CHEESA: Chemical Engineering Research Articles
ISSN **2614-8757 (Print)**, ISSN **2615-2347 (Online)**
Available online at: http://e-journal.unipma.ac.id/index.php/cheesa

Research Article

Enhancement of the Quality of Onion Drying Using Tray Dryer

Peningkatan Kualitas Pengeringan Bawang Merah Menggunakan Tray Dryer

Siska Nuri Fadilah[1)], Achri Isnan Khamil[1)], Maktum Muharja[1*)], Rizki Fitria Darmayanti[1)], Viqhi Aswie[2)]
[1)]Universitas Jember, Department of Chemical Engineering, Faculty of Engineering, Kalimantan street 37 Jember 68121, Indonesia
[2)]MAN 1 Kota Sukabumi, Pramuka street No. 04, Sukabumi 43144, Indonesia

**correspondence email*: maktum@unej.ac.id

Received: 22 September 2022;
Revised: 22 November 2022;
Accepted: 23 November 2022;

doi: *10.25273/cheesa.v5i2.13968.74-81*

Abstract

Previous reports showed that there has been a continuous increase in the annual production of onion in Indonesia, and it is inversely proportional to the market price. The price drop is often caused by the high water content, which makes it easy to rot. Preservation of onions through a tray dryer is a good preservation method because it is effective and does not require much energy. Therefore, this study aims to determine the effect of variations in time, material thickness, and air velocity on the drying rate of onions. The samples were sliced to a size of 2 - 5 mm, followed by drying for 60 min using a tray dryer with different air rates between 4 - 7 m/s, and the rate of the process was observed every 15 min. The results showed that the drying time reduced the humidity in the chamber. The highest rate of 0.525 g/min was obtained at the peak air rate of 7 m/s. ANOVA results revealed that variations in time, onion thickness, and flow rate have a significant effect on increasing the drying rate of onions. This indicates that the method can be an effective and efficient solution to optimize the drying of the commodity.

Keywords: drying; humidity; onion; tray dryer

Abstrak

Produksi bawang merah di Indonesia selalu mengalami kenaikan setiap tahunnya, tetapi peningkatan ini berbanding terbalik dengan harganya di pasaran. Penurunan harga disebabkan oleh kandungan air yang tinggi, sehingga mudah membusuk. Pengawetan bawang merah melalui pengeringan tray dryer saat ini menjadi pilihan karena efektif dan tidak membutuhkan energi yang besar. Penelitian ini bertujuan untuk mengetahui pengaruh variasi waktu, ketebalan bahan dan kecepatan udara terhadap laju pengeringan bawang merah. Penelitian dilakukan dengan pengirisan bawang merah berukuran 2 - 5 mm, kemudian dikeringkan selama 60 menit menggunakan tray dryer dengan variasi laju udara 4 – 7 m/s. Pengamatan laju pengeringan dilakukan setiap 15 menit. Hasil penelitian menunjukkan waktu pengeringan dapat menurunkan kelembaban udara. Laju pengeringan tertinggi sebesar 0,525 g/menit didapatkan saat laju udara tertinggi 7 m/s. Hasil ANOVA menunjukkan bahwa variasi waktu, ketebalan bahan, dan laju udara berpengaruh secara signifikan terhadap peningkatan laju pengeringan bawang merah. Dengan demikian, metode ini menjadi solusi yang efektif dan efisien untuk mengoptimalkan pengeringan bawang merah.

Kata kunci: *bawang merah; kelembaban; pengeringan; tray dryer*

1. Introduction

Onion (*Allium ascalonicum*) is one of the horticultural commodities with sufficient potential to be developed into a superior commodity [1]. It also contains beneficial chemicals, such as natural fiber, various vitamins, organic acids, phenolic compounds, and antioxidants. Furthermore, every 100 g of red onion contains 84.18 g of water, 0.93 g of fiber, and 2.43 g protein [2]. Previous reports showed there has been an annual increase of 5.11% in its production volume over the years [3]. However, this increase is inversely proportional to the market price, due to the high water content of onions, which accelerates microbial growth and spoilage [4]. This indicates that a method is needed to extend its shelf life, increase added value, and diversify of the products.

One of the common food preservation techniques is drying, which is the simplest process to reduce the water content of a material [5]. Drying onion to a certain moisture content can extend shelf life, hence, it is an alternative to keep the price of the commodity from falling during the harvest season [6]. Furthermore, one of the end results of this process is a powder product. Traditional drying is often carried out using sunlight, but it is considered less effective due to uncertain weather conditions [7]. It can also be performed with vacuum frying, but the process has some drawbacks, such as high energy demand and operating temperatures. This method is often used in vacuum frying for large-scale industrial drying only [8]. Drying can also be carried out using an electric-powered oven, but the operating costs are very high and the operation as well as maintenance require skilled personnel [4]. One of the technologies with the simplest and easiest technique is a multilevel tray dryer, which uses hot air in an enclosed space. The mechanism involves direct drying because the hot air is in contact with the material [1]. This technology can be applied to food ingredients that are sensitive to heat and are easily moldy.

Drying with a tray dryer is relatively efficient in energy consumption, suitable for small-scale industries, and the operating temperature is not too high. Manfaati et al. [2] reported onions drying (species Bima) using a tray dryer with variations in temperature and time. The results also showed that the moisture content was reduced to 4% at the optimum temperature, indicating that the both resultsvariables greatly affected the process. Prasetyaningsih & Mulyanti [9], carried out a similar experiment using variations in thickness, flow rate, and temperature. The results showed that the thinner the material, the greater the temperature and drying rate, which facilitated the decrease in moisture content and shortened the time required.

Based on the review of previous studies, several factors are involved in the drying process using a tray dryer. Findings also showed temperature, time, material thickness, and air flow rate are the most problematic factors. Although several studies have explored the use of the tray dryer, but none of them dicussed variations in time, flow rate, and material thickness simultaneously, which are very important. Therefore, it is necessary to determine the relationship of these three parameters with the drying process to obtain the optimum conditions for optimization. Therefore, this study aims to determine the optimum point through an optimization process based on analysis of variations of temperature, time, flow rate, and thickness of the material to reduce the water content of shallots and increase their shelf life.

2. Research Methods

2.1 Materials

Fresh onions were obtained from the Tanjung market, Jember, with uniform humidity. Physiologically, the samples used were red onions with good quality.

2.2 Experimental procedure

The main instrument used in this study is a tray dryer model SF-25H with a size of 250 mm, capacity of 42 m^3/min, 190 W power, 280 r/min speed, 220-240 V voltage, and 50 Hz frequency, as shown in Figure 1. The description of the instruments in Figure 1 is as follows; heater power button (1), temperature control (2), fan power button (3), fan speed control button (4), temperature button (5), temperature displays (6), sensor of dry bulb temperature before and after tray (7 and 9), wet bulb temperature sensor before and after tray (8 and 10), analytical balance inside dryer (11), and tray (12). The rectangular tray dryer was equipped with perforated metal shelves. The rack was used to accommodate the material, which needs to be dried. The tray dryer was also equipped with a thermometer, a fan to regulate air circulation, as well as an anemometer (HoldPeak HP-866B, Taiwan), which was used to measure the fan air velocity. Furthermore, several supporting tools were used, including a stop watch to adjust the drying time, a ruler to measure the thickness of the sample, a knife to cut raw materials, and a digital scale (GSF G-4405, China) to measure the mass of the sample.

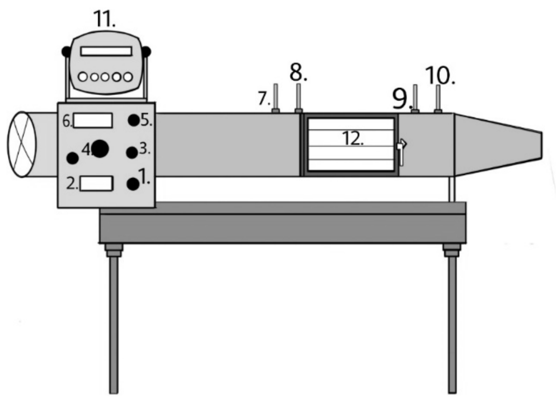

Figure 1. Schematic diagram of tray dryer

The union was peeled, sliced, and its thickness was then measured. Furthermore, slices with a fixed thickness of ± 2 mm were used for experiments with time variables and fan air flow rates. For the thickness variable, the onion was sliced into sizes of 2, 3, 4, and 5 mm. The tray dryer was then heated to a temperature of 55 °C, and a total of 50 g of the material was weighed. The onions were then rearranged on a perforated tray lined with aluminum foil to ensure that the samples were not piling up on each other. The tray containing the ingredients was inserted into the dryer. The fan air rate was set at 5.0 m/s for experiments using variations in time and thickness, while others with different fan air rates were set at 4, 5, 6, and 7 m/s. Sampling of mass data was carried out every 15, 30, 45 and 60 min for time variations. Meanwhile, for the thickness and fan air rate variables, sample mass data were collected after drying for 60 min. The last step was to calculate the values of T1, T2, T3 and T4 on the temperature reader every time the sample was weighed.

2.3 Statistical analysis

One-way analysis of variance (ANOVA) was carried out to analyze the effect of the variables on the drying rate using MINITAB 16. The level of significance of 95% was selected to determine the effect of the factors. Sig stands for significance, which indicates statistical research error. The best study significance (sig) was obtained when the value was less than 5% (0.05) [10-12]. Determination of humidity can be performed using psychrometric charts through dry and wet bulb temperature data.

3. Results and Discussion

3.1 Humidity in a chamber of tray dryer

When a wet solid sample comes in contact with a air whose humidity is lower than its water content, it releases some of the moisture until it a balance point is achieved. Therefore, the humidity in the drying chamber affects the effectiveness of the process, and the level in the chamber is presented in Figure 2.

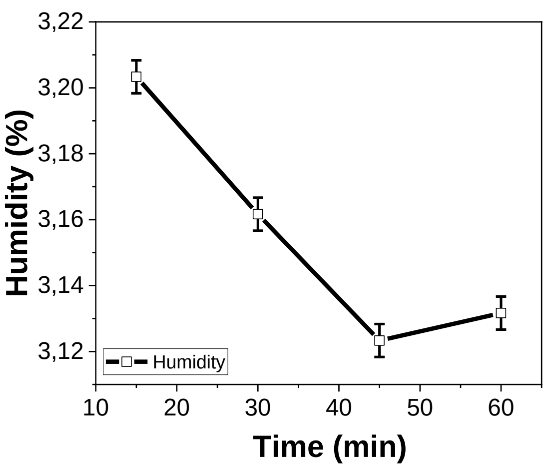

Figure 2. Effect of time on the humidity in a chamber of tray dryer

The optimal humidity level was 3.123% at 45 min. The results showed that the long drying time can significantly reduce the humidity in the chamber with sig value of 0.00<0.05. This is because the extended time causes longer contact with heating air, which allows more water in the material and chamber to be evaporated [8]. It can also lead to increased precipitation (condensation) of water molecules in the air, and this decreases its charges [13]. This is in line with a previous study, which revealed that the higher the temperature of the drying air, the higher the heat energy, which causes more mass of the liquid to be evaporated [14].

3.2 Effect of time on drying rate

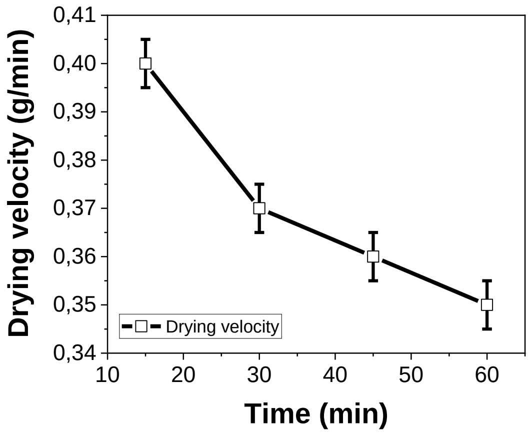

Figure 3. Effect of time on drying rate

Figure 3 shows that a long drying time can reduce the rate of the process significantly (P<0.05). At the beginning of drying, there was a large decrease in the rate until the 30th min. This was because the moisture content of the material was still high at the start of the process, and it was easily evaporated. At the end of drying, namely 30 to 60 min, the water bound to the material has decreased slowly, which caused reduced evaporation and slow rate [15]. The highest drying rate was obtained in the first 15 min, namely 0.4 g/min. According to Sari et al. [16], the time is inversely proportional to the rate of the process. The decrease in rate is proportional to that of the water content of the material. Reduction of moisture takes place continuously with the length of drying time. This is also in line with Sari and Prabawa [17] that the longer the time, the lower the drying rate.

3.3 Effect of thickness on drying rate

Figure 4 shows a graph of the relationship between onions thickness and drying rate. Furthermore, the thicker the material, the longer the time required to evaporate the moisture content. This is because the mass of water in the middle of the thick pile has difficulty reaching the surface. The thickness of material causes airflow to accumulate in the center of the material [18]. It also affects the drying rate significantly, based on the ANOVA results with a sig value of 0.01 <0.05.

The process of drying onions at a temperature of 55 °C, an air rate of 5 m/s for 60 min with thickness of 2, 3, 4, and 5 mm occurred at rates of 0.183, 0.150, 0.117, and 0.133 g/min, respectively. The highest value was obtained when the thickness of the material was 2 mm. This indicates that the thinner the onion, the greater the reduction in water content. A thin material has a larger surface area, which causes greater contact with the heating medium, thereby accelerating the evaporation time of the water content [19].

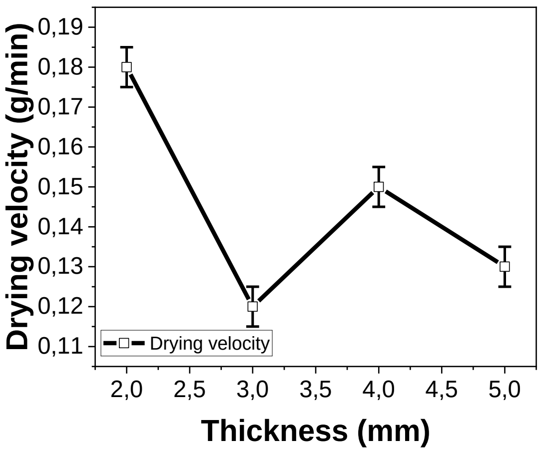

Figure 4. Effect of onions thickness on drying rate

In this study, there was a discrepancy with the literature, namely at a thickness of 4 and 5 mm, the drying rate was predicted to be smaller than 3 mm. This decrease occurred due to the transfer of water vapor by diffusion or through capillary. Furthermore, the diffusion was caused by the difference in the concentration of water vapor between the inner and the surface solids. It often occurs in solids that are not porous, such as paste, soap, gelatin, glue, flour, wood, leather, paper, textiles, and various foodstuffs. Movement of vapor through capillaries was observed because when the water was evaporated, meniscus was formed, which produces tension in its surface. This causes the build up of capillary forces that displaces water through the pores to surface. Vapor movement through capillaries occur in porous solids and granular form, such as clay, sand, soil, and minerals [20].

3.4 Effect of air flow rate on drying rate

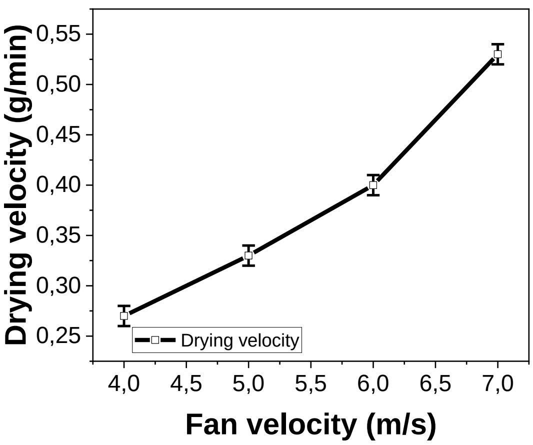

Figure 5. Effect of air flow rate on drying rate

Figure 5 shows that the drying rate increased significantly (sig value of 0.012<0.05) along with the air velocity. The highest rate of 0.525 g/min was obtained at the highest fan velocity of 7 m/s. This phenomenon was due to the increase in the air rate, which caused increment in the diffusion of hot air into the material to be dried, thereby increasing the amount of water that can evaporate [21]. Additionally, the drying process involves the movement of heat from the medium to material as well as mass transfer to the media dryer. The process starts when hot air flows across solid sheet surface. Displacement of heat occurred by conduction through the tray hot or radiation from the surface of the heated material. Hot air flowing released some of the heat, and this causes evaporation/mass transfer of water from air-dried sample until it reaches an equilibrium state. Large amounts of air can carry large amounts of water vapor, which increase the drying rate and produce good quality dry products [22]. Previous study conducted by Hasibuan, et al. (2020) stated that the fan air rate facilitated the process [23]. Further studies also need to develop a drying kinetics model. Process design and the best-operating conditions can be determined quickly, measurably, and accurately with the availability of kinetics data.

4. Conclusion

In improving the quality of drying onions using a tray dryer, the time variable can reduce the humidity in the chamber. Furthermore, air flow rate, material thickness, and time affect the drying rate. By using a temperature of 55 °C, the optimum rate of the process was obtained during the first 15 min of the experiment, namely 0.4 g/min. Furthermore, the optimum thickness with the best drying rate was 2 mm at 0.183 g/min. The fan air rate of 7 m/s was the best and the process occurred at a rate of 0.533 g/min. The results also showed that the relative humidity of the material increased along with the fan air velocity and decreased with with an increase in drying time. The significance values for each of the parameters used, such as time, material thickness, and flow rate were $0.00<0.05$; $0.01<0.05$; and $0.012<0.05$, respectively, which indicates they met the statistical validity of the data.

In conducting this study, the air humidity must be kept dry to ensure that the drying process takes place optimally. There is also a need to review other parameters, such as temperature and pressure to obtain the optimum conditions as well as for larger scale.

References

[1] Manfaati, R., Baskoro, H., & Rifai, M. M. (2019). Pengaruh Waktu dan Suhu terhadap Proses Pengeringan Bawang Merah menggunakan Tray Dryer. *Fluida*, 12(2), 43–49. doi: 10.35313/fluida.v12i2.1596

[2] Manfaati, R., Baskoro, H., & Rifai, M. M. (2020). Characterization of Drying Shallots (Allium cepa L.) Using Tray Dryer. *CHEESA: Chemical Engineering Research Articles*, 3(2), 71–78. doi: 10.25273/cheesa.v3i2.7660.71-78

[3] Statistika, B. P. (2021). Provinsi Jawa Barat Dalam Angka 2021.

[4] Yanti, A. T. Y., Abizard, A., Fitriani, Al Fatih, M., & Anggara, M. (2021). Mesin Pengering Bawang Merah Menggunakan Double Blower dan Sensor Suhu DHT22 Arduino di Desa Brangkolong Kecamatan Plampang, Sumbawa. *Jurnal Teknik dan Sains*, 2(1), 1–7.

[5] Darianto, Amrinsyah, & Sitohang, H. T. S. (2019). Analisa Pengaruh Waktu dan Turbulensi Asap Pada Mesin Pengering Ikan Lele. *Journal of Mechanical Engineering Manufactures Materials and Energy*, 3(2), 130–142. doi: 10.31289/jmemme.v3i2.3029

[6] Dewayani, W., Samsuri, R., Septianti, E., & Halil, W. (2019). Kajian Jenis Pengeringan dan Beberapa Bahan Pengisi terhadap Kualitas Bubuk Bawang Merah Varietas Pikatan. *Jurnal Pengkajian dan Pengembangan Teknologi Pertanian*, 22(3), 251–262. doi: 10.21082/jpptp.v22n3.2019.p251-262

[7] Zamharir, Sukmawaty, & Priyati, A. (2016). Analysis of Heat Energy Utilizationin Onion (Allium ascalonicum, L.) Drying using Green Houses Gasses (GHG) Dryer. *Jurnal Ilmiah Rekayasa Pertanian dan Biosistem*, 4(2), 264–274.

[8] Purnamasari, I., Meidinariasty, A., & Hadi, R. N. (2019). Prototype Alat Pengering Tray Dryer Ditinjau dari Pengaruh Temperatur dan Waktu Terhadap Proses. *Jurnal Kinetika*, 10(03), 25–28.

[9] Prasetyaningsih, Y., & Mulyanti, S. (2018). Pengaruh Suhu dan Laju Alir Pengeringan pada Bawang Putih Menggunakan Tray Dryer. *Prosiding Seminar Nasional Teknik Kimia "Kejuangan" Pengembanagn Teknologi Kimia untuk Pengolahan Sumber Daya Alam Indonesia*, (April), 1–6.

[10] Muharja, M., Umam, D. K., Pertiwi, D., Zuhdan, J., Nurtono, T., & Widjaja, A. (2019). Enhancement of sugar production from coconut husk based on the impact of the combination of surfactant-assisted subcritical water and enzymatic hydrolysis. *Bioresource Technology*, 274(November 2018), 89–96. doi: 10.1016/j.biortech.2018.11.074

[11] Muharja, M., Fadhilah, N., Darmayanti, R. F., Sangian, H. F., Nurtono, T., & Widjaja, A. (2020). Effect of severity factor on the subcritical water and enzymatic hydrolysis of coconut husk for reducing sugar production. *Bulletin of Chemical Reaction Engineering & Catalysis*, 15(3), 786–797. doi: 10.9767/BCREC.15.3.8870.786-797

[12] Muharja, M., Albana, I., Zuhdan, J., Bachtiar, A., & Widjaja, A. (2019). Reducing Sugar Production in Subcritical Water and Enzymatic Hydrolysis using Plackett- Burman Design and Response Surface Methodology. *Jurnal Teknik ITS*, 8(2), 56–61. doi: 10.12962/j23373539.v8i2.49727

[13] Adha, F., Mustaqimah, & Agustina, R. (2018). Study of Thin Layer Drying Turmeric (Curcuma domestica VAL.) Characteristics Using Tray Dryer. *Jurnal Ilmiah Mahasiswa Pertanian*, 3(1), 1–11.

[14] Rahayuningtyas, A., & Kuala, S. I. (2016). Pengaruh Suhu dan Kelembaban Udara pada Proses Pengeringan Singkong (Studi Kasus: Pengering Tipe Rak). *Jurnal Penelitian dan Pengabdian Masyarakat*, 4(1), 99–104.

[15] Ummah, N., Purwanto, Y. A., & Suryani, A. (2018). Penentuan Konstanta Laju Pengeringan Bawang Merah (Allium ascalonicum L.) Iris Menggunakan Tunnel Dehydrator. *Warta IHP: Journal of Agro-based Industry*, 33(2), 49–56.

[16] Sari, D. K., Kustiningsih, I., & Lestari, R. S. D. (2017). Pengaruh Suhu dan Waktu Pengeringan terhadap Mutu Rumput Laut Kering. *Jurnal Teknika*, 13(1), 43–50.

[17] Sari, D. K., & Prabawa, S. (2019). Effect of drying time and temperature on the characteristics of fig leaf tea (Ficus carica l.). *Jurnal Teknologi Hasil Pertanian*, 12(2), 68–77.

[18] Ridhatullah, M. A., & Hasibuan, R. (2019). Effect of Material Thickness and Amount of Desiccant on Drying Rate of Ginger (Zingiber officinale Roscoe) at Solar Dryer Integrated with Desiccant. *Jurnal Teknik Kimia*, 08(2), 61–66. doi: https://doi.org/10.32734/jtk.v8i2.1882

[19] Elfiana, E., Usman, U., Sami, M., Ridwan, R., Intan, S. K., Rahmawati, C. A., & Pardi, P. (2021). Desiminasi Oven Drying Vacuum (ODV) Untuk Pengeringan Rempah Bandrek Siap Saji Di Desa Kumbang Kecamatan Syamtalira Aron Kabupaten Aceh Utara. *Proceeding Seminar Nasional Politeknik Negeri Lhokseumawe*, 5(1), 147–154.

[20] Yando, A. M., & Paramita, V. (2017). Studi Pengaruh Suhu Dan Ketebalan Irisan Terhadap Kadar Air , Laju Pengeringan Dan Karakteristik Fisik Ubi Kayu Dan Ubi Jalar. *Metana*, 13(1), 23–29. doi: https://doi.org/10.14710/metana.v13i1.17514

[21] Effendy, S., Syarif, A., Wardani, D. K., & Amalia, I. (2019). Prototype Rotary Dryer Dengan Bahan Bakar Biomassa Prototype Rotary Dryer With Biomass Fuels Reviewed From the Influence of Air Flow Rate and. *Jurnal Kinetika*, 10(01), 1–6.

[22] Sari, D. K., & Lestari, R. S. D. (2016). Pengaruh Laju Alir Udara Pengering terhadap Pengeringan Kulit Manggis. *Teknika: Jurnal Sains dan Teknologi*, 12(1), 35. doi: 10.36055/tjst.v12i1.6614

[23] Hasibuan, R., Pane, Y. M., & Hanief, S. (2020). Effect of Air Velocity and Thickness to Drying Rate and Quality Temulawak (Curcum Xanthorrhiza Roxb) using Combination Solar Moleculer Sieve Dryer, *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches*, 389–394. doi: 10.5220/0010103503890394

[24] Alimny, A. N., Muharja, M., & Widjaja, A. (2019). Kinetics of Reducing Sugar Formation from Coconut Husk by Subcritical Water Hydrolysis. *Journal of Physics: Conference Series*, 1373(1), 12006. doi: 10.1088/1742-6596/1373/1/012006

[25] Fachri, B. A., Rizkiana, M. F., & Muharja, M. (2020). A Kinetic Study on Supercritical Carbon-dioxide Extraction of Indonesian A Kinetic Study on Supercritical Carbon-dioxide Extraction of Indonesian Trigona sp . Propolis. *IOP Conf. Series: Materials Science and Engineering*, 742(012001), 1–5. doi: 10.1088/1757-899X/742/1/012001