.62</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Nabal</td>
<td>82.8</td>
<td>79.6</td>
<td>10.26</td>
<td>12.87</td>
<td>0.65</td>
<td>0.68</td>
<td>NA</td>
</tr>
<tr>
<td>Peters</td>
<td>83.1</td>
<td>NA</td>
<td>7.49</td>
<td>NA</td>
<td>0.69</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

<sup>a</sup> = results based on wet sample weight in triplicates  
<sup>b</sup> = analysis at beginning of season (Sept - Nov)  
<sup>c</sup> = analysis towards end of season (Feb – March)  
NA = Fruits not available, out of season

Size does not necessarily mean the bigger it is, the better oil yield it’ll produce. Freitas et al (1998) reported the avocado fruit as containing about 70-80% water and 8-30% fat depending on the variety. The different varieties were tested and analysed for parameters; moisture content, fat content, ash content and minerals as reported in Table 2 above.

Moisture content was analysed using the Dehydrating oven set at 105°C for two hours until a constant weight is maintained. The results thus show the inconsistency between the fruit sizes and the available water present. However, the two trials conducted at the beginning of the season and towards the end of the season have shown a decrease in moisture content and fair increase in fat content. Fat extraction of the fruits were extracted using the Soxhlet extraction method with Petroleum Ether (boiling point 30-60°C) as the extracting solvent and final product calculated based on the sample’s original wet mass. The unavailability of the Hass variety towards the end of the second round would have given a good complete comparison with the other varieties. The ash content gives a good indication of the level of minerals each variety contains. The higher the ash content the more minerals
it contains. Nonetheless, there was no significant difference between the ash values as presented for all 9 varieties during both trials.

The most common mineral for avocado is potassium which is also referred to as the “youth” mineral and one other reason for its use in the cosmetics industry. All 9 varieties were ashed using the Muffle Furnace method according to AOAC Official methods of Analysis and proceeded for mineral analysis using the Atomic Absorption Spectroscopy (AAS).

The dominating mineral found in all 9 varieties was potassium (K). Interestingly, the other two minerals, magnesium (Mg) and calcium (Ca), is reported by Hofman et al (2002) to have some adverse effect on the quality of the avocado. The presence of Ca can delay softening of the fruit and interaction with K and Mg during the uptake of nutrients from the soil can have adverse effect on the fruit quality. Rooyen and Boyer (2006) indicated that interactions between minerals could be more important in determining avocado quality than individual elements. They also reported on the downside for the Pinkerton variety as it develops a physiological disorder known as “mesocarp or flesh discolouration”. The Fuerte variety had the most K with a fair amount of Mg and Ca as well. Minerals are considered vital for growth, maintenance of health and the necessary physical energy provider.
From the trials conducted for variety analysis on its nutritional results, the recommended variety to be used for oil extraction trials in method identification is the **Fuerte** variety. The recommended variety was identified to be the most common tree found in farms that we visited. It is also important to note that the farms referred to were families with two to three avocado trees.

**b. Avocado Oil Extraction- Properties and Technology**

The many healthy benefits of the avocado fruit as stated in (a) above hence the need for value adding of the fruit. The variety identified in (a), **Fuerte**, was the variety used for trialing the extraction methods. There were two methods trialed for oil production for the research phase of this project. Extraction of the oil requires disruption of both the oil cells and the finely dispersed oil emulsion in the fruit pulp. Werman and Neeman (1987) mentioned the two methods for better oil quality extraction to be; extracting with an organic solvent which can break up cell walls for oil release; the second method is by centrifuge force.

The first trialed method was high heat extraction of the oil by using the Soxhlet Solvent Extraction method with Petroleum Ether (b.p. 30-60°C) as the extracting solvent. This method took at least three days (~24hours) to finalize the final extraction of sample and with consistent monitoring for control of water and solvent used. The temperature required for such method to work is at 90-100°C; unfortunately, a lot of the nutrients in the avocado are heat sensitive and tend to lose tendency at high temperature. The oil produced was however compared to a product produced by laboratory extraction of controlled temperature so as to maintain some quality of the oil which was also the second trialed method. The oil produced from such method can result in more extra steps of *refining, bleaching and deodorizing (RBD)* the oil sample which gives a light coloured oil with good stability but with little taste and reduced beneficial health components. (Wong *et al*, 2011).

For the second trialed method, the temperature settled with was between 45-49°C, malaxing of the pulp was carried out with the Omnimixer set for approximately 2 hours or until oil starts dispersing and settling on the top then Centrifuged at RPM of 12,000 x g for another 1hour. This method is the laboratory or bench top version for the widely used method by oil manufacturing industries known as the “cold press” technology. Cold pressed avocado oil is defined as oil extracted using mechanical or physical means at temperatures below 50ºC. (Wong *et al*, 2011) The oil yields from the two methods are as listed in Table 3.
Table 3. Oil yield from two trial methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Temperature (°C)</th>
<th>Oil yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soxhlet Extraction</td>
<td>Petroleum Ether</td>
<td>90 – 100</td>
</tr>
<tr>
<td>(b.pt 30-60°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifuge (Cold press)</td>
<td>12,000 x g</td>
<td>45</td>
</tr>
</tbody>
</table>

*The values presented are from the average of three determinations calculating from wet mass basis.

The cold pressed oil extraction yielded by far, a high oil content compared to the Soxhlet extraction, consequently, the need for use in the food industry has resulted in further analysis of the two extracted oil in terms of their quality. The cold press method does not require any reagent addition which reasonably can be used for consumption. Previous research on Avocado oil extraction for developing countries by Bizimana et al. (1993) has recommended the use of specific salts (CaCO₃ and CaSO₄) and substitutes the use of a centrifuge instead for settling at a specific temperature. The recommended salts will only increase the cost and price for the end product and thus additional steps in getting an RBD oil.

Table 4 shows results for comparison reason between the two methods. The quality of both oil were tested using the Oxitester Analyser equipment which fortunately tests for Peroxide value, Acid value as well as Free Fatty acid as % of Oleic acid as a measurement indicator. Iodine value was manually analysed using the Wijs method.

Table 4. Chemical characteristics for extracted avocado oil

<table>
<thead>
<tr>
<th>Parameters</th>
<th> Standard Values</th>
<th>Soxhlet Extracted Oil</th>
<th>Centrifuge Force Extracted Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroxide Value (mEq/kg oil)</td>
<td>0.5 – 8.0</td>
<td>32.21</td>
<td>13.89</td>
</tr>
<tr>
<td>Acid Value (%)</td>
<td>0.2 – 2.0</td>
<td>&gt; 3.5</td>
<td>1.18</td>
</tr>
<tr>
<td>Free fatty acid (% as oleic acid)</td>
<td>0.1 – 1.0</td>
<td>0.17</td>
<td>1.10</td>
</tr>
<tr>
<td>Iodine Value (g/100g of oil)</td>
<td>NA</td>
<td>7.17</td>
<td>7.10</td>
</tr>
<tr>
<td># Colour (L,a,b)</td>
<td>NA</td>
<td>L =30.22</td>
<td>L = 40.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a = -0.37</td>
<td>a = -9.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b = 19.01</td>
<td>b = 27.15</td>
</tr>
</tbody>
</table>

#L = indicates brightness level, a = (+) red (-) green, b = (+) yellow (-) blue. Mean of triplicates.

^ Standard values from Woolf et al (2009) NA not available
Peroxide value (PV) is the measurement of oxygen level within a sample and a good indication of the rancidity of a sample during storage. However, the higher the value, the more likely the sample will have a shorter shelf life. The instant results given by the new Oxitester Analyser limits the exposure of the sample to oxidation and having any adverse effect on the end result. The oil extracted from the centrifuge force tends to have a much lower PV compared to the Soxhlet extracted oil.

The acid value is a measure of the amount of carboxylic acid groups in a chemical compound such as fatty acid. Free fatty acids (FFA) however are fatty acids that are not attached to other molecules which are vital sources of fuel for the body due to large yield of energy metabolism. FFA is however measured in the presence of the most dominant unsaturated fatty acid in the avocado oil which is oleic acid. The higher the value, the more unsaturated fatty acids present which is a good indication for the high smoking point for the oil. The smoke point for avocado oil as reported by Woolf et al (2009) is ≥ 250ºC. The higher smoke point works really well for deep fried food which makes it suitable for quick searing food in very hot oil.

The iodine value (IV) determines the amount of unsaturation contained in oils. The higher the IV, the more unsaturated fatty acid bonds or the more carbon to carbon double bonds are present in a fat. The importance of unsaturated fatty acid in avocado oil is also determined by the increase in iodine number. Nonetheless, the values remain constantly the same for both oil samples.

Colour measurement was taken with a Konica Minolta CR-400 Chroma-Meter. The cold press oil sample indicated a light to dark, green-yellowish approach whereas, the Soxhlet extracted oil indicated a darker yellowish-green approach. The avocado oil gets its dark green emerald colour from the partial inclusion of the skin during the production of the oil.

The focus for this research to produce a consumable end product for the food industry which was why the extracted oil from the centrifuge force “cold press” trial was used.
Avocado oil contains monounsaturated fatty acids that lower bad cholesterol and increase the good cholesterol. Monounsaturated fatty acids are long carbon chain with at least one carbon to carbon double bond. As reported by previous research on the fatty acids available in avocado oil, the majority of available fatty acids in avocado oil are unsaturated fatty acids.

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>Symbol</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitic</td>
<td>C16:0</td>
<td>31.21683</td>
</tr>
<tr>
<td>Stearic</td>
<td>C18:0</td>
<td>9.845967</td>
</tr>
<tr>
<td>Palmitoleic</td>
<td>C16:1 n-7</td>
<td>0.713533</td>
</tr>
<tr>
<td>Oleic</td>
<td>C18:1 n-9</td>
<td>38.71593</td>
</tr>
<tr>
<td>Linoleic</td>
<td>C18:2 n-6</td>
<td>18.25843</td>
</tr>
<tr>
<td>Linolenic</td>
<td>C18:3 n-3</td>
<td>1.2493</td>
</tr>
</tbody>
</table>

$m$ number before colon indicates number of carbon atoms in the fatty acid chain, number after indicates number of double bonds, n indicates the double bond position in the chain.

The predominant fatty acid found in the recovered avocado oil in Table 5, from the cold press technology, indicates an increase in Oleic Fatty acid which is a monounsaturated fatty acid. The total percent for unsaturated fatty acids found in the recovered cold press oil is approximately 60% and total saturated fatty acids present is approximately 40%. The high number of the healthy unsaturated fatty acids in the avocado oil contributes to the high smoke point for the oil. In comparison with other vegetable oil for smoke point (>250°C), avocado oil by far has the highest smoke point which can be useful for high heat or deep fried food. Appendix 3 gives a chromatographic view of the extracted fatty acid profile for the avocado oil. The fatty acid profile was conducted using a gas chromatography (GC).

Cold pressed avocado oil, with its distinctive green colour, is a relatively new oil in the commercial culinary oil industry. The oil is slowly making its mark in the industry with the “cold press” technology and its control temperature environment, is a new challenge for other oil products already out in the market. This technology was recently introduced in neighboring New Zealand through Olivado Ltd, a leading Avocado oil producer in the northern most part of NZ. Witnessing the actual operation of the machine has been an eye opening experience in terms of actual industrialized equipment as compared to laboratory bench top trials. The process works by grounding of the pulp then transferred into malaxers for continuous malaxing with water that controls the temperature of the process to maintain below 50°C. The solid and liquid phases are left to settled prior proper separation by centrifugation. The wonderful part of this whole process is that the quality of the oil is
The Organisation has however started work on the extension of the old New Product Development (NPD) section to house the cold press machines. The second phase of this research is currently awaiting funding negotiations through a recent Cabinet seating. The organisation has however, started to think two steps ahead and has prepared the factory-like setting for the machines. This prospect will enhance the commercialization opportunities of this research and build the organisation’s capacity building in terms of research and development for the betterment of the country and counteract on food security related issues.

c. New Product Development

The oil produced from the cold press extraction was used for trials in new product prototype for our local market as well as a potential export product. The main target for this project is to utilize the abundant availability of the fruit when it is in season and with this in mind, the food industry was the priority focus. The cosmetic industry is fairly developing but can be another option to consider utilizing the unsaponifiable portion of the oil. Therefore, two products were put on trial and error research for the last segment of the work plan set up.

Three trials were conducted for the production of Avocado butter as a new product development targeting the use of local produce for the production of the butter as shown in Figure 4. Lemon juice was used as a colour preservative; this is to help with the colour preservation of the product and a good source of vitamin C. The butter product is a water-in-fat emulsion which considerably needs an emulsifier to act as the binding agent for the two separate entities. Consequently, the emulsifier used for the trialed butter was the egg yolk. Food safety was a major issue for the trialed formulations as raw consumption of egg yolk can create problems, hence the need for careful processing and formulation adjustments. The trials have yet to finalise as time limitation for this research was due but continuous trial into the correct/final formulation as well as consumables to be used was not a most favourable option for this portion of the study. (Proposed work plan for product prototype to be completed at end of September 2011).

The second product trialed for a product prototype was the infusion of the Avocado oil with available flavours which in this case was the chilli flavour, which was bought locally from an available supermarket in the form of essential oil. The end product produced a change in oil colour from the attractive emerald green colour to a lighter reddish to yellow appearance.
Nonetheless, another project in the pipeline of the organisation for the moegalo (lemon grass) can be used alternatively as a flavor enhancer for the products.

![Figure 4. Avocado Butter and avocado oil infused chili flavoured](image)

Other new product opportunities can be explored more given the time availability as the season only happens twice a year.

One major setback during the research phase was the timely deliverance of expected orders to arrive. Samoa being isolated from the rest of the world and with limited means of transportation of goods into the country, orders was hard to retrieve as it took almost 3 to 5 months for a specific order to arrive due to late correspondences and items consolidation for shipment.

### d. Improvement in Import and Export Potential

Reports from the Central Bank of Samoa on imported commodities have listed Fats and Oils as one of the imported product into the country which is mainly imported by the private sector. A recent Import Price Index review from the Samoa Bureau of Statistics (for the last quarter of 2010) has shown a 0.6% increase in the price of Fats and Oils which unfortunately, is still on the increase if compared to the previous quarter. The trend for imported products into the country varies greatly and the dollar value is not consistent for each period. Samoa has enough supplies to produce and manufacture its own oil. This can really help substitute the new and unusual looking oil products that are imported into the country.

Manufacturing the oil locally on the other hand can increase foreign earnings through export of the product to overseas market as a cooking oil or as products produced from the oil. Recently in the first quarter of 2011, a big increase in the export of coconut oil and mainly destined for the bio-fuel generated field with a small portion destined for the food
Industry. Unfortunately, Samoa seems to be spending more on imported products and less revenue recovery from exported goods. Consequently, the more good reason to manufacture and produce the oil from this wasted fruit which is available locally.

e. **Benefits**

Avocado oil when produced locally can benefit the country for reasons as stated below;

1. With its healthy nutritional values, it can act as a healthy alternative considering the increasing incidence of diet related diseases in the country; avocado oil provides a much healthier alternative to be used in food preparation with its healthy fatty acid profile and other healthy nutrients.

2. The oil can be a substitute for the imported oil used for food preparation as stated in (d) it can reduce the importation of oil into the country and we have more than enough supply of the fruit when in season to provide support for this substitution.

3. Locally produced avocado oil mean more chance of exporting high quality avocado oil, considering the increase in value of avocado oil in overseas markets it will have great export potential.

4. The Government of Samoa has urged the people to go back and work on their land instead. It can provide local people with economical options for the utilization of locally grown and available produce such as avocado. This project, however, can be really useful for rural communities as it can provide village councils with revenue earning opportunities as well as making the youths be more working productive for their future development.
Conclusion and Recommendations

Avocado fruits are highly nutritious fruits which unfortunately have very small market access locally when it is in season. The only means of value adding for the utilization of the fruit is by the production of the Avocado oil. The oil can be produced as virgin oil from locally grown Fuerte variety considering it’s one of the most common varieties available locally. The high nutritious profile for the fruit and oil; with its high mineral content as well as high in the good fatty acids can be a good selling point for local consumer’s consideration. However, even with the number of avocado fruits available; there still needs to be a specific farming area to grow and prune the Fuerte variety to be able to cater for the proposed machine.

The cold press technology is the best technology for the extraction of the avocado oil as it retains all its natural flavor, nutrients and healthy properties. Thus the quality of the oil at the end of the processing line is well maintained. However, the oil has high chlorophyll content which makes it very unstable when exposed to direct sunlight. A future research of interest into the shelf life stability of the oil in terms of its kinetic photo oxidation as to what exposure level can have adverse effect on the quality of the oil can be another idea in the pipeline to continue studies on the local fruit. The technology requires little investment due to the few processes involved which is rather simple and straightforward and it also requires no reagent addition; hence the more reason to be used as culinary cooking oil for the food industry.

Therefore, Avocado oil is the exact answer for the utilization of this wasted fruit. It can act as a substitute for imported oil and used continuously for its healthy composition and the by-products produced from the oil can be exported to overseas markets together with the oil as a culinary cooking oil commodity.
Acknowledgement

This research would not have been made possible if it wasn’t for the kind assistance of the Australian government through its AusAID programme. The funding provided has been of great help in providing equipments/consumables for this research and for this we are really grateful and will look forward to a working partnership in the near future.

I would like to acknowledge our former CEO, who now resides as SROS’s Minister, for his word of guidance and mentoring in carrying out of this research.

I would also like to acknowledge the great assistance from the Atele Horticulture Center’s staff for accepting our request to conduct on site research in their orchards. Lastly, to the great people at SROS who have put in tireless efforts during the research period for this project, on behalf of my team, we say Faafetai tele lava.
References

9. V. Bizimana, W.M. Breene and A.S. Csallany, Avocado Oil Extraction with Appropriate Technology for Developing Countries, JAOCS, Vol. 70, no. 8 (August 1993)
10. Werman, M. J. and Neeman, I. Avocado Oil Production and Chemical Characteristics, JAOCS, Vol 64, no. 2 (February 1987)

Additional Reading Materials:

Appendices

Appendix 1. Map of Surveyed Area

Green highlighted area covered during the survey. Total number of farms/families visited:
Families: ~30
Number of trees: 2 to 3 trees per family
Most common Avocado tree(s):
1. Fuerte
2. Edranol
3. Buebla
4. Peters

Selling price (out in farm area(s)): $1 SAT to 50sene per avocado
Selling price at the Fruit market/stalls: $2 to $3 SAT per avocado
### Appendix 2. Avocado Variety

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<th>Avocado Variety</th>
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<td>Peters</td>
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Appendix 3. Fatty Acid Profile – Gas Chromatography (GC) analysis of Avocado oil

AVOCADO FATTY ACID PROFILE
Client: INDUSTRIAL RESEARCH DIVISION (SROS)

Chromatogram S2_1Ms C:GCsolution\Date2010\Pamowax Column\Avocado research\S2_1Ms.g - Channel 1

Intensity

75000
50000
25000
0

0 10 20 30 40 min
Appendix 4. Cold Press Technology – Alfa Laval