Vol. 12, No. 1 (2023) : 212 - 222 DOI : http://dx.doi.org/10.23960/jtep-l.v12i1.212-222

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Drying Vanilla Using A Hybrid Dryer

Warji Warji[1]✉, Tamrin Tamrin[1], Sapto Kuncoro[1], Budianto Lanya[1], Hani Muzaqi[1]

[1]Program Studi Teknik Pertanian, Fakultas Pertanian, Universitas Lampung, Lampung, INDONESIA

Article History :

Received : 18 July 2022
Received in revised form : 28 November 2022
Accepted : 3 January 2023

Keywords :
Drying,
Hybrid postharvest,
Vanilla.

✉Corresponding Author:
warji1978@gmail.com

ABSTRACT

Vanilla (Vanilla planifolia Andrew) is a plant that has high economic value; the plant is oriented for export. Postharvest handling is necessary to produce good quality vanilla; One of them is the drying process. This study aims to measure the drying time of vanilla, measure the decrease in moisture content, and analyze the efficiency of drying wet vanilla using a rack-type hybrid dryer. The research was conducted with three treatments, namely: drying using solar energy, drying using electrical energy, and drying using solar energy and electrical energy (hybrid). Based on the results of the study, it was found that drying using solar energy, drying using electrical energy, and drying using solar energy and electrical energy (hybrid) took 15 days, 17 days, and 13 days, respectively. The initial moisture content of drying is about 91.25% which decreases to about 32.44% at the end of drying. The efficiency of the three treatments was 6.39%, 1.58%, and 0.92%, respectively.

1. INTRODUCTION

Vanilla (Vanilla planifolia Andrew) is one of the plants that is oriented to export because it has quite a high economic value (Condro, 2017; Makki & Subairi, 2020). Vanilla is nicknamed "green gold" because of its very high price. Indonesian vanilla has been known for a long time in the international market as a Java vanilla bean (Ilham *et al*., 2004). The area of vanilla plantations in Indonesia in 2020 is 9,291 hectares with production 1,412 tons (Direktorat Jenderal Perkebunan, 2021).

Vanilla has various types and benefits in the food sector (Junarli *et al*., 2017), especially as a flavoring agent (Atya *et al*., 2021; Sinha *et al*., 2008), while in the non-food sector, it is used as a raw material for perfume (Chandrayani & Natha, 2016; Brunschwig *et al*., 2009). The benefits of vanilla combined with honey in the health sector are to increase appetite, increase endurance and stamina, and improve blood circulation. The delicious aroma of vanilla can also be used for aromatherapy.

Better process technology and production of derivative products must be prepared to add value to vanilla processing, anticipate market developments, and open up markets for vanilla-based products. This condition must be maintained and even improved. The right strategy is needed to support the development of vanilla in Indonesia so that the productivity level of vanilla plants and farmers' income are always in good and sustainable conditions. The drying process is a very critical post-harvest stage because it can affect the quality (Agustina *et al*., 2016; Waluyo *et al*., 2021). One of them is the drying process used to dry the vanilla so that the shelf life and quality of the vanilla become better and last longer.

Drying is a process of reducing the water content of materials by using heat energy. The drying process that is generally carried out by the community to dry agricultural products is using direct sunlight (sun drying). This drying process has many drawbacks such as the drying process depends on the weather, requires a large drying area, the dried material is easily contaminated with dust and dirt, and many of the drying products are scattered. Sun drying or sun drying provides a less stable temperature during the drying process (Lestari *et al*., 2020a). The difference in temperature and humidity during the day and at night is too high (Safrina *et al*., 2019), even morning temperatures are different from those during the day (Nino & Neonbeni, 2020). Based on this, artificial drying is needed which is drying using technology in the form of mechanical devices (Putra *et al*. 2018). This artificial drying not only uses sunlight as a heat source to dry materials but can also be combined with electrical energy, fuel oil, biomass, and gas (Warji & Tamrin, 2021; Suhendar *et al*., 2017). Drying using a dryer produces better quality than drying directly in the sun.

The shelf-type hybrid dryer is one of the dryers that can be used to dry vanilla. Drying using a hybrid system utilizes solar thermal energy with the addition of other energy sources (electricity, biomass fuel, coal, etc.). This study aims to measure the drying time of vanilla, measure the decrease in water content, and analyze the drying efficiency of wet vanilla using a rack-type hybrid dryer.

2. MATERIALS AND METHODS

This research was carried out from January to March 2022 at the Agricultural Engineering Power and Equipment Lab. and the Post-Harvest Bioprocess Engineering Lab. at the Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung. The tools used in this study were stoves, pans, rack-type hybrid dryers, lux meters, kWh meters, cameras, ovens, cups, thermometers, digital and analog scales. The material used in this research is wet vanilla. The rack-type hybrid dryer is presented in Figure 1.

Figure 1. Rack-type hybrid dryer (Warji & Tamrin, 2021)

2.1. Design of Experiment

Drying process was conducted using different energy sources, namely solar energy, electrical energy, and hybrid (combination of solar and electrical energy). Each treatment was performed using 7 kg of wet vanilla pods with two replications. The stages of the research are presented in the flowchart of Figure 2.

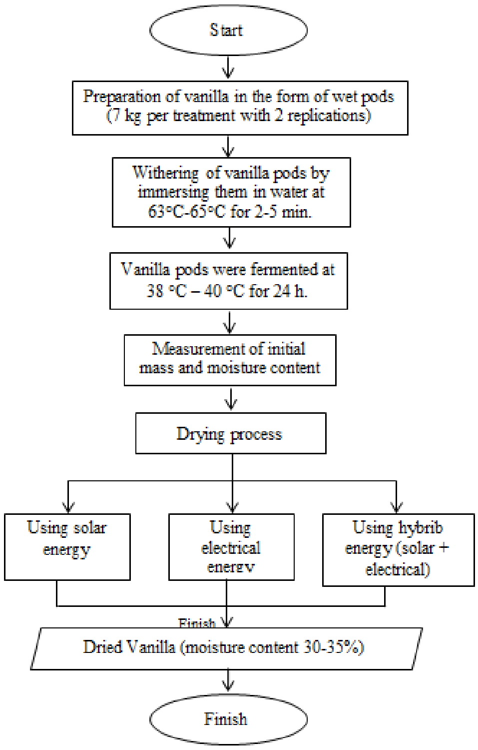

Figure 2. Flowchart of research steps

2.2. Research Parameters

Parameters measured include (1) drying temperature, (2) drying time, and (3) electricity consumption. Parameters observed for efficiency analysis include (4) water vapor load, (5) drying rate, (6) measurement of moisture content, (7) source energy (input), (8) energy utilized (output), and (9) drying efficiency.

a. Drying Temperature

Drying air temperature measurements were carried out using a thermometer placed inside the device on each shelf and a thermometer outside the device to determine the ambient temperature, and observed every hour.

b. Drying Time

Drying time is the time needed to dry the vanilla, starting when the appliance is exposed to sunlight or when the electricity is turned on until the desired vanilla moisture content is reached, namely 30% - 35%.

c. Electrical Energy Consumption

Electrical energy consumption is measured using a kWh meter. The consumption of electrical energy is used to calculate the efficiency of using electrical energy.

d. Water Vapor Load

The load of water vapor (W_{vapor}) was calculated as:

$$W_{vapor} = \text{Initial weight (kg)} - \frac{(1-M_1) \text{ x Initial Weight (kg)}}{(1-M_2)} \quad (1)$$

where W_{vapor} is water vapor load (kg H_2O), M_1 is initial water content (% wb), M_2 is final water content (% wb).

e. Drying Rate

Drying rate (Ḿ) over drying time of t (hour) is presented in (kgH_2O/h) and was calculated according to the following equation :

$$\acute{M} = \frac{W_{vapor}}{t} \quad (2)$$

f. Water Content

Water content (M) was calculated from initial mass (m_{bb}) and final mass (m_{bk}) of sample according to the following equation:

$$M = \frac{m_{bb} - m_{bk}}{m_{bb}} \quad (3)$$

g. Energy Source (Input)

Input energi (Q_{in}) utilized during drying was calculated from consumed electricity through:

$$Q_{in} = P\text{ (kW)} \times \sum t\text{ (h)} \quad (4)$$

where P is electricity power (W).

Meanwhile, input energy from solar (Q_{sun}) was calculated through equation 5 (Nursanti, 2010):

$$Q_{sun} = I \times \tau \times A \times t \quad (5)$$

where Q_{sun} was expressed in (kJ), I is solar radiation flux (watt/m^2), τ is transmissivity of polycarbonate (90%), and A is aperture area (m^2). The value of solar radiation was calculated by converting the results of measurements using a lux meter and converted to W/m^2 unit.

h. Energy Utilized (Output)

The amount of energy utilized during drying can be calculated by the equation (Taib, 1988):

$$Q = Q_1 + Q_2 \quad (6)$$

where Q is the amount of heat used to heat and evaporate the water of the material (kJ), Q_1 is amount of heat used to evaporate the water of the material (kJ), and Q_2 is amount of heat used to heat the water material (kJ).

$$Q_1 = W_{\text{vapor}} \times H_{\text{lb}} \quad (7)$$

with W_{vapor} is water vapor load (kg H_2O), and H_{lb} is latent heat of water (kJ/kg). The latent heat value of water is temperature dependent and can be calculated by the following equation:

$$H_{lb} = 2.501 - (2.361 \, x \, 10^{-3}) \times T \times 1000 \quad (8)$$

where *T* is the temperature in the drying chamber (°C) (Hartanto *et al*., 2011).

$$Q_2 = m \times C_p \times \Delta \quad (9)$$

with *m* is mass of dried material (kg), *Cp* is specific heat of material being dried (kJ/kg °C), and DT is material temperature rise (OC).

i. Drying Efficiency

Drying efficiency (*Eff*) was calculated based on the comparison between the amount of energy to evaporate the water of the material with the source energy from electricity and solar energy, using the equation:

$$Eff = \frac{Q_{out}}{Q_{in}} \times 100\% \quad (10)$$

where Q_{out} is energy used to evaporate water and heat the material (kJ), and Q_{in} is energy from energy sources that enter the drying chamber (kJ).

2.3. Data Analysis

Data from observations and calculations in the form of drying rate, changes in moisture content, drying temperature, energy consumption, equipment capacity and drying efficiency were analyzed using Microsoft Excel, presented in tables and graphs.

3. RESULTS AND DISCUSSION

3.1. Drying Temperature

Based on testing with solar energy, the highest recorded temperature was 65 °C, while the lowest temperature was 25 °C. The average temperature is 43.2 °C. Drying temperature fluctuations with solar energy are strongly influenced by the intensity of sunlight; the temperature in the morning is lower than the temperature in the afternoon.

Based on testing using electrical energy, the highest temperature is 44 °C, while the lowest temperature is 26 °C. While the average temperature is 35.4 °C. The average ambient temperature is 26.2 °C.

Based on testing with hybrid energy, the highest temperature was 65ºC, while the lowest temperature was 27 °C, and the average temperature was 41.29 °C. The average ambient temperature in this test is 26.38 °C. The distribution of drying temperatures is presented in Figure 2. The average temperature of this hybrid is higher than drying with electric heating but lower than drying with electricity.

Drying using solar energy has a higher temperature than testing using electric and hybrid energy; this is because at the time of testing using a sun dryer, it was only carried out during the day, namely for 7 hours per day (from 09.00 WIB to 16.00 WIB) and no drying and temperature measurements were carried out at night. While hybrid and electric drying using a hybrid dryer are carried out 24 hours per day; specifically for drying with electricity during the day is placed indoors so that it does not get additional energy from the sun so that the average drying temperature is lower. While hybrid drying gets solar heating and additional electrical energy; the daytime temperature was the highest of the other two treatments but on average in the afternoon, evening, and morning it was lower than the sun drying treatment. This causes the average hybrid drying temperature to be lower than drying with solar energy alone.

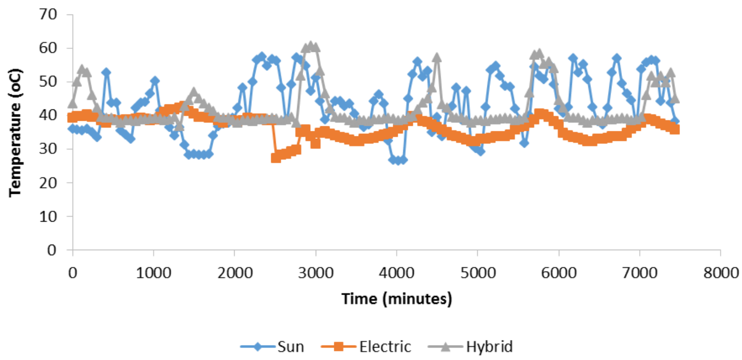

Figure 2. Drying temperature for different drying modes

3.1. Moisture Content and Drying Time

The results of the water content test showed that the fastest decrease in water content was found in tests using solar energy and electrical energy (hybrid), followed by testing using solar energy, and testing using electrical energy. The initial moisture content of the three was 92.07%, 90.48%, and 91.91% then decreased to 32.86%, 31.61%, and 32.82% at the end of drying respectively (Figure 3). The results of the drying of the three have met the requirements for the drying water content of vanilla pods; The condition for the moisture content of dry vanilla pods is 25-38% (Anandito *et al*., 2010; BSN, 2022).

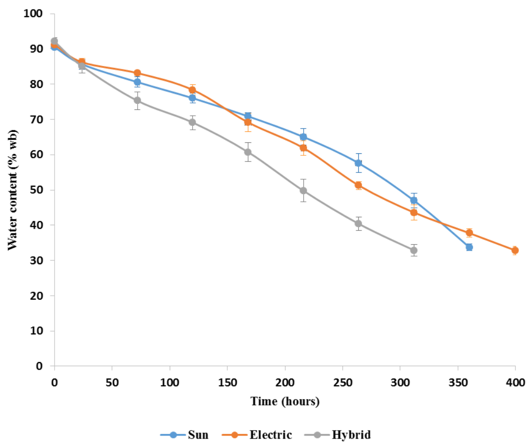

Figure 3. Graph of the decreasing water content of vanilla under different drying modes

The decrease in water content on drying vanilla is very slow because the vanilla pods are pod-shaped and the water content in the wet vanilla pods is very high; the initial moisture content is an average of 91.25%. Decreasing the water content should be done slowly; slow drying cannot be done with flash drying. A rapid decrease in moisture content requires high temperatures; this causes the surface of the vanilla pod to dry quickly but the water content inside the pod is still high (Wibisono & Djoowasito, 2005).

Drying time testing using solar energy, testing using electrical energy, and testing using solar energy and electrical energy (hybrid) were 360 hours (15 days), 400 hours (17 days), and 312 hours (13 days), successively. The average drying temperatures of the three tests were 21 °C, 35.35 °C, and 41.29 °C, respectively; with the ambient temperature of the three was 30.29 °C, 26.19 °C, and 26.60 °C, respectively.

The drying process using a hybrid dryer can be carried out continuously or continuously so that vanilla drying can run faster than drying using solar heat; although drying in the sun has a higher temperature, it can only be done during the day. Hybrid drying is faster than electric drying because the hybrid drying temperature is higher than electric drying even though the time is the same continuously day and night.

Meanwhile, the problem with drying vanilla using solar energy is that the vanilla drying process is very dependent on the weather during the drying process; this is in line with the constraints of drying cassava chips using sunlight (Warji & Tamrin, 2021).

3.2. Drying Rate

The drying rate of vanilla is presented in Table 1. The results showed that the amount of water evaporated during the drying process using solar energy was 4.121 kgH_2O so the drying rate of wet vanilla in drying using solar energy was 0.0114 kgH_2O/h. For drying materials using electrical energy, the vapor load of evaporated water is 4.136 kgH2O, so the drying rate is 0.0103 kgH_2O/h. While testing the material using electrical and solar energy (hybrid) the vapor load of the evaporated water is 4.145 kgH_2O so that the drying rate is 0.0133 kgH_2O/h.

Table 1. Drying rate under different drying modes

Drying Mode	W_{vapor} (kgH_2O)	Average Drying Temperature (^oC)	Drying Rate (kgH_2O/h)
Sun	4.121±0.038	43.21±0.396	0.0114±0.00011
Electric	4.136±0.141	35.35±1.206	0.0103±0.00035
Hybrid	4.145±0.059	41.29±0.588	0.0133±0.00019

The results showed that the higher the temperature used and the more energy distributed, the faster the drying rate. According to Winarno (1995) that the higher the drying temperature, the faster evaporation occurs, so that the water content in the material is lower.

3.2. Source Energy (Input)

Vanilla drying is carried out using two sources of heat energy, namely solar thermal energy and electrical energy. The solar radiation value obtained in the drying process is 336.38 W/m^2. The energy produced in drying with materials using solar thermal energy is 833,700.18 kJ. The resulting solar energy is 208,740.18 kJ. The drying process uses sunlight in this dryer using a fan to remove moisture from the drying chamber. The amount of electrical energy needed by the driving fan is 624,960 kJ.

Drying using electrical energy for 400 hours produces energy of 935,776.8 kJ. Meanwhile, drying using solar energy and electricity (hybrid) for 312 hours produces

1,974,024.1 kJ of energy, with 494,280.1 kJ of solar energy and 1,479,744 kJ of electrical energy.

Based on research that has been carried out, the greatest energy during the drying process is found in drying using electricity and solar energy (hybrid). This is because in hybrid drying the drying process uses two energy sources, namely electricity and solar energy. Drying time also affects the source of energy in drying vanilla; dry the material to a moisture content below 35%. The longer the drying time, the more energy is used (Table 2).

Table 2. Energy sources (Input) under different drying modes

Drying mode	Solar energy (kJ)	Electrical energy (kJ)	Energy input (kJ)
Sun	208,740.18±7305.91	624,960±3,124.80*	833,700.18±6,777.75
Electrical	0	935,776.80±7,798.14**	935,776.80±7,798.14
Hybrid	171,679.58±5150.39	1,479,744±9,485.54**	1,651,423.58±14,635.93

*Energy for fan blower; **Energy for heater and fan blower

3.3. Energy Utilized (Output)

The energy used in drying is divided into two, namely energy to evaporate the water in the material and energy to heat the material. The energy to evaporate water is obtained from the multiplication of the water vapor load (W_{vapor}) and latent heat (H_{lb}). The latent heat obtained from drying with a load using solar energy is 2,429.5 kJ and the energy to evaporate water in the material is 2,380.91 kJ/kg. Meanwhile, the energy for heating the material is 93.08 kJ, so the total energy used in the drying process uses solar energy, which is 2,473.99 kJ.

The latent heat from drying with a load using electrical energy is 2,439.2 kJ/kg, the energy for evaporating water in the material is 2,244.064 kJ, and the energy for heating the material is 66.12 kJ so that the total energy needed in drying uses electrical energy of 2,310.184 kJ.

While the latent heat generated from drying with a load using solar energy and electricity (hybrid) is 2,438.7 kJ/kg, the energy to evaporate water in the material is 2,024.121 kJ, and the energy to heat the material is 107.57 kJ so that the total energy needed in drying using solar energy and electricity (hybrid) is 2,131.691 kJ.

Drying with materials using solar energy and electrical energy (hybrid) is drying which has higher total energy compared to other drying modes (Table 3). This is due to the large amount of water vapor load in the material being removed. Based on research conducted by Lestari et al. (2020b), the energy required for drying the material is related to the initial mass of the material, the greater the mass of the material being dried, the greater the amount of water that must be evaporated from the inside so that the energy used for drying it will be greater.

Table 3. Energy used (Output)

Drying mode	Latent Heat (kJ/kg)	Energy to vaporize water (kJ)	Energy to heat material (kJ)	Energy utilized (Output) (kJ)
Sun	2,429.50	14,625.59	52.52	14,720.11
Electric	2,439.20	14,830.34	66.12	14,896.66
Hybrid	2,438.70	15,046.78	107.57	15,154.35

3.4. Efficiency

3.4.1. Drying Efficiency

The highest drying efficiency is found in drying with materials using solar energy with an efficiency value of 6.39% (Table 4). However, having a higher efficiency value compared to other drying methods is not directly proportional to the speed at which the water content decreases in the material. The decrease in water content in drying using solar energy tends to be slower, it even takes quite a long time, namely 15 days to reduce the water content as desired. This is because drying with solar energy only uses an effective time of 8 hours per day if the other two treatments use 24 hours per day. Vanilla drying requires a long drying time, Wibisono & Djoyosumito (2005) stated that drying using an oven with a temperature of 50 C requires more than 7 days. While Helmi (2008) states that drying vanilla at room temperature takes 30-45 days and the process becomes faster if it is dried in an oven, which takes 10 days.

Table 4. Drying efficiency of different drying modes

Drying mode	Drying Efficiency (%)
Sun	6.39±0.0073
Electricity	1.58±0.0067
Hybrid	0.92±0.0041

All drying efficiency values using a dryer still show results that are less effective for drying vanilla, with the efficiency value obtained still below 10%. Based on research conducted by Sari (2014), the low-efficiency value is due to the high intensity of the sun entering the drying system but not being utilized optimally. The way that can be done to increase drying efficiency is by rotating the racks during drying so that each rack is not in the same position from the beginning to the end of drying. This method has the potential to increase drying efficiency because by rotating the drying rack, the temperature received by the material will be more uniform (Sains *et al*., 2020).

The low efficiency of vanilla drying is also caused by the slow drying process of vanilla; the fast drying process cannot be applied to the vanilla drying process, fast drying can make the outer vanilla shell harden while the inside of the vanilla is not yet dry. Only a little of the heat energy provided is utilized to evaporate water vapor. This condition allows vanilla to be dried using an intermittent system (intermittent drying) so that the energy required for drying is smaller so that the efficiency becomes greater.

3.4.2. Performance Efficiency

The real capacity of the three tests on the hybrid dryer is 7 kg. The capacity of this hybrid dryer is 0.7 kg per rack. The maximum capacity of this rack-type hybrid dryer is 6 kg per rack; the hybrid capacity of 60 kg. Drying performance efficiency of 11.67%. The drying capacity of vanilla can still be increased because the shelf conditions are not yet optimally filled with vanilla pods (Figure 4) so the efficiency can be increased.

Figure 4. Spread vanilla pods on a drying rack

4. CONCLUSION

Based on the results of the research that has been carried out, it can be concluded (1) the average final moisture content obtained in drying vanilla with solar energy after drying for 15 days is 31.61%, drying with electrical energy after drying for 17 days is 32.82%, and drying with energy solar energy and electric energy (hybrid) after drying for 13 days by 32.86%; (2) the rate of drying vanilla using solar energy is 0.0114 kgH_2O/h, drying with electrical energy is 0.0103 kgH_2O/h, and drying with solar energy and electric energy (hybrid) is 0.0133 kgH_2O/h; (3) the efficiency value of the hybrid dryer for drying vanilla with solar energy is 6.39%, drying with electricity is 1.59%, and drying with solar energy and electric energy (hybrid) is 0.92%; (4) the real capacity of the hybrid dryer for drying vanilla with solar energy is 0.06 kg/hour, drying with electric energy is 0.01 kg/hour, and drying with solar energy and electric energy (hybrid) is 0.02 kg/hour. O'clock. The maximum theoretical capacity of this rack-type hybrid dryer is 6 kg per rack so in this hybrid drying, vanilla can be added to 5.3 kg per rack to maximize the capacity of the drying device.

ACKNOWLEDGEMENT

Thank you to the Dean of the Faculty of Agriculture, University of Lampung, who has funded this research through the Research Grant of the Faculty of Agriculture, University of Lampung in 2021.

REFERENCES

Agustina, R., Syah, H., & Moulana, R. (2016). Karakteristik pengeringan biji kopi dengan pengering tipe bak dengan sumber panas tungku sekam kopi dan kolektor surya. *J. Agrotechno*, ***1***(1), 20–27.

Anandito, R.B.K., Basito, B., & Handayani, H.T. (2020). Kinetika penurunan kadar vanilin selama penyimpanan polong panili kering pada berbagai kemasan plastik. *Agrointek*, ***4***(2), 146-150.

Direktorat Jenderal Perkebunan. (2021). *Statistik Perkebunan Non Unggulan Nasional*. Kementerian Pertanian. Jakarta: xxx + 538 pp.

Brunschwig, C., Collard, F.X., Bianchini, J.P., & Raharivelomanana, P. (2009). Evaluation of chemical variability of cured vanilla beans (*Vanilla tahitensis* and *Vanilla planifolia*). *Natural Product Communications*, ***4***(10): 1393–1400.

Chandrayani, P.M.W., & Natha, K.S. (2016). Pengaruh harga, kurs dollar Amerika Serikat dan produksi terhadap ekspor vanili di Provinsi Bali Tahun 1991-2013. *E-Jurnal Ekonomi Pembangungan Universitas Udayana*, ***5***(2), 236-259.

Condro, N. (2017). Penanganan pascapanen vanili (*Vanilla planifolia*) sebagai upaya pengembangan vanili menjadi salah satu komoditas unggulan Kabupaten Jaya Pura. *Dinamis*, ***2***(12), 100-103.

Hartanto, N., Warji, W., & Rusdiyanto, W. (2011). Karakteristik pengeringan kulit manggis dengan alat pengering hybrid tipe rak. *J. Agrotek* ***5***(2), 83-90

Helmi, Z. (2008). Pengolahan dan penganekaragaman hasik vanili berdasarkan standar mutu nasional. *Tabloid Sinar Tani*. 27 Agustus 2008.

Ilham, N., Suhartini, S.H., & Sinaga, B. M. (2004). Penawaran ekspor panili Indonesia. *J. LITTRI*, ***10(2)***, 41-50.

Lestari, N., Samsuar, Novitasari, E., & Rahman, K. (2020a). Kinerja cabinet dryer pada pengringan jahe merah dengan memanfaatkan panas terbuang kondensor pendingin udara. *Jurnal Agritechno*, ***13***(1), 57-70

Lestari, T., Nelwan, L.O., Darmawati, E., Samsudin, S., & Purwanto, E.H. (2020b). Kombinasi metode penjemuran dan pengeringan tumpukan untuk memperbaiki mutu biji kakako kering. *Jurnal Teknik Pertanian Lampung*, ***9***(3), 264-275.

Makki, M., & Subairi, H. (2020). Peningkatan ekonomi pesantren melalui budidaya vanili dengan sistem agrikultur di Kabupaten Bondowoso. *Jurnal Istiqro: Jurnal Hukum Islam, Ekonomi dan Bisnis*, ***6***(1), 40-57.

Nino, J., & Neonbeni, E.Y. (2020). Analisisi kadar aflatoksin jagung lokal timor pada perlakuan lama pengeringan dengan udara alamiah. *Jurnal Teknik Pertanian Lampung*, ***9***(4), 336-342.

Nursanti, L.S. (2010). Pengeringan Biji Kakao Menggunakan Alat Pengering Hybrid Tipe Rak. *Skripsi.* Fakultas Pertanian, Universitas Lampung. Bandar Lampung.

Putra, M.A., Asmara, S., Sugianti, C., & Tamrin, T. (2018). Uji kinerja alat pengeringan jagung (*Zea mays* ssp. mays). *Jurnal Teknik Pertanian Lampung*, ***7***(2), 88-96.

Safrina, D., Farida, S., Brotojoyo, E., & Kamila, I. (2019). Pengaruh ketinggian tempat tumbuh.dan metode pengeringan terhadap organoleptik dan kadar asiatikosid pegagan (*Centella asiatica* (L) Urb). *Jurnal Teknik Pertanian Lampung*, ***8***(3), 208-213.

Sari, I.N., Warji, W., & Novita, D.D. (2014). Uji kinerja alat pengering hybrid tipe rak pada pengeringan chip pisang kepok. *Jurnal Teknik Pertanian Lampung*, ***3***(1), 59-68.

Badan Standarisai Nasional (BSN). (2022). SNI 01-0010-2002. Badan Standarisai Nasional, Jakarta.

Sinha, A.K., Sharma, U.K., & Sharma, N. (2008). A comprehensive review on vanilla flavor: extraction, isolation and quantification of vanillin and others constituents. *International Journal of Food Sciences and Nutrition*, ***59***(4), 299-326.

Suhendar, E., Tamrin, T., & Novita, D.D. (2017). Uji kinerja alat pengering tipe rak pada pengeringan chip sukun menggunakan energi listrik. *Jurnal Teknik Pertanian Lampung*, ***6***(2), 125-132.

Taib, G., Said, S., & Wiraatmadja. (1988). *Operasi Pengeringan pada Pengolahan Hasil Pertanian.* PT. Mediatama Sarana Perkasa. Jakarta.

Waluyo, S., Saputra, T.W., & Permatahati, N. (2021). Mempelajari karakteristik fisik biji kakao *(Theobrema cacao* L.) pada suhu pengeringan yang berbeda. *Jurnal Teknik Pertanian Lampung*, ***10***(2), 200-208.

Warji, W., & Tamrin, T. (2021). Hybrid dryer of cassava chips. *IOP Conf. Ser.: Earth Environ. Sci.* ***757***, 012027.

Wibisono, Y., & Djoyowasito, G. (2005). Desain alat pengendali suhu untuk pengeringan panili (*Vanilla planifolia* Andrews). *Jurnal Teknologi Pertanian*, ***6***(2), 86-92.