Original Article

Comparative Investigation on Drying Efficiency of the Solar Dryer Using Aluminium as the Absorber Plate Against The Stainless Steel Absorber Plate for Drying Copra

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Abstract

Aim: The objective of this study is to compare the drying efficiency of aluminium and stainless steel absorber plates in coconut drying. **Materials and Methods:** The sample size for the groups were determined as 20 for each group, a total of 40 for the groups using a simple sample size calculator, with G power of 80% by keeping threshold 0.05, confidence interval 95% and enrollment ratio as 1. As comparison groups, the control and experimental groups were chosen. Coconut samples on stainless steel absorber plate served as the control group, whereas coconut samples on aluminium absorber plate served as the experimental group. A hot air oven and a formula were used to determine the moisture content of these coconut samples. **Results:** The results demonstrate that the mean moisture content reduction for aluminium is 31.15%, while the mean moisture content reduction for stainless steel is 25.36% for coconut samples. With a p value of 0.007, the independent samples t-test revealed that both groups are statistically significant for moisture content reduction. **Conclusion:** The drying effectiveness of aluminium and stainless steel absorber plates was evaluated in terms of moisture content reduction, and it was determined that aluminium absorber plates had a better drying efficiency than stainless steel absorber plates.

Keywords: Solar Drying, Drying Efficiency, Copra, Stainless steel, Novel Aluminium Absorber Plate, Moisture Content.

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INTRODUCTION

The objective of this study is to compare the drying efficiency of novel aluminium and stainless steel absorber plates in coconut drying. Coconut is one of the trees which have versatile uses like coconut leaves (thatch roof and handicrafts), coconut sap (sugar, toddy and vinegar) coconut shell (charcoal) etc, hence it is called the 'Tree of life' (Yang, Iqbal, and Qadri 2018). Coconut and its edible products like coconut water, coconut oil etc have been gaining popularity after getting recommended by chefs and celebrities to be used in cooking, baking and external application for its enormous healing properties (Lockyer and Stanner 2016). Coconut oil has been used for thousands of years safely without any risk and a number of studies have been used to prove its healing properties, ability to improve overall health and proven to be more effective than Aricept in the treatment of Alzheimer's disease(Fife 2012). Medium chain fatty acid is the type of fatty acid which is mostly present in the coconut oil which is digested and converted to energy easily and does not increase cholesterol or the possibility of getting heart diseases which is caused by long chain fatty acids which is present mostly in the animal fat (Carandang 2003). Coconut oil is obtained by dry processing and wet processing method, in dry processing the dehusked coconut is split and dried to get copra, followed by crushing of copra in an oil expeller to extract the coconut oil (Withana-Gamage, Perera, and Wanasundara 2020). Drying is used to eliminate the moisture content present in the product to the required amount in order to increase the shelf life and preserve food for a longer time hence drying is one of the most unavoidable techniques for preserving large quantities of foods, but conventional drying techniques consume a lot of energy hence solar dryer is the best alternative to conventional drying (Khaing Hnin et al. 2019). Disadvantages of drying like nutrient loss, colour loss and quality deterioration in the food products can be overcome by switching to solar drying techniques (Wakjira 2010).

Materials and Methods

To evaluate the drying efficiency of the two absorber plates namely, aluminium and stainless steel, a solar dryer setup was built, and kept under the meteorological conditions of Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai (latitude 13.02°N, longitude 80.01°E). The moisture content of the samples was tested in the highway engineering laboratory at Saveetha School of Engineering using a hot air oven. With the help of a simple clinic sample size calculator the sample size was determined as 20 for each group by keeping G power as 80%, threshold as 0.05 and a confidence interval of 95%. This computation was produced based on the researcher's prior findings (Mohanraj 2014).
For comparison, two groups were chosen namely experimental and control groups. The experimental group's coconut samples were placed on an aluminium absorber plate in the solar dryer setup, whereas the control group's coconut samples were placed in a stainless steel absorber plate and left to dry for two days. Chlorinated polyvinyl chloride (CPVC) pipes with an inner diameter of 76 mm were used to construct the sun dryer experimental setup. Pipe fittings such as tees, elbows, and three-way joints were used. The framework measured 760 mm in length, 380 mm in width, and 915 mm in height. Stainless steel and aluminium absorber plates have dimensions of 305 mm in length, 305 mm in width, and 1 mm in thickness. To hold the reflecting mirror, the external attachment was added in the structure. A 6 mm thick clear polycarbonate sheet was used to cover the structure. This dryer runs on the greenhouse effect and uses sun radiation as its only source of energy.. Greenhouse effect inside the dryer is created with the help of polycarbonate sheets (Udomkun et al. 2020). The absorber plates were placed in the specified area of the framework.
The coconut water was removed from high-quality coconuts, and the coconut samples of the same size were placed in the aluminium and stainless steel absorber plate as shown in Figure 2. The following steps were used to determine the moisture content of the fresh and dried samples using a hot air oven: The sample's initial weights (Wi) were recorded, it was held in a hot air oven for 6 hours, with the temperature kept at 130°C throughout, the sample's final weights (Wf) were calculated. The moisture content was determined using the following equation (1), with the help of the collected data (Mohanraj and Chandrasekar 2009).

$$Wet\ basis\ moisture\ content\ (Mwb) = \frac{(Wi-Wf)}{Wi} \times \mathbf{100} \qquad (1)$$

The moisture content of fresh and dried samples was determined as initial and final moisture content respectively (Deepa et al. 2015). The readings of moisture content reduced was calculated by subtracting the final moisture content from the initial moisture content and it is shown in Table. 1.

Statistical analysis
SPSS v.26 statistical software was used to calculate mean, standard deviation and standard error. In total 20 readings were taken for analysing each group in order to achieve 95% confidence level with P value <0.05. In this work independent variables used are the two types of absorber plates taken for study and the dependent variable is moisture content reduction (%). Independent sample t-test was used to analyse the outcomes of this study.

RESULTS

The values of the calculated moisture content reduction of coconut samples using aluminium and stainless steel absorber plates is shown in Table 1. Table 2 displays group data such as mean, standard deviation, and standard error mean values. The value of mean moisture content reduced by aluminium is 31.15% and stainless steel is 25.36% for coconut. The independent samples t-test has been used, and the results are shown in Table 3, which reveals that both groups are statistically significant for the reduction of moisture content, with a p value of 0.007. Figure 1 illustrates the photographic image showing coconut samples placed in stainless steel and aluminium absorber plate in the solar dryer setup. Figure 2 shows the photographic image showing the moisture content of the coconut samples that were determined using a hot air oven. In terms of mean and standard deviation, a bar chart compares the value of reduction in moisture content of coconut samples by novel aluminium and stainless steel as the absorber plate as shown in Fig. 3. The mean and standard deviation value of aluminium absorber plate is higher than that of stainless steel absorber plate.

DISCUSSION

It is noted from the results, the moisture content of coconut was efficiently lowered by aluminium absorber plate in contrast to stainless steel absorber plate. The reason for the better drying efficiency of novel aluminium absorber plate is its high thermal conductivity and high energy propagation rate when compared with stainless steel, which helps in the conversion of solar radiation to thermal energy (Majid et al. 2015). This study has a fischer value of 8.169 and a significance value of 0.007 which shows that both the groups have a significant difference.

The effect of thermal conductivity of the absorber plate on solar fraction of an solar water heater was studied and found that the solar fraction improved by 4% to 7% when the aluminium absorber plate is replaced in the place of a steel and the solar fraction improved only by 1% when the steel absorber plate is replaced by copper absorber plate (Shariah et al. 1999). An experiment has done to desalinate water using a solar still which has an absorber plate and parabolic reflector made of aluminium and found that the production of desalinated water by the solar still has increased by 75% when a parabolic concentrator is used (Sa et al. 2017). The condensation effect of solar still which is attached with a solar heater has been studied and the study shows that the aluminium condenser plate used in solar still has performed well due to its high thermal conducting property (Mamkagh and Anderson 2018). The above mentioned research articles suggest that the aluminium absorber plate has better drying efficiency which is in line with our study. The thermal characteristics of the stainless steel and aluminium is studied which revealed that the aluminium having lesser thermal storage rate when compared with stainless steel and also stainless steel reached a maximum temperature of 50.1℃ whereas aluminium obtained a temperature of only 48.3℃ (Majid et al. 2015). Aluminium as a metal can undergo degradation in high humidity and condensation humidity (Dudita et al. 2015). The above two research articles suggest that aluminium has lesser overal drying efficiency than stainless steel that impacts the drying efficiency of aluminium and also the degradation of aluminium in high humidity will impact the quality of drying food product thereby affecting the drying efficiency respectively which are not in line with our study.
The limitations for this research are the regional meteorological effect of particular stations and the unpredictable climatic condition. The scope of this study is to investigate the drying performance of aluminium and stainless steel absorber plates under various climatic conditions. The impact of drying efficiencies of different absorber plates at different regions can be studied and analysed as a future work of this study.

CONCLUSION

A solar dryer setup was used to dry the coconuts, which has two absorber plates made of aluminium and stainless steel. The absorber plate's ability to reduce the moisture content of coconut samples were assessed, and the mean moisture content reduction was determined to be 31.15% for aluminium and 25.36 % for stainless steel, as shown in Table 2. Based on these findings, it can be stated that aluminium performs better as an absorber plate for drying coconut than stainless steel.

Declarations
Conflict of interest
No conflict of interests in this manuscript.

Author contributions
Author (QHKMA) was involved in the construction of experimental setup,sample collection, data analysis and manuscript writing. Author (TS) was involved in processing the idea, data verification, and critical review of the manuscript.

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TABLES AND FIGURES

Table 1. The calculated values of the % reduction in moisture content of coconut samples by using aluminium and stainless steel as absorber plates has been tabulated and is shown below.

S.No	Reduction in moisture content - Aluminium (%)	Reduction in moisture content - Stainless steel (%)
1	33.08	25.31
2	33.92	25.65
3	31.98	25.78
4	32.25	25.95
5	32.78	26.11
6	32.59	26.28
7	31.86	26.47
8	33.52	26.62
9	31.28	26.85
10	31.71	24.97
11	32.91	24.74
12	28.66	24.51
13	28.54	24.23
14	28.92	23.98
15	28.79	23.75
16	29.23	23.55
17	29.58	23.19
18	29.77	27.11
19	29.37	27.02
20	32.24	25.06

Table 2. Group statistics - Aluminium absorber plate gives increased % of reduced moisture content than stainless steel absorber plate (Mean - 31.1490 and standard deviation - 1.82876) from the collected samples. The standard error mean value for stainless steel absorber plate is 0.27138 and for aluminium absorber plate is 0.40892.

Group	N	Mean	Std. Deviation	Std. Error Mean
Aluminium	20	31.1490	1.82876	0.40892

Stainless steel	20	25.3565	1.21363	0.27138

Table 3. Tabulation for independent sample t - test. The outcome of the independent sample t-test shows a significant difference between the control group and experimental group. The significant value P = 0.007 (P<0.05, t value is 11.803 & 11.803; and the df is 38 & 33.017).
confidence interval of the difference.

Independent Samples Test										
Levene's Test for Equality of Variances				**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Reduction in moisture content (%)	**Equal variances assumed**	8.169	0.007	11.803	38	<0.001	5.79250	0.49078	4.79897	6.78603
	Equal variances not assumed			11.803	33.017	<0.001	5.79250	0.49078	4.79402	6.79098

Fig. 1. Photographic image showing coconut samples placed in stainless steel and aluminium absorber plate in the solar dryer setup.

Fig. 2. Photographic image showing the moisture content of the coconut samples that were determined using a hot air oven.

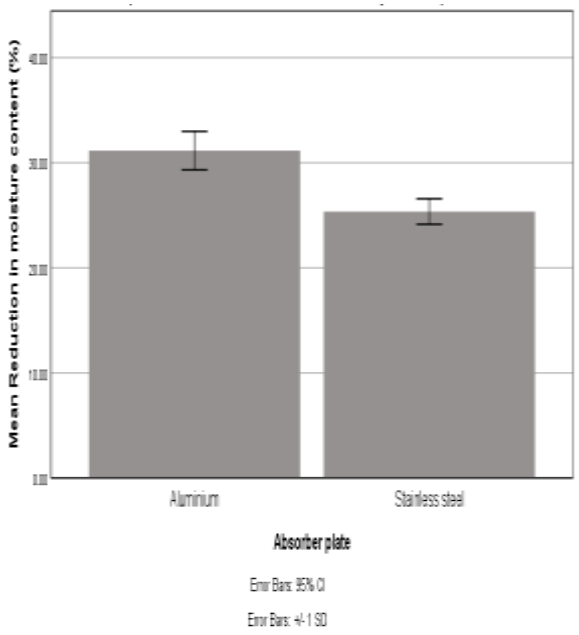

Fig. 3. The bar chart compares the reduction of moisture content in terms of percentage between aluminium absorber plate and stainless steel absorber plate. The mean value of moisture content reduced is comparatively better in aluminium absorber plate than stainless steel absorber plate. X axis: Types of absorber plate. Y axis: Mean value of moisture content reduced +/- 1 SD.