QUALITY IMPROVEMENT OF COPRA THROUGH THE IMPLEMENTATION OF WHITE COPRA DRYING OVEN

By Ahmad Zubair Sultan

QUALITY IMPROVEMENT OF COPRA THROUGH THE IMPLEMENTATION OF WHITE COPRA DRYING OVEN

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Abstract. The common process of making copra is by drying under sunlight or fumigating by utilizing biomass (coconut shell). The disadvantages of this method of drying and fumigation are that processing time lasts for 5-7 days and it is very dependent on weather conditions. In addition copra quality was often unstable, mouldy and moisture content is not suitable therefore cannot fulfill requirements as white copra. Selayar regency has known as a copra producing centre in South Sulawesi, therefore it becomes one of the considerations of choosing community creativity program (PKM) partners from this region. The goal to be achieved is the process of transferring technology to partners so that motivate other coconut farmers who will eventually be able to increase their income. The output of this activity is the result of a white copra drying oven. The program implementation phase begins with the design of the drying oven at the Politeknik Negeri Ujung Pandang (PNUP) mechanical workshop followed by demonstration of equipment usage at the partner location and the final stage of the activity is the delivery of the equipment to the partners. From the result of testing equipment, the quality obtained was 10.14% moisture content, 54.15 oil content and 0.05% free fatty acid level for 25 hours drying time. This result has met the C Grade of SNI standard.

1. Introduction

Selayar Regency as an area of interest is the largest coconut producer in South Sulawesi. Coconut trees grow almost in all areas from the coastal area to remote areas as smallholder plantations. Coconut is indeed one of the important plantation commodities in Selayar and plays a role in people's lives, especially from the economic aspect with production of 24,189.54 tons in 2006 and increased by 27.83% in 2007. The most profitable coconut industry today is the manufacture of copra [1]. The process of making copra is fairly simple, that is, only with the heating process so that it is mostly made by coconut farmers. Although the processing of copra is only drying, it turns out that there are several ways of drying copra, which in turn can affect the results of copra [2].

White copra is a fairly profitable commodity; currently white copra is sold stable at a price of 9,000-10,200 rupiah/kg while brown copra only 5,000-5,900 rupiah/kg. What is mostly done in the coconut producing centres so far is processing coconut into copra (black copra), besides because the method is simple, also because black copra does not demand additional requirements such as white copra [3]. In South Sulawesi, the commodity of white copra is not yet popular, besides because most coconut farmers do not know the processing procedure, also because there is no appropriate technology available that they can implement [4].
The copra drying system carried out can affect the quality of the copra produced. White copra is the copra produced by oven, the quality is good, and the moisture content is small and clean. Copra

making is very decisive in determining the quality of copra, because the quality of copra products will affect the price, so the knowledge of the method or technique of making copra is absolutely considered by farmers who make copra. There are two types of copra on the market, namely white copra and chocolate copra. Both of them are the result of different drying methods [5]. Drying copra by using a drying machine will produce white copra with better quality if we compare it with the drying method under sun exposure or fogging.

The common method of making black copra is the sun-drying method or the smoking method. Black copra is widely used for cooking oil, usually for local factories in the country. How to make copra is very easy, the coconut is split and then dried for 8 hours, after that it is chopped so that it is separated and separated from the shell, chopped into small pieces, so that the hemisphere is split again into 4, then dried again until the moisture content reaches 5 %. After drying according to the specifications, copra is immediately packed and ready to be marketed. Making copra using the fumigation method is usually done by means of coconut meat being put into the fumigation stoves by utilizing fuel in the form of coconut fibre or shell. The disadvantage of this drying method is that it takes quite a long time which is 5-7 days and is very dependent on weather conditions, while the smoking method takes approximately 3 days. Besides that the quality of copra is often unstable, mouldy and the moisture content is not maximal [6, 7].

The method and process of making copra which they have been doing so far is that the coconut is cleaved and placed on top of the fumigation stoves by utilizing fuel in the form of coconut fibre or shell. After the dry coconut is removed, it is pruned to remove it from the shell, while the new coconut is raised again above the *para-para* (fumigation place) [4]. The gouged coconuts are then chopped into small pieces for more even drying. Every kilogram of copra requires 6-8 fresh coconuts. The usual drying steps are the moisture content of fresh coconuts (in the range of 50-55%) over a 24 hour drying period down to a range of 35%, in the next 24 hours it is reduced from 35% to 20%, and in the next 24 hours to be in the range of 6% to 5% according to the standards requested by collectors [8]. Direct smoking like this will produce copra with less good quality if compared to copra from indirect heating because hot smoke does not directly come into contact with copra, besides the colour of copra becomes blackish brown and smells of smoke because of direct contact between fruit flesh and smoke from combustion and also the use of inefficient energy and fuming temperatures is difficult to control [8].

Suheiti [9] have developed copra dryer plastic housings. The method for improving copra processing technology by using sunlight as an energy source, in the form of a "plastic house" with a transparent plastic roof and walls. The principle of this plastic dryer house is to convert long waves of sunlight into short waves. By heating the air, the drying power is higher and because it is heated the temperature of the air inside the drying chamber becomes greater than outside. The drying process with a plastic house takes 4 days with a mushroom concentration of 8%. But the drawback of this tool is that the service life is not long because transparent plastic is very easily to be torn exposed by shell flakes or even by the coconut meat itself.

Other research that has been developed is a tray dryer. This tool was designed by Anderson [10] using kerosene stoves as an energy source. Drying with oven tray dryer takes 14 hours with the quality on each rack is not the same. The shortcomings of this tool are too many dryer components making it complicated to operate and kerosene fuel which is very scarce nowadays, although gas can be used as a substitute energy source but in some cases the supply of gas is also not guaranteed smoothness in some areas especially in copra-producing centres such as Selayar Island.

The output that will be produced in accordance with the activity plan is to produce a device in the form of a blower drying system oven that can use electrical energy for heat sources. In addition, it is also equipped with a blower to flatten the temperature in the drying chamber and the thermostat to regulate the temperature automatically. This oven dryer is expected to benefit partners in the form of: 1) speed up the drying process. 2) Improve the quality of copra so that white copra can be produced which costs much higher. 3) Increase partner income by increasing the economic added value of copra selling prices and 4) motivate other coconut farming communities to get to know the right technology so they can design and make tools/machines according to their needs.

2. Research Method

Some of the problems related to copra quality that are often complaints by copra farmers are: case hardened copra (external hardening with tissue rupture), red copra (incipient bacterial invasion), scorhed copra (caramelized and broken from overheat), black copra (overburnt, showing triangulation), over ripe copra (from germinated drupes), distorted copra (rubbery, from immature drupes), bacterial deterioration (delayed drying /yellow slime on raw copra), pitted copra (advanced bacterial invasion), discloured gummy copra (showing adhering contaminants), friable stored copra (covered with frass-copra dust), deteriorated sun-dried copra (bacterial pitting/fungal erosion, from rain water contamination), advanced fungal deterioration (confluent moulds), refuse copra (sour, black, decomposed copra with rank smell, extreme biological deterioration (testa residue only) and entomological deterioration (showing associated copra beatles).

The problem solving method offered is designing and manufacturing white copra dryer oven, completed by blower system. The use of an oven guarantees free copra from contamination of dirt and bacteria due to the continuous drying process [11], while the use of a blower guarantees the circulation of hot air evenly [6] to all parts of the oven so that there will not be a scorched part of copra while elsewhere has not reached the desired moisture content.

Referring to the objectives to be achieved, then the methods used are applicable problem solving [11]. Based on this method, the solution to the problem is to develop a copra dryer oven with an air circulation system using a blower with the following detailed steps:

a) Preparation phase; what is done in this preparation phase is a field survey of drying conditions used by potential partners and the preparation of materials and equipment needed.
b) Calculation and Work Phase; what is done in this stage is the calculation of equipment components, making equipment components and assembling equipment components that have been made or purchased.
c) Stages of Testing; Tools that have been assembled are tested, whether they have fulfilled a predetermined target. If it has not fulfilled, revisions / adjustments are made both in the workshop to reach the target. This stage will be carried out repeatedly until data about the right temperature is obtained to obtain optimal production time.
d) Demonstration; At this stage the machine that has been tested and gives results according to the purpose of the activity, then performed a demonstration in the form of the application of a copra drying oven for the copra business group "Sari Alang" Selayar Regency. Partners in this activity are groups of farmers who have workers who are skilled in processing coconut into copra as the main livelihood to support their family's needs. In addition, manuals are also made starting from the selection of materials, equipment used, making ovens, operating methods and maintenance

After the oven is finished, the partners will be shown a demonstration of how to use the oven. In addition, a module containing instructions for making, operating and maintaining a drying oven is provided with the hope that copra farmers around the partner area can develop their own oven according to their needs.

3. Result and Discussion

3.1. Equipment Testing Result

Testing the oven for white copra dryer is done by looking at the extent to which the effectiveness of the dryer is like the required drying time and the results of copra drying. The quality of copra produced is determined by the uniform distribution of temperature in each part of the drying chamber. An increase in temperature that occurs every 1 hour is recorded until it reaches a stable temperature of 50oC. The results of temperature measurements on each shelf for a given time interval are given in Table 1 and Table 2 without and using blower respectively.

Table 1. Data Results of Oven Temperature Measurement without Blower

Rack	Drying Temperature (˚C) during Drying Time (minutes)				
	15	**30**	**45**	**60**	**75**
1	43	50	55	57	62
2	39	48	53	54	59
3	38	46	49	51	56
4	35	43	45	46	50

Table 2. Data Results of Oven Temperature Measurement using Blower

Rack	Drying Temperature (˚C) during Drying Time (minutes)				
	15	**30**	**45**	**60**	**75**
1	51	54	55	57	59
2	50	54	55	57	59
3	50	54	55	57	59
4	48	53	55	57	59

To analyze measurement data, a two-factor analysis of variance is applied. For the hypothesis test on different shelves, the hypothesis is used as follows:

H0 = the temperature on different shelves is the same

H1 = the temperature on different shelves is not the same

whereas for the hypothesis test at different drying times the hypothesis is used as follows:

H0 = the temperature at different drying times is the same.

H1 = the temperature at different drying times is not the same.

while criteria for acceptance and rejection are as follows:

If $F_{count} < F_{table}$ then H0 is accepted and H1 is rejected.

If $F_{count} > F_{table}$ then H0 is rejected and H1 is accepted.

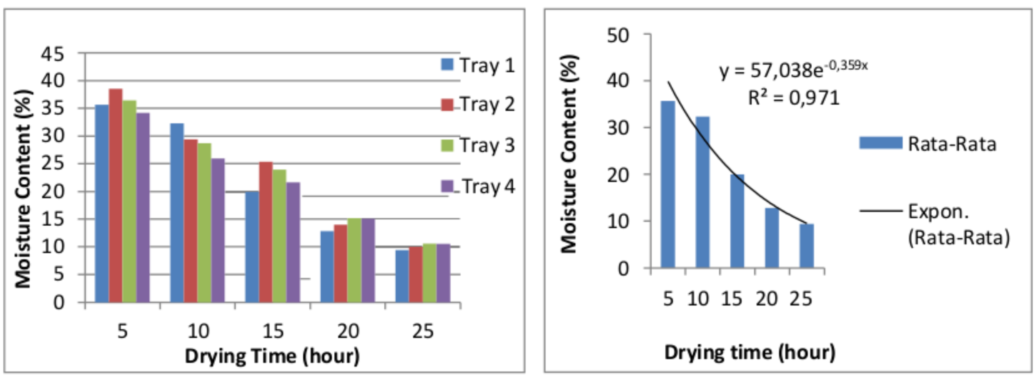
The variance analysis can explain the conditions on different shelves and at different drying time at once. Table 3 provides the results of the ANOVA for Oven Temperature Measurement. From the results of analysis of variance it can be concluded that in ovens without blowers the temperature distribution on different shelves is different (not well distributed) whereas in ovens with blowers the temperature distribution on different shelves is no different (temperatures are well distributed).

Table 3. ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Racks	*1.8*	*3*	*0.6*	*1.945946*	*0.176088*	*3.490295*
Drying time	*196.3*	*4*	*49.075*	*159.1622*	*2.76E-10*	*3.259167*
Error	*3.7*	*12*	*0.308333*			
Total	*201.8*	*19*				

Table 3 shows, that for different shelves, value of F_{count} = 1.95 while the F_{table} = 3.49. Because $F_{count} < F_{table}$ it can be concluded that H0 is accepted and H1 is rejected, meaning that statistically the temperature on the different racks is the same. Or in other words that in an oven with a blower, the temperature distribution on different shelves is not different (the temperature is already well distributed). For different drying times, F_{count} = 159.16, while F_{table} = 3.26. Because $F_{count} > F_{table}$ it can be concluded that H0 is rejected and H1 is accepted, meaning that statistically the temperature at different drying times is not the same.

The performance of the drying oven in terms of the rate of decrease in moisture content during a particular drying time is given in Figure 1.



(a) (b)

Figure 1. Distribution of copra moisture content after a certain time interval on each shelf (a) and Equation lines to predict moisture content after 25 hours (b)

Figure 1 shows the decrease in moisture content at different drying times for each shelf. The moisture content achieved after 20 hours of drying does not meet the standard moisture content for copra SNI quality C so that the drying is continued for more than 25 hours. Moisture content after drying after 25 hours can be predicted by the equation of the line according to figure 2. With the same quality class, generally drying in the sun or fumigation takes 5 to 7 days [4]. From Graph 4.2, it can also be seen that no fungus was observed for the results of drying 25 hours or 20 hours after the copra was stored for 2 days.

A comparison of copra as a result of fumigation and heating is given in Figure 2. The copra from fumigation is slightly black due to the build-up of soot on the copra's outer surface. Although on the one hand, this coating has a good effect on inhibits mould growth, but visually less attractive to traders so that the price is lower. Copra from the oven is pure white and has no mould. The price of copra on the market is generally 3 times higher than black copra.

(a) (b)

Figure 2. Comparison of copra from fumigation (a) and oven heating results (b)

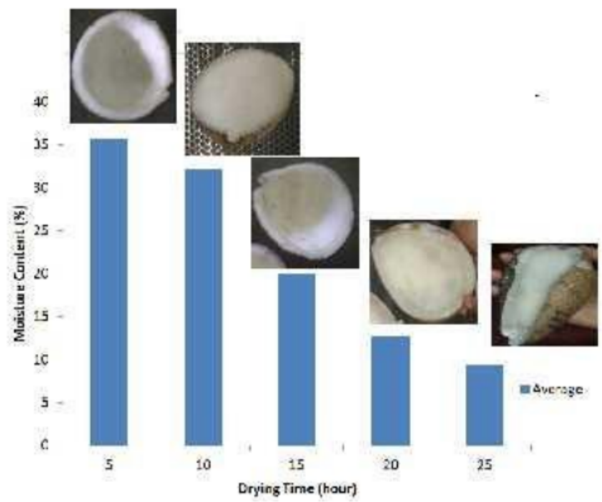


Figure 3. Changes in physical form of white copra according to the rate of decrease in moisture content during drying time

Figure 3 shows the changes that occur and visual appearance of copra during drying takes place. This visual change is greatly influenced by the moisture content remaining during the heating process. Through laboratory testing, copra oil content, moisture content and free fatty acid content of white copra produced were obtained as data from Table 2.

Tabel 2. Measurement Data of White Copra Oil Levels

No	Temperature	Sample	Drying Time	Moisture Content (%)	Oil Content (%)	Free Fatty Acid Content (%)
1	40-50°C	White Copra Sampel 1	25 hours	9,54	55,35	0,07
2	40-50°C	White Copra Sampel 2	25 hours	10,52	53,46	0,04
3	40-50°C	White Copra Sampel 3	25 hours	10,36	53,63	0,06

Source: Test results at the PNUP Chemistry Department laboratory

3.2. Calculation of Heating Load

To calculate how much heat is needed to raise the oven temperature from 30ºC to 60ºC with a room size of 850 mm x 650 mm x 1000 mm, the following equation can be used:

$$Er = E_2 - E_1$$

$$E_1 = A_r.\sigma.T_1^4$$

$$E_2 = A_r.\sigma.T_2^4$$

Known :

$$T_1 = 30^o C = (30 + 273) = 303^o K$$

$$T_2 = 60^o C = (60 + 273) = 333^o K$$

$$A_r = (2pt + 2lt) = (2x0,85x1,0) + (2x0,65x1,0) = 3,0\,m^2$$

$$E_1 = 3,0 \cdot 5,66x10^{-8} \cdot (303)^4$$

$$= 3,48x10^{-7} \cdot 8,43x10^9$$

$$= 1431,23 \text{ Watt}$$

$$E_2 = 3,0 \cdot 5,66x10^{-8} \cdot (333)^4$$

$$= 3,48x10^{-7} \cdot 12,3x10^9$$

$$= 2087,93 \text{ Watt}$$

$$E_r = 2087,93\text{Watt} - 1431,23 \text{ Watt} = 656,7 \text{ Watt}$$

The heat emitted by the heater can be calculated by the following equation:

$$E_h = A_h \cdot \sigma \cdot (T_h)^4$$

$$A_h = 2\pi \cdot r \cdot l$$

Information :

r = *heater radius*(m)

l = *heater long* (m)

Known :

$$T_h = 100^o C = (100 + 273) = 373^o K \qquad r = 5mm = 0,005m$$

$$\sigma = 5,66x10^{-8}\,W/m^2 \qquad l = 35cm = 0.35\ m$$

$$A_h = 2 \cdot 3{,}14 \cdot 0{,}005\text{m} \cdot 0{,}35\text{m} = 0{,}1099\ \text{m}^2$$

$$E_h = 0{,}1099\text{m}^2 \cdot 5{,}66\text{x}10^{-8} \cdot (373)^4$$

$$= 6{,}2203\text{x}10^{-9} \cdot 1{,}9356\text{x}10^{10}$$

$$= 120{,}4\ \text{Watt}$$

Number of *heater* (n *heater*) used :

$$n\ heater = \frac{E_r}{E_h} = \frac{656{,}7\ \text{Watt}}{120{,}4\ \text{Watt}} = 5{,}45 = 6\ \text{unit}$$

So the number of heaters used to heating the oven with a room size of 850 mm x 650 mm x 1000 mm from temperature of 30°C up to reach of 60°C are 6 pieces.

3.3. Electricity Consumption

Known : for one *heater* has a power = 300 watts, in this equipment there are 6 pieces used. Then the total power was 1800 watt, while for electric current:

$$I = \frac{P}{V}$$

$$I = \frac{1800}{220}$$

$$I = 8{,}2\ \text{A}$$

Then the electrical energy is used for 1 hour (3600 second) was:

$$\omega = V.I.t$$

$$\omega = 220.8{,}2.3600$$

$$\omega = 6494400\ \text{joule}$$

$$\omega = 6500\text{Kj}$$

4. Conclusion

Drying time to reach 12% moisture content according to SNI with the method of sun drying or fumigation is 144 hours (6 days) with capacity of approximately 100 pieces / 144 hours which is 0.69 pieces / hour. While the drying method with the white copra dryer is 25 hours with a capacity of 24 pieces / 25 hours which is 0.96 pieces / hour. Copra produced with the white copra drying oven is copra with a moisture content quality, an average of 10%, an average oil content of 54%, and a maximum free fatty acid content of 4% with the quality of the copra produced on each rack is equal statistically.

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making is very decisive in determining the quality of copra, because the quality of copra products will affect the price, so the knowledge of the method or technique of making copra is absolutely considered by farmers who make copra. There are two types of copra on the market, namely white copra and chocolate copra. Both of them are the result of different drying methods [5]. Drying copra by using a drying machine will produce white copra with better quality if we compare it with the drying method under sun exposure or fogging.

The common method of making black copra is the sun-drying method or the smoking method. Black copra is widely used for cooking oil, usually for local factories in the country. How to make copra is very easy, the coconut is split and then dried for 8 hours, after that it is chopped so that it is separated and separated from the shell, chopped into small pieces, so that the hemisphere is split again into 4, then dried again until the moisture content reaches 5 %. After drying according to the specifications, copra is immediately packed and ready to be marketed. Making copra using the fumigation method is usually done by means of coconut meat being put into the fumigation stoves by utilizing fuel in the form of coconut fibre or shell. The disadvantage of this drying method is that it takes quite a long time which is 5-7 days and is very dependent on weather conditions, while the smoking method takes approximately 3 days. Besides that the quality of copra is often unstable, mouldy and the moisture content is not maximal [6, 7].

The method and process of making copra which they have been doing so far is that the coconut is cleaved and placed on top of the fumigation stoves by utilizing fuel in the form of coconut fibre or shell. After the dry coconut is removed, it is pruned to remove it from the shell, while the new coconut is raised again above the *para-para* (fumigation place) [4]. The gouged coconuts are then chopped into small pieces for more even drying. Every kilogram of copra requires 6-8 fresh coconuts. The usual drying steps are the moisture content of fresh coconuts (in the range of 50-55%) over a 24 hour drying period down to a range of 35%, in the next 24 hours it is reduced from 35% to 20%, and in the next 24 hours to be in the range of 6% to 5% according to the standards requested by collectors [8]. Direct smoking like this will produce copra with less good quality if compared to copra from indirect heating because hot smoke does not directly come into contact with copra, besides the colour of copra becomes blackish brown and smells of smoke because of direct contact between fruit flesh and smoke from combustion and also the use of inefficient energy and fuming temperatures is difficult to control [8].

Suheiti [9] have developed copra dryer plastic housings. The method for improving copra processing technology by using sunlight as an energy source, in the form of a "plastic house" with a transparent plastic roof and walls. The principle of this plastic dryer house is to convert long waves of sunlight into short waves. By heating the air, the drying power is higher and because it is heated the temperature of the air inside the drying chamber becomes greater than outside. The drying process with a plastic house takes 4 days with a mushroom concentration of 8%. But the drawback of this tool is that the service life is not long because transparent plastic is very easily to be torn exposed by shell flakes or even by the coconut meat itself.

Other research that has been developed is a tray dryer. This tool was designed by Anderson [10] using kerosene stoves as an energy source. Drying with oven tray dryer takes 14 hours with the quality on each rack is not the same. The shortcomings of this tool are too many dryer components making it complicated to operate and kerosene fuel which is very scarce nowadays, although gas can be used as a substitute energy source but in some cases the supply of gas is also not guaranteed smoothness in some areas especially in copra-producing centres such as Selayar Island.

The output that will be produced in accordance with the activity plan is to produce a device in the form of a blower drying system oven that can use electrical energy for heat sources. In addition, it is

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also equipped with a blower to flatten the temperature in the drying chamber and the thermostat to regulate the temperature automatically. This oven dryer is expected to benefit partners in the form of: 1) speed up the drying process. 2) Improve the quality of copra so that white copra can be produced which costs much higher. 3) Increase partner income by increasing the economic added value of copra selling prices and 4) motivate other coconut farming communities to get to know the right technology so they can design and make tools/machines according to their needs.

2. Research Method

Some of the problems related to copra quality that are often complaints by copra farmers are: case hardened copra (external hardening with tissue rupture), red copra (incipient bacterial invasion), scorhed copra (caramelized and broken from overheat), black copra (overburnt, showing triangulation), over ripe copra (from germinated drupes), distorted copra (rubbery, from immature drupes), bacterial deterioration (delayed drying /yellow slime on raw copra), pitted copra (advanced bacterial invasion), discloured gummy copra (showing adhering contaminants), friable stored copra (covered with frass-copra dust), deteriorated sun-dried copra (bacterial pitting/fungal erosion, from rain water contamination), advanced fungal deterioration (confluent moulds), refuse copra (sour, black, decomposed copra with rank smell, extreme biological deterioration (testa residue only) and entomological deterioration (showing associated copra beatles).

The problem solving method offered is designing and manufacturing white copra dryer oven, completed by blower system. The use of an oven guarantees free copra from contamination of dirt and bacteria due to the continuous drying process [11], while the use of a blower guarantees the circulation of hot air evenly [6] to all parts of the oven so that there will not be a scorched part of copra while elsewhere has not reached the desired moisture content.

Referring to the objectives to be achieved, then the methods used are applicable problem solving [11]. Based on this method, the solution to the problem is to develop a copra dryer oven with an air circulation system using a blower with the following detailed steps:

a) Preparation phase; what is done in this preparation phase is a field survey of drying conditions used by potential partners and the preparation of materials and equipment needed.
b) Calculation and Work Phase; what is done in this stage is the calculation of equipment components, making equipment components and assembling equipment components that have been made or purchased.
c) Stages of Testing; Tools that have been assembled are tested, whether they have fulfilled a predetermined target. If it has not fulfilled, revisions / adjustments are made both in the workshop to reach the target. This stage will be carried out repeatedly until data about the right temperature is obtained to obtain optimal production time.
d) Demonstration; At this stage the machine that has been tested and gives results according to the purpose of the activity, then performed a demonstration in the form of the application of a copra drying oven for the copra business group "Sari Alang" Selayar Regency. Partners in this activity are groups of farmers who have workers who are skilled in processing coconut into copra as the main livelihood to support their family's needs. In addition, manuals are also made starting from the selection of materials, equipment used, making ovens, operating methods and maintenance

After the oven is finished, the partners will be shown a demonstration of how to use the oven. In addition, a module containing instructions for making, operating and maintaining a drying oven is provided with the hope that copra farmers around the partner area can develop their own oven according to their needs.

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3. Result and Discussion

3.1. Equipment Testing Result

Testing the oven for white copra dryer is done by looking at the extent to which the effectiveness of the dryer is like the required drying time and the results of copra drying. The quality of copra produced is determined by the uniform distribution of temperature in each part of the drying chamber. An increase in temperature that occurs every 1 hour is recorded until it reaches a stable temperature of 50oC. The results of temperature measurements on each shelf for a given time interval are given in Table 1 and Table 2 without and using blower respectively.

Table 1. Data Results of Oven Temperature Measurement without Blower

Rack	Drying Temperature (˚C) during Drying Time (minutes)				
	15	**30**	**45**	**60**	**75**
1	43	50	55	57	62
2	39	48	53	54	59
3	38	46	49	51	56
4	35	43	45	46	50

Table 2. Data Results of Oven Temperature Measurement using Blower

Rack	Drying Temperature (˚C) during Drying Time (minutes)				
	15	**30**	**45**	**60**	**75**
1	51	54	55	57	59
2	50	54	55	57	59
3	50	54	55	57	59
4	48	53	55	57	59

To analyze measurement data, a two-factor analysis of variance is applied. For the hypothesis test on different shelves, the hypothesis is used as follows:

H0 = the temperature on different shelves is the same
H1 = the temperature on different shelves is not the same

whereas for the hypothesis test at different drying times the hypothesis is used as follows:

H0 = the temperature at different drying times is the same.
H1 = the temperature at different drying times is not the same.

while criteria for acceptance and rejection are as follows:

If $F_{count} < F_{table}$ then H0 is accepted and H1 is rejected.
If $F_{count} > F_{table}$ then H0 is rejected and H1 is accepted.

The variance analysis can explain the conditions on different shelves and at different drying time at once. Table 3 provides the results of the ANOVA for Oven Temperature Measurement. From the results of analysis of variance it can be concluded that in ovens without blowers the temperature distribution on different shelves is different (not well distributed) whereas in ovens with blowers the temperature distribution on different shelves is no different (temperatures are well distributed).

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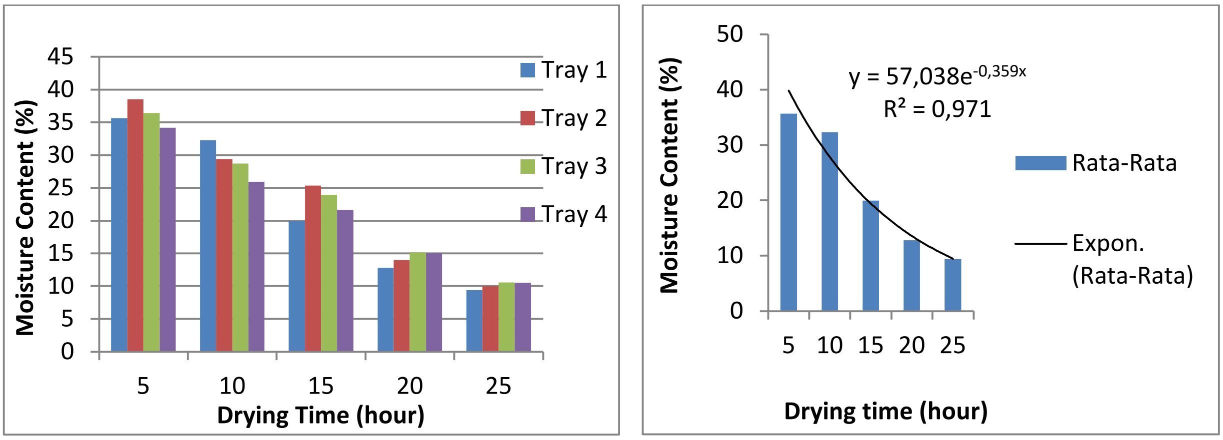
Table 3. ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Racks	*1.8*	*3*	*0.6*	*1.945946*	*0.176088*	*3.490295*
Drying time	*196.3*	*4*	*49.075*	*159.1622*	*2.76E-10*	*3.259167*
Error	*3.7*	*12*	*0.308333*			
Total	*201.8*	*19*				

Table 3 shows, that for different shelves, value of F_{count} = 1.95 while the F_{table} = 3.49. Because $F_{count} < F_{table}$ it can be concluded that H0 is accepted and H1 is rejected, meaning that statistically the temperature on the different racks is the same. Or in other words that in an oven with a blower, the temperature distribution on different shelves is not different (the temperature is already well distributed). For different drying times, F_{count} = 159.16, while F_{table} = 3.26. Because $F_{count} > F_{table}$ it can be concluded that H0 is rejected and H1 is accepted, meaning that statistically the temperature at different drying times is not the same.

The performance of the drying oven in terms of the rate of decrease in moisture content during a particular drying time is given in Figure 1.



(a) (b)

Figure 1. Distribution of copra moisture content after a certain time interval on each shelf (a) and Equation lines to predict moisture content after 25 hours (b)

Figure 1 shows the decrease in moisture content at different drying times for each shelf. The moisture content achieved after 20 hours of drying does not meet the standard moisture content for copra SNI quality C so that the drying is continued for more than 25 hours. Moisture content after drying after 25 hours can be predicted by the equation of the line according to figure 2. With the same quality class, generally drying in the sun or fumigation takes 5 to 7 days [4]. From Graph 4.2, it can also be seen that no fungus was observed for the results of drying 25 hours or 20 hours after the copra was stored for 2 days.

A comparison of copra as a result of fumigation and heating is given in Figure 2. The copra from fumigation is slightly black due to the build-up of soot on the copra's outer surface. Although on the one hand, this coating has a good effect on inhibits mould growth, but visually less attractive to traders so that the price is lower. Copra from the oven is pure white and has no mould. The price of copra on the market is generally 3 times higher than black copra.


(a) (b)

Figure 2. Comparison of copra from fumigation (a) and oven heating results (b)

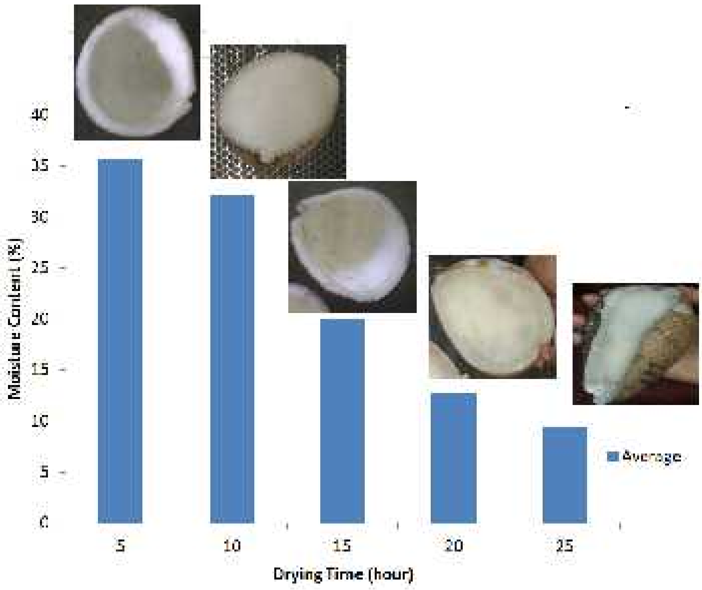


Figure 3. Changes in physical form of white copra according to the rate of decrease in moisture content during drying time

Figure 3 shows the changes that occur and visual appearance of copra during drying takes place. This visual change is greatly influenced by the moisture content remaining during the heating process. Through laboratory testing, copra oil content, moisture content and free fatty acid content of white copra produced were obtained as data from Table 2.

Tabel 2. Measurement Data of White Copra Oil Levels

No	Temperature	Sample	Drying Time	Moisture Content (%)	Oil Content (%)	Free Fatty Acid Content (%)
1	40-50ºC	White Copra Sampel 1	25 hours	9,54	55,35	0,07
2	40-50ºC	White Copra Sampel 2	25 hours	10,52	53,46	0,04
3	40-50ºC	White Copra Sampel 3	25 hours	10,36	53,63	0,06

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Source: Test results at the PNUP Chemistry Department laboratory

3.2. Calculation of Heating Load

To calculate how much heat is needed to raise the oven temperature from 30ºC to 60ºC with a room size of 850 mm x 650 mm x 1000 mm, the following equation can be used:

$$Er = E_2 - E_1$$

$$E_1 = A_r \pm .T_1^{\,4}$$

$$E_2 = A_r \pm .T_2^{\,4}$$

Known :

$$T_1 = 30^o C = (30 + 273) = 303^o K$$

$$T_2 = 60^o C = (60 + 273) = 333^o K$$

$$A_r = (2pt + 2lt) = (2x0,85x1,0) + (2x0,65x1,0) = 3,0\ m^2$$

$$E_1 = 3,0 \cdot 5,66x10^{-8} \cdot (303)^4$$

$$= 3,48x10^{-7} \cdot 8,43x10^9$$

$$= 1431,23\ \text{Watt}$$

$$E_2 = 3,0 \cdot 5,66x10^{-8} \cdot (333)^4$$

$$= 3,48x10^{-7} \cdot 12,3x10^9$$

$$= 2087,93\ \text{Watt}$$

$$E_r = 2087,93\text{Watt} - 1431,23\ \text{Watt} = 656,7\ \text{Watt}$$

The heat emitted by the heater can be calculated by the following equation:

$$E_h = A_h \cdot \sigma \cdot (T_h)^4$$

$$A_h = 2\pi \cdot r \cdot l$$

Information :

r = *heater radius* (m)

l = *heater long* (m)

Known :

$$T_h = 100^o C = (100 + 273) = 373^o K \qquad r = 5mm = 0,005m$$

$$\sigma = 5,66x10^{-8} W/m^2 \qquad l = 35cm = 0.35\ m$$

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$$A_h = 2 \cdot 3{,}14 \cdot 0{,}005\text{m} \cdot 0{,}35\text{m} = 0{,}1099\ \text{m}^2$$

$$E_h = 0{,}1099\text{m}^2 \cdot 5{,}66\text{x}10^{-8} \cdot (373)^4$$

$$= 6{,}2203\text{x}10^{-9} \cdot 1{,}9356\text{x}10^{10}$$

$$= 120{,}4\ \text{Watt}$$

Number of *heater* (n *heater*) used :

$$n\ heater = \frac{E_r}{E_h} = \frac{656{,}7\ \text{Watt}}{120{,}4\ \text{Watt}} = 5{,}45 = 6\ \text{unit}$$

So the number of heaters used to heating the oven with a room size of 850 mm x 650 mm x 1000 mm from temperature of 30ºC up to reach of 60ºC are 6 pieces.

3.3. Electricity Consumption

Known : for one *heater* has a power = 300 watts, in this equipment there are 6 pieces used. Then the total power was 1800 watt, while for electric current:

$$I = \frac{P}{V}$$

$$I = \frac{1800}{220}$$

$$I = 8{,}2\ A$$

Then the electrical energy is used for 1 hour (3600 second) was:

$$\omega = V.I.t$$

$$\omega = 220.8{,}2.3600$$

$$\omega = 6494400\ \text{joule}$$

$$\omega = 6500\text{Kj}$$

4. Conclusion

Drying time to reach 12% moisture content according to SNI with the method of sun drying or fumigation is 144 hours (6 days) with capacity of approximately 100 pieces / 144 hours which is 0.69 pieces / hour. While the drying method with the white copra dryer is 25 hours with a capacity of 24 pieces / 25 hours which is 0.96 pieces / hour. Copra produced with the white copra drying oven is copra with a moisture content quality, an average of 10%, an average oil content of 54%, and a maximum free fatty acid content of 4% with the quality of the copra produced on each rack is equal statistically.

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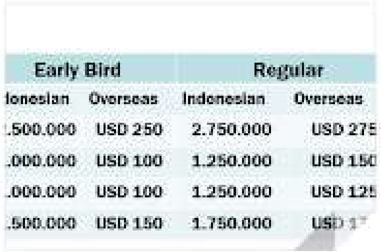

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