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KOPERNIK PROJECT REPORT – EXPERIMENTATION PROJECTS

IMPROVING PROCESSING TECHNOLOGIES: CACAO BEANS PHASE TWO

CONTEXT

Situated in the western part of Tabanan regency, Angkah village covers an area of 1,802 km^2 and consists mostly of rice fields and small plantations. Local economic activity relies heavily on agriculture, specifically commodities such as rice, cacao, cloves and coconut. Tabanan regency produces 28 percent of Bali's annual cacao harvest, making it Bali's second largest producer after Jembrana regency.[1]

Angkah village has a population of 2,179[2], consisting mainly of farmers, who own small plantation, as well as plantation workers. It is common practice for these farmers to form a working group, known as a *UPH, Unit Pengolahan Hasil* or crop processing unit, where members coordinate their farming activities.

Farmers in Angkah own cacao plantations ranging in size from 0.15-2ha, with an average size of 0.52ha. In a typical season, the cacao yield can reach up to 300 kg/ha. This production volume is below the national average of 1,000 kg/ha[3]. The peak cacao season lasts from May to September, and low season is typically from October until December.

These farmers currently dry their beans directly under the sun, spreading the beans out on the ground. As well as being weather dependent and vulnerable to attack from pests, the current outdoor floor drying process is viewed by local farmers as inefficient and time-consuming.

[1] *(2013), Badan Pusat Statistik, Provinsi Bali. Plantation Production (tons) According to the Commodities and Regency / City in Bali in 2013, Retrieved from https://bali.bps.go.id/linkTabelStatis/view/id/88*
[2] *Selbar Officer (Aug1, 2015) Selemadeg West District, Tabanan Regency website, Retrieved from http://selbar.tabanankab.go.id/profil-desa/desa-angkah/*
[3] *BPTP (2008) Teknologi Budidaya Kakao, Seri Buku Inovasi: BUN/13/2008, Retrieved from http://kalbar.litbang.pertanian.go.id/ind/index.php?option=com_content&view=article&id=266:gernas-kakao&catid=66:program-utama&Itemid=209*

HYPOTHESIS

We hypothesized that the modified HSD will produce a higher quality product in a shorter amount of time when compared to the original HSD design and compared to traditional FSD methods.

METHODOLOGY

Kopernik applied the same method as phase one of our cacao drying experimentation project.

The fresh cacao beans were purchased from *Unit Pengolahan Hasil (UPH) Subak Abian Buana Mekar* (Processing Unit of Subak Abian Buana Mekar), Kopernik's local partner for this project. While individual farmers do not usually ferment the cacao beans, *UPH* does ferment beans, and for this reason, we tested beans that had been fermented using a three-tier fermentation box that Kopernik had previously built for them.

50 kilograms of beans were first weighed and then stored inside the fermentation box for five days. The indoor and outdoor temperatures were measured daily using a thermometer.

Drying cacao beans is an important part of the post-harvest production chain. The water content of the bean must be reduced from approximately 60 percent at the end of fermentation to less than 7.5 percent to reach the requirements of the market, particularly for export.[4] Drying also facilitates a reduction in the bitterness and astringency of the beans, encouraging the development of the chocolate brown colour characteristic of well-fermented beans.[5]

Two methods were tested to dry the fermented cacao beans:

1. The Hybrid Solar Dryer (HSD) – modified from Kopernik's first design;
2. The Floor Solar Dryer (FSD) – the current traditional practice in Angkah village.

The following table summarizes the experimentation methodology of the drying process (Figure 2):

DRYING PROCESS	HSD	FSD	Quality Testing
DURATION	7 days	7 days	1 day
TOOLS	- Thermometer and - Hygrometer	- Thermometer - Hygrometer	- Cutter - Weight Scale
MEASUREMENT	- Sample temperature and moisture - Outdoor and indoor temperature/humidity	- Sample temperature and moisture - Outdoor temperature/humidity	- Temperature (Celcius) - Moisture content - Drying quality - Flavour characteristic - Number of drying days

Figure 2. Summary of the experiment's methodology

[4] Mossu, G. (1992) Drying. In: *Cocoa. The Tropical Agriculturalist.* London: MacMillan. Pages 73-77
[5] *ibid.*

FINDINGS

Temperature

The findings demonstrated that:

- Modifying the roofing material to polycarbonate **increased the temperature inside the solar dryer** to a more effective level than the original design;
- Inside the modified HSD, the temperature was on **average 4.77 °C higher than for the FSD method.**

We compared the temperature between the HSD and the FSD methods using a digital thermometer daily. As shown in the chart below (Figure 3), the temperature trend inside the HSD was generally higher than the temperature for the FSD method.

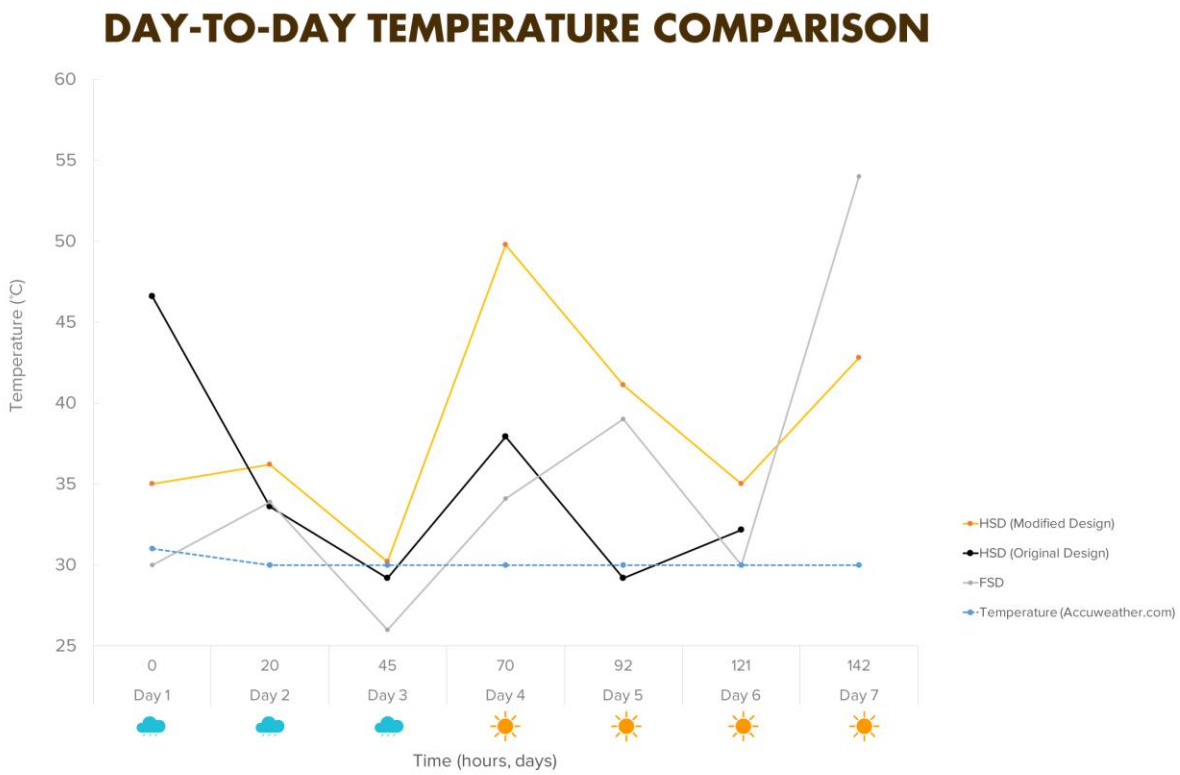

Figure 3. Temperature comparison between HSD and FSD

Moisture Level

The findings demonstrated that:

- Modifying the HSD design to include an exhaust fan **reduced the moisture level to a more appropriate level** inside the HSD from the first design to the second design;
- The **7% moisture level target was attained faster** using the modified HSD when compared to the FSD method.

With the first design, the average moisture level of the beans was two times higher than the the FSD-dried beans. By installing an electric exhaust fan to control the indoor moisture level, the modified HSD had an average moisture level that was 74 percent lower than the original design.

The moisture content of the beans dried in the HSD reached a value of 7 percent in 121 hours, while beans dried using the FSD method reached a value of 7 percent in 142 hours (Figure 4). The modified HSD was 14.7 percent faster than the FSD method but Kopernik expected the HSD to improve the drying process at a more significant level than this.

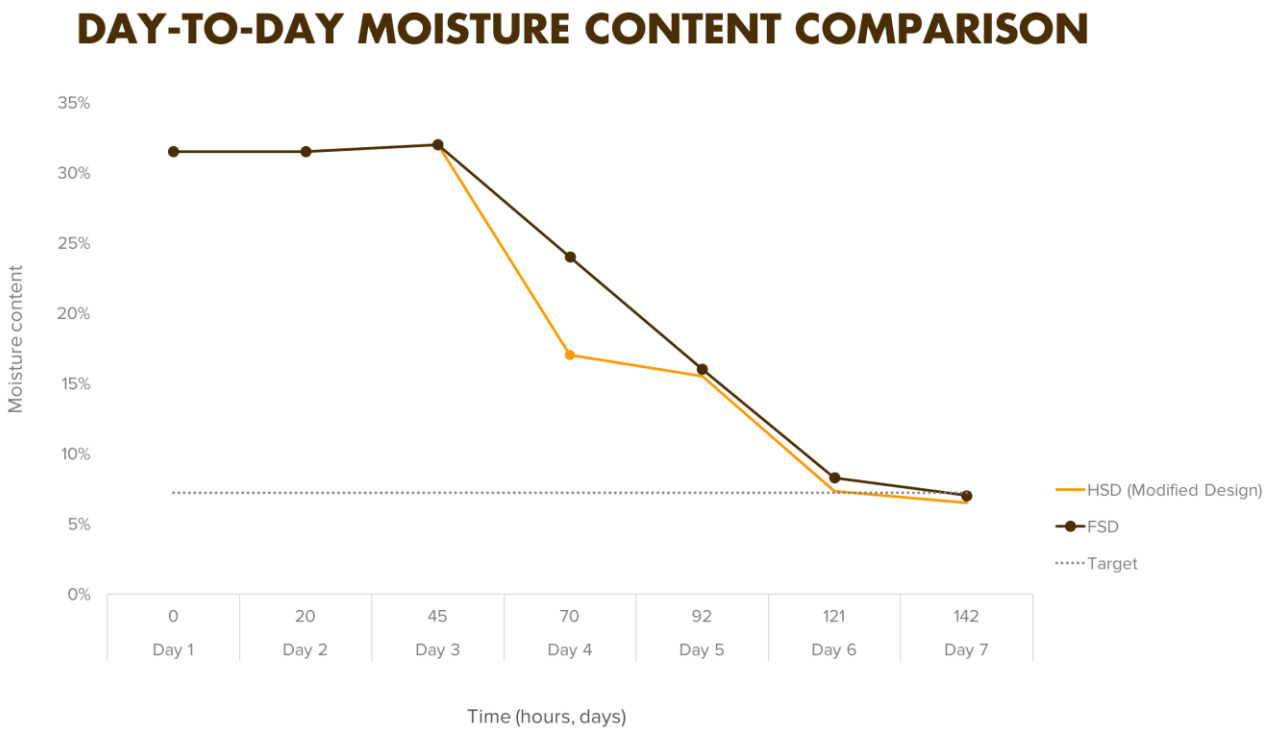

Figure 4. Day-to-day moisture content level comparison between the HSD and FSD.

Kopernik expected that the modified HSD would reduce the drying time of cacao beans by at least two days or 48 hours, but in fact the result was less than one day at 21 hours. We believe the reason for this is that the exhaust fan we installed was electric and we experienced a 48 hour power outage during our seven-day data collection period. This caused unfavorable drying conditions for the cacao beans inside the HSD during this time, affecting the overall results. While we chose an electric fan because power outages are not common in this area, solar drying designs for remote communities are better when equipped with solar batteries or a generator to avoid this issue.

Efficiency

The benefits of the modified HSD are most relevant when it is rainy season. During the rainy season, the risk cacao farmers face is that they can't dry their beans at all, particularly when totally reliant on the FSD method. When they can't dry the beans under the sun because of higher than anticipated rain, farmers have to find a buyer for the raw beans, a difficult task as the main market is for dried cacao beans. If farmers have to sell to a middle man, they may only receive IDR5,000/kg (~US$0.40).

While the average days required for the FSD method to reach a 7 percent moisture level is seven days, this is when the conditions are perfect, sunny with no rain. During these perfect conditions, a farmer would still be required to flip the beans to get an even result. This step is not necessary with the HSD. If there is intermittent rain, the farmer will need to collect his produce to protect it from the rain and then re-lay the beans on the floor when the sun returns, a time-consuming job.

Quality

To gain additional insights on the quality of the cacao beans dried in the modified HSD, Kopernik engaged a cacao expert from a local chocolate factory in Bali.

The criteria below defines high quality cacao beans:

1. There is some porosity in the bean;
2. The cacao leaf in the bean is completely dried;
3. No rotten-smell can be detected;
4. The moisture content is under 7.5 percent[6];
5. There is a slight citrus-sour taste in the bean.

With this expert, we conducted a cut-test on the cacao beans dried by the modified HSD. The expert observed some porosity and a completely dried leaf, as seen in the images below:

Image 2: the cut test performed on the modified HSD-dried beans

[6] Food and Agricultural Organization (FAO). Recommended International Practice for Cacao; International Cocoa Organization: Drying for Cocoa Beans.

The expert did not detect the citrus-sour flavor but confirmed there was no rotten-smell. Additionally, he confirmed the moisture content level had reached 7 percent. In the cacao expert's opinion, a better quality could be reached with more uniform temperature control in the HSD, but the results we achieved, even with the power outage, were appropriate for commercial milk chocolate producers.

CONCLUSION

In this project we modified our original HSD design to incorporate polycarbonate roofing and an exhaust fan, and achieved a faster drying process when compared to the FSD method for drying cacao beans. The HSD process also did not require as much manual work to complete as the FSD method, particularly in the rainy season where farmers may not be able to dry their beans at all. While the quality of the beans could be improved, they were still appropriate for the mass chocolate market.

TESTIMONIAL :

There has been a positive change in the Hybrid Solar Dryer's performance compared to the previous one. The roofing and exhaustion modification has helped to increase the temperature inside the HSD. Increased temperature means improved performance for cacao drying time, and it makes the post-harvest processes more efficient. We wish Kopernik could increase the capacity of HSD so that we can process a bigger volume of cacao.
- Adi, Chief of UPH Subak Buana, Tabanan, Bali

RECOMMENDATION

Based on the data collected, Kopernik's recommendations are:

1. Solar dryer designs should consider a backup source of electricity such as a battery to account for blackouts, avoiding a reduction in capacity caused by a stationary exhaust fan;
2. Kopernik to review all data collected through five project phases related to solar drying. Kopernik to compile a report collating our findings and insights before embarking on future solar drying project phases.

LEARN MORE

Kopernik has published the project report for the Improving Processing Technologies: Cacao Beans Phase One, Increasing Farmer Incomes: Solar Drying Solutions Phase One and the Improving Drying Processes: The Solar Bubble Dryer Phase One project

In early 2018, Kopernik will also publish the project report for the Increasing Farmer Incomes: Solar Drying Solutions Phase Two project

Furthermore in early 2018, our Solar Dryer Manual will be available on for all to access, illustrating a "How To" guide to build a small-scale 300kg capacity solar dryer from locally available materials.