Pertanika Journal of

SCIENCE & TECHNOLOGY

JST

VOL. 26 (3) JUL. 2018

PERTANIKA
JOURNALS

A scientific journal published by Universiti Putra Malaysia Press

Journal of Science & Technology

Journal of Science & Technology

About the Journal

Overview

Pertanika Journal of Science & Technology (JST) is the official journal of Universiti Putra Malaysia published by UPM Press. It is an open-access online scientific journal which is free of charge. It publishes the scientific outputs. It neither accepts nor commissions third party content.

Recognized internationally as the leading peer-reviewed interdisciplinary journal devoted to the publication of original papers, it serves as a forum for practical approaches to improving quality in issues pertaining to science and engineering and its related fields.

JST is a **quarterly** (January, April, July and October) periodical that considers for publication original articles as per its scope. The journal publishes in **English** and it is open to authors around the world regardless of the nationality.

The Journal is available world-wide.

Aims and scope

Pertanika Journal of Science and Technology aims to provide a forum for high quality research related to science and engineering research. Areas relevant to the scope of the journal include: bioinformatics, bioscience, biotechnology and bio-molecular sciences, chemistry, computer science, ecology, engineering, engineering design, environmental control and management, mathematics and statistics, medicine and health sciences, nanotechnology, physics, safety and emergency management, and related fields of study.

History

Pertanika was founded in 1978. A decision was made in 1992 to streamline Pertanika into three journals as Journal of Tropical Agricultural Science, Journal of Science & Technology, and Journal of Social Sciences & Humanities to meet the need for specialised journals in areas of study aligned with the interdisciplinary strengths of the university.

After almost 25 years, as an interdisciplinary Journal of Science & Technology, the revamped journal now focuses on research in science and engineering and its related fields.

Goal of *Pertanika*

Our goal is to bring the highest quality research to the widest possible audience.

Quality

We aim for excellence, sustained by a responsible and professional approach to journal publishing. Submissions are guaranteed to receive a decision within 14 weeks. The elapsed time from submission to publication for the articles averages 5-6 months.

Abstracting and indexing of *Pertanika*

Pertanika is almost 40 years old; this accumulated knowledge has resulted in Pertanika JST being abstracted and indexed in SCOPUS (Elsevier), Thomson (ISI) Web of Knowledge [BIOSIS & CAB Abstracts], EBSCO & EBSCOhost, DOAJ, ERA, Cabell's Directories, Google Scholar, MyAIS, ISC & Rubriq (Journal Guide).

Pertanika Journal of

SCIENCE & TECHNOLOGY

Vol. 26 (3) Jul. 2018

PERTANIKA JOURNALS

A scientific journal published by Universiti Putra Malaysia Press

JST

Journal of Science & Technology

AN INTERNATIONAL PEER-REVIEWED JOURNAL

ABSTRACTING AND INDEXING OF PERTANIKA JOURNALS

Pertanika is almost **40 years old**; this accumulated knowledge has resulted in the journals being abstracted and indexed in **SCOPUS** (Elsevier), Clarivate Analytics [*formerly known as Thomson (ISI)*] **Web of Science™ Core Collection-** Emerging Sources Citation Index (ESCI). Web of Knowledge [BIOSIS & CAB Abstracts], **EBSCO** and EBSCOhost, **DOAJ**, **ERA**, **Google Scholar**, **TIB**, **MyCite**, Islamic World Science Citation Center (ISC), ASEAN Citation Index (ACI), **Cabell's Directories** & Journal Guide.

Pertanika Journal of Science & Technology
Vol. 26 (3) Jul. 2018

Contents

Short Communication

Foreword

Welcome to the **Third Issue 2018** of the Journal of Science and Technology (JST)!

Pertanika bids farewell to Dr. Nayandeep Singh Kanwal whose service ended this month. We thank him for his contribiutions and wish him every success in his future endeavour.

JST is an open-access journal for studies in science and technology published by Universiti Putra Malaysia Press. It is independently owned and managed by the university and is run on a non-profit basis for the benefit of the world-wide science community.

This issue contains **45 articles,** of which **four** are review articles, **one** is a short communication and **40** are regular research articles. The authors of these articles hail from several countries namely, **Malaysia**, **Indonesia**, **Germany**, **Denmark**, **Afghanistan**, **Saudi Arabia**, **Canada**, **Italy**, **India**, **Iraq** and **Iran**.

The first review article in this issue reports briefly on remotely sensed imagery data application in a mangrove forest (*Zulfa, A. W.* and *Norizah, K.*), while the second is on a preliminary study on paper-sheet-based epoxy composites designed for repairing work application and their properties (*Muhamad Hellmy Hussin*). The next review article looks at platelet transcriptome-based approaches in the fight against dengue and other diseases (*Suppiah, J., Sakinah, S., Chan, S. Y., Wong, Y. P., Bala, J. A., Lawal, N., Benelli, G., Subbiah, S. K.* and *Chee, H. Y.*), while the final review article examines forensic body height estimation by measuring unsegmented fingers of Javanese subjects in Indonesia (*Athfiyatul Fatati* and *Myrtati D. Artaria*).

The short communication discusses the effectiveness of the quick coherence technique using the heart rate variability-biofeedback technology on the recovery of heart coherence among university students (*Abdul Qahar Sarwari* and *Mohammad Nubli Wahab*).

The 40 regular articles cover a wide range of topics. The first article is on the association of FDG-PET (SUVmax) and an inflammatory marker in predicting tumour aggressiveness (*Ahmad Saad, F. F., Abdullah, N. S., Shaharuddin, S.* and *Nordin, A. J.*). The following articles look at: a comparative analysis of contrast enhancement techniques for medical images (*Randeep Kaur, Meenu Chawla, Navdeep Kaur Khiva* and *Mohd Dilshad Ansari*); the preparation and thermal properties of cellulose acetate/polystyrene blend nanofibres via the electrospinning technique (*Rosdi, N. H., Mohd Kanafi, N.* and *Abdul Rahman, N.*); an experimental analysis of condensation in a helical coil tube (*Rashed Ali* and *Nitin P Gulhane*); a modified wiener filter for restoring landsat images in remote sensing applications (*Kalaivani K* and *Asnath Victy Phamila Y*); GPU-based optimisation of pilgrim simulation for *hajj* and *umrah* rituals (*Abdur Rahman Muhammad Abdul Majid, Nor Asilah Wati Abdul Hamid, Amir Rizaan Rahiman* and *Basim Zafar*); ultrasound-assisted extraction of natural colourants from the husk of *cocos nucifera* in comparison with agitated-bed extraction (*Rodiah, M. H., Nur Asma Fhadhila, Z., Noor Asiah, H. , Aziah, M. Y.* and *Kawasaki, N.*); distinct pH-dependent aggregation of citrate-capped colloidal gold in presence of citrate competitors (*Fatemeh Javadi-Zarnaghi, Fahimeh Hosseini* and *Dorsa Mohammadrezaei*); experimental evaluation of jatropha oil methyl ester (JOME) and fish oil methyl ester (FOME) in a compression ignition engine with exhaust gas recirculation (*K. Bhaskar* and *S. Sendilvelan*); decomposition of benders for distribution networks with a cross-docking centre (*Manpreet Singh, Divya Aggarwal* and *Vijay Kumar*); distance correlation between plaintext and hash data by genetic algorithm (*Farjami, Y., Rahbari, D.* and *Hosseini, E.*); simulation of fermentation compounds for bioethanol production using different separating agents (*S. M. Anisuzzaman, D. Krishnaiah, A. Bono, F. A. Lahin* and *Syazryn R. I.*); the study of time lag on plant growth under the effect of toxic metal as a mathematical model (*Kalra, P.* and *Kumar, P.*); optimisation of the multireservoir operation policy using a teaching-learning-based optimisation algorithm (*Jayantilal N. Patel* and *Pranita N. Balve*); determination of the optimal pre-processing technique for spectral data of oil palm leaves with respect to nutrients (*Helena Anusia James Jayaselan, Wan Ishak Wan Ismail, Nazmi Mat Nawi* and *Abdul Rashid Mohamed Shariff*); a novel entropy algorithm for state sequence of the Bakis Hidden Markov Model (*Jason Chin-Tiong Chan* and *Hong Choon Ong*); a portable and low-cost multi-sensor for real-time remote sensing of water quality in agriculture (*Sandeep Bansal* and *G. Geetha*); an adaptive mechanism to optimise routing performance in mobile ad hoc networks (*B. Nithya, C. Mala* and *Abhishek Agrawal*); design of the side-sensitive group runs chart with estimated parameters based on expected average run length (*You Huay Woon*); DSSBD, an intelligent decision-support system for residual life estimation of the PN junction diode (*Shivani* and *Cherry Bhargva*); theoretical development of biaxial fabric prestressed composites under tension-tension fatigue loading (*Nawras H. Mostafa, Z. N. Ismarrubie, S. M. Sapuan* and *M. T .H. Sultan*); drying characteristics of *curcuma longa* using solar dryer (*Fhelix August Soebiantoro, Elieser Tarigan, Lie Hwa, Violita Putri Halim* and *Lanny Sapei*); exploration of tritrophic interaction for enhancing conservation biological control of insect pests in the role of analytical chemistry (*Surjani Wonorahardjo, Nurindah, Dwi Adi Sunarto, Sujak* and *Setya Ayu Aprilia*); OPH-LB, an optimal physical host for load balancing in a cloud environment (*Sakshi Chhabra* and *Ashutosh Kumar Singh*); an evaluation of network intrusion detection systems through a statistical analysis of the CIDDS-001 dataset using machine-learning techniques (*Abhishek Verma* and *Virender Ranga*); protocols-performance investigation using ad hoc WLAN for healthcare applications (*Piyush Yadav, Rajeev Agrawal* and *Komal Kashish*); detection of spam using particle swarm optimisation in feature selection (*Surender Singh* and *Ashutosh Kumar Singh*); evaluation of the ball-milling process for the production of carbon particles from rice straw waste (*Asep Bayu Dani Nandiyanto, Rosi Oktiani, Rena Zaen, Ari Arifin Danuwijaya, Ade Gafar Abdullah* and *Nuria Haristiani*); implementation of a markerless augmented reality method to visualise the philosophy of batik based on android (*Isma Widiaty, Ivan Yustiawan, Yudi Wibisono, Ade Gafar Abdullah, Cep Ubad Abdullah* and *Lala Septem Riza*); metaheuristicopt, an R package for optimisation based on meta-heuristics algorithms (*Lala Septem Riza, Iip, Eddy Prasetyo Nugroho* and *Munir*); a natural circulation system for advanced fast reactors with lead-bismut as a coolant (*Ade Gafar Abdullah, Zaki Su'ud* and *Asep Bayu Dani Nandiyanto*); using the jolly balance spring method to determine the pure water surface tension coefficient (*Duden Saepuzaman, Muhamad Gina Nugraha, Regiana Dewi, Fitri Kafiyani* and *Fanny Herliyana Dewi*); an analysis of attacks on mail disposition systems secured by digital signatures equipped with AES and RSA algorithms (*Herbert Siregar, Enjun Junaeti* and *Try Hayatno*); the technical efficiency chemical industry in Indonesia using the stochastic frontier analysis (SFA) approach (*Amir Machmud, Asep Bayu Dani Nandiyanto* and *Puspo Dewi Dirgantari*); a validation of UML model and OCL expressions using the USE tool (*Arifa Bhutto* and *Dil Muhammad Akbar Hussain*); a photonic crystal-based micro mechanical sensor in an SOI platform (*Indira Bahaddur, Preetha Sharan* and *P. C. Srikanth*); an adaptive MOEMS-based micro pressure sensor using photonic crystal (*Johnson, O. V.* and *Preeta Sharan*); photonic crystal-based micro interferometer biochip (PC-IMRR) for early stage detection of melanoma (*Nandhini, V. L., K. Suresh Babu, Sandip Kumar Roy* and *Ketan Pandit*); cheat-proof communication through a cluster head (C3H) in a mobile ad hoc network (*Abu Sufian, Anuradha Banerjee* and *Paramartha Dutta*); and wavelength selectivity using an adaptive shortest path algorithm for optical network (*Piruthiviraj P, Preeta Sharan* and *Nagaraj Ramrao*).

I anticipate that you will find the evidence presented in this issue to be intriguing, thought-provoking and useful in setting new milestones. Please recommend the journal to your colleagues and students to make this endeavour meaningful.

All the papers published in this edition underwent Pertanika's stringent peer-review process involving a minimum of two reviewers comprising internal as well as external referees. This was to ensure that the quality of the papers justified the high ranking of the journal, which is renowned as a heavily-cited journal not only by authors and researchers in Malaysia but by those in other countries around the world as well.

I would also like to express my gratitude to all the contributors namely, the authors, reviewers and editors for their professional contribution towards making this issue feasible.

JST is currently accepting manuscripts for upcoming issues based on original qualitative or quantitative research that opens new areas of inquiry and investigation.

Chief Executive Editor
Prof. Dato' Dr. Abu Bakar Salleh
executive_editor.pertanika@upm.my

Pertanika J. Sci. & Technol. 26 (3): 1265 - 1274 (2018)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Drying Characteristics of Curcuma longa Using Solar Dryer

Fhelix August Soebiantoro[1], Elieser Tarigan[2,3], Lie Hwa[1], Violita Putri Halim[1] and Lanny Sapei[1]*

[1]Department of Chemical Engineering, Faculty of Engineering, University of Surabaya, Raya Kalirungkut, Surabaya 60293 East Java, Indonesia
[2]Department of Electrical Engineering, Faculty of Engineering, University of Surabaya, Raya Kalirungkut, Surabaya 60293 East Java, Indonesia
[3]Center for Renewable Energy Studies, University of Surabaya, Raya Kalirungkut, Surabaya 60293 East Java, Indonesia

ABSTRACT

Curcuma longa (turmeric) is a rhizomatous herbaceous perennial plant which is widely cultivated in tropical regions, such as Indonesia. It has been intensively used for medical purposes as an ingredient of traditional medicine for a long time. In order to extend its shelf-life, turmeric is generally dried under the sun prior to use. This method generally takes a longer time and is less controlled, thus yielding less qualified products. This experiment was carried out using a manually designed solar dryer for improving the drying process of turmeric. The drying process using solar dryer is shorter and also protects the samples from dirt, insects, as well as direct contact with UV radiation which may deteriorate its bio-active compounds. The drying was done until moisture of about 10% content was achieved. In general, it took about 450 minutes in the solar dyer in comparison to that of 480 minutes using sun drying to reach the equilibrium moisture content. This was caused by a higher temperature profile distributed inside the solar dryer accelerating the drying process. The use of solar dryer has the potential to be further developed to replace the conventional sun drying method of herbs.

Keywords: Curcuma longa, drying process, solar dryer, sun drying, turmeric

ARTICLE INFO

Article history:
Received: 18 December 2017
Accepted: 29 June 2018

E-mail addresses:
k.fhelixas@gmail.com (Fhelix August Soebiantoro)
elieser@staff.ubaya.ac.id (Elieser Tarigan)
liehwa@staff.ubaya.ac.id (Lie Hwa)
violitahalim12@yahoo.co.id (Violita Putri Halim)
lanny.sapei@staff.ubaya.ac.id (Lanny Sapei)
*Corresponding Author

ISSN: 0128-7680

INTRODUCTION

Curcuma longa (turmeric) is known as *kunyit* by Indonesians. This herb is very popular in Indonesia because of its benefits. Turmeric has been used as a spice for traditional Indonesian cuisines, as a traditional drink and the most popular as the main ingredient for traditional medicines because of its high antioxidant contents. Turmeric has also been reported to have a role in preventing diseases such as cancer due to its powerful antioxidant properties and anti-carcinogenic action. It is also said to prevent cardiovascular diseases (Prathapan, Lukhman, Arumughan, Sundaresan, & Raghu, 2009).

Herbs including turmeric must be initially well-dried before being used as the ingredients of traditional medicines. This helps reduce the moisture content, thus also functions as a disinfection, microbial decontamination and long-term preservation in order to prolong its shelf-life (Schweiggert, Carle, & Schieber, 2007). In Indonesia, herbs are simply dried under the sun immediately after they are harvested. The direct contact of sunlight could destroy the bioactive compounds retained in the samples. Besides that, the drying process is uneasy to maintain since temperature and humidity tend to fluctuate. Furthermore, there has been a greater risk for being contaminated due to insects, birds, or other animals, and dust (Weiss & Buchiner, 2001). Solar dryer has become one of the drying alternatives harnessing the sun energy but in a more controlled way and could eliminate the contaminants. Heat from the sun is collected and transferred indirectly to the herbs, thus preventing the deterioration of their bioactive compounds and improving the overall product quality. Solar dryer has been categorised into 2 types - either active or passive, depending on the presence of fan / blower facilitating the air flow inside the solar dryer.

The main purpose of this work is to study the drying characteristics of turmeric using a passive type solar dryer. The solar dryer was self-designed by Suyanto and Antoro (2016) and has been continually modified to improve its performance for drying herbs in a more efficient and controlled way.

MATERIALS AND METHODS

Turmeric (*Curcuma longa*) was purchased from Jagir Local Market, Surabaya, Indonesia. The turmeric was separated from dust and dirt. It was then sliced horizontally with a thickness of about 3 mm and weighed about 7 grams as a sample using a balance (Mettler, Toledo) before being dried. It was dried under the sun and in the solar dryer until reaching a constant weight and the final moisture content was below 10% (Ministry of Health Republic of Indonesia [KEMKES], 1994).

The solar dryer was self-designed using aluminum for the body, plywood board for the door, glass for the heat collector, and black painted aluminum for absorbing heat from the sunlight. There were four trays arranged vertically as sample containers. The details of the solar dryer design are shown in Figure 1.

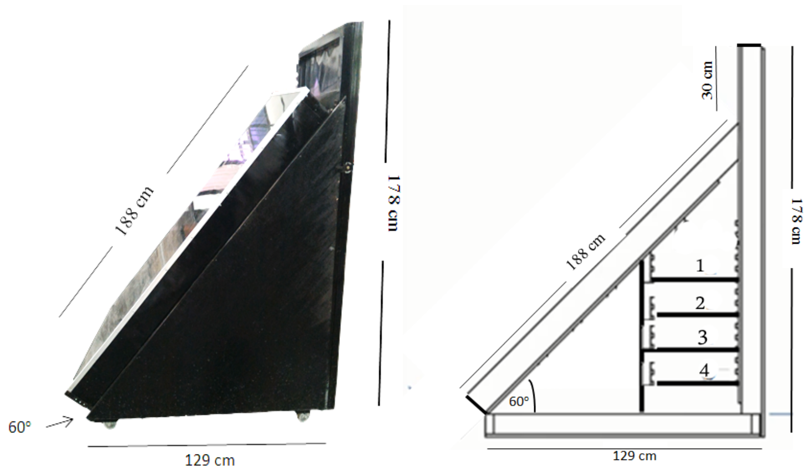


Figure 1. Self-designed solar dryer

Approximately two kg turmeric samples were distributed on all trays (tray 1, 2, 3, 4). There was a boundary circle area in the middle of each tray containing of three to four slices for samplings. The temperature of each tray was recorded using thermocouple every five minutes and the sample was weighed every 30 minutes. All trays were rotated downwards every two hours (Figure 2) in order to equalise heat distribution absorbed in each tray since the first tray generally received maximum sun radiation. The solar dryer was moved from time to time following the sun direction.

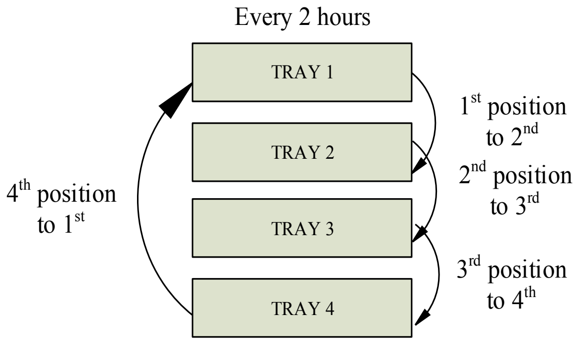


Figure 2. The sequence of tray rotation

The sampling process was conducted in two days. On the first day, sampling was conducted from 9.00 a.m. until 3.00 p.m. The data was simply continued by the sampling taken on the following day starting from 9.00 a.m. until it reached equilibrium weight. Sun drying was also conducted for the comparison of the drying process conducted in the solar dryer. The turmeric slices were evenly distributed on a tray and placed under the sun until the drying process was completed. During the samplings, two slices of turmeric samples in the middle of the tray were weighed every 30 minutes. The air temperatures, both dry bulb and wet bulb temperatures were measured using alcohol thermometers and the corresponding RHs were calculated using the psychrometric chart.

Results were presented as drying curves whereby free moisture content (X) was monitored versus the drying time (Geankoplis, 2003). Free moisture content was obtained by deducting the equilibrium moisture content (X^*) from the moisture content at certain time (X_t). The calculation of X_t and X can be seen in equation (1) and (2).

$$X_t = \frac{W_t - W_d}{W_d} \qquad [1]$$

where X_t = moisture content at certain time (kg H_2O/kg dry weight); W_t= sample weight at certain time (kg); W_d= sample dry weight (kg) obtained after sample was dried at 120°C for about two hours.

$$X = X_t - X^* \qquad [2]$$

where X = free moisture content (kg H_2O/kg dry weight); X_t = moisture content at certain time (kg H_2O/kg dry weight); X^*= equilibrium moisture content (kg H_2O/kg dry weight). The drying rates were also analysed using equation (3) (Geankoplis, 2003).

$$R = R_c.A = -L_s \frac{dX}{dt} \qquad [3]$$

where R_c= constant drying rate (kg H_2O/ minutes), Ls= sample dry weight (kg), dX/dt= rate of free moisture changes per time (kg H_2O/ (kg dry weight. minutes)). The data was processed using Microsoft Excel 2013 and Curve Expert Professional 2.3.0.

RESULTS AND DISCUSSION

Sun Drying

Drying process under the sun was dependent on the ambient air temperatures and RH. The temperatures and RH profiles during the experiment are presented in Figure 3. Dry air temperatures ranged from 35°C to 41°C with mean temperature of about 38.5°C, and RHs were in the range of about 51% to 65%.

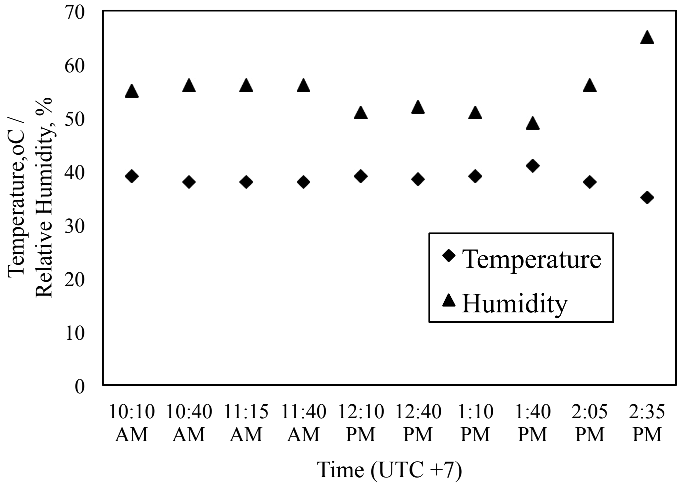


Figure 3. Temperature and relative humidity profiles during sun drying

The drying characteristics of turmeric using sun drying mode can be seen in Figure 4. The free moisture contents continuously decreased until it became constant. Drying began with the constant rate (from 0 minutes until 150 minutes) followed by the falling rate (from 150 minutes until it reached constant moisture content). Drying of turmeric under the sun took about eight hours (480 minutes) to reach the required moisture content of 10% or free moisture content of about 11.1%, according to Indonesian government regulations.

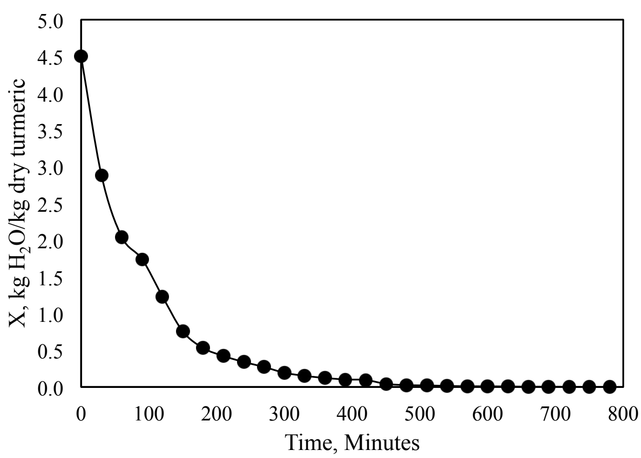


Figure 4. Free moisture content versus time during sun drying

Solar Drying

During the experiment using the solar dryer, the measured temperatures on each tray fluctuated depending on heat intensity. The highest temperature achieved during drying was about 55°C and occurred between 12:24 p.m. to 1.00 p.m. The temperature profiles on each tray inside the solar dryer are shown in Figure 5.

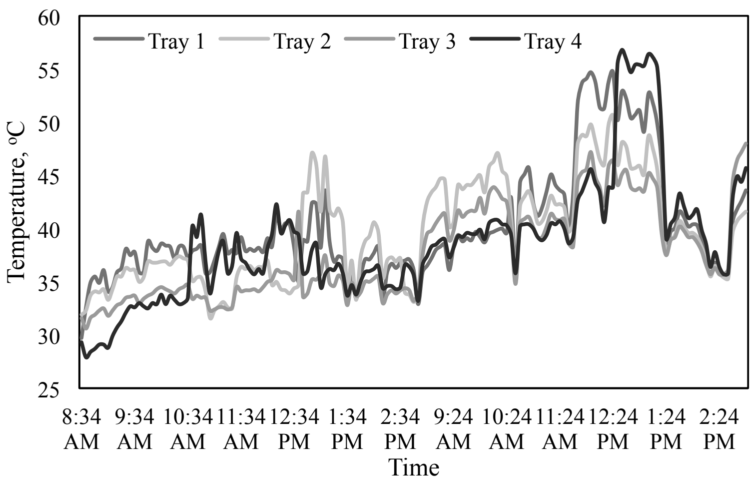


Figure 5. Temperature profiles on each tray inside the solar dryer

The trays which were placed on the top received the highest heat radiation from the sun than the others, thus would reach the highest temperature leading to sample overheating compared to the samples placed on the lower trays. Therefore, trays were rotated during the experiment as shown in Figure 2, so that the temperatures were more evenly distributed amongst the trays. It was evident that the temperature profiles in all trays did not differ very much. The average temperature on each tray was about 37°C to 40°C and the average was about 39°C, which was slightly higher than the average air temperature during sun drying. The temperature inside the solar dryer generally was higher compared to the ambient temperature during sun drying (Weiss & Buchiner, 2001). This was due to heat accumulation in the sunlight collector which was then transferred to the air drying up the samples.

The turmeric drying characteristics in each tray can be seen in Figure 6. Free water content of the turmeric decreased over time until it became constant. Furthermore, after 360 minutes, the free water content of turmeric dried in all four trays approached zero, even though the initial water contents were different and all reached the equilibrium water contents after about 450 minutes of drying. This indicates that homogeneous heat transferred on each rotated tray. Borah, Hazarika, and Khayer (2015) previously also dried turmeric using a passive solar dryer. It took about 11 hours to dry the samples until reaching the constant weight. This indicates comparable performance of this self-designed solar drying with other existing passive solar dryers.

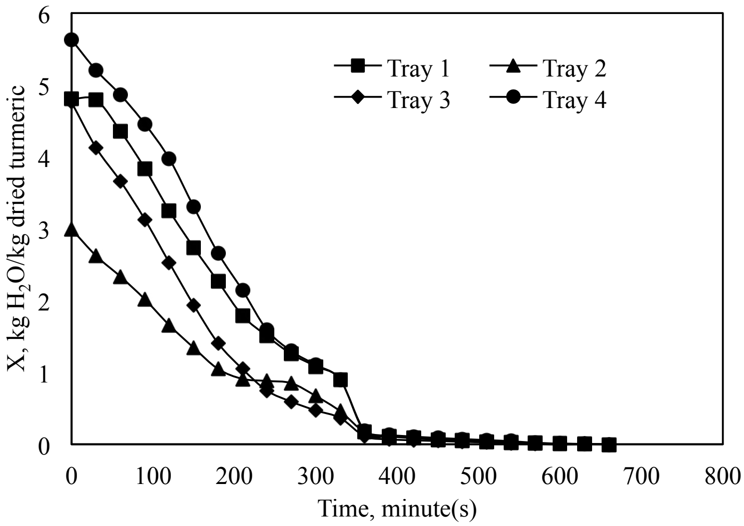


Figure 6. Free moisture content versus time during solar drying

Drying of turmeric at constant rates was indicated by the abrupt linear decrease at the beginning of the drying process. The slope corresponded with the constant drying rate. The steeper the slope the faster the rate of drying was. The differences in these constant drying rates could be due to unsteady temperature profiles (Figure 5) during the rotation of the trays. The calculated constant drying rates of turmeric dried in both solar dryer as well as under the sun are shown in Table 1.

Table 1
Constant drying rate of turmeric

Drying	Tray	Constant drying rate (R_c) [kg H_2O/minutes]
Solar Drying	1	0.01869
	2	0.01863
	3	0.01749
	4	0.01988
Sun Drying	-	0.02442

The constant drying rate of turmeric dried under the sun was a little higher than that dried in the solar dryer. This could be due to more dynamic air flow during sun drying accelerating the drying process during the first period. However, it took 480 minutes for drying turmeric under the sun compared to the time required in the solar dryer of about 450 minutes, until reaching the equilibrium moisture content. This was plausible that the falling rate of turmeric in solar dryer was higher than that of sun drying. Falling rate occurred after the constant rate when rate of water diffusion from the sample surfaced to the air and was higher than the rate of water diffusion from the pores inside the samples to the surface. During the overall drying process, the average temperatures in the solar drying were slightly higher than the air temperature during sun drying. This would then increase the water mass transfer to the air due to the increase gradient between the saturated vapor pressure inside the sample and partial vapor pressure in the air (Geankoplis, 2003). The colours of the samples dried inside the solar dryer were more preserved compared to those dried under the sun based on the visual observation (Figure 7). This result shows the potential use of the solar dryer for drying herbs in order to prolong their shelf life as well as to ensure their quality. To be able to be used in an active mode, the modification of solar dryer should be further developed in order to improve its performance.

(a)

(b)

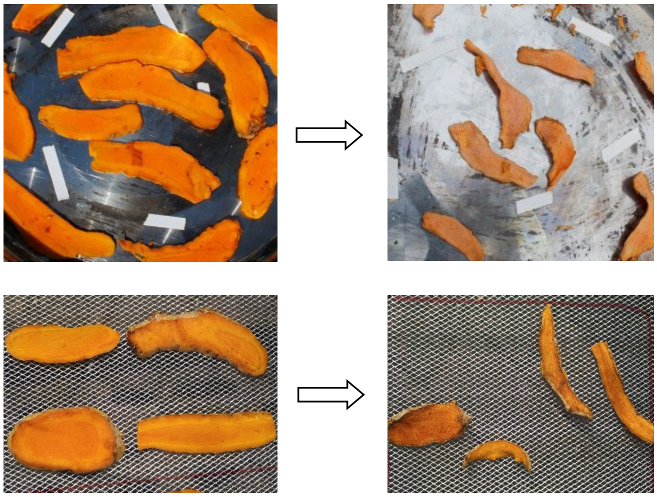


Figure 7. (a) Turmeric (*Curcuma longa*) before and after being dried under direct sun; (b) Turmeric (*Curcuma longa*) before and after being dried in the Self-designed solar dryer

CONCLUSION

Drying of turmeric (*Curcuma longa*) was conducted in a manually designed solar dryer which consisted of four trays. The drying process in all trays was quite similar and the average temperatures on the trays were about 40°C to 41°C. Overall, the drying process of turmeric using the solar dyer was better in comparison to that under the sun in terms of drying time and sample quality. It took about 450 minutes in the solar dryer compared to 480 minutes under the sun for the samples to reach the equilibrium moisture content. The colour of turmeric was better preserved in the solar dryer since the UV radiation did not directly impinge on the samples. Thus, solar dryers should be widely developed and used for producing improved quality of herbs.

REFERENCES

Borah, A., Hazarika, K., & Khayer, S. M. (2015). Drying kinetics of whole and sliced turmeric rhizomes (*Curcuma longa* L.) in a solar conduction dryer. *Information Processing in Agriculture, 2*(2), 85-92.

Geankoplis, C. J. (2003). *Transport process and separation process principles* (4th Ed.). New Jersey, USA: Prentice Hall.

Ministry of Health Republic of Indonesia (1994). *Keputusan menteri kesehatan republik Indonesia nomor: 661/IMENKES/SK/VII/ 1994 tentang persyaratan obat tradisional* [Decree of the minister of health of the republic of Indonesia number: 661 / IMENKES / SK / VII / 1994 about traditional medicines requirements]. Jakarta, Indonesia: Ministry of Health.

Prathapan, A., Lukhman, M., Arumughan, C., Sundaresan, A., & Raghu, K. G. (2009). Effect of heat treatment on curcuminoid, colour value and total polyphenols of fresh turmeric rhizome. I*nternational Journal of Food Science Technology, 44*(7), 1438–1444.

Schweiggert, U., Carle, R., & Schieber, A. (2007). Conventional and alternative processes for spice production - A review. *Trends Food Science Technology, 18*(5), 260–268.

Suyanto, T. A., & Antoro, D. A. (2016). *Desain pengering tenaga surya (solar dryer) untuk pengeringan bahan herbal* [Design of solar dryers (diesel dryer) for drying herbs]. Surabaya, Indonesia: University of Surabaya.

Weiss, W., & Buchinger, J. (2011). *Solar drying*. Austria. Retrieved from http://www.aee- intec.at/0uploads/dateien553.pdf

also developed by scimago: SCIMAGO INSTITUTIONS RANKINGS

SJR Scimago Journal & Country Rank

Enter Journal Title, ISSN or Publisher Name

Home | Journal Rankings | Country Rankings | Viz Tools | Help | About Us

Pertanika Journal of Science and Technology

8

H Index

Country Malaysia - SIR Ranking of Malaysia

Subject Area and Category
Agricultural and Biological Sciences
- Agricultural and Biological Sciences (miscellaneous)

Chemical Engineering
- Chemical Engineering (miscellaneous)

Computer Science
- Computer Science (miscellaneous)

Environmental Science
- Environmental Science (miscellaneous)

Publisher Universiti Putra Malaysia

Publication type Journals

ISSN 01287680

Coverage 2010-ongoing

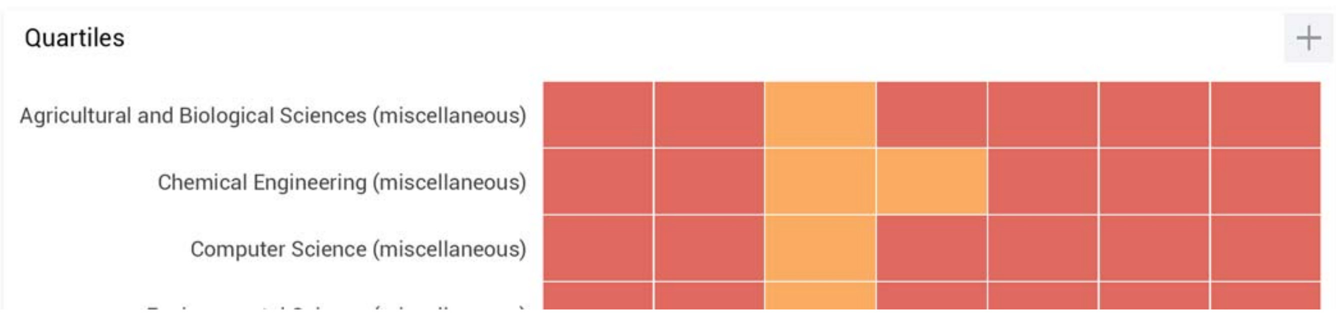
Scope Pertanika Journal of Science and Technology aims to provide a forum for high quality research related to science and engineering research. Areas relevant to the scope of the journal include: bioinformatics, bioscience, biotechnology and bio-molecular sciences, chemistry, computer science, ecology, engineering, engineering design, environmental control and management, mathematics and statistics, medicine and health sciences, nanotechnology, physics, safety and emergency management, and related fields of study.

Homepage

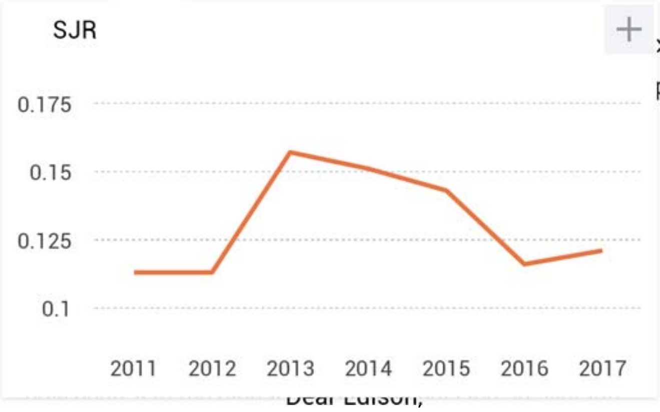
How to publish in this journal

Contact

Join the conversation about this journal

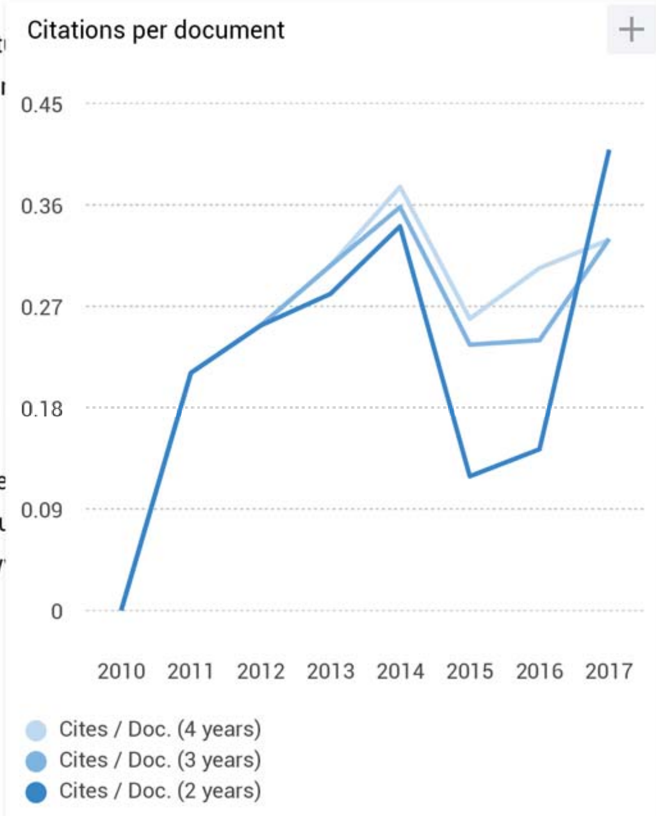


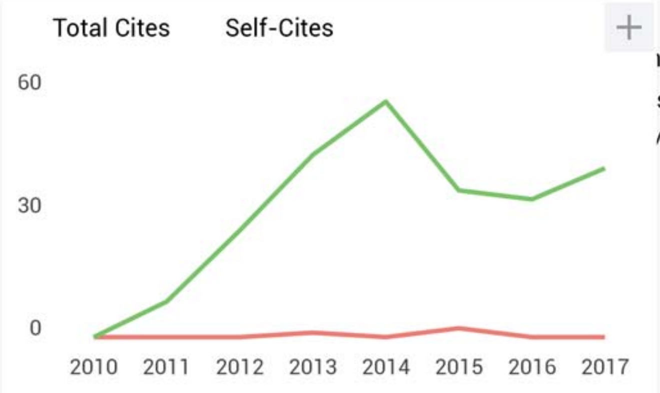
E



cult

p ar

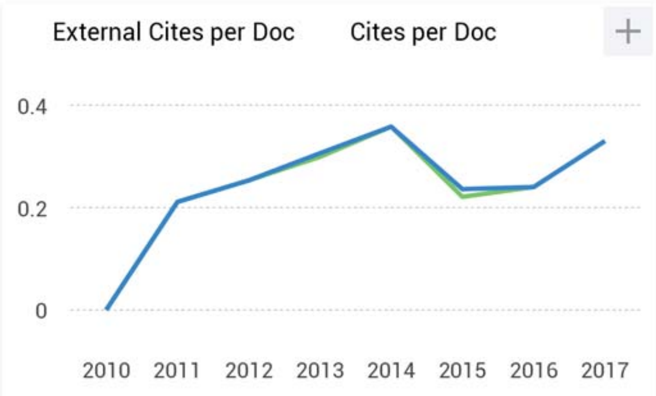


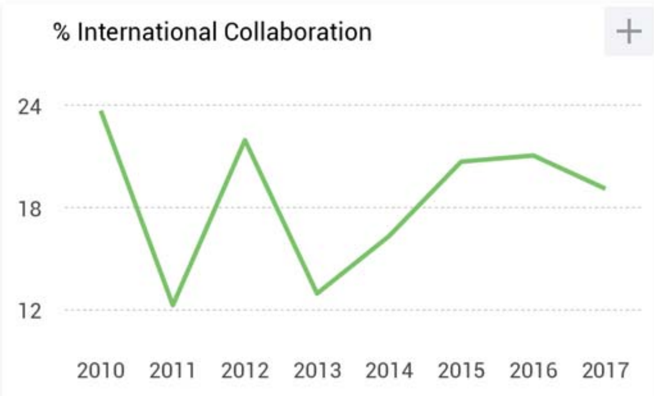


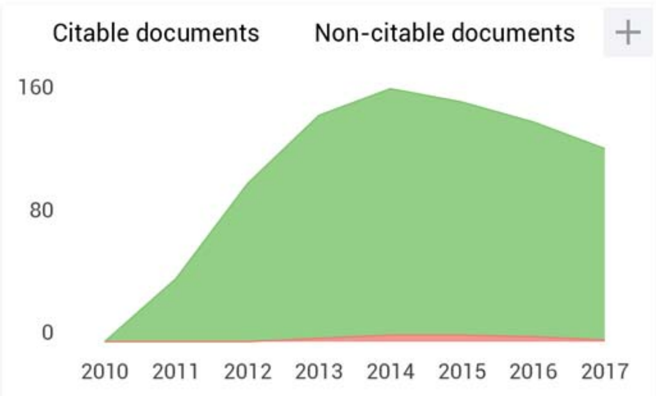
ime

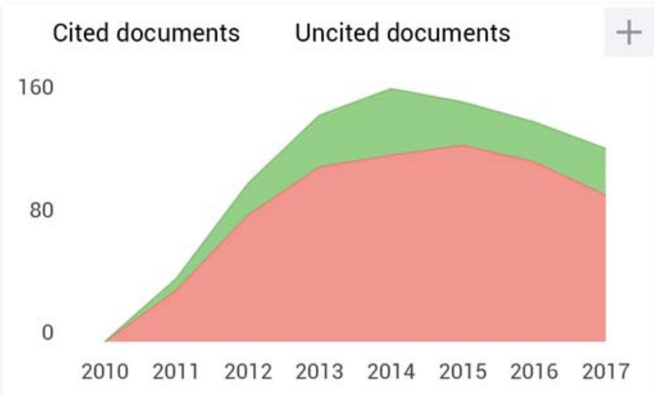
stru

/w









Show this widget in your own website

Just copy the code below and paste within your html code:

possibility to dialogue through comments linked to a

h general doubts about the processes of publication in the