STUDY THE DRYING KINETIC OF FOOD PRODUCTS BY USING SOLAR DRYER AND OPEN SUN DRYING

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A report submitted
In fulfilment of the requirement for the degree of
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DECLARATION

I declare that this project entitled “Study the Drying Kinetic of Food Products by Using Solar Dryer and Open Sun Drying” is the result of my own work except as cited in the references.

Signature : …….

Name : MUHAMMAD SYAMIM BIN MOHD ISA

Date : ……...…….

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : …….

Supervisor's Name : DR. SUHAIMI BIN MISHA

Date : ……..…….

DEDICATION

I dedicate this to my mother Kamariah binti Maidu and my father Mohd Isa bin Kader who have supported me throughout the process. I also dedicated this dissertation to my supervisor for this project Dr. Suhaimi Bin Misha, who always guided me until I completed this study. I will always be grateful for the help that had been given to me.

ABSTRACT

Open sun Drying is one of the oldest preservation processes that still be used until now. However, this way of drying degrades the quality of the dried products due to exposed to dust and pests. Open sun drying had only sun as the source of the energy. Nowadays, many types of solar dryers were produced. Based on a review of literature on the solar drying, there are three types of solar dryers which are direct solar dryers, indirect solar dryers and mixed mode dryers. Although it was said that solar dryer was better than open sun dryer, evidence is needed to prove it. In this report, the drying kinetics of food was investigated in a solar dryer and under open sun dryer. The solar dryer used was mixed mode solar dryer. The mixed mode solar dryer dries the product by direct radiation through transparent cabinet walls and by air heated from solar collectors. Both data for drying product are recorded for each 15 minute. The drying data fitted into different mathematical models of the drying curves. The performance of these models was investigated by comparing the coefficient of determination (R^2), reduced chi-square(X^2) and root mean square error (RMSE) between the observed and predicted moisture ratio. The mathematical model of drying curves used to get the value of predicted moisture ratio. The best model for both drying process had the highest value of coefficient of determination (R^2) and lowest value of reduced chi-square(X^2) and root mean square error (RMSE).

ABSTRAK

Pengeringan sinar matahari secara terbuka merupakan proses pengawetan tertua yang masih digunakan sehingga kini. Walaubagaimanapun, proses pengeringan ini menjejaskan kualiti produk kering kerana terdedah kepada habuk dan serangga perosak. Pengeringan sinar matahari secara terbuka hanya membekalkan matahari sebagai sumber tenaga. Pada zaman ini, pelbagai jenis pengering suria telah dihasilkan. Berdasarkan kajian ilmiah mengenai pengeringan solar, terdapat tiga jenis pengering suria iaitu pengering suria langsung, pengering suria tidak langsung dan pengering mod campuran. Dikatakan bahawa pengering solar lebih baik daripada pengering matahari secara terbuka, namun bukti diperlukan untuk membuktikannya. Dalam laporan ini, pengeringan makanan diuji menggunakan pengering solar dan pengering di bawah matahari terbuka. Pengering solar yang digunakan adalah pengering solar mod campuran. Pengering suria mod campuran mengeringkan produk menggunakan radiasi matahari melalui dinding kabinet telus dan pengaliran udara yang dipanaskan dari pengumpul suria. Kedua-dua data untuk proses pengeringan direkodkan setiap 15 minit. Data pengeringan dimasukkan ke dalam model pengeringan yang berbeza. Prestasi model ini diuji dengan membandingkan pekali penentuan (R^2), *reduced chi-square* (X^2) dan *root min square error* (RMSE) antara nisbah kelembapan yang diperoleh melalui eksperimen dan nisbah kelembapan ramalan diperoleh melalui model pengeringan.diramalkan. Model terbaik untuk kedua-dua proses pengeringan perlulah mempunyai nilai pekali penentuan tertinggi (R^2) dan nilai terendah *reduced chi-square* (X^2) dan *root min square error* (RMSE).

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Cannot be denied the fact that my family is my strength. I would like to take this opportunity to express my greatest gratitude to my mother Kamariah binti Maidu and my father Mohd Isa bin Kader for supporting me.

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LISTS OF ABBREVIATION

H_2O	-	Water
R^2	-	The coefficient
$\chi 2$	-	Reduced chi-square
RMSE	-	Root mean square error
UV	-	Ultraviolet radiation
ML	-	Moisture loss
m_i	-	Initial mass
m_f	-	Final mass
MC		Moisture content
W_i	-	Weight initial
W_d	-	Weight after drying process
MR	-	Moisture ratio
Me	-	Equilibrium moisture content
M	-	Moisture content at any time
Mo	-	Initial moisture content
$MR_{exp,i}$	-	Experimental moisture ratio
$MR_{pre,i}$	-	Predicted moisture ratio
N	-	Number of observations
n	-	Number constants

CHAPTER 1

INTRODUCTION

1.1 Background

Solar energy is the solar radiation that can be transform to other energy such as electricity and heat (Energy Information Administration, 2005). Solar energy is part of renewable energy that can regenerate or inexhaustible. Anyways, the source of solar energy that distributed by sun is unlimited (Duad, 2008). The use of solar energy displaces conventional energy, which is usually a result in a proportional decrease in greenhouse gases emissions.

One of the methods of food preservation is drying process. The purpose of this method is to reduce the water activity in the product. The reduced of water content in a product will affect inhibits the growth of microorganisms, and reduces the reaction, resulting in prolonged product life. In addition, the weight of the product is lighter for transport and saves space. There are many different methods for drying such as sun drying, freeze drying, solar drying, and oven drying (Ahmed *et al.*, 2013)

Important part in dryer food is moisture. It does not meant that the product has to be zero moist. Mostly, all materials contain at least a small volume of moisture. Moisture product can be determine by the mass of materials, however the relative percentage is dynamic and therefore it unfixed. The amount or volume of water in a material or substance is what it called as moisture content. The complex intermolecular bonding properties within

the substance matrix make the H_2O difficult to measure. Therefore, the water content of a sample material is then referred to as moisture content.

The important factor in drying technology is the mathematical modeling of the process and the preparation of the experiment (Doymaz, 2014). The problem solving based on mathematical terms which is using mathematical formulations to study the effects of different components and then make predictions. It is basically based on the design of the set of equations to describe the system as accurately and clearly as possible. Specific product drying features and mathematical models are required in the design, construction, and operation of drying systems. Mathematical modeling can help to find problem solution, understanding the system and produce the better design or control of a system.

1.2 Problem statement

Solar energy has become widely used in the food drying industry. This process save more costs because using sunlight as power source and less usage of electricity. Process open sun drying exposed to dust and pests will harm the quality of product. In this study, two process will be done using open sun and solar drying machines. The performance of drying process is difficult to be observed and analysed. The use of drying curve will be more effective to compare and determine the most efficient of drying method. Mathematical modelling will be used to get the drying curves. The coefficient (R^2), reduced chi-square ($\chi 2$) and root mean square error (RMSE) are needed for selecting the best model to describe the drying curve.

1.3 Objectives

The objectives of this project are:

i. Determine the moisture content of the food product
ii. Conduct experiment to dry food product using existing solar dryer and open sun drying
iii. Select the appropriate mathematical modelling for drying kinetic of the product

1.4 Scope

To achieve this main of the research, many references need to be use related to drying process. The study also focuses on the moisture content needed in the food product. Other than that, the time for the experiment will depends on the weather. This project can be carried out in good weather only as it depends on sunlight. Next, about the food product. The suitable food product will be selected for drying process such as mee wantan, fish cracker, apple or egg. Finally, a comparison process of drying between solar dryer and open sun dryer by using mathematical modelling.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Drying is defined as the process of moisture removal due to simultaneous heat transfer and mass (El-Sebaii and Shalaby, 2012).Drying is a old method of food preservation, such as vegetables, fruits, fish, grains and others (S. and Bala, 2012).Sun radiation, ambient temperature, wind speed and relative humidity are important factors in this process. However, other factors such as the initial moisture content, crop type, crop absorption, and product mass per unit area are exposed. The methods of drying under open sun for food preservation have been practiced since ancient times (Sharma, C. R. Chen and Lan, 2009). The removal of moisture from a product occurs due to the difference in vapor pressure caused by the product and the surrounding medium (Sahdev, 2014). Moisture from the inside absorbs to the surface of the product to fill the evaporated surrounding moisture. The Figure 2.1 demonstrate the process of sun drying work (Okhtay, Ghasem and Farokh, 2014). This is the first method used to preserve agricultural products, grains, fruits, fish and others. The product will be sown on land exposed to sunlight.

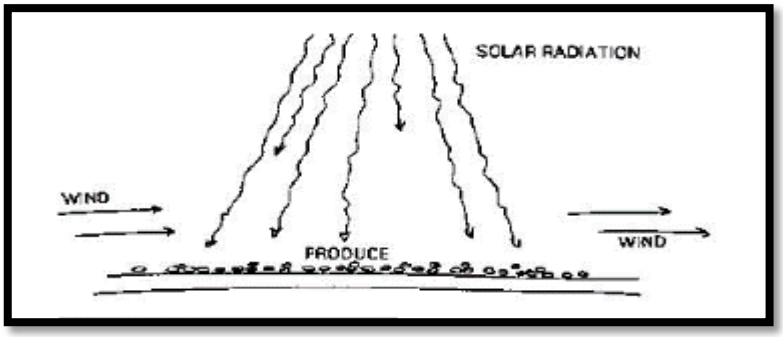

Figure 2.1 Process of Sun Drying (Okhtay, Ghasem and Farokh, 2014)

2.2 Drying Kinetic

Drying kinetic is the activity of movement of moisture content in the material. In general, it can be inferred as a decrease in moisture content. Drying kinetics is a representation of the drying rate versus drying time or moisture content (Bennamoun, 2019). The drying kinetics of food are complex phenomena and for some products are rare in literature because not all foods have been tested using drying. Kinetic drying is used to express the process of moisture removal and its relation to process variables. Therefore, a good understanding of the drying rate is important to develop a drying model (Gupta, S.V. and Patil, 2014).

2.3 Sun Drying

The easiest way to dry agricultural products, fruits, vegetables or whole grains is by sun drying. In this method, the product is placed on the soil in a thin layer exposed to sunlight and dried until get the required moisture content needed (Sahdev, 2014).

Process Open Sun Drying show that not all the sunlight falling on the surface is absorbed but it is also reflected as shown in Figure 2.2. The absorbed radiation and surrounding air help to heat the surface. This heat is also used to evaporate moisture from the surface into the surrounding air. The part of this heat is lost through long wave length

radiations to the atmosphere and conduction to the ground (Sahdev, 2014). The using of open sun drying processes due to low capital, not high in operating costs and little expertise is required. The fact is open sun drying only possible in areas with sunny weather. The open sun drying process is not protected from rain, wind and dust. This process also often get disturb by insects and other animals. This will cause the quality to fall such as the color and vitamin content of some fruits and vegetables (Patel, Shah and Bhargav, 2013).

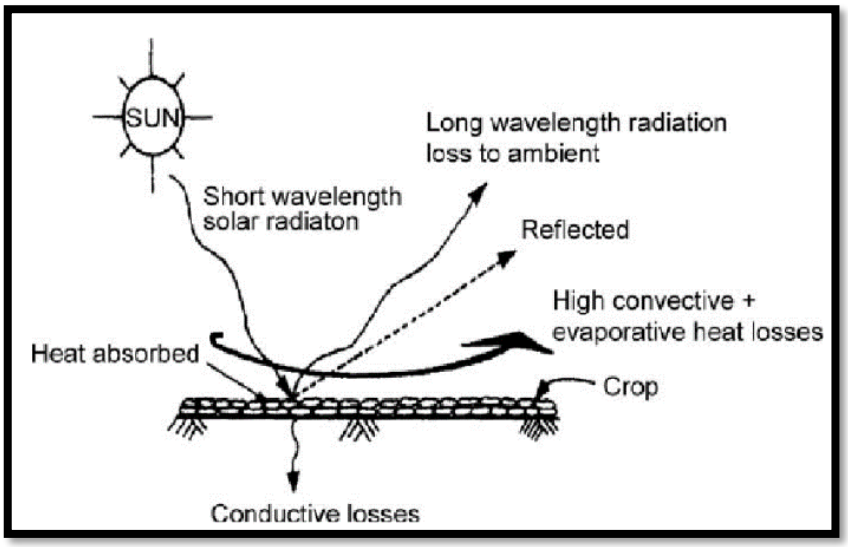

Figure 2.2 Process Open Sun Drying

2.4 Solar Drying

Open sun drying has many limitations and the use of modern drying technology is not economical for drying agricultural produce. Therefore, solar drying systems as an alternative to open sun dryers have been developed to dry agricultural produce. Solar drying is achieved by direct sunlight. Solar energy received by a drying chamber depends on the time of daylight, climate, weather, atmospheric purity, and location (Dhumne, Bipte and Jibhkate, 2015).

Figure 2.3 show that the inside of the dryer is coated with black or black absorbent material. So the drying process will be faster. Although, the cold air flows from below but sunlight will warms air inside it. Then, the warm air goes up and leaves the chamber. On sunny days, the sunlight dependent on the angle of the sun relative to horizon (Fodor, 2006).

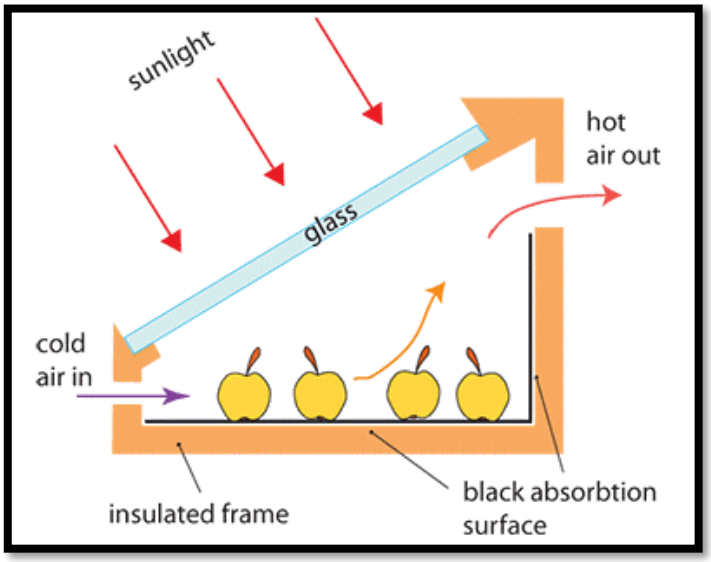

Figure 2.3 Concept of Solar Dryer

Solar energy is free, renewable, abundant, and environmentally friendly. The two basic limitations faced by solar dryers are sunlight and weather conditions. The advantages and disadvantages of this process are shown in the Table 2.1 (Toshniwal and S. R Karale, 2013).

Table 2.1: The Advantage and Disadvantage of Solar Drying System

Advantages	**Disadvantages**
1) Better Quality of Products are obtained 2) It Reduces Losses and Better market price to the products. 3) Products are protected against flies, rain and dust; product can be left in the dryer overnight during rain, since dryers are waterproof. 4) Prevent fuel dependence and Reduces the environmental impact 5) It is more efficient and cheap.	1) Quality of products are not obtained in some cases. 2) Adequate solar radiation is required. 3) It is more expensive Require more time for drying.