DEHUMIDIFIER DRYING OF SEAGRASS SIMPLICIA AT LOW TEMPERATURE FOR ANTIOXIDANT AND PHENOLIC PRESERVATION

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ABSTRACT

Syringodium isoetifollium is seagrass a marine plant which is mostly found in Indonesian sea waters. Phenol is a kind of sensitive heat compound which will damage at high temperatures. This research aimed to study the effect of temperature using a dehumidified drying machine on the quantity of phenol content and testing of this antioxidant activity and the evaluation of drying characteristics of seagrasses such as decrease of moisture content, the distribution of temperature drying, relative humidity, and energy consumption. In this research, the independent variable was temperatures (30 °C, 40 °C, and 50 °C) and the dependent variables were phenol content and antioxidant activity of the seagrasses. The phenol content of each extract was measured with a microplate reader using a Follin-Ciocalteu reagent. The antioxidant activity was measured with the 1,1-diphenyl-2-picrylhydrazyl (DPPH) method. The result showed that the highest content of phenolic compounds (80.42766 ± 0.409) and antioxidant activity (88.4185 ± 32.0709) was found in the dehumidified dryer at a temperature of 40 °C. There were significant differences between temperatures of 30 °C and 50 °C. Dehumidifier drying at 30 °C, 40 °C, and 50 °C required 13 hours, 12 hours, and 7.5 hours to reach the final moisture content of seagrass 18-20% from the initial moisture content of 89.4% ± 0.04% (wb). The total phenol content and antioxidant activity with a temperature treatment of 40 °C dehumidifier drying machine showed the best results compared to temperatures of 30 °C, 50 °C, and oven at 40 °C. Based on the same temperature treatment, dehumidifier drying requires a faster time (12 hours) than oven drying (17 hours). The appropriate temperature and time of drying can produce the optimal total phenol and antioxidant activity.

Keywords: Antioxidant; Dehumidified drying; Relative humidity; Seagrass; Temperature

INTRODUCTION

Seagrass is a marine plant found a lot in Indonesia. The area of seagrass in all Indonesian seas that has been verified by the Oceanographic Research Center-LIPI is 293.464 ha. Seagrass contains phenolic compounds and antioxidant activity that are beneficial for human health. Several studies have been conducted (Baehaki *et al.*, 2016; Santoso *et al.*, 2012; Yuvaraj *et al.*, 2012). The various advantage of herbal plants, such as anti-diabetic, anti-carcinogenic, antimicrobial, and antioxidant appear in diverse functions. A phenolic compound, as well as secondary metabolite components, have been reported as the major components having health superiority, and various measured antioxidant values, such as reducing power, scavenging, and inhibition capability of free radicals (Farzaneh *et al.*, 2015).

In the preliminary study, seagrass has a high moisture content of 89.35% ± 0.04% (w.b) which requires a mechanical dryer to control temperature and reduce moisture content in a shorter time than conventional drying. Luximon-Ramma *et al.*

(2002) reported that drying to find bioactive compounds, especially phenols, requires less heat energy. Phenol compounds have properties that are sensitive to heat treatment. In recent literature, the impact of different drying techniques on the phenol content and antioxidant activities of seagrass has been examined. Three drying methods were employed, including sunlight, wind, and convective ovens, which affected the phenol content and antioxidant activities. As a result, there is a need for innovative drying methods (Paryono *et al.*, 2021; Santoso *et al.*, 2012). One of the main objectives of drying techniques is to retain the maximum amount of nutrients during processing and storage, as temperature, drying time, and moisture removal can significantly affect the color and nutrient contents, such as total phenolic and ascorbic acid contents (Mrad *et al*., 2012).

The main objective of this study was to examine how temperature affects the phenol content and antioxidant activity of seagrasses using a dehumidified drying machine, while also analyzing the drying characteristics of seagrasses, including moisture content, temperature distribution during drying, relative humidity, and energy consumption.

METHOD

Chemicals and Materials

Reagent-grade chemicals, including Follin-Ciocalteu, 2,2 diphenyl-1 pikrilhidrazil (DPPH), gallic acid, natrium carbonate, ethanol, and distilled water were purchased from Sigma-Aldrich, Singapore. The seagrass material was collected from the coast of Kondang Merak, Malang, Indonesia. Seagrass was found in the dept 0.5 – 10 m. The fresh seagrass was first washed with fresh water and then with distilled water to remove all extraneous material, such as epiphyte, salt, and sand particles, among others. then proceed with the drying process.

Drying Experiment

To initiate the drying process of seagrass, the initial moisture content was determined and the material's mass was measured. The weight of the dried material was then determined to establish a reference point for reducing the moisture content during each observation in every tray. A total of 40 g of seagrass was weighed and placed in three trays with a total capacity of 120 g. The seagrass was dried using a dehumidifier at three temperature treatments (30 °C, 40 °C, and 50 °C) until the moisture content was reduced to 18-20%, and the mass was recorded in triplicate every 30 minutes. The dehumidifier fan speed was set to 3.40 m/s, which was the optimal speed to reach the drying chamber. Additionally, convective drying was carried out at 40 °C as the control group until the moisture content reached 18-20%, and the mass was recorded every 30 minutes in triplicate.

The Dehumidifier Drying Machine Design

The design of dehumidified drying machine was described in Figure 1. It combined three main components namely a dehumidifier unit (B), a heat recovery unit (D), and a tray dryer machine (E). A Dehumidifier unit is a unit used to produce dry air through the dehumidification process. The dehumidifier utilizes the refrigeration cycle of the condenser. Condensation occurs when the temperature in the dehumidifier unit reaches the dew point temperature. Dew point temperature is the air temperature at which water vapour begins to condense. The dry air produced by the dehumidifier unit was flown into the drying chamber. The hot air released by the condenser (C) was used to increase the dry air temperature by using a heat recovery unit (D). The heat recovery unit operates between two air sources at different temperatures to transfer heat energy from the condenser to heat the dehumidified dry air through a heat exchanger (Xu *et al.*, 2019). The control box (A) was developed for temperature and relative humidity data acquisition with an airflow controller. The working principle of the airflow controller was based on the comparison between the air temperature in the dehumidifier unit and the calculated dew point temperature from the ambient temperature.

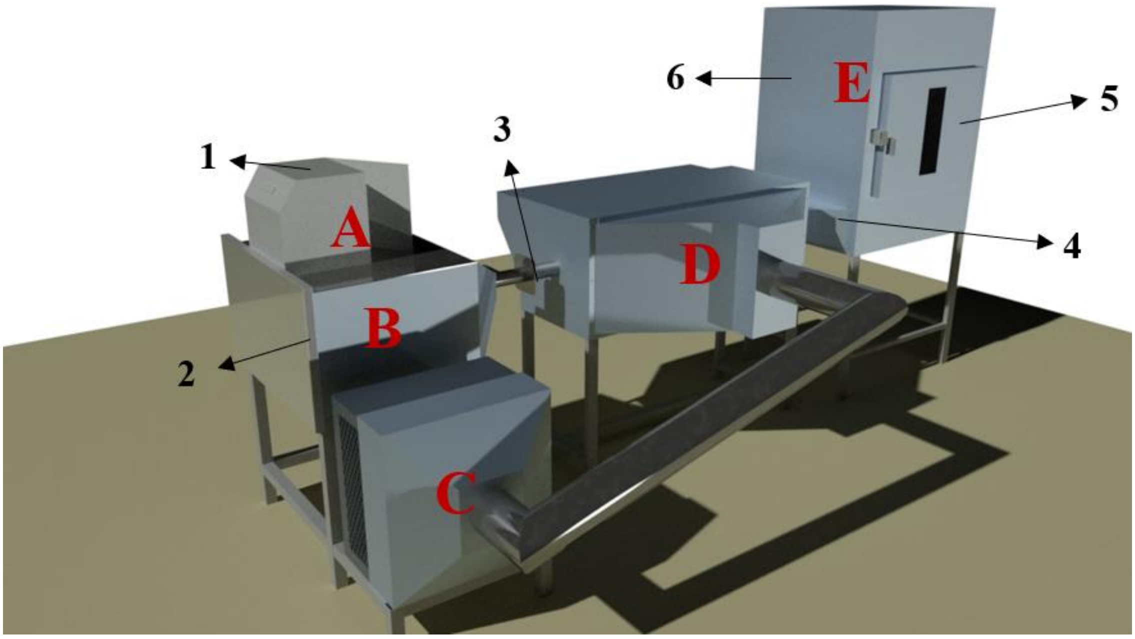

Figure 1. The Dehumidifier Drying Machine Design (A. Control box; B. Dehumidifier unit; C. Condenser; D. Heat recovery unit; E. Drying chamber. DHT22 sensor position: 1. Ambient; 2. Dehumidifier unit; 3. Air outlet after dehumidifier chamber; 4. Air outlet after heat recovery unit; 5. Drying chamber; 6. Air outlet after drying chamber)

The dehumidifier drying machine consists of five major components: a control box, a dehumidifier chamber, a condenser, a heat recovery unit, and a drying chamber. Its body is constructed of stainless steel 304 and the drying chamber contains three trays with dimensions of 52 cm x 52 cm, which are used for drying seagrass. The control box contains various electronic components including an arduino mega, arduino uno, RTC DS3231, SD card module, 1 channel relay, cable, 16x2 LCD, and I2C LCD. It is made of black acrylic material with a length of 27 cm, a width of 24 cm, a height of 24 cm, and a thickness of 2 mm. Other components of the machine include a condenser (Samsung, AR09KRFLAWKX type), a fan (YWF4E-300S type), and a suction blower (Nankai).

The dehumidifier dryer machine has 3 trays with a total capacity of 120 g seagrass, each tray is filled with 40 g seagrass. The tray dryer heating process is generated by conduction from a heated tray, the forced convection flow of hot air across the tray, and radiation from a heated surface. The uniform distribution of airflow over the trays is the key to the successful operation of the tray dryer (Misha *et al*., 2013). Susilo *et al*. (2021) reported that the successful implementation of the data acquisition system and airflow control system led to the effective optimization of temperature and relative humidity distribution during the drying process.

Performance Test

The performance of the dehumidifier machine was calculated based on the change in temperature, relative humidity, consumption of energy, and the decrease in seagrass moisture content. The total required energy was the amount of energy consumed for heating, decreasing Relative Humidity, fans, and other electricity needs (Li *et al*., 2020) :

a. Heater

$Q_{heater} = W_{heater} \times t$ ....(1)

b. Dehumidifier

$Q_{dehumidifier} = W_{dehumidifier} \times t$ ....(2)

c. Fan

$Q_{fan} = W_{fan} \times t$ ....(3)

d. Blower

$Q_{blower} = W_{blower} \times t$ ....(4)

e. Electronic components

$Q_{elektronic} = W^{elektronic} \times t$ ....(5)

f. the dried seagrass

$Q_{seagrass} = m \times cp \times \Delta T$ ....(6)

$Qw = Wi \times Cp_{water} \times \Delta T$ ....(7)

$Wr = Wi – Wf$ ....(8)

The efficiency of the dehumidifier drying machine was calculated by the following formula (Singh, 2003):

$$P = \frac{Q_{evaporation}}{P_{Electricity}} \times 100\% \quad (9)$$

The calculation of moisture content using the formula (Charmongkolpradit *et al.*, 2021):

Weight loss (g) = initial weight (g) – after dried weight (g) .... (10)

$$MC = \frac{weight\ loss\ (g)}{initial\ weight\ material\ (g)} \quad (11)$$

Analysis of The Content of Total Phenol, and Antioxidant Activity

Initially, the dried seagrass was powdered (50 mesh) for the preparation of total phenolic and antioxidant activity (Susilo *et al.*, 2022). Extraction of seagrass using ethanol solvent and maceration method (Baehaki *et al.*, 2017). Analysis of the content of total phenol content using the colourimetric method with Follin-Ciocalteu reagent (Kim *et al.*, 2021). Gallic acid was used as the standard for total phenol and the total phenol content was expressed in mg GAE/g. Analysis of antioxidant activity was carried out based on the colourimetric method (Tilak *et al.*, 2004). This analysis consisted of the antioxidant 2,2-diphenyl-1-picrylhydrazyl (DPPH), which tested the sample's ability to reduce DPPH free radicals, and the antioxidant 2,20-azino-bis(3-ethylbenzothiazoline-6 sulphonic acid) (ABTS), namely tested the sample's ability to scavenge ABTS free radicals. The intensity of the colour change of the chromogen formed was measured for its absorbance using a microplate reader. After obtaining the absorbance values, the sample's antioxidant activity was determined by calculating the concentration value of 50% inhibition of free radical activity (IC50) using a regression equation. To obtain the IC50 value, the known values of A and B were entered into the equation with Y=50.

The IC 50 value was calculated by the following formula: (Salazar-Aranda *et al.*, 2011).

$y = C1 + C2 \ln(x)$ .... (12)

Note : y = inhibition percentage
C1 = the slope
C2 = the intercept
x = the concentration of sample (mg/l)

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistic 25 (IBM Corp, New York, USA) Significant differences ($p \leq 0.05$) between means were evaluated by one-way ANOVA and Duncan's multiple range test. Results of tables and figures are presented as mean ± standard deviation of two independent technological determinations. All analyses were done in triplicate.

RESULTS AND DISCUSSION

Dehumidifier Drying Machine

The drying machine is described in Figure 1. There were five main units: the electronic control box unit, the dehumidifier unit, the condenser unit, the heat recovery unit, and the drying chamber unit. The data acquisition and airflow control hardware were stored inside the electronic control box unit. The total capacity of the machine is 120 g consisting of 3 batches where the capacity of each batch is 40 g of seagrass.

Temperature and Relative Humidity

The temperature and relative humidity data were taken from the data acquisition system. Observation of RH and temperature values using DHT22 sensors placed at six points, ambient dehumidifier unit, air outlet after dehumidifier unit, air outlet after heat recovery unit, drying chamber, and air outlet after drying chamber. Observations were made every 30 minutes until the seagrass water content reached 18-20%. RH and temperature observation are performed automatically with an Arduino-based data acquisition control system. Drying was carried out at temperatures of 30 °C, 40 °C, and 50 °C. The temperature distribution 30 °C, 40 °C, and 50 °C consecutively were described in Figure 2a, Figure 2b, and Figure 2c. The relative humidity distribution 30 °C, 40 °C, and 50 °C temperature treatment consecutively, were described in Figure 3a, Figure 3b, and Figure 3c and the average measurement during drying is served in Table 1.

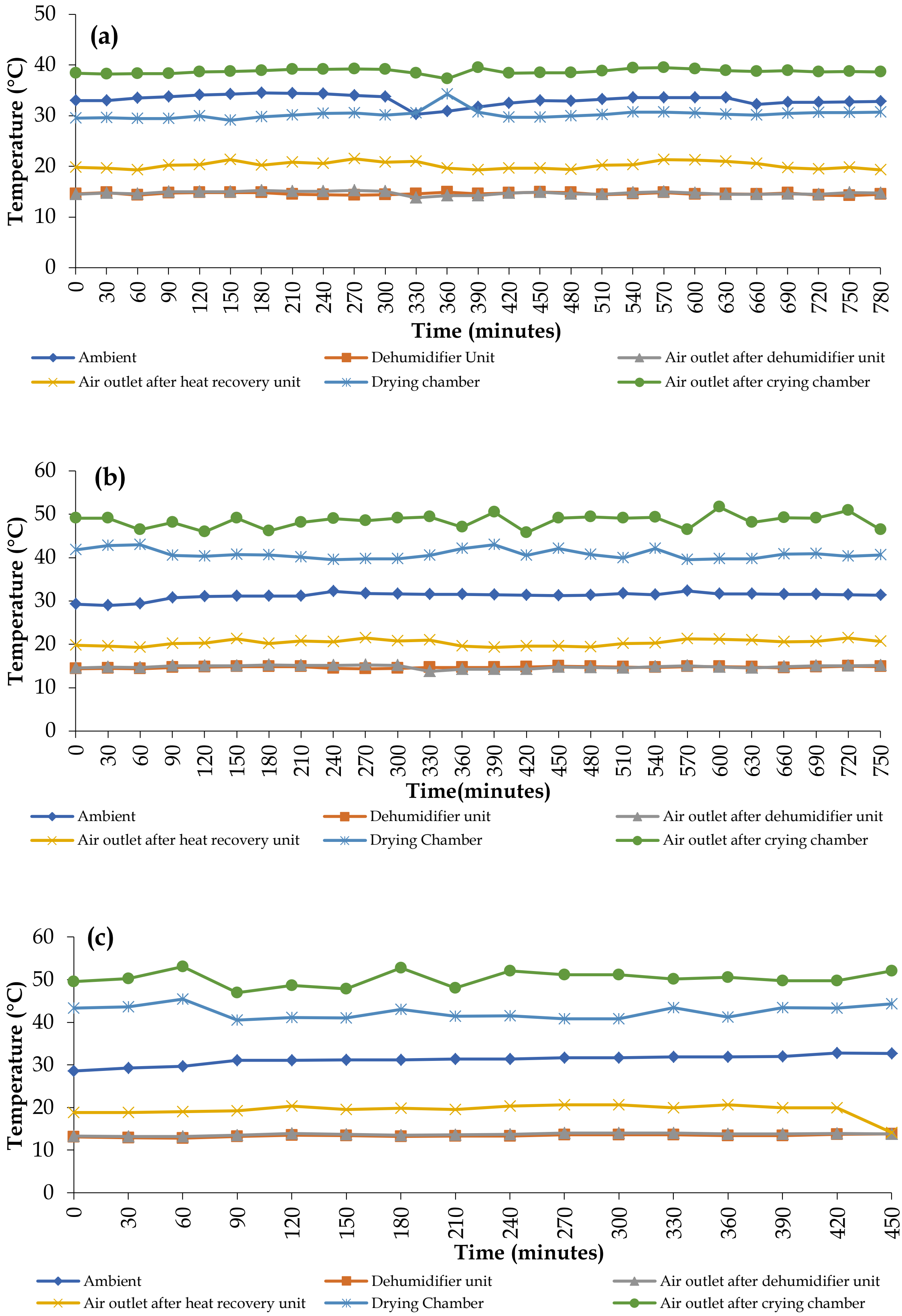

Figure 2. The Temperature Distribution at 30 °C (a); 40 °C (b); and 50 °C (c) Treatments

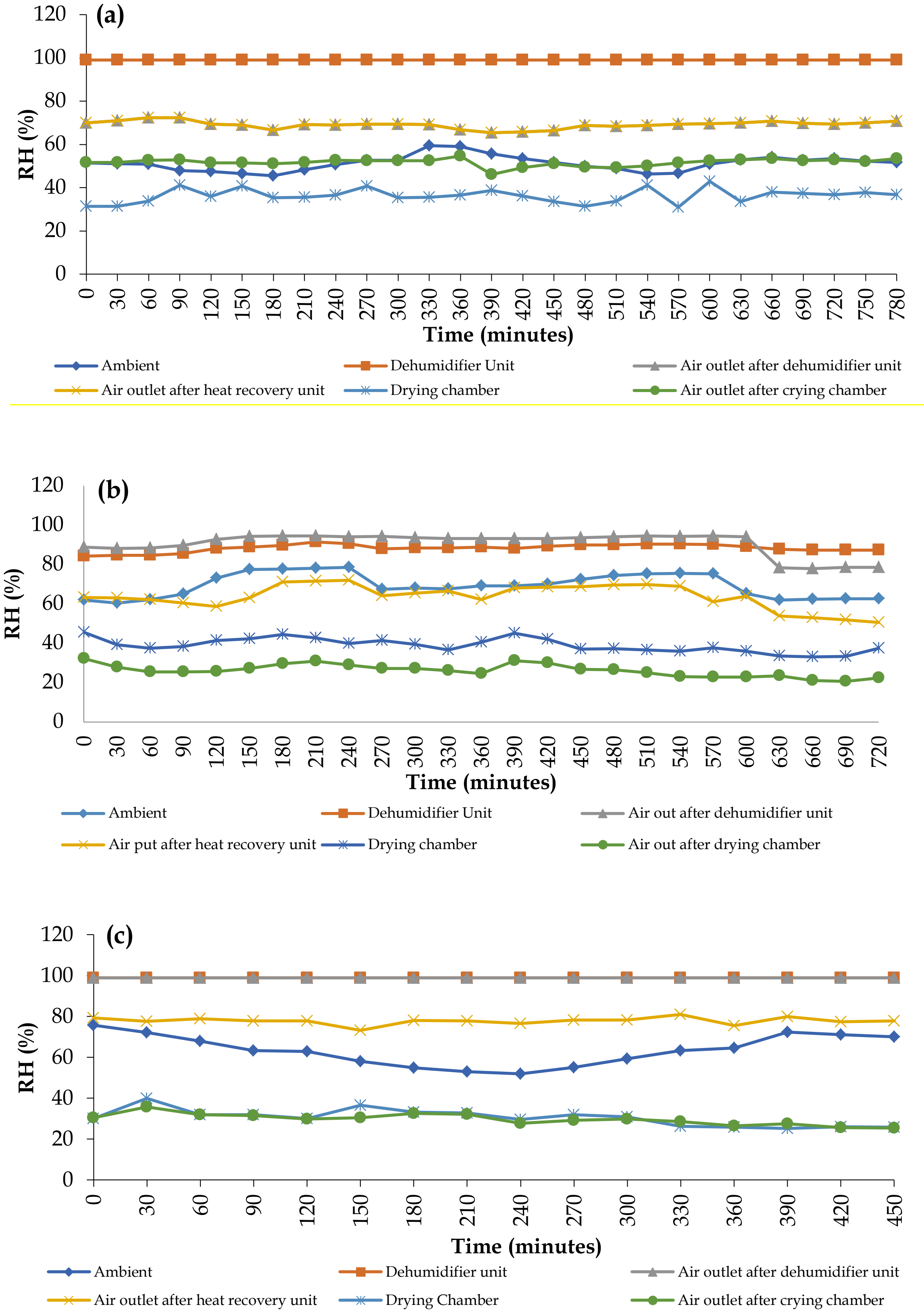

Figure 3. Relative Humidity Distribution Value During Drying at 30 °C (a); 40 °C (b); and 50 °C Treatments

Table 1. The Average Measurement Data During Drying

Temperature	Position	Temperature (°C)	Relative Humidity (%)
30 °C	Ambient	33.11 ± 1.64	51,27 ± 9.78
	Dehumidifier unit	14.6 ± 0.68	99.62 ± 2.74
	Air outlet after dehumidifier unit	14.72 ± 0.67	99.70 ± 1.99
	Air outlet after heat recovery unit	20.21 ± 0.55	78.75 ± 1.97
	Drying chamber	30.27 ± 0.91	36.27 ± 3.26
	Air outlet after drying chamber	48.51 ± 2.13	26.46 ±1.72
40 °C	Ambient	32.18 ± 1.19	70.51±8.44
	Dehumidifier unit	14.63 ± 0.65	99.62 ± 2.74
	Air outlet after dehumidifier unit	14.75 ± 0.63	99.70 ± 1.99
	Air outlet after heat recovery unit	20.56 ± 0.83	77.23 ± 2.6
	Drying chamber	40.06 ± 0.8	31.93 ± 2.25
	Air outlet after drying chamber	48,45 ± 1.97	33.42 ± 0.51.
50 °C	Ambient	31.23 ± 0.649	63.53 ± 3.267
	Dehumidifier unit	13.36 ± 0.592	99.62 ± 2.74
	Air outlet after dehumidifier unit	14.72 ± 0.67	99.70 ± 1.99
	Air outlet after heat recovery unit	19.42 ± 0.622	77.86 ± 2.05
	Drying chamber	50.26 ± 1.133	30.542 ± 1.09
	Air outlet after drying chamber	29.73 ± 3.557	26.52 ± 1.49

Observations of ambient temperature and RH describe the condition of the air before entering the dehumidifier dryer. ambient air is the air around the dryer. The ambient temperature during drying tends to be stable, while the RH will decrease during the day because the water vapour in the air is reduced. The average temperature in the drying chamber at temperatures of 30^{o}C, 40^{o}C, and 50 ^{o}C was 30.27 ± 0.91 ^{o}C; 40.06 ± 0.8 °C; 50.26 ± 1.133 °C. The RH in the dehumidifier chamber was stable at 99% due to the condensation process. The air temperature will decrease after passing through the evaporator so that the water vapour would drip into the container at the bottom of the dehumidifier chamber. Successive average relative humidity in the drying chamber were recorded at 36.27 ± 3.25%, 35.76 ± 3.47%, and 30.54 ± 4.12% for temperature treatments of 30 °C, 40 °C, and 50 °C, respectively.

The value of relative humidity reduction using a dehumidifier dryer (60-70%) was greater than using solar drying (50%) and oven drying (52.98%). However, it is lower than the dehumidifier dryer at a capacity of 0.853 kg (75.31%) (Susilo *et al.*, 2020). Adding a dehumidifier can reduce the relative humidity value by much more than solar and oven dryers. Dehumidifier drying was conducted by lowering the relative humidity of the drying air. If the RH of the drying air was low, a lot of moisture will be absorbed from the material. if using solar drying and an oven the moisture content in the air causes the air to become moist, which makes the drying process longer (Susilo *et al.*, 2021). The drying process applied the result of the low moisture content resulting from dehumidification. The drying chamber receives air that has a low RH which can lower the drying temperature so that the quality of the seeds is maintained and also speeds up the drying process (Rahayuningtyas and Kuala, 2016). However, the relative humidity value of the drying chamber is smaller at the larger capacity of seagrass.

Moisture Content of Seagrass

Table 2. shows that the reduction in moisture content (wet basis) is the crucial factor for the postharvest management of the marine plant, and it is achieved through the decrease in mass during the drying time with the respective temperature treatment. The dehumidifier drying method has a faster drying time compared to the convective drying method. Moreover, the top tray experiences the highest drying rate during dehumidifier drying since hot air rises. For this study, three trays were filled with 40 g of the sample, resulting in a total capacity of 120 g. Figure 4a, Figure 4b, Figure 4c, and Figure 5 showed a stable mass reduction rate, but each tray has a different drying process time. The top tray takes the fastest time than the middle tray and bottom tray. The drying process on the top tray is faster because the hot air flows from the side, and the hotter air collects in the top position of the drying chamber. So the materials in the top tray got more hot air than the middle and bottom trays.

Energy Consumption

The total electric power used during drying in kWatt was served in Table 3. The total electric power of the dryer is 1.98781 kW then multiplied by the drying time in hours. Total electric power results at each drying temperature will be different because the drying time is different too. In drying at 50 °C, the drying time is 7.5 hours so the energy produced by the dryer is 14.908 kWh or 12819.138 kcal. In drying with a temperature of 40 °C, the drying time is 12 hours and the total energy yield is 23.85372 kWh or 20510.621 kcal. Meanwhile, drying at 30 °C requires a drying time of 13 hours and the total energy yield is 25.841 kWh or 22219.8496 kcal. the higher the temperature (50 °C) the faster the drying time (7.5 h) and the higher the temperature (50 °C) the lower the energy consumption (14.90 kWh).

Table 2. Equipment Used, Temperature, Drying Time, and % Final Moisture Content of Seagrass for Drying Methods

Drying method	**Equipment**	**Temperature (°C)**	**Time (hour)**	**Final moisture (%)**
Dehumidifier drying	Laboratory scale dehumidifier drying machine	30	13	17.03 ± 0.83
		40	12	18.59 ± 0.89
		50	7.5	16.98 ± 1.89
Convective drying	Convection oven	40	17.5	17.81 ± 0.73

Table 3. Calculation Efficiency and Energy Consumption of Dehumidifier Drying

Temperature (°C)	Position	Time (h)	Efficiency (%)	Consumption Energy(kWh)
30	Top Tray	13	0,092	25,84
	Middle Tray		0,091	
	Bottom Tray		0,091	
40	Top Tray	12	0,103	23,85
	Middle Tray		0,103	
	Bottom Tray		0,103	
50	Top Tray	7.5	0,168	14,90
	Middle Tray		0,168	
	Bottom Tray		0,169	

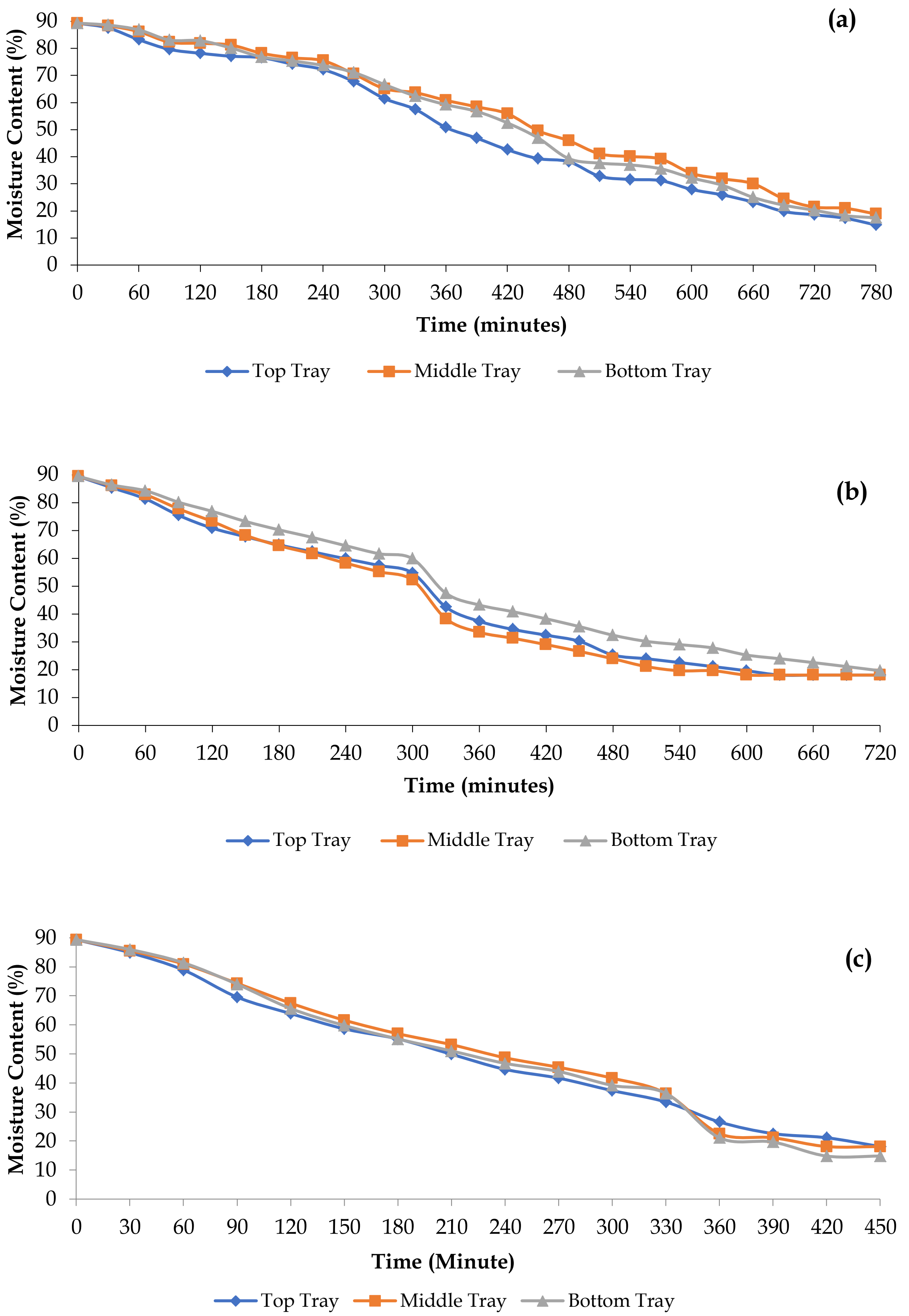

Figure 4. The Moisture Content (wb) of Seagrass at a Temperature 30 ^{o}C (a); 40 ^{o}C (b); and 50 ^{o}C (c) Dehumidifier Drying

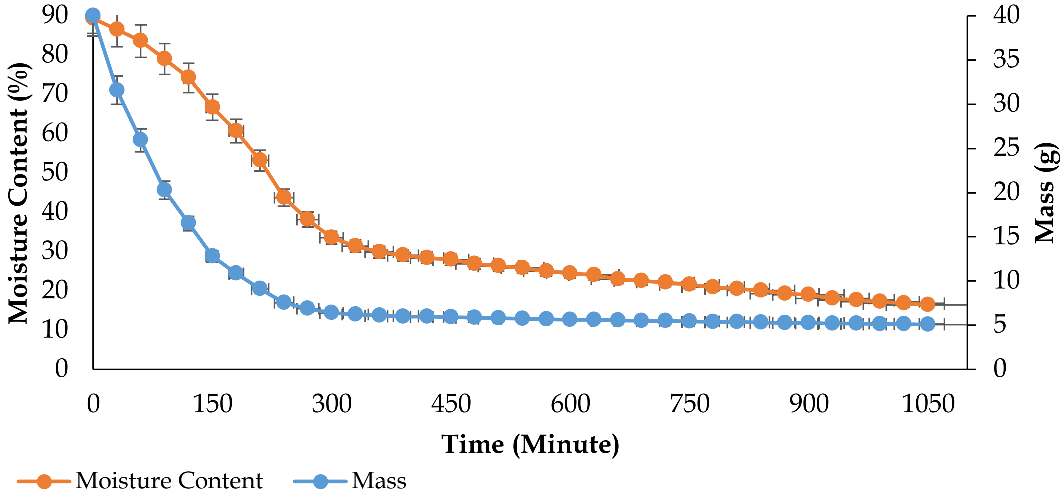

Figure 5. The Moisture Content of Seagrass at 40 °C Using the Convective Oven Drying

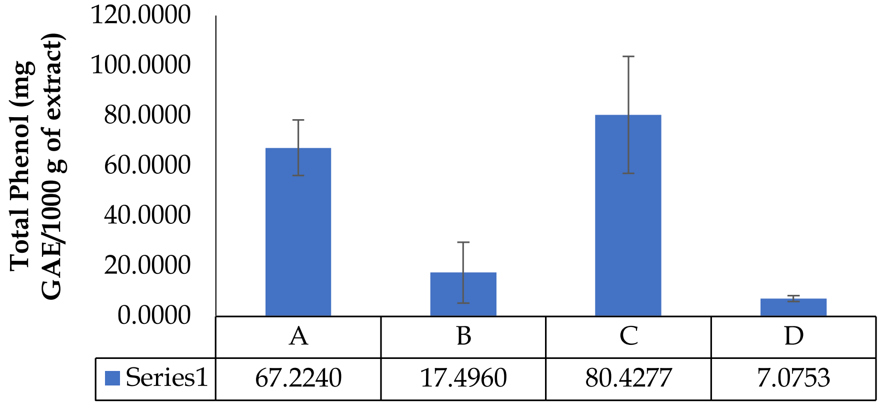

Figure 6. Total Phenolic Content of Seagrass (*Syringodium isoetifolium)*

Total Phenolic Content

Phenolic compounds are compounds that are widely found in all types of plants. The functions of phenolic compounds include lignin as a building block for plant cell walls and anthocyanins as pigments in flowers (Harborne, 1998). The content of phenol compounds is very sensitive, unstable, and prone to degradation. The main degradation includes temperature, oxygen content, and light. Heating with increasing drying temperature will cause damage to most of the phenolic compounds (Vatai *et al.*, 2009).

The total phenolic content of the seagrass extract was determined by the Follin-Ciocalteu method. Figure 6 indicated the highest total phenolic content found in the dehumidifier drying method at the temperature of 40°C was 80.42766 ± 0.409 (mg GAE/1000 g of extract). Based on the ANOVA test temperature on the drying method there was a significant effect on total phenolic content. Then Duncan test showed at the temperature of 30 °C and 50 °C there was a significant effect with the dehumidifier drying method at 40 °C and convective drying at 40 °C on total phenolic content.

Table 4 showed the difference in temperature affects the total phenol of seagrass. The loss of phenolic compounds on the temperature of drying methods may have been caused by enzymatic processes that occurred during drying. These drying methods could not inactivate the degradative enzymes such as polyphenol oxidases; therefore drying methods can degrade phenolic compounds during long-time drying procedures (Kim *et al.*, 2021). Recent research also demonstrated that temperature affects the stability of phenolic content in herbal infusions (Riehle *et al.*, 2013). Garau *et al.* (2007) reported that longer drying times reduced phenolic content for orange by-products. reported that there is a relationship between temperature and phenolic compounds, the content of phenolic compounds decreases with increasing temperature, and it is caused by the decomposition of phenolic compounds. According to Lim and Murtijaya (2007), the reduction in phenolic compounds during the drying process may be attributed to enzymatic reactions that take place during the process. In order to prevent this, conventional sun drying or microwave drying can be used to deactivate the polyphenol oxidases. However, both enzymatic and non-enzymatic reactions that occur during the drying of fresh plant tissues can lead to significant alterations in the phytochemical composition.

Table 4. Effects of Drying Method on Total Phenolic Content, Gallic Acid Equivalents (mg GAE/1000 g of Extract)

Component	Total Phenolic Content			
	CD40 (A)	DH30(B)	DH40(C)	DH50(D)
Phenol Content	67.2240 ± 11.092a	17.496 ± 12.1426b	80.42766 ± 0.409a	7.0753 ± 1.1875b

Antioxidant Activities

IC50 is an antioxidant ability to reduce free radicals by 50%. The smaller the IC50 value, the higher the antioxidant activity. Specifically, a compound is said to be a very active antioxidant if the IC50 value is less than 50 mg/ml, said to be active if it is 50-100 mg/ml, moderate if it is 101-250 mg/ml, said to be weak if it is 250-500 mg/ml and is said to be inactive if the value is more than 500 mg/ml (Jun *et al.*, 2003). Antioxidants are chemical compounds that can donate one or more electrons to free radicals so that these free radicals can be quenched (Sunardi, 2007).

Figure 7 showed the content of antioxidant activity at temperatures of 30, 40, and 50 °C dehumidifier drying method and convective drying method at 40 °C. The highest antioxidant activities found in the dehumidifier drying method at 40 °C were 88.4185 ± 32.0709a (ppm), followed by a convective drying machine at 40 °C 103.9572 ± 19.47 ppm and a dehumidifier machine at 50 °C 199.3641 ± 55.9454 ppm. The lowest antioxidant activity content in the drying treatment of the dehumidifier machine at 50 °C was 236.4581 ± 42.280 ppm. The decrease in antioxidant activity due to drying is related to the degradation of biologically active compounds at high temperatures, either chemically, enzymatically or thermally (Nicoli *et al.*, 1999). In addition, the increase in antioxidant capacity after drying may be related to Maillard Reaction Products (MRPs), which can be formed as a result of heat treatment or storage time and generally exhibit strong antioxidant properties (Kamiloglu *et al.*, 2014). During the drying process, the activation of oxidative enzymes, such as polyphenol oxidase and peroxidase, can lead to the loss of phenolic compounds and antioxidant activity. In addition, the binding of protein phenolic compounds, changes in chemical structure, or low extraction efficiency are other factors associated with the loss of total phenolic and antioxidant activity (Gümüşay *et al.*, 2015).

Table 5 indicates the difference in temperature affects antioxidant activity. Based on the ANOVA test (Table 6), the temperature of the drying method there was a significant effect on antioxidant activities. Then Duncan test showed at the temperature of 30 °C and 50 °C there was a significant effect with the dehumidifier drying method at 40 °C and convective drying at 40 °C on antioxidant activities. The dehumidifier drying method at 40 °C and convective drying at 40 °C exhibit higher antioxidant activities compared to the dehumidifier drying at 30 °C and 50 °C. There could be various factors that contribute to this outcome, including the elevated temperature, longer drying time, storage duration of raw materials, variations in the morphology of seagrass (such as leaf, stem, and root), as well as external factors such as the presence of oxygen, light exposure, and extraction procedures.

Drying methods that use high temperatures to dehydrate seagrass cause a dramatic loss of phenolic content and antioxidant activity (OrphAnides *et al.*, 2013). DPPH assay is based on the ability of antioxidants to act as radical scavengers and FRAP assay measures the ability of antioxidants to perform as reducing agents. Using the optimal temperature of the drying method minimizes the degradation of heat-sensitive compounds such as antioxidant phenols because of the dehydration of the plant material.

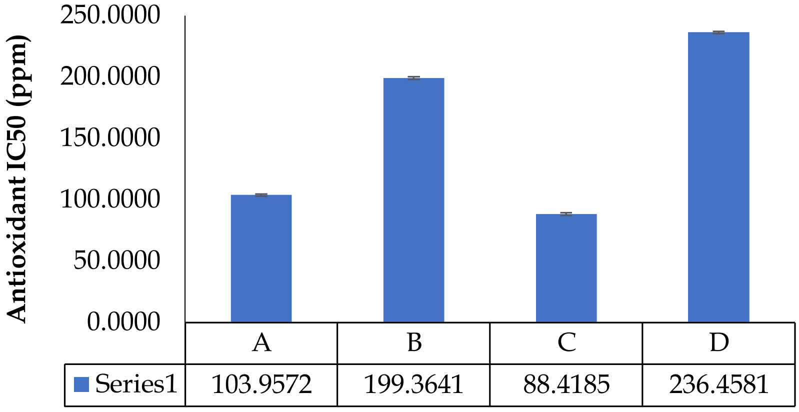

Figure 7. Antioxidant Activities of Seagrass (*Syringodium isoetifolium)*

Table 5. Effects of Drying Method on Antioxidant Activities, IC 50 (mg/L)

Component	Antioxidant Activities			
	CD40 (A)	DH30(B)	DH40(C)	DH50(D)
Antioxidant Activities	103.9572 ± 19.47820a	199.3641 ± 55.94545b	88.4185 ± 32.0709a	236.4581 ± 42.2808b

Table 6. ANOVA of Antioxidant Activities

Antioksidan	ANOVA				
	JK	DB	KT	F`	Sig.
Treatment	46875,771	3	15625,257	9,881	0,005
Galat	12651,015	8	1581,377		
Total	59526,785	11			

CONCLUSION

The present study revealed that the choice of temperature treatment in the drying process had a significant impact on the overall phenol content and antioxidant activity. The ideal temperature range was identified as 40 °C for both dehumidifier drying and convection drying methods. The dehumidifier drying method at 30 °C, 40 °C, and 50 °C took 13 hours, 12 hours, and 7.5 hours, respectively, to lower the initial water content of seagrass from 89.35% to 18-20%. In contrast, oven drying at 40 °C required 17.5 hours to achieve the same moisture content level. The dehumidifier drying technique at 30 °C, 40 °C, and 50 °C ensured stable temperature and relative humidity levels inside the drying chamber. Conversely, high-temperature drying procedures led to a significant reduction in phenolic content and antioxidant activity.

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