# Effect of Air Velocity and Thickness to Drying Rate and Quality Temulawak (Curcum Xanthorrhiza Roxb) using Combination Solar Moleculer Sieve Dryer

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Keywords: Curcuminoid, Combination solar moleculer sieve dryer.

Abstract: Temulawak (Curcuma xanthorrhiza Roxb) contains an active ingredient called curcuminoid which is a substance that has many benefits in the health field. The active ingredient of high heat sensitive curcuminoids for the dryer temperature uses relatively moderate temperatures and with low RH. This research using combination solar molecular sieve, where the air from environment is first passed through a molecular sieve box and then passed to the collector and then to the drying chamber in contact with the dried material. The operating air speed conditions to the dried material varied 1,2, and 3m/s and thickness of varied 25, 50 and 75mm. Reserch aims to study and obtain the best drying process and effect operating conditions on dry temuawak quality. Drying is done at 8:00 am to 4:00 pm. with an initial moisture content of 85%. Dry Temulawak was analyzed according to parameters of SNI 8171: 2015. The results showed that the best air velocity at 3 m/s with a thickness of 25mm obtained the highest drying rate of 0.226gr/cm$^2$hour. The best quality of dry ginger is in the condition of drying 2 m/s with a thickness of 25mm produced dry ginger with moisture content below 10% and curcuminoid value of 1,46%.

## 1 INTRODUCTION

Temulawak (Temulawak xanthorrhiza) is one of herbal medicinal plants that have chemical content of curcuminoid which is efficacious in the health as anti-cholesterol, anti-oxidant, overcoming of liver disease, overcoming of kidney disorder, smooth digestion, nourish the heart and others.

The active ingredient of curcuminoid that is contained in temulawak can be lost during post-harvest processing, if farmers do not understand how to overcome them. One important factor in maintaining the active ingredient in temulawak is the drying process. The drying technique that has been carried out by farmers, especially in developing countries, is by conventional drying which is directly under the sun. In this technique, drying cannot guarantee quality of uniformity due to changing weather, temperature too high at midday, and materials that are dried in the open are not guaranteed cleanliness (Hasibuan, 2009) (Dina l, 2015).

Solar energy that is abundant on the face of the earth especially in tropical countries is an infinite wealth if managed properly. Indonesia is one of the tropical countries with sunshine throughout the year. This sunlight can be used as a source of energy which is very potential to dry agricultural products. But tropical countries have high air humidity (RH) so the drying time is longer than 1 week. Long drying times can damage materials and remove the active ingredients in the materials. Therefore a drying system is needed that can dry the material at moderate and low RH conditions. Using a drying system combination of solar energy and molecular sieve can reduce the RH content of the environment air with a moderate drying temperature so it will not damage the active material in the dried material..

## 2 EXPERIMENTAL

### 2.1 Material and Equipment

This study used fresh temulawak obtained from the town markets. Silica gel was selected as the molecular sieve for the drying process due to economic reason. The equipments used for the drying process of temulawak included a metal fan (Φ



Hasibuan, R., Pane, Y. and Hanief, S.
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DOI: 10.5220/0010103503890394
In *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR 2018) - Research in Industry 4.0*, pages 389-394
ISBN: 978-989-758-449-7

30 cm) to conduct air to the molecular sieve, solar collector and drying chamber. A humidity sensor or hygrometer was used to measure sample humidity in drying chamber, a thermocouple to measure temperature, a stainless steel connector for connecting the humidity sensor and temperature sensor, a load cell for weighing temulawak and coneccted to a controller and a data acquisition system. The construct materials consisted of glass plate to cover solar collector and desicator, aluminum plates and iron frames for solar collector, molecular sieve and drying chamber.

## 2.2 Design and Construction

The preliminary study consisted of 2 parts, i.e. (i) to investigate reduce of moisture content and drying rate and; (ii) to examine the quality of dried temulawak. In order to design the drying system, it should be noted that the integrated system of solar

Energy and molecular sieve applying dried air for the drying process. The very low humid dried air was produced by conducting the air from atmosphere through a silica gel molecular sieve. The solar energy will be converted to heat energy in the solar collector. The heat will be applied to remove water vapor from the humid air.

In the context of designing the drying system, the drying unit consisted of three main parts, i.e. the solar collector, the molecular sieve (desiccant) and the drying chamber as shown in Fig.1 shows the picture of the overall integrated solar drying – molecular sieve system applied for drying temulawak. The integrated solar drying – molecular sieve system was installed on a roof of a 4th floor building to receive direct sunlight across from north to south to obtain

## 2.3 Maximum Sunlight Exposure

The solar collector is in line with the desiccant, while the position of solar collector and desiccant is in a slope of 20 – 30$^{O}$ with the horizontal line. As shown in (Fig 2.1), there are drying plates on the upper part of the drying chamber to place the harvested temulawak to be dried.

In the morning, evening and night or in grey/rain weather the drying medium only applies dried air yielded by conducting the atmospheric air to the silica gel molecular sieve (desiccant). The fan conducted the air from the atmosphere through the drying chamber. On the other hand, on a strong hot day the accumulated heat energy in the solar collector is used to heat the air from the atmosphere. At the same time, the drying process was carried out because the temperature in the drying chamber was elevated due to incident light entered the drying chamber passing through the upper part of the chamber. The drying process of emulawak was escalated by the dried air conducted from the silica gel molecular sieve. The drying unit is provided by two exhausters to conduct the air circulation. A PVC (poly vinyl chloride) connector (Φ 1.5 in) is installed between the solar connector and the molecular sieve, and the other one between the molecular sieve and the drying chamber.

In order to investigate reduce moisture content and the drying rate, a series of experiments was conducted by varying the speed of fan rotation and the size of samples temulawak in the drying chamber in two terms, i.e. (i) the normalized moisture content vs. time and (ii) the drying rate vs. time in dry basis.

Regarding the product quality, this study examined the product of dried temulawak encountered with the physical appearance and chemical composition before and after the drying process applying the designed integrated solar drying – silica gel molecular sieve system.

## 2.4 Solar Collector

The solar collector (Fig 2.1) is a wood rectangular box **(200 cm x 60 cm x 30 cm)** covered by an aluminum plate. In the middle part of the solar collector (a distance of 15 cm from bottom part), a black aluminum plate **(200 cm x 60 cm x 1 cm)** was placed to absorb light and converted it to heat. The hot aluminum plate heated the air stream both in the upper and lower parts. The upper part of the solar collector is covered by a transparent glass plate **(200 cm x 60 cm x 0.8 cm)**.

## 2.5 Molecular Sieve

The molecular sieve or desiccant (Fig 2.1) is a wood rectangular box **(25 cm x 20 cm)** with aluminum plates covered the outside and inside parts. The inside aluminum plate was black painted and the upper part covered by a transparent glass plate. The desiccant (molecular sieve) consists of two chambers where each chamber filled **by kg** silica gel and alternating operated. The function of the desiccant is to produce dried air.

### 2.6 Drying Chamber

The drying chamber (Fig 2.1) is made of an aluminum plate **(80 cm x 80 cm x 120 cm)** in black painted. There are 1 hole-trays placed inside the drying chamber to put the temulawak samples. The dried air was conducted from the bottom part aided by a fan passing through the temulawak samples and gone out via the upper part.

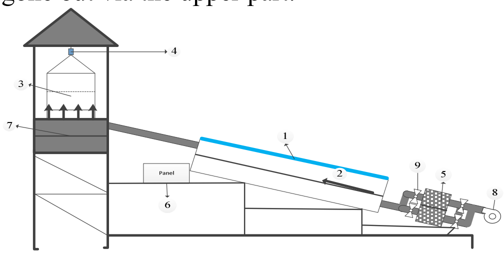



Figure 1: Scematic of Research Using Moleculer Sieve Solar Dryer Combination with Desicator Position Before Collector

Information figure: 1. Transparant glass 2. Solar Collector 3. Drying Chamber 4. Load Cell 5. Desicator 6. Panel Load Cell, RH & T 7. Fan 8. Blower 9. Valve

## 3 RESULT AND DISCUSSION

Combination solar drying + molecular sieve with air velocity of 1m/s, obtained environment air temperature data ranges from 25.8°C - 36°C, relative humidity (RH) ranges from 62.7% - 96.6%, and solar radiation range from 51.9 watt/m$^2$- 691.9 watt/m$^2$. At the air velocity of 2 m/s, obtained air environment temperature ranges from 28.3°C - 36.4°C, relative humidity (RH) ranges from 57% - 93.4%, and solar radiation range from 81.9 watt/m$^2$- 713,1 watt/m$^2$. At the air velocity of 3m/s, obtained environment air temperature data ranges from 25.4°C - 38.1°C, relative humidity (RH) ranges from 46.9% - 93%, and solar radiation range from 106.9 watt/m$^2$- 744.4 watt/m$^2$. During solar drying + molecular sieve look at the air temperature in the optimum drying chamber reaching 55.0°C - 56.7°C at (11:00 - 13:00) am.

### 3.1 Drying Rate, Moisture Ratio and Time

Moisture ratio and draying rate is projected as rate of decline weight ingredient every 5 minutes or rate of decline moisture content during the drying process. In the drying processs is obtained by plot data of moisture ratio and drying ratee with time that can be seen on picture below :

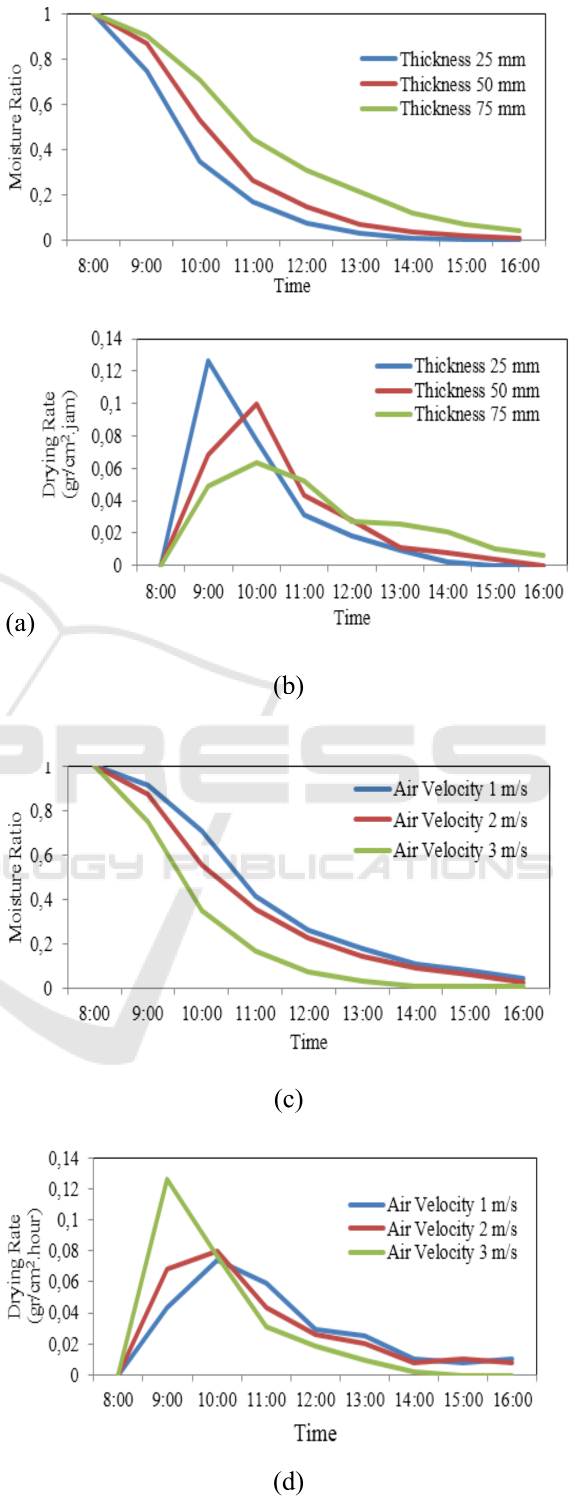



Figure 2: (a) Moisture ratio vs Time with Air Velocity 3 m/s (b) Drying Rate vs Time with Air Velocity 3 m/s (c)

Moisture ratio vs Time with Thickness 25 mm (d) Drying Rate vs Time Time with Thickness 25 mm.

On that picture can be seen that chart of Drying rate and time is fluctuate. But overall can be seen that on early drying rate is up and then decreases along increasingly moisture content. Decreasing water content explaines that water content in wet ingredient is still potentially to evaporate at the end of drying. It happens because during the drying processs , there is a free water which more easy to evaporate at early drying , and there is a water bound that is difficult to move up to surface of ingredients, so rate evaporation of water is getting more and more decrease (Supriyono, 2003). When air velocity is 3 m / s and the thickness is 25 mm, drying of water content and drying rate decline very significant. This is affected by steam that evaporates from ingredient is free water but at air velocity is 1 m / s and thickness is 75 mm, drying rate tends to be slower. This is caused by free water that collides with other material components thus making the rate of drying is slow. Drying in the afternoon declines drying rate to be constant. Declining weight in the afternoon not too significant because in the afternoon tends to release bound water . Drying is continue decrease until the drying processs is done or curcuma has reached the equilibium moisture content.

Decreasing the value of MR (Moisture Ratio) is affected by decline value moisture content of the material during the drying processs . And decreasing water content is affected by increase temperature air dryer . Increasing temperature air drying reduces time that required for reach every level ratio humidity since the heat transfer processs in room drying increases . Whereas , on high temperature , displacement of hot and mass will increase and moisture content of the material will increasingly reduced (Amanto l, 2015).

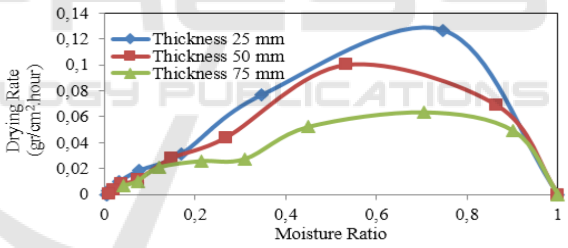
Based on the figure, the drying process shows an increase of drying rate of materials where most of the dryer air is used completely to evaporate water on the surface of the material and begin to decrease as the air temperature decreases but in the afternoon it begins to decrease. This is because drying in the afternoon tends to evaporate bound water.

From the average experiments that is done on each variation, the drying rate fluctuates constantly. This shows drying rate at high air velocity variations and thinner material thickness is faster than variations at low air velocity and large material thickness. This is because the high air velocity makes the free water content in the material is forced out and Nothing is entangled in the material, if low air velocity makes the water content in the material is difficult to get out due to lack of encouragement and water tends to be difficult to get out. The thickness of the material also affects the drying rate if the material is thick then the water is difficult to get out of the material because the free water collide with other material components and also the thin material makes the water will more easily come out due to fewer material components. The greater the air velocity used, the higher the drying rate, and vice versa, and if the thickness of the material is greater then the drying rate will be less and vice versa, the use of desiccation and the role of radiation intensity have a higher impact.

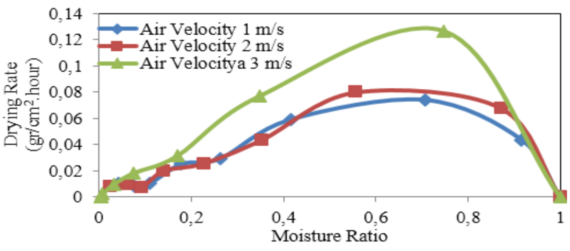
Drying rate will decrease along decline water content during drying . The amount of water bound will more reduce . Changing from the constant drying rate to be decrease drying rate for different materials will happen on different water content . The highest drying rate happens on early drying with air velocity is 3 m/s and thickness is of 25 with value 0,226 gr/cm$^2$.jam.

## 3.2 Characteristic of Drying

Characteristics of drying is projected as drying rate to moisture ratio during drying processs . In the drying processs is obtained by plot of data drying rate with moisture ratio that can be seen on picture below.




(a)




(b)

Figure 3: Moisture ratio vs Time (a) with Air Velocity 3 m/s (b) with Thickness 25 mm

There are 3 period drying , such as period of drying rate increases, constant drying rateand period of drying rate decreases .where on firts period happens a very important event , because on this period, half of the drying processs, happens (Fortienawati, and Melly Agustia, 2015)

Based on theory , characteristics curve on drying curcuma uses combination solar dryer + molecular sieve with variation air velocity and material thickness already corresponding with theory Where there are three period drying that is period of drying rate increases, period of drying rate decreases, and constant drying ratethat can be seen on curve at air velocity is 3 m/s and thickness is 25 mm.

On picture can be seen that period of drying rate increases up suddenly towards top curve ( rate drying maximum ). On maximum drying rate, period of constant drying rate should be seen because on this stage , the surface of ingredient will always be wet , so drying rate will be constant . But period of constant drying rate couldn't be seen on all variation air velocity. The highest points from curve characteristic drying is maximum drying rate , which depends on condition operation drying (at this point is air velocity and material thickness).

Analysis Quality of Curcuma Zanthorrhiza is done according to national standard in National Research and Standardization Agency (BARISTAN).

Table 1: Test quality result dry curcuma with thickness 25 mm

| Air Velocity, m/s | Moisture Content, %, Max | Curcuminoid Content, %, Min | Ash Content, %, Min |
|---|---|---|---|
| 1 | 11,7 | 0,71 | 5,46 |
| 2 | 8,0 | 1,46 | 5,32 |
| 3 | 3,4 | 0,6 | 5,32 |

Table 2: Test quality result dry curcuma with thickness 50 mm

| Air Velocity, m/s | Moisture Content, %, Max | Curcuminoid Content, %, Min | Ash Content, %, Min |
|---|---|---|---|
| 1 | 8,4 | 1,13 | 5,325 |
| 2 | 5,6 | 0,81 | 5,64 |
| 3 | 6,3 | 0,72 | 5,31 |

Table 3: Test quality result dry curcuma with thickness 75 mm

| Air Velocity, m/s | Moisture Content, %, Max | Curcuminoid Content, %, Min | Ash Content, %, Min |
|---|---|---|---|
| 1 | 15,9 | 1,48 | 5,47 |
| 2 | 16,8 | 1,64 | 5,38 |
| 3 | 12,5 | 0,99 | 5,67 |

From the table above, the result of dry temulawak's test using a dryer solar combination–molecular sieve with variation in air velocity and thickness of the material can be seen that the quality of dried temulawak has a distinctive color, odor, and taste according to fresh ginger. It means that there is almost no significant change in physical properties between fresh ginger and dried ginger (figure 3.4). According to SNI temulawak is divided into 3 qualities, quality 1 curcuminoid content> 2%, quality 2 levels of curcuminoid 1-2%, quality 3 levels of curcuminoid <1%. Curcuminoid level in this study is consisted at two qualities, there are quality 2 and 3, while quality 1 was not available because in this study did not pay attention to temulawak varieties that is used. Ginger was obtained from traditional markets with any variety. Curcuminoid which is obtained at high drying conditions at 3 m/s and a thickness at 25 mm produces smaller curcuminoid because air that moving faster will increase the rate of evaporation of water to the surface of the material more quickly and the possibility of curcuminoid that follow vapor will move rapidly to the material surface. However in general, the dry temulawak in this study contains curcuminoid in accordance with SNI. The best drying conditions is with a drying air velocity at 2 m / s, a thickness at 25 mm . It produces dry temulawak with moisture content less than 10% and a curcuminoid value 1.46%.

Figure 4: Wet and Dry Temulawak

## 4 CONCLUSIONS

This study showed that the designed integrated solar drying – molecular sieve system has successfully conducted the drying process of temulawak. Air velocity and thickness of materials that affect drying rate and quality of drying temulawak.The best air velocity at 2 m/s with thickness 25 mm, produces dry temulawak which has almost no significant change in physical, color, smell and tasteDry temulawak with the best drying conditions is air velocity 2 m/s and thickness 25 mm produces temulawak with moisture content < 10 % and curcuminoid value of 1,46 %.

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