

# On-farm trials for proven cocoa fermentation and drying method

TECHNICAL REPORT

**#114**



On-farm trials for proven cocoa fermentation and drying method  
TR#114

Client: Department of Foreign Affairs and Trade  
ABN: 47 065 634 525

Prepared by  
AECOM Services Pty Ltd Brisbane  
Level 8, 540 Wickham Street Fortitude Valley, QLD 4006 Australia  
T +61 7 3553 2000  
F +61 7 3553 2050  
[www.aecom.com](http://www.aecom.com)

ABN 46 000 691 690

2018

Job No.: 42444251

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

© AECOM Services Pty Limited. All rights reserved.

No use of the contents, concepts, designs, drawings, specifications, plans etc. included in this report is permitted unless and until they are the subject of a written contract between AECOM Services Pty Limited (AECOM) and the addressee of this report.

AECOM accepts no liability of any kind for any unauthorised use of the contents of this report and AECOM reserves the right to seek compensation for any such unauthorised use.

#### Document Delivery

AECOM Services Pty Limited (AECOM) provides this document in either printed format, electronic format or both. AECOM considers the printed version to be binding. The electronic format is provided for the client's convenience and AECOM requests that the client ensures the integrity of this electronic information is maintained. Storage of this electronic information should at a minimum comply with the requirements of the Electronic Transactions Act 2002.

# Quality Information

<b>Date</b>	<b>15 January 2018</b>
<b>Prepared by</b>	<b>Scientific Research Organisation of Samoa (SROS)</b>
<b>Reviewed by</b>	<b>Bronwyn Wiseman (PHAMA Deputy Team Leader)</b>

Revision History				
Rev	Revision Date	Details	Authorised	
			Name/ Position	Signature
1	15 January 2018	FINAL	Stephanie Symon, PHAMA Operations Manager	

# Table of Contents

Quality Information .....	3
Table of Contents .....	4
Acronym List .....	5
Acknowledgement.....	5
1.0 Introduction.....	6
2.0 Background.....	6
2.1 Quality checks.....	6
2.1.1 Standard physical tests.....	6
2.1.2 Standard chemical test.....	6
2.1.3 Product development.....	6
3.0 Objectives.....	7
4.0 Methodology & data collected.....	7
4.1 Research design.....	8
4.1.1 Harvesting and storage of pods.....	8
4.1.2 Breaking the pods.....	9
4.1.3 Fermentation.....	9
4.1.4 Post fermentation .....	11
4.1.5 Drying .....	11
4.1.6 Sorting .....	13
5.0 Quality tests.....	14
5.1 Physical and chemical tests .....	14
5.2 Cut test .....	14
5.3 Cocoa liquor.....	15
6.0 Future work.....	17
Annex 1: Cut test chart used for evaluation.....	18

# Acronym List

Acronym	Description
GoS	Government of Samoa
SROS	Scientific Research Organisation of Samoa
PHAMA	Pacific Horticultural and Agricultural Market Access Program
CEMA	Commodities Export Marketing Authority (Solomon Islands)

## Acknowledgement

The Scientific Research Organisation of Samoa (SROS) expresses its appreciation to the Pacific Horticultural and Agricultural Market Access Program (PHAMA) for the funding support which has allowed the conduct of this critical study to assist efforts aimed at revitalising the cocoa industry.

The SROS also acknowledges the support of its partners namely, the cocoa farm owners, Melzi Plantation, as well as Nia and Phil Belcher of Ola Pacifica Chocolates for agreeing to assist the project through the evaluation of bean quality through chocolate-making.

# 1.0 Introduction

Cocoa continues to be one of the Government of Samoa's (GoS) priority crops and efforts to revitalise the industry continue to attract donor funding support. The Australian and New Zealand governments, in particular, have new programs assisting the cocoa industry in Samoa with a particular focus on the supply side of the value chain because while the market has opened up again, supply is a major constraint.

The SROS conducted a comparative study funded by PHAMA under which the local fermentation and drying method was compared with a proven method from another Australian-funded study in Vietnam. The results from this research found the overseas fermentation and drying method to produce better quality beans for chocolate-making.

This follow-up work took the preferred method and implemented it on a farm site with the aim of conducting much larger trials using selected farmers' resources. This first farm trial was conducted on Mulitalo Sena's farm (Melzi Plantation) in Upolu and forms the first part of this report.

## 2.0 Background

Melzi Plantation (Upolu) and Kolone Vaai (Savaii) were the two selected farmers who supplied cocoa for the initial research and were also the recipients of solar dryers funded by the PHAMA program. The same farmers are used for this part of the work.

### 2.1 Quality checks

Two SROS staff members attended the Cocoa Quality Laboratory Training funded by PHAMA in the Solomon Islands and conducted by the Commodities Export Marketing Authority (CEMA) in February 2016. The training involved learning three major attributes in testing for bean quality.

These were:

#### 2.1.1 Standard physical tests

- % of foreign matters/debris
- Bean count
- Cut test
- Shell content
- Moisture content

#### 2.1.2 Standard chemical test

- pH
- Fat content

#### 2.1.3 Product development

- Cocoa liquor preparation
- Chocolate tasting (sensory evaluation)

The trials included testing for cocoa bean quality as outlined above and this was either carried out on-site or in the laboratory using equipment funded by the program.

## 3.0 Objectives

The objectives of this second trial were to implement the proven overseas method on the farm site and confirm the effects on the quality of cocoa beans and resultant end products. The ultimate goal is to use an evidence-based approach to improve local fermentation practices to ensure the quality of cocoa beans.

The specific aims were to:

- Trial the overseas recommended methods, specifically the fermentation method in combination with the solar dryer out in the field;
- Confirm the quality of beans and resultant end products;
- Collect data to establish a database for cocoa quality attributes for formulation of a National Standard for exported fermented, dried cocoa beans.

It should be noted, however, that this trial was very late as funding was received in the first week of June, the same week the farmer collected his last harvest for the season. This impacted on the amount and quality of pods available for use and the size of our batch.

## 4.0 Methodology & data collected

The fermentation method used was the proven overseas method from the research trial conducted by SROS in 2016, and originally adapted from the AusAid-funded study “Cocoa Processing Methods for the Production of High Quality Cocoa in Vietnam”.

## 4.1 Research design

Figure 1 outlines the research methodology used for the Upolu trial and will also be used for the Savaii trial.

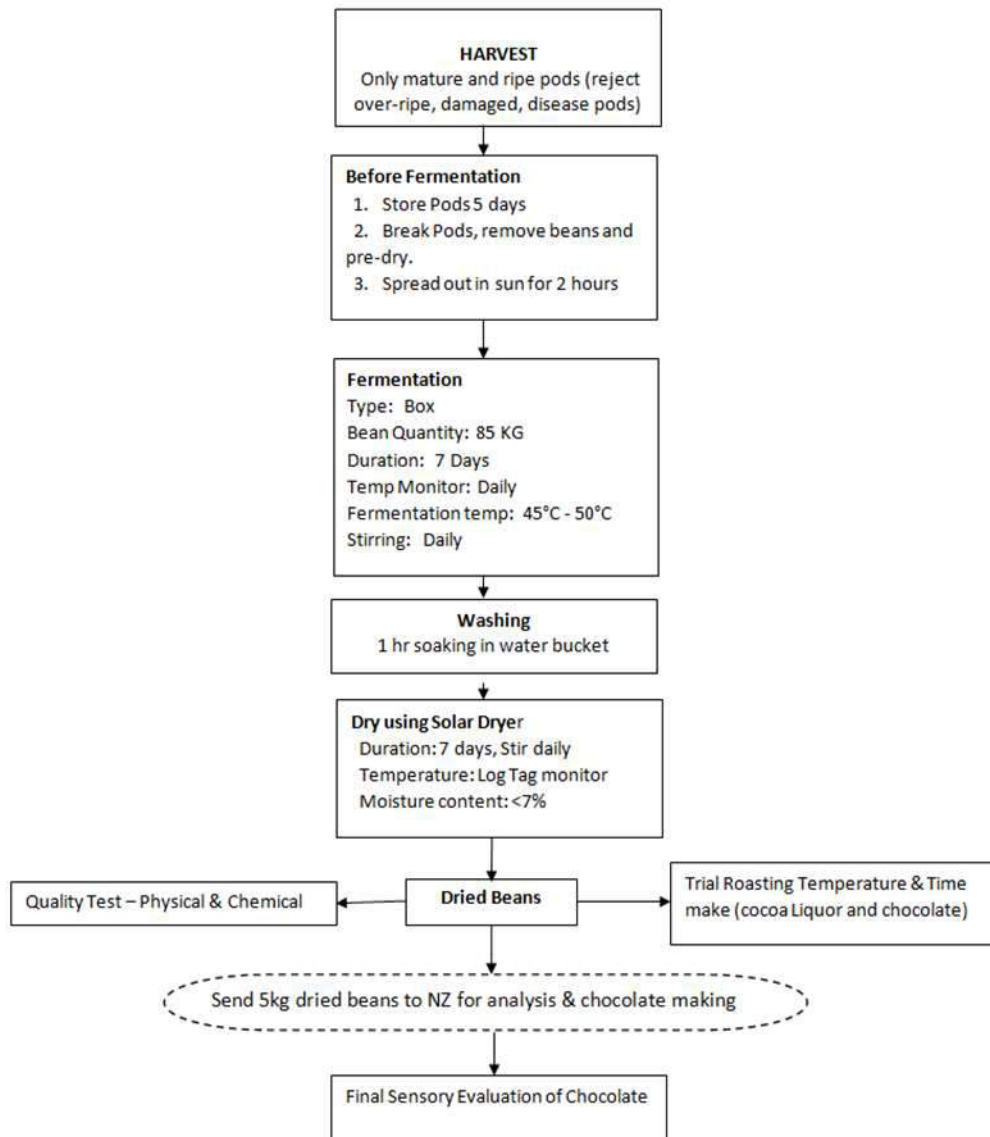


Figure 1: Flow chart of the research design.

### 4.1.1 Harvesting and storage of pods

The last harvest for the season collected on 7th June from Melzi Plantation was used for this trial. All three cocoa varieties were available on this farm, *Criollo*, *Forastero* and *Trinitario*, with *Trinitario* being the most dominant variety. The pods were screened for damage and infection and affected pods were discarded before the remainder were stored for 5 days in a wooden box (Figure 3) prior to opening.

The team visited the farm again the next day to check if another harvest was possible to increase the number of pods used, unfortunately there were no more fruits.





**Figure 2: Harvested cocoa pods**



**Figure 3: Storage**

A total of 1,126 pods were stored for 5 days to ensure they had fully ripened before opening for fermentation. The pods were stored in a cool, dry place to reduce the possibility of fungal contamination. This storage period reduces the moisture level of opened pods, which greatly assists with fermentation due to increased temperature. The pods should not be stored for too long otherwise the beans tend to germinate.

### 4.1.2 Breaking the pods

Pods were carefully broken with a blunt knife to avoid damaging the beans (Figure 4). Defective, diseased and damaged beans (Figure 5) were discarded and this resulted in the removal of 159 pods from the original 1,126. The beans were then spread out in the sun on a plastic sheet for approximately two hours (Figure 6) which allowed further reduction in moisture loss. In the end, the total bean weight used for fermentation was only 85kg.

A lot of the pods were discarded due to germination and fungal growth.



**Figure 4: Breaking the pods**



**Figure 6: Pre-dry in the sun**



**Figure 5: Defected beans**

### 4.1.3 Fermentation

The fermentation process can be conducted using heap, basket or box fermentation. Box fermentation (Figure 7) was used in this study and is the most common method used, particularly for large-scale operations. The 85 kilograms of wet beans were placed in the fermentation box with a temperature log tag and covered with banana leaves (Figure 8). The beans were turned daily (Figure 9) with temperature monitoring (Figure 10) and a cut test conducted at the end of 7 days of fermentation to observe the internal colour change for extent of bean fermentation (Figure 11).

The daily turning of beans assists in raising the temperature during fermentation as it allows more moisture/water to be lost at the bottom and the incorporation of air results in more even fermentation.

Graph 1 below shows the temperature profile obtained throughout the 7 days of fermentation.



Figure 7: Box fermentation



Figure 8: Covered with banana leaves



Figure 9: Turning the beans

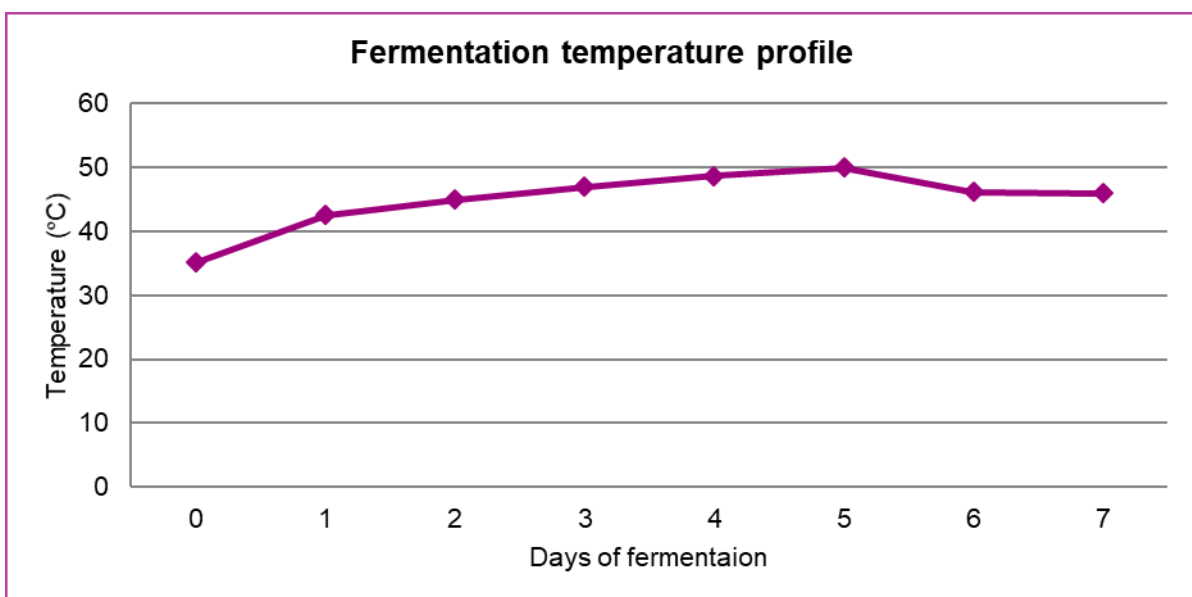


Figure 10: Daily temperature monitors



Fig 11: Cut test after fermentation

Graph 1: Temperature recordings during the 7-day fermentation period



The fermentation temperatures indicated the maximum temperature (50°C) was reached on the fifth day. For best fermentation results the optimum temperature range is between 45°C and 50°C, and the closer to 50°C, the better the quality of dried cocoa.

#### 4.1.4 Post fermentation

After fermentation, the beans were washed and soaked in buckets of water for two hours (Figure 12). The washing process removed dirt and immature beans which tended to float. The beans were also re-weighed (91kg) after washing, and the defective beans and foreign matter weighed separately (392g). The wet beans were then taken into the solar dryer (Figure 13) for drying.



*Figure 12: Washing*



*Figure 13: Solar dryer*

#### 4.1.5 Drying

The beans were spread out evenly inside the solar dryer (Figure 14) with the temperature log tag and digital thermometer placed inside to monitor the temperature (Figure 15). A moisture analysis done on-site indicated the beans were fully dried on the 7th day (Figure 16). The recommended moisture content for dried beans is <7% and the moisture content observed from the drying process was 5.3% (Figure 17).



*Figure 14: Spreading the beans*



*Figure 15: Temperature monitors*





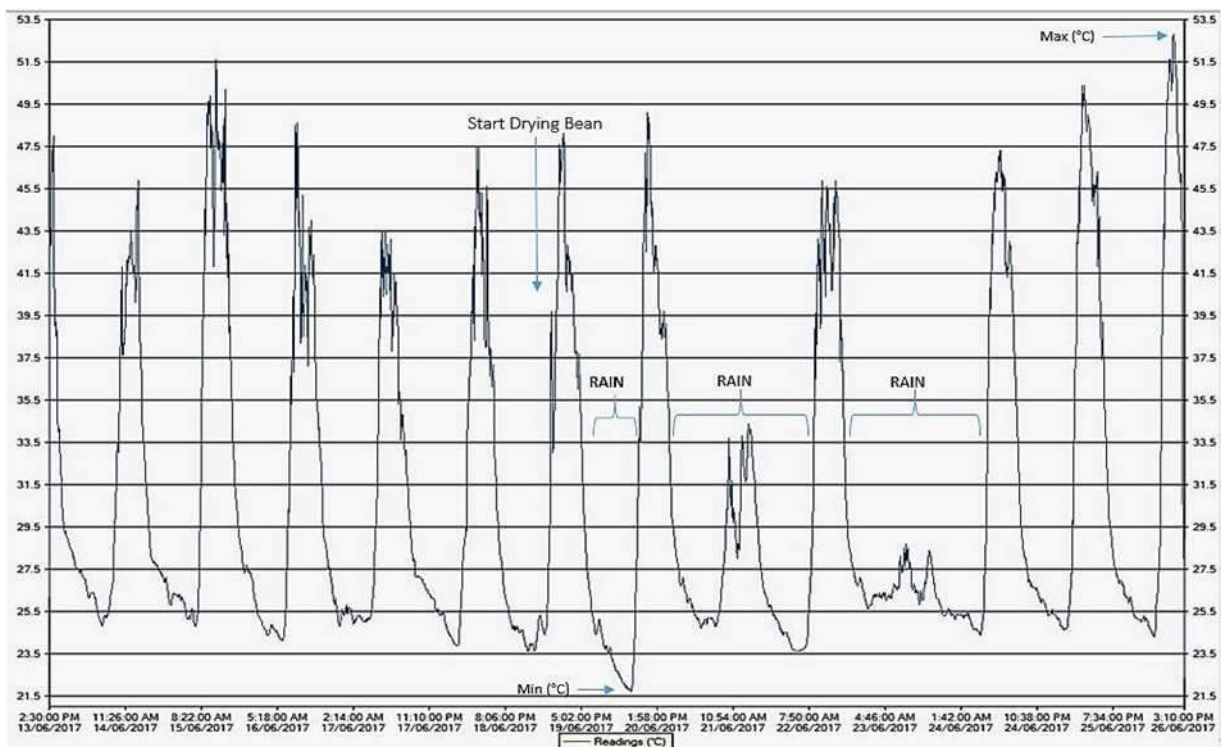
**Figure 16: Moisture meter**



**Figure 17: Dried beans (32kg)**

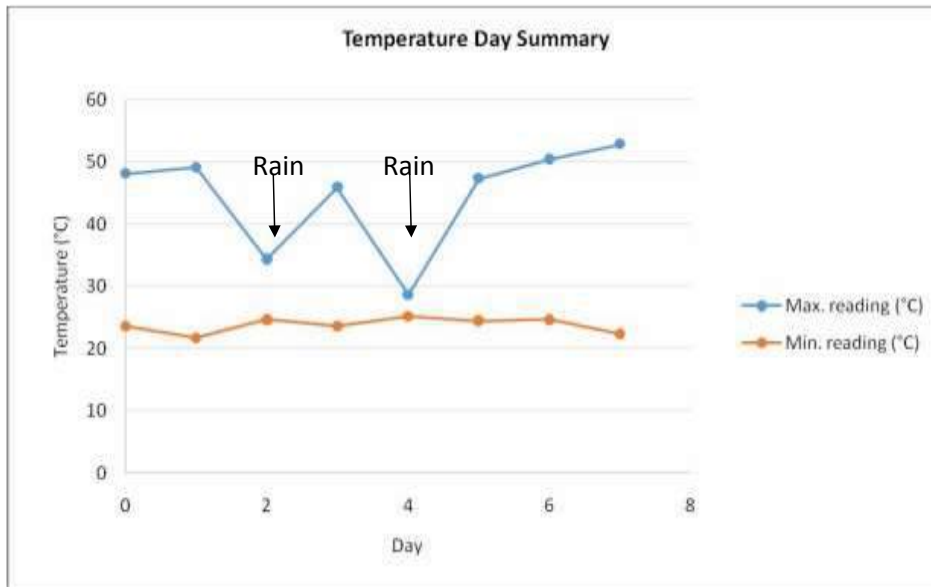
The dried beans weighed around 32kg after drying with a recovery rate of 37% from the 85kg fresh weight and 35% recovery from the 91kg weighed after soaking in water. This is within the expected recovery rate range of 30-40%.

The two temperature measuring devices placed in the solar dryer recorded the dryer performance. The temperature log automatically logged readings (Graph 2) while the temperature display device had manual readings (Graph 3) taken every afternoon when the cocoa was turned during the drying period.



**Graph 2. Temperature data from the temperature log tag of the solar dryer**

The temperature logger indicated the average daily temperature to be 30.9°C with a maximum of 52.8°C and a minimum of 21.7°C. On some days rain affected the average daily reading over the seven days and this is obvious in Graph 3 on days two and four.



**Graph 3: Manual recorded temperature readings from the temperature display device**

The plastic covering used for the solar dryer is not of the recommended quality (should be thicker) and this is expected to be replaced soon when an order arrives from Australia. The new plastic covering is expected to better retain heat within the dryer and result in higher temperatures and less drying time for the cocoa. However, there has been no confirmation of this.

#### 4.1.6 Sorting

The dried beans collected were taken to the SROS laboratory and sorted to remove the flat and poor-quality beans (Figure 14 & 15). From the sorted beans, 15kg was kept by the SROS for its quality tests and 17kg was returned to the farmer. A 5kg sample (Figure 15) was packed and sent to Ola Pacifica in New Zealand for evaluation and chocolate-making while the rest was used for bean quality analysis and trials for roasting time and temperature and for making cocoa liquor samples.



**Figure 18: Sorting**



**Figure 19: Defective dried beans**



**Figure 20: 5kg sent to Ola Pacifica**

This sorting process is crucial to ensure quality beans are selected for export or the chocolate industry while the sub-standard beans can be used for producing Samoan cocoa. The fact that more than 50% of dried beans was considered sub-standard indicated the quality of pods used for the trial which was from the very last harvest. A lot of germinated, diseased and light weight beans were found.

## 5.0 Quality tests

As discussed earlier the physical and chemical tests are crucial for ensuring quality beans are selected. Some of the critical factors affecting the results of these two tests include the selection of pods, proper fermentation, drying to the proper moisture level, and ensuring beans are free of abnormal odours and mould contamination. The cut test in particular is an essential quality test which must always be performed for every batch of fermented beans.

The procedures for the analysis of the physical attributes and pH of the beans were adopted from the Laboratory Manual of Methods for Analysis of Dried Cocoa Beans' of the Commodities Export and Marketing Authority (CEMA) of the Solomon Islands.

### 5.1 Physical and chemical tests

Listed in Tables 1 and 2 below are the results for the physical and chemical tests with the exception of the cut test.

Table 1: Physical analysis		
Test	Sample reference	
	Fermented solar-dried cocoa beans	Standard
Foreign matter	< 5%	<5%
Bean count	88 beans / 100 g	80 -100 beans/100g
Shell content	12.1%	15-17%
Moisture	5.7%	5.5- 7%
Dry bean recovery rate	37%	30- 40%

Table 2: Chemical analysis		
Test	Sample reference	
	Fermented solar-dried cocoa beans	Standard
Fat	50	55 -56%
pH	5.2	3.8 – 5.5

The results indicate the beans selected from the sorting process meet most of the test standards with the exception of the shell and fat content which were both lower than the set limits. The shell content reflected the amount of waste consisting of the shells when separated from the cotyledons and this low result was actually good, but may reflect that beans used could have had less shell intact. The fat, however, was lower than the levels required for beans intended for the chocolate industry, but this supports the results of the earlier research which also indicated low fat levels in the beans.

### 5.2 Cut test

Cocoa beans are graded on the basis of the count of defective beans from the cut test. The cut test reveals the presence of certain defects which may cause off-flavours and indicates the degree of fermentation of the beans which has a bearing on the resultant flavour and quality. The International Standards Organisation cut test procedure states that for a complete determination of bean quality, the beans shall be opened or cut lengthwise through the middle, so as to expose the maximum cut surface of cotyledons. Appendix 1 shows the chart used for assessing the quality of beans using the cut test.

The cut test was conducted using a guillotine knife cutter on 100 beans randomly selected from the batch. Figure 21 shows the first 50 beans in the guillotine just after cutting and Figure 22 shows all the 100 beans used for the cut test evaluation.



Figure 21: Guillotine



Figure 22: Cut test after solar drying

Table 3: Cut test results		
Observations	Result	Interpretation
No. Dark brown/blackish	13%	Over fermented
No. of brown	74%	Fully fermented
No. of partly brown/purple	4%	Half/partially fermented
No. of purple	0%	Under fermented
No. of slaty	0%	Not fermented
No. of insect damage	0%	Defective bans
No. of mould	4%	Defective beans
No. of germinated beans	2%	Defective beans
No. of Criollo	3%	Optional

The cut test indicated that 13% of the randomly selected beans were over fermented, 74% were fully fermented and 4% partially fermented. There were mouldy (4%) and germinated beans (2%) found and this low percentage again reflects the importance of screening at the pod opening stage as well as after drying. The cut test results were quite good, indicating the fermentation process was successful in ensuring quality beans were produced and fully fermented.

## 5.3 Cocoa liquor

The team also used the remaining beans to conduct trials for different roasting times and temperature profiles for the cocoa. The pH was also evaluated to determine if there was a time/temperature effect on the roasted beans.

Table 4: Roasting temperature, time and pH		
Temperature (°C)	Roasting time (min)	pH
100	60	5
150	30	5.19
155	30	5.15
160	30	5.1



Table 4: Roasting temperature, time and pH		
165	25	5.17
170	20	5.15

Figure 18 below outlines the process used within the laboratory to make cocoa liquor samples using each roasting profile and the samples are now stored in the freezer to be assessed together with any samples that will be produced by Ola Pacifica.



**Figure 23: Cocoa liquor-making flow chart in the laboratory**

The samples are all 80% cocoa and 20% sugar with no other additives. These samples are representative of the future direction the cocoa industry in Samoa needs to consider in the production and export of cocoa liquor bars, which offer higher value than exporting the beans alone.



## 6.0 Future work

For this first trial, the quality evaluation by Ola Pacifica, a buyer of Samoan beans, is essential to independently verify that this new fermentation and drying method produces quality beans. The cocoa mass samples made by SROS will also be assessed internally by staff together with any samples prepared by Ola Pacifica although it will not be the main quality determinant for the beans.

A proposed second trial is planned for Savaii and this needs to take place in light of some issues encountered in this first trial. These issues include:

- Ensuring the trial takes place during the upcoming main fruiting season and not at the end as this affects the quality of pods used,
- The solar dryer should have the recommended plastic covering in place to determine if there is a difference in heat retainment and drying times,
- A larger batch should be fermented which is more representative of commercial farmer practices to realistically determine the quality of the fermentation practice,
- Include funding support for samples to be sent for quality assessment/feedback from buyers of the cocoa beans as this was not formally included in this first trial

This progress report will be completed after the second trial to be conducted in Savaii. Hopefully, the administrative process will be quicker so funding is received in time for the next big fruiting season.

# Annex 1: Cut test chart used for evaluation

