جامعة الشهيد حمّه لخضر - الوادي
Université Echahid Hamma Lakhdar - El-Oued

People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

Echahid Hamma Lakhdar University, Eloued

Faculty of Science and Technology

Department of Renewable Energies InMechanical

théme

study of the effect of flow direction on drying kinetics

Dissertation submitted in Partial Fulfillment of the Requirements

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Submitted By:

- DOUDI Abde Nasser
- AD Mohammed
- SMAMA Brahim

Supervisor

* A. Lauoini

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Acknowledgment

My thanks go first of all to Almighty God for the will, the health and the patience that he gave me to finish this modest work. I thank my supervisor A.LAOUINI who helped me, directed and directed towards the success.
I also address my thanks to the the members of the jury And all the researchers of the research unit in the renewable energies center in the desert
Thank you also to all the people who have contributed, near or far.

Finally, thank you to all our loved ones.

Dedication

In the name of the love we feel in both

People around me who are still with me

Tightly backed throughout this long journey.

To our dear parents who have always been Anurone

The way of life reaches me

Throughout our school years,

"Oh GodKeep. "

For our whole family.

To all our friends and loved ones.

Summary

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GENERAL INTRODUCTION

GENERAL INTRODUCTION

During most of the year, Algeria receives a lot of sunshine. It benefits from an average annual sunshine period of about 2,500 hours, and receives on a horizontal level an average daily solar energy of 16.2 to 27 MJ / m2[1]. This energy is sufficient to meet the energy demand for drying agricultural products, especially in summer [2].

The rising prices and fuel shortages have led to in-depth studies and research into the use of solar energy as an alternative source of energy, particularly in developing countries.

The most commonly used solar energy device has been considered solar drying, as a way of preserving food. Drying fruits, vegetables and meats is one of the most important processes of energy consumption in the manufacturing industry

Food which is a great way to reduce post harvest expenditures which losses [3].

In the open air (direct exposure or sun) for millennia, solar drying of crops, fruits, vegetables and meats has been practiced all over the world. It has been used for the drying of wheat, vegetables , meats, fish and other consumer food items. Most of the world's supply of dried fruits and vegetables remains historically dried (direct exposure or sunlight) without technological assistance. Large-scale output does, however, restrict the use of standard outdoor drying. The conventional drying method suffers from many problems including lack of capacity to properly monitor the drying process, time variability, high labor costs, need for large areas, contamination with insects and other foreign bodies.Solar energy solutions have come up with collecting machines, or solar dryers [3].

A properly built solar dryer will ease the inconvenience of open sun drying, and enhance the dry (final) product qualities. The modelling of solar drying of agricultural products has been studied by many scientists and there are also simulation studies of solar dryers (direct, indirect) and the actions of different vegetables and fruits,

characterized by drying kinetics.

The goal of this experiment is to research the effect of certain parameters on the drying kinetics of certain food products used in agriculture (paprika, potatoes and peas) in order to establish separate curves. Drying of the experimental results carried out at the Hama Lakhdar University experimental site. Use indirect solar dryer with forced load.

This work has four chapters.

The first chapter presents a study related to the solar field.

The second semester is devoted to studying the types of solar dryers, solar collectors.

The third chapter is devoted to identifying the equipment and tools used during the drying process.

The fourth chapter is devoted to the experimental tests conducted on the solar system that were conducted according to the description and the results mentioned.

CHAPTER: I

THE SOLAR FIEL

I.1 Introduction

The sun, water, wind, wood and other plant products have as many natural resources capable of generating energy thanks to man-made technologies; their low environmental effect makes them energy sources. Future faced with the nuclear waste disposal dilemma and greenhouse gas emissions.There are various types of renewable energies that are inexhaustible energy sources such as solar , wind, hydropower , biomass, and geothermal. Their common features are that they do not contain polluting emissions and thus help counter the greenhouse effect.

In this chapter we will first concentrate on some scientific notions about solar radiation (sun, existence, strength, etc.), the various physical processes of radiation, the composition of the atmosphere and these effects on solar radiation. Thus, the various components of solar radiation.

I.2Definition SOLAR ENERGY

Solar energy is radiation from the sun capable of producing heat, causing chemical reactions, or generating electricity. The total solar energy utilization on Earth is significantly greater than current and projected energy requirements in the world. If appropriately harnessed, this highly popular source has the potential to meet all futureenergy needs. In the 21st century, solar energy is expected to become increasingly attractive as a source of renewable energy due to its inexhaustible supply and unspoiled nature, in stark contrast to limited fossil fuels, coal, petroleum, and natural gas.

Solar energy is a renewable resource and does not emit any greenhouse gases in the energy generation process. In addition, sunlight varies by geographical location,season and time of day, which creates restrictions on its use .[4]

I.3 Source of solar energy

The main source of energy is the sun, it is a star in the solar system closest to the earth situated at a distance of approximately 150 million kilometers from the planet, and the sun releases enormous quantities of energy which, after traveling this distance, reaches the earth's surface, emits a radiation that can be assimilated in the first approximation to that of a black body at 5800 ° k.This radiation released by the sun in the form of electromagnetic waves, which continues to enter us for about 8 minutes. Its light, at a speed of 300000km / s, is located in the wavelength band between 0.25 and 3µm 98 percent of the energy emitted.[4]

On the human level, the sun is of paramount importance because it is at the origin of life on earth, providing it with huge amounts of energy called enlightenment whichresponsible for the environment and meteorological phenomenon is solar ra.diation[5]

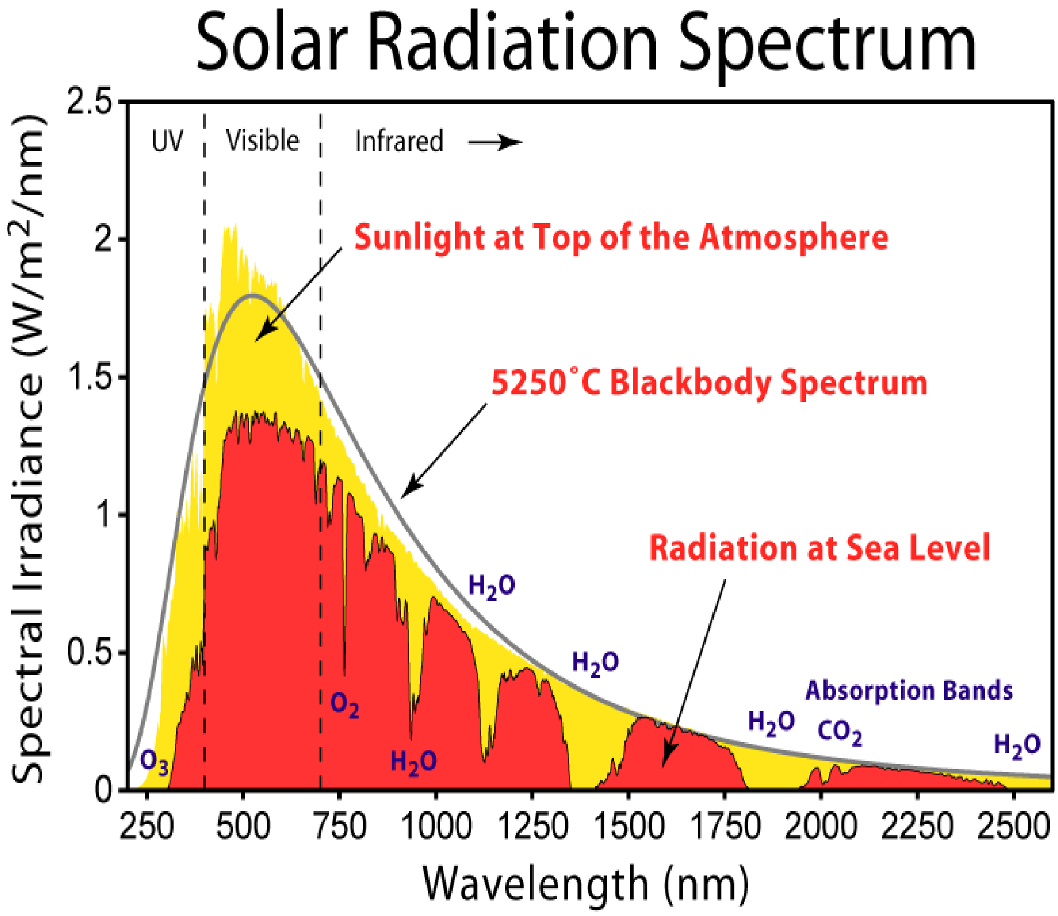


Figure I.1: Solar radiation spectrum

I.4 Solar energy technologies

This section describes the three technologies for converting solar energy; photovoltaic (PV), solar heating and cooling (SHC) and concentrated solar energy (CSP). The two technologies (SHC, CSP) have received great attention in many industrial countries for better navigation on the food dryer.

a. Photovoltaic

Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid.

PV devices can be used to power anything from small electronics such as calculators and road signs up to homes and large commercial businesses.

b. Solar Heating & Cooling

Solar heating & cooling (SHC) technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications. These technologies displace the need to use electricity or natural gas. Today, Americans across the country are at work manufacturing and installing solar heating and cooling systems that significantly reduce our dependence on imported fuels. We need smart policies to expand this fast; growing, job; producing sector. The U.S. Solar Heating & Cooling Alliance is adivision of SEIA focused on growing the solar heating & cooling market through reducing barriers and advocating for policies on the federal, state, and local levels.

c. Concentrating Solar Power

Concentrating solar power (CSP) plants use mirrors to concentrate the sun's energy to drive traditional steam turbines or engines that create electricity. The thermal energy concentrated in a CSP plant can be stored and used to produce electricity when it is needed, day or night. Today, roughly 1,815 megawatts (MWac) of CSP plants are in operation in the United States.

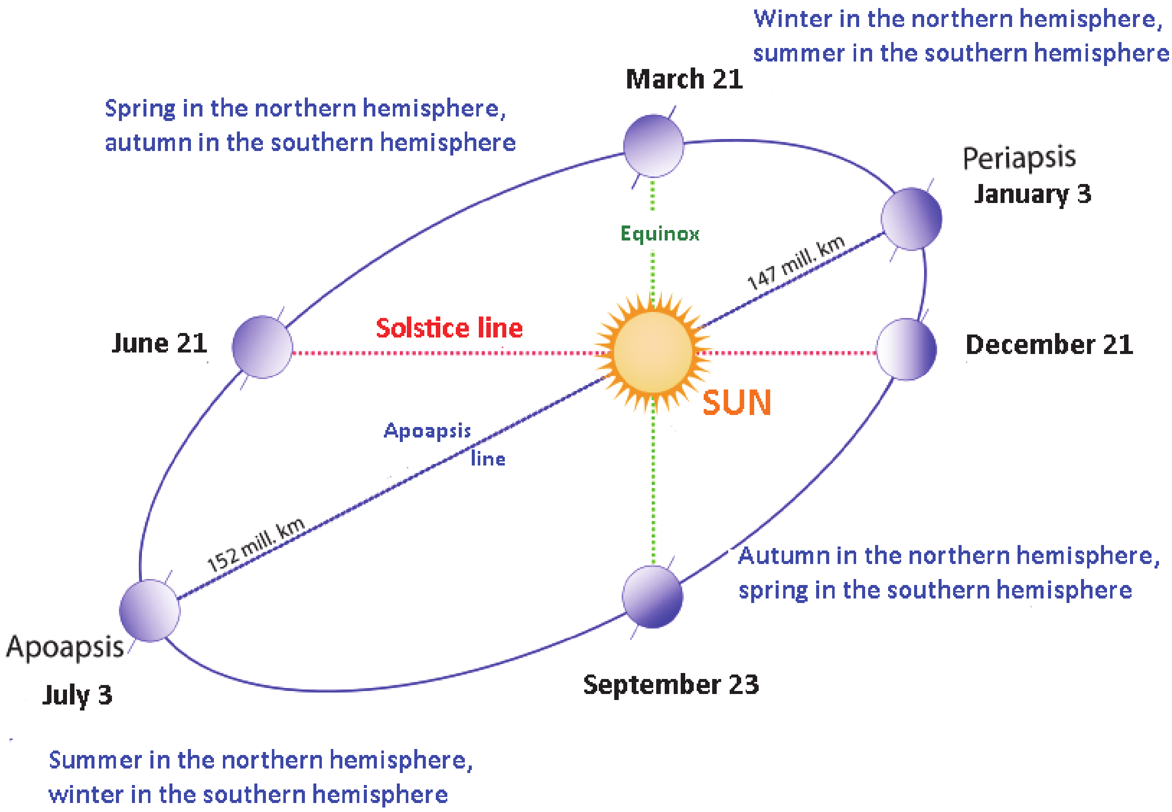
I.5 Earth movements around the Sun

In one year the Earth orbits around the Sun, in a plane called a "ecliptic." The Planet rotates on itself for 365.25 days, as it orbits the Sun in the same direction (FigureI.2). The Earth's axis of rotation remains parallel to itself throughout this annual revolution, but is tilted 23.5 ° from the normal to the ecliptic plane.

The Earth's passage around the Sun takes place at an angular velocity of about 30 km / s, creating a trajectory of around one billion kilometers per year. From the Earth's North Pole's point of view, this latter flies counterclockwise in its orbit. At midday this direction corresponds to the west of an observer situated on the Earth's equator.

The Planet is nearest to the Sun in the winter solstice (December 21): 147 million km and in the summer solstice it is the furthest: 153 million km, with an average distance of 149.5 million km. During the equinoxes of spring (February 21) and fall (September 21) the planet intersects the minor axis of its orbit. It turns on itself over a 24 hour cycle. Its rotation axis (the axis of the poles) has a fixed orientation in space, it makes an angle to the normal of the ecliptic plane[6].

The Earth's axis of rotation upon itself is inclined relative to the celestial ecliptic pole. The angle formed by the Earth-Sun axis with the equatorial plane is called declination. The variation ranges from +23o27 summer solstice (June 21) to-23o27 winter solstice (December 23), canceled twice a year on February 21st.And September 23 (these are the equinoxes), and the seasons are responsible. Then the diurnal and nocturnal parts of the day at the equinoxes have the same duration; the decline goes through 0o (-23o27 <<< + 23o27)[7].



FigureI.2: Movement of the earth around the sun

I.6 Position of the sun in relation to the earth

It is possible to determine the position of the sun in the celestial vault depending on the time and the position of the observer on the earth.

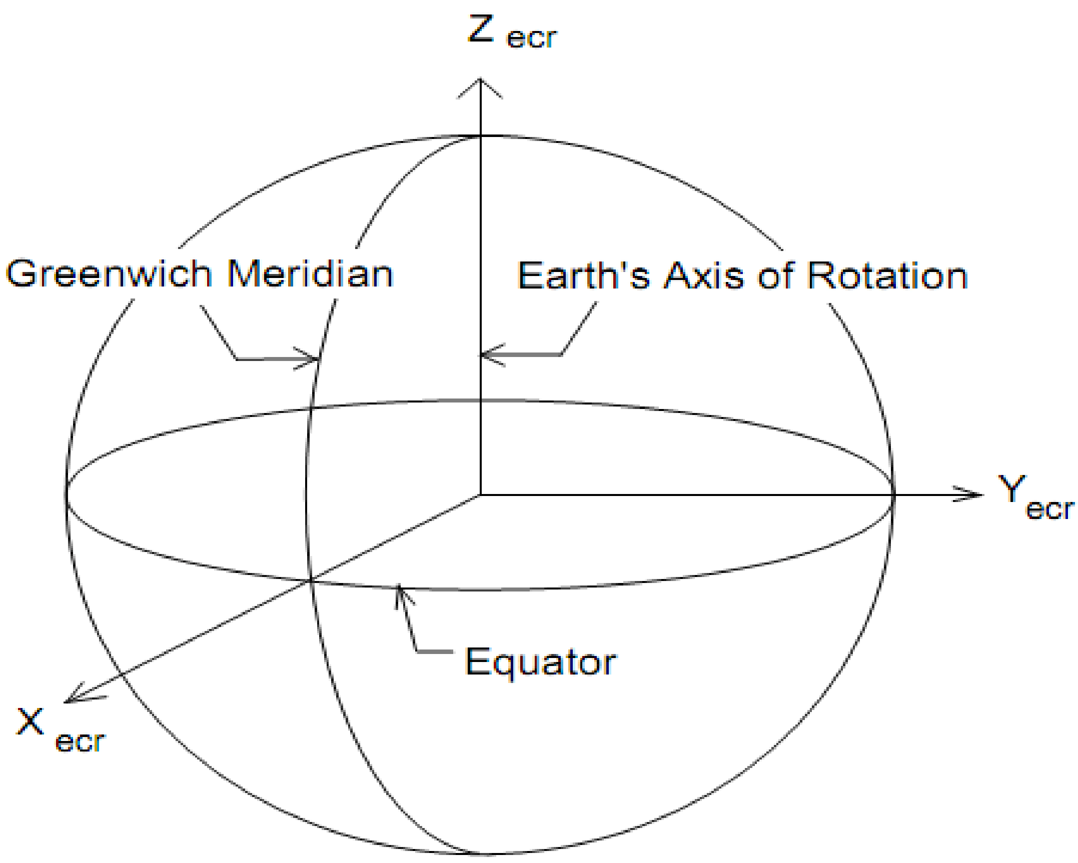
I.6.1 Locating a site on the surface of the earth

To locate a given site on the earth's surface, the following quantities are defined:

*Latitude (θ) is the angle θ that the vertical of the place makes with the equatorial plane. If θ> 0, the site is in the northern hemisphere, otherwise the site is in the southern hemisphere (FigureI.3).

*Longitude (φ) is the angle φ formed by the Greenwich meridian and the meridian of the place in question. Longitude is between -180 (west) and +180 (east). As the earth takes 24 hours to make a revolution on itself (360 °), each hour represents 15 ° of longitude deviation and therefore, each degree of longitude represents 4 minutes .

The altitude (z) is the vertical distance expressed in meters, separating the considered point of the terrestrial relief from the sea level, taken as a reference surface [8].



FigureI.3: Terrestrial coordinates

I.6.2 The apparent path of the sun

The position of the sun in the celestial vault is identified at any time of the day by two coordinate systems:

a) Equatorial coordinates

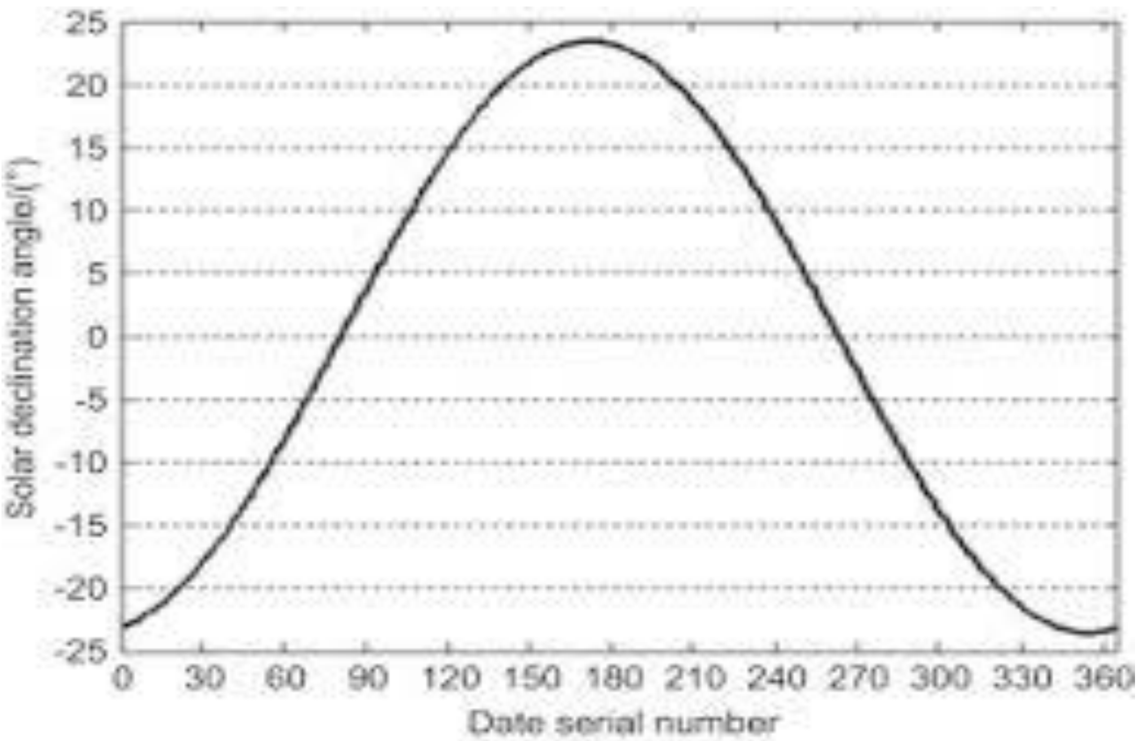
Equatorial coordinates are independent of the observer's position on earth, but they are related to the time of observation. The position of the sun is expressed by two angles which are:

*The declination δ

This is the angle formed by the direction of the sun and the equatorial plane, the declination varies sinusoidally during the year (FigureI.4). Several expressions have been developed to evaluate the declination, the simplest is the one used by Cooper [6].

$$\delta=23.45\sin 360365(J+284) \quad (I.1)$$

Where is the day of the year number from 1 to 365. The following figure shows the change in solar declination depending on the day of the year [18].



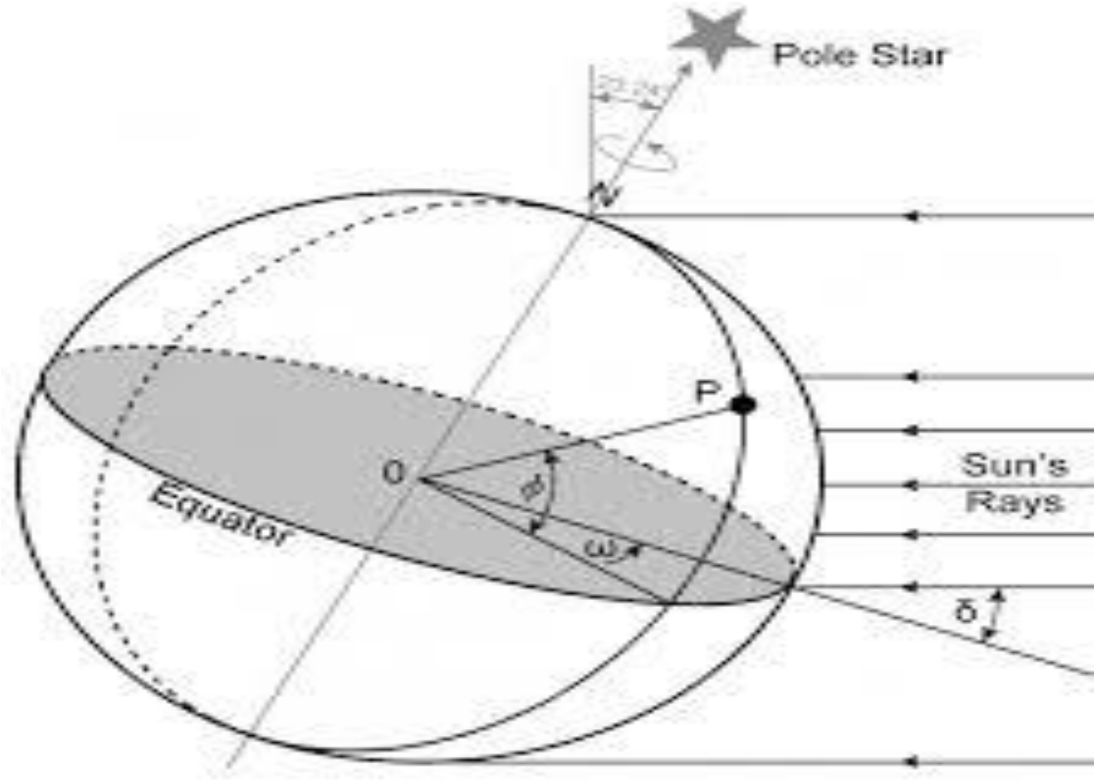
FigureI.4: Solar declination according to the day of the year

*The hour angle ω

The hour angle measures the movement of the sun with respect to noon which is the moment when the sun passes to the meridian plane of the zenith place. This angle is formed between the projection of the sun on the equatorial plane at a given moment and the projection of the Sun on this same plane at true noon. The hour angle is given by the following relation [10]:

$$\omega= 15(TSV- 12) \quad (I.2)$$

Where TSV is true solar time.



FigureI.5: Hour angle ω of the sun

b) Horizontal coordinates

The sun is identified by the following magnitudes:

*The angle of the solar height γ

It is the angle between the direction of the sun and the horizontal planeγ varies from 0 ° to 90 ° towards the zenith and from 0 ° to -90 ° towards the nadir. The angle of the solar height is given by [8].

$$\text{Sin}\ \gamma = \sin\theta \sin\delta + \cos\theta \cos\delta \cos\omega \quad \text{(I.3)}$$

*azimuth ψ

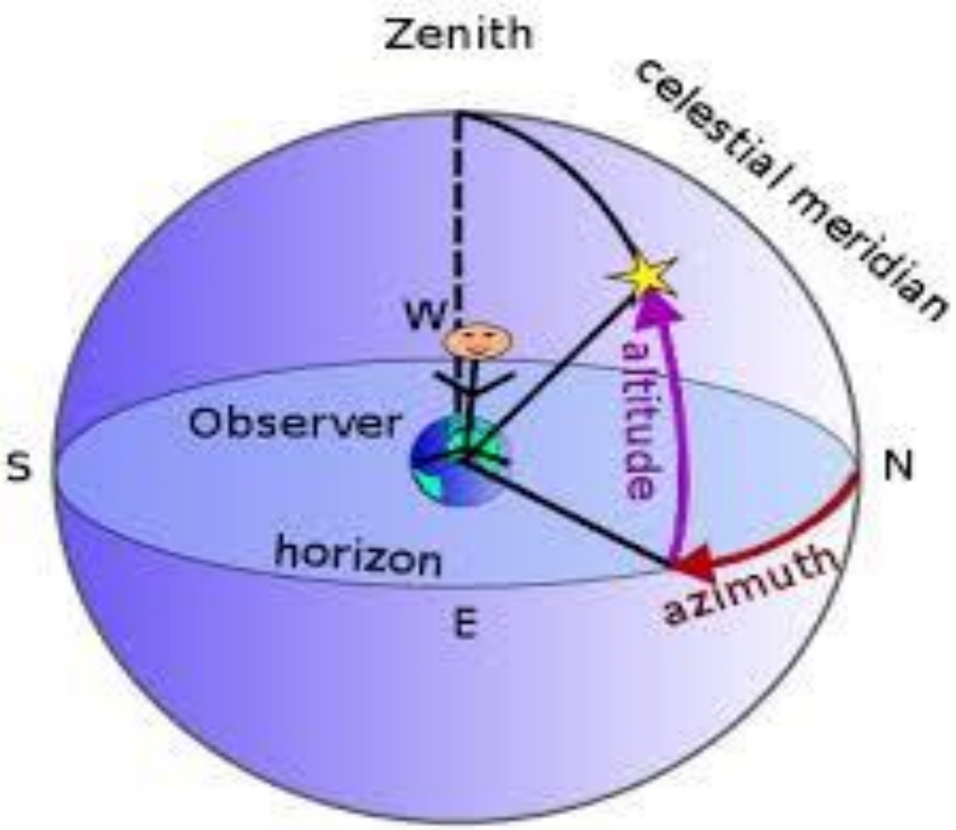
The azimuth is the angle between the vertical plane containing the solar ray and the south direction. It is counted from 0 ° to 360 ° from the south in the retrograde direction. The relation which gives the azimuth is given below:

$$\cos\psi = (\sin\gamma \sin\theta - \sin\delta \cos\gamma \cos\theta \quad \text{(I.4)}$$

*The zenith distance Z

It is the angle between the direction of the sun and the vertical of the place (zenith). The angle Z is complementary to γ [11]

$\cos Z' = \sin\delta \sin\theta + \cos\delta \cos\theta \cos\omega$ (I.5)



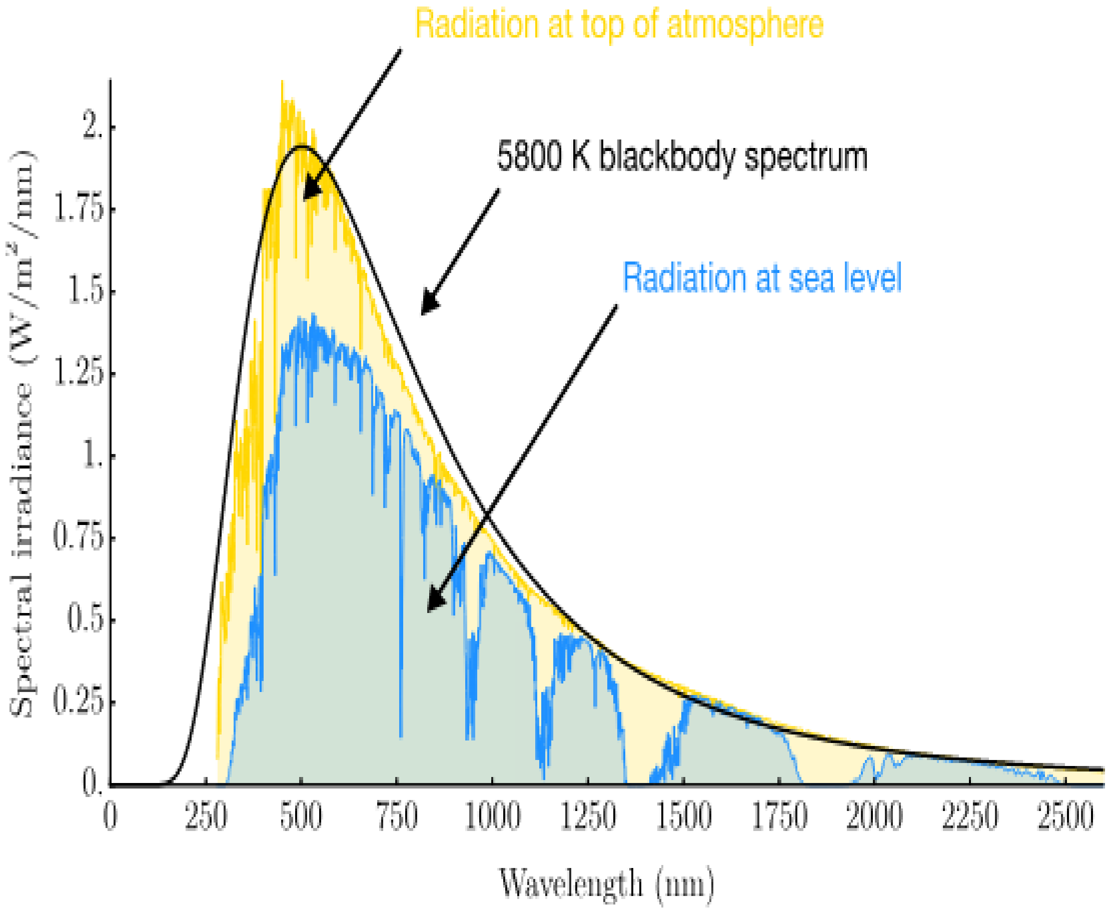
FigureI.6: Solar coordinates according to the horizontal coordinate system

I.6.3Solar radiation spectrum

The Sun's emission of electromagnetic waves is correctly modeled at 5800 kelvin by a black body, and thus can be represented by Planck 's law. The main emission is in the green (π = 504 nm), and the radiation distribution is about half in visible light, half in infrared, with an ultraviolet 1 per cent.

Having reached sea level, that is, having traversed the whole atmosphere of the Earth, most of the solar radiation was absorbed. In particular, on the opposite spectrum, we can see the absorption bands for ozone (which absorbs a significant portion of ultraviolet rays), oxygen , carbon dioxide and water[7].

The solar radiation obtained at the top of the atmosphere, in a plane perpendicular to the solar rays and equal to its average value for an earth-sun point. When this radiation enters the atmosphere to enter the surface of the planet, it is greatly attenuated by the different constituents of the latter due to the absorption and diffusion phenomena.



FigureI.7: Spectral distribution of solar radiation

I.6.4 Earth-sun distance correction factor

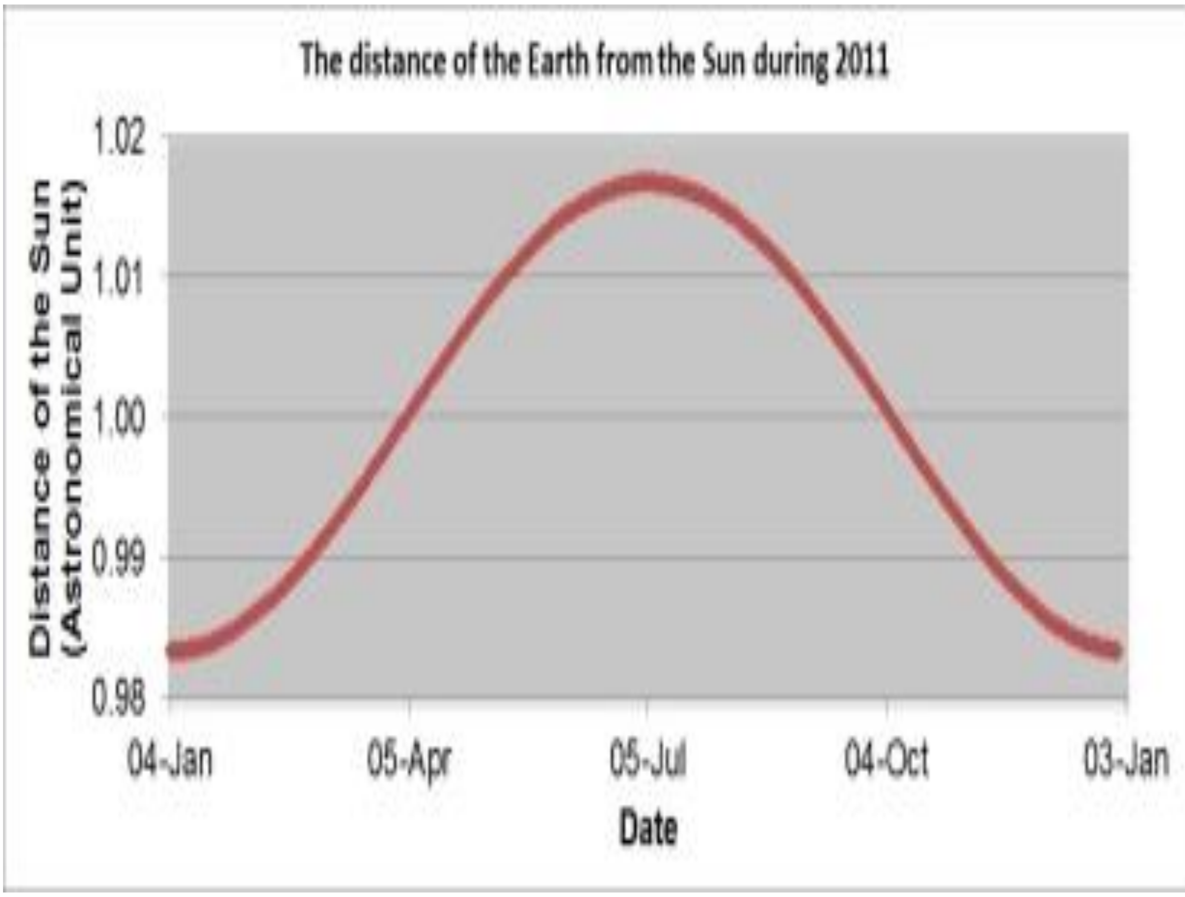
During a revolution, the distance between the earth and the sun varies significantly due to the elliptical path of the earth around the sun (see figuresI.2 andI.8). This factor depends on the number of the day of year J from 1 to 365, which is determined using TableI.2, and knowing the number of the day in the month, we calculated the correction factor for the earth-sun distance. (Ct-s) corresponding using equation [12]:

$$Ct{-}s=1+0.034\cos(0.986J'-2)) \qquad \text{(I-6)}$$

with:

$J''=2\ \pi J/365.25$

J: The number of the day of the year from January 1.



FigureI.8: Variations in the distance of the earth-sun during the year [13]

*Sunshine duration

The sunshine duration of day S0 is the time from the sunrise moment, until sunset, in the absolute absence of clouds, this time equal to the astronomical length of the day, is easily obtained by the following equations in relation to the angle hourly:

$S0=(\frac{2}{15})\omega$ (I.7)

*Extraterrestrial solar radiation

Extraterrestrial solar radiation (outside the atmosphere) is solar radiation which hits the atmospheric layer surface. The following equation is given for getting the global solar irradiation (G0: W / m2 / day) on a horizontal surface at the upper limit of the atmosphere:

$G0=24\pi g0(\cos\theta\cos\delta\sin w+\sin\theta\sin\delta\pi 180w)$ (I.8)

$g0=I0(1+0.033\cos 360.J365)$ (I.9)

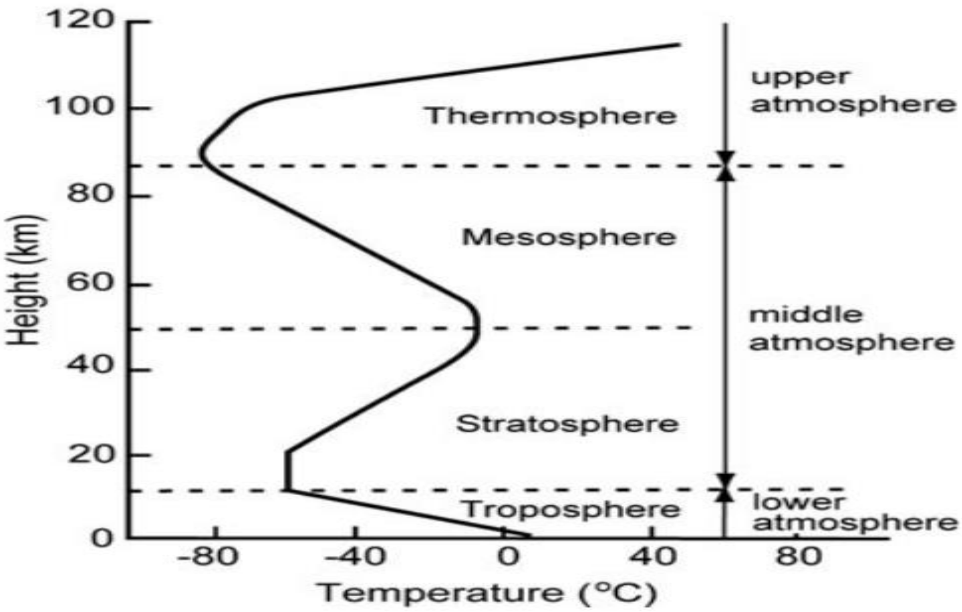
With
I0: Constante solaire (W/m2)

I.7 Solar radiation passing through the atmosphere

I.7.1 The atmosphere

The atmosphere is made up of layers superimposed on each other. From the ground, we can distinguish the troposphere, the stratosphere, then the mesosphere, followed by the thermosphere (FigureI.9).

Dry air is composed of 78% nitrogen, 21% oxygen, 0.9% argon and 0.03% carbon dioxide (CO_2) and gases whose concentration varies spatially and over time. , such as water vapor H_2O, carbon dioxide CO_2 ... etc., Each of the constituent gases of the atmosphere absorbs radiation in selective wavelengths thus delimiting numerous absorption bands. We add to this the aerosols which are particles either of natural origin, such as sand, rain, ice crystals or volcanic dust, or of artificial origin such as those produced by industry, cars or vehicles. heating [7].



FigureI.9: The vertical structure of the atmosphere

I.7.2 Attenuation of solar radiation

The atmosphere modifies the spectrum of solar radiation through absorption processes by different gases, diffusion by air molecules, aerosols and clouds.

a) Atmospheric absorption

Atmospheric gas absorption is known to be limited, since it only affects very particular duration radiations. The key explanation for this is water vapor (H2O), ozone (O3), oxygen (O2), and carbon dioxide (CO2).

Water vapor, the most essential after-air constituent, exhibits many bands of absorption at wavelengths greater than 0.65 µm. The band is the broader, varying from 2.4 to 2.8 µm. Also, absorption is the highest at this level.

Specific water vapor absorption is about 10 percent.[14]

b) Diffusion

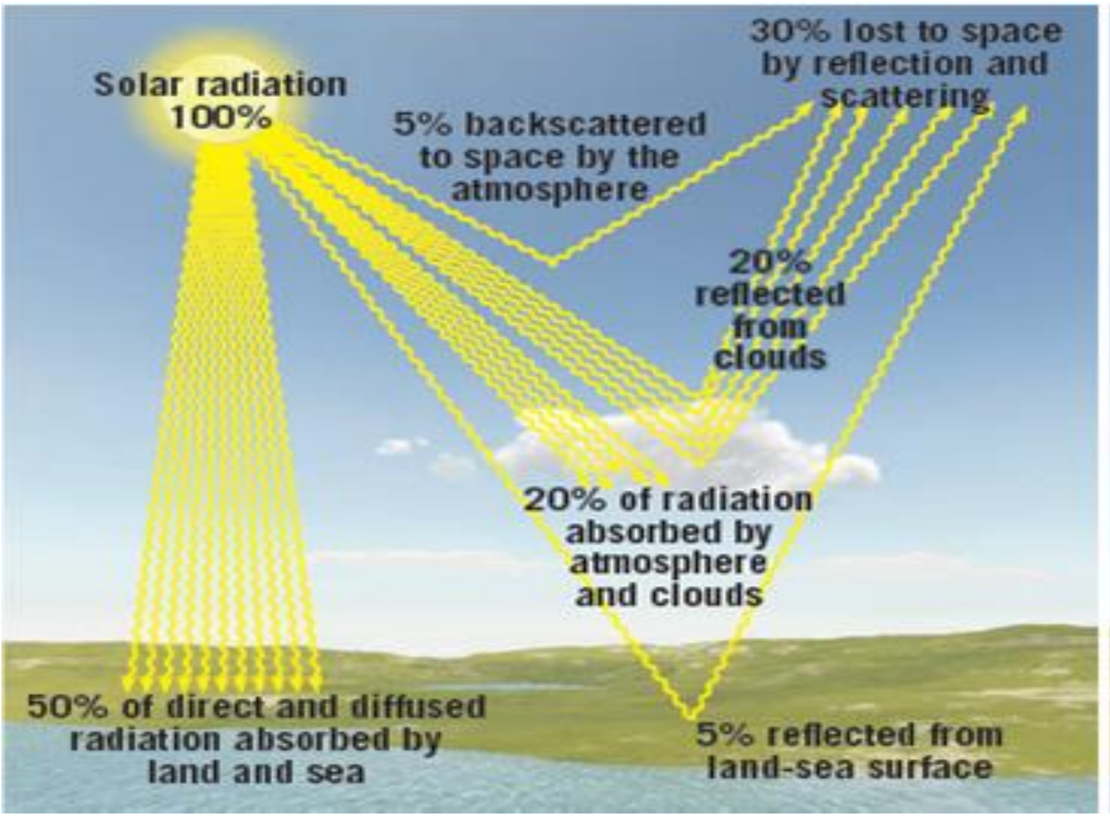
Diffusion is a transfer of solar radiation that interacts in all directions with gas bubbles, droplets and aerosols, without altering wavelength. Two types of scattering can be differentiated, depending on the size of the scattering particles in relation to the wavelength of the incident radiation: Rayleigh scattering and Mie scattering.

Rayleigh scattering specifically affects clean , dry air molecules, such as nitrogen and oxygen. It is selective scattering caused by particles which have a much smaller diameter than the wavelength of the incident. On average, taking into account the path of the sun and the various wavelengths, Rayleigh is scattered about 13 percent of incident solar radiation The coefficient of extinction characterizing this form of dispersion is given by the following relation[15]:

$Kr\lambda$=0.008735λ−4(I.10)

The phenomena of absorption and diffusion by the clouds significantly reduce the radiation received on the ground particularly for the wavelengths greater than 1 µm. Clouds are particles whose dimensions are far greater than the lengths of ultraviol waves.Thus cloud scattering is independent of wavelength in this region of the solar spectrum[16].

The rate of cloud attenuation depends primarily on its thickness, composition, and distribution in the atmosphere. A layer of clouds can reflect incident radiation back into the atmosphere, as thin as possible. As for cloud absorption of radiation, it is less pronounced. The thickest clouds only consume about 8 percent of the energy from the incident. Figure I.10 shows the contribution of several particular phenomena.



FigureI.10: Processes of transmission, absorption, scattering and reflection in the atmosphere

I.7.3 Clouds

A cloud is made up of millions of tiny drops of water or ice crystals if the air temperature is very low, floating in the air.

A cloud forms when water vapor becomes liquid, that is, when humid air cools and the vapor condenses on tiny particles.

Clouds can be divided into three categories according to the characteristic level of appearance:

low clouds, mid-level clouds (mid-level clouds) and high clouds capping at altitudes around ten kilometers.

Meteorologists have thus identified a limited number of characteristic shapes depending on the altitude and the formation conditions [17].

I.8 Conclusion

The aim of this chapter was to present the essential concepts on the solar deposit, namely the terrestrial coordinates, the sun's movement, various solar radiation components, and others. Solar irradiation depends on a variety of factors, such as sunlight, temperature, geographic location, time of day, and the composition of cloud layers. Many research works have been built on the estimation of solar irradiation on the ground to make the sizing of a solar installation and forecast solar radiation, the knowledge of solar capacity to make solar thermal heating installations or for electricity production compels the best calculated of the various irradiation parameters.

CHAPTER: II

GENERAL CONCEPTS ABOUT DRYING

II.1INTRODUCTION

Drying is an activity aimed at extracting water from a wet body, partially or entirely, by evaporating this water. This process entails the transfer of heat and mass.

Drying is commonly used in the chemical industry where operations such as sedimentation , filtration or dewatering are also complemented with it. The drying grounds can be grouped as follows:

* Ensure commodity quality and buffer the seasonality of other agricultural or industrial operations.

*Reduce the weight and volume of the goods to reduce their bulk and make shipping simpler.

*Change in substance in form, texture, nutritional and organoleptic properties.

II.2 DRYING

II.2. 1Definition

Drying is one of the oldest methods of fruits and vegetables preservation. It is currently a versatile and widespread technique in the food industry as well as a subject of continuous interest in food research. Drying is a critical step in the processing of dehydrated products because of the high energy requirement of the process (due to low thermal efficiency of dryers).

II.2.2 The purpose of drying

The main aim of drying fruits and vegetables is the removal of moisture up to certain level at which microbial spoilage and deterioration chemical reactions are greatly minimized. In addition to preservation, the reduced weight and bulk of dehydrated products decreases packaging, handling, and transportation costs. Furthermore, most food products are dried for improved milling or mixing characteristics in further processing. In contrast, with literally hundreds of variants actually used in drying of particulates, solids, pastes, slurries, or solutions, it provides the most diversity among food engineering unit operations.

II.2.3 Drying principles

Drying is basically a phenomena of removal of liquid by evaporation from a solid.

Mechanical method for separating a liquid from a solid are not generally considered drying. In the following section an attempt is made to provide a concise overview of the fundamental principles of drying process for agricultural products.

Drying involves two types of transfer: the transfer of thermal energy from the environment to the liquid to be evaporated, and the mass transfer from the interior of the solid to its surface and then the transition to the gas phase. The drying speed is directly linked to these two transfer modes.

II.3 Areas of use

a. Food industry

Much of the food we eat has undergone drying.

Drying can be a necessary step in the production of the product or a role in preserving the food. There are fewer than 200 types of industrial dryers in the food sector. We can cite for example:

* Pasta

* The crystallized sugar is obtained by evaporation

* Fruit juices are prepared from a concentrate obtained by vaporization

* The salt (mineral deposit) is crushed, dissolved, purified before being wrung and finally dried until it becomes refined salt.

* Certain powdered products: cocoa, milk.

b. Paper industry

The paper is obtained by drying the pulp on heated rotary rollers.

c. Wood industry

The wood which has just been felled and sawed contains a high degree of humidity which prevents its immediate use under the correct conditions; otherwise there is a risk of changes in size and shape of the wood .

II .4WET AIR

Convection drying is the most common drying process in the chemical industry; it consists of acting on the substance to dry a current of gas or air (low humidity) and hot that vaporizes the solid's humidity and enters the vapor by converting it into a cooled gas or humid air. Humid air is a combination of dry air and water vapour. We describe underneath the significant quantities.

II .4.1 Absolute humidity (X)

Appelée aussi humidité spécifique, ou teneur en eau; représentant le rapport de la masse de la vapeur d'eau (mv.e) contenue dans un volume V de l'air humide sur la masse d'air sec (ma.s) contenue dans ce même volume.

$$x = \frac{m_{v.e}}{m_{a.s}} \quad (II.1)$$

II .4.2 Relative humidity (φ)

Relative humidity (φ) is the ratio of the pressure of water vapor in air (PV) to the saturation pressure (PS, θ) of this water vapor at temperature θ.

$$Q = \frac{p_v}{p_{s;\theta}} \quad (II.2)$$

In practice, we use much more absolute humidity (X) than PV pressure, therefore we give the ratio between the absolute humidity (X) of the air for a certain temperature and XS absolute humidity corresponding to the state of saturation for the same temperature; ratio called degree of saturation Ψ

$$\Psi = \frac{x}{x_s} \quad (II.3)$$

II .4.3Dry temperature T and wet temperature TH of the air

The dry temperature of the air or of a gas is called the temperature indicated by a bare temperature probe placed in the current of air or gas. The wet bulb temperature (or wet bulb temperature) is the temperature indicated by the thermometer when the bulb of the thermometer is covered with a wet wick (impregnated with liquid water eg: fabric, cotton, etc.

The difference (T-TH) represents the relative humidity of the air.

*It is equal to zero if the air is saturated with water vapor, that is to say φ = 100% therefore no evaporation possible.

* It increases with the difference [PS (θ) - PV] which is the driving term of mass transfer.

II .4.4 Enthalpy of humid air

The enthalpy of humid air defines the energy content of this air. The enthalpy denoted H of 1kg of dry air associated with Ykg of water vapor at θºC represents the quantity of heat to be supplied to this mixture under a constant pressure to bring it from the reference temperature of 0ºC to the temperature of θ ° C. The reference states to be considered are liquid water and dry gas at 0ºC.

The enthalpy of humid air H is the sum of the enthalpy of air and the enthalpy of water.

$$H = CP_a\theta + Y(L_v + CP_e\theta)(II.4)$$

Where eacpetcpare respectively the specific heat of air and water in the gaseous state and VL is the latent heat of vaporization of water at 0ºC.

II . 5CHARACTERISTICS OF WET SOLIDS

II .5.1 Absolute humidity

The absolute humidity of a solid, also known as dry-based water or moisture content, is determined by the amount of liquid contained in the substance compared to its dry mass.

$$X = \frac{M_h - M_s}{M_s}(II.5)$$

II .5.2 Relative humidity:

The relative humidity of a solid, also referred to as water content, or water-based water content, is determined by the liquid mass contained in the substance relative to its moist density.

$$\varphi = \frac{M_h - M_s}{M_h}(II.6)$$

II .5.3 Hygroscopicity:

Hygroscopicity is the body's ability to absorb airborne moisture. Owing to the surface forces and capillary force which are a function of the nature of the liquid, the nature of the solid and the temperature, the presence of moisture in a solid expresses itself at any vapor pressure. This importance of vapor pressure allows the distinction between two major types of solids.

a - When the liquid adheres to the external surface of a solid, it is retained by not very intense surface forces.

The trapping of the liquid within the pores by adsorption brings capillary forces into action which are all the more intense as the interstices are finer. Moisture is held only weakly in the case of large capillaries. During the drying process, which is performed by evaporating the surface liquid, the latter is progressively replaced by liquid coming from the solid interstices.

A solid behaving in this way is not hygroscopic.

b - When the pores presented by the solid are extremely fine, the capillary forces are intense and can retain significant amounts of moisture in depth. In such a case, the moving water is nothing more than bound water or water vapor. This solid is said to be hygroscopic.

II .5.4 Behavior of a wet solid in the presence of a gas

Let us consider a wet solid, of humidity X, subject to the action of a constant gas current, containing a certain amount of the liquid associated with the solid in the form of a vapour. Under constant pressure and at a given temperature, the gas mixture is defined by its relative humidity π which is the quotient of the partial vapor pressure PV in the mixture at the same temperature.

If the vapor pressure Pm (vapor pressure at the wetted surface) of the liquid associated with the solid varies from PV, it is formed between two phases present, a transition of matter tending towards a state of equilibrium which is reached when PV = Pm.

* If PV> Pm this moisture transfer takes place from the gaseous atmosphere to the solid and corresponds to an adsorption phenomenon, that is to say to wetting of the solid.

* If PV <Pm, the transfer of matter takes place from the solid to the gas phase and corresponds to desorption, that is to say to drying of the solid.

* When PV = Pm the equilibrium state is reached and there is no transfer of matter for a given temperature, the pressure remaining constant, at each value of the relative humidity φ of the atmosphere corresponding to a value humidity at equilibrium Xeq of the solid, and one can build an equilibrium isotherm, relating to the solid considered [Figure II.1].

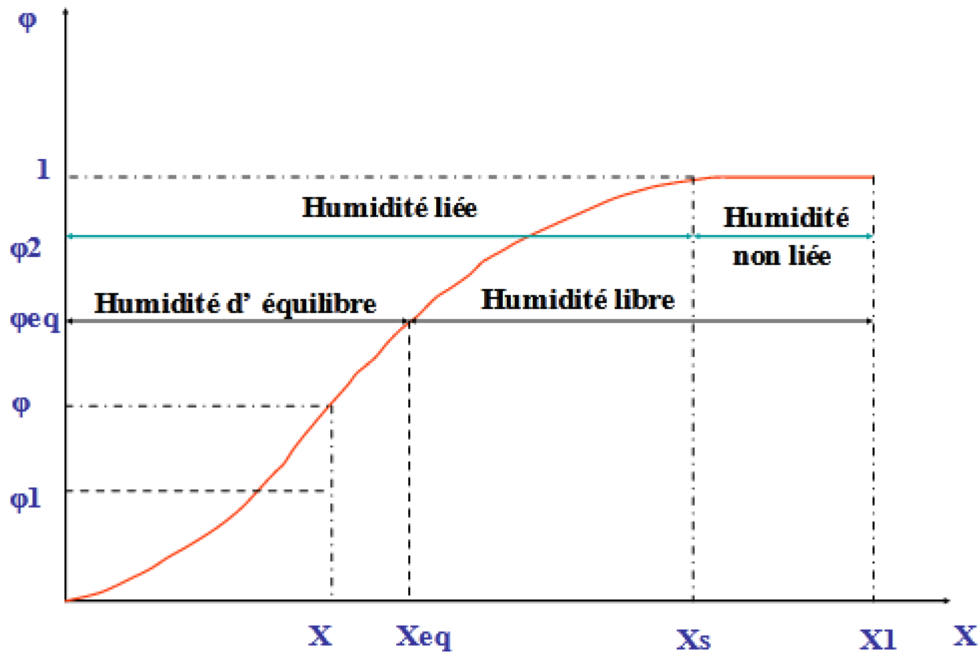


Figure II.1: Equilibrium isotherm.

We see in figure 2.1, that the humidity X of a solid can only be in equilibrium with an atmosphere whose relative humidity is φeq. If the relative humidity of the atmosphere is: 1- φ1 <φeq there is desorption that is to say drying of the solid. 2- φ2>φeq there is adsorption that is to say wetting.

Let Xs be the humidity of a solid in equilibrium with an atmosphere saturated with humidity (φ = 1).

If a solid of humidity X1 > Xeq is exposed to a continuous gas current of relative humidity, it can lose its humidity until it becomes equal to Xeq which is the equilibrium humidity of the corresponding solid to ÿeq. Although an extended stay in this atmosphere would not lessen its humidity below Xeq. The difference (X1-Xeq) reflects the free moisture that can evaporate by itself.

When the humidity of a solid is less than Xs, it exerts a vapor pressure lower than that of pure liquid at the same temperature; it is called moisture bound to the solid, it consists of the liquid contained in the fine capillaries or in solution retained in the cell walls of the solid, or adsorbed on the surface of the solid.

If, on the contrary, the humidity of the solid is greater than Xs, it is called unbound humidity: the vapor pressure which it exerts is that of the pure liquid at the temperature where one operates. This humidity can be read on the diagram, it is equal to (X1-Xs).

II.6 FORMS OF WATER IN FOOD

The water in a food can generally come in three forms:

II.6.1 Hdration watery

Wetting water is retained either in the form of a membrane that adheres to the solid's outer surface, or through capillary forces associated with the liquid's surface tension in the interstitial spaces and pores, and this water is called free water.

II.6.2Constitution water

Water constitution is a part of a solid 's intimate molecular structure, such as the water found in gels. Its removal fully forms dehydration in one form or another, and changes the solid structure, which is not our target during drying. Dehydration is followed by alteration of the product 's initial molecular structure.

II.6.3Water vapour

Water vapor that is combined with dry air fills open spaces that are unsaturated with water.

II.7 WATER ACTIVITY IN FOOD

Aqueous activity AW is a classic quantity, used from a biological point of view to determine the potential in which a substance decomposes in a given atmosphere. It matches the ratio between the pressure of the food water vapor and the pressure of the pure water vapor at the same temperature.[20]

$$A_W = \frac{\text{partial pressure of water in a lim ent a } \theta_0}{\text{partial pressure of pure water } \theta_0} \qquad \text{(II. 7)}$$

II.8DRYING CURVES

he drying curves are represented either by the variations in the absolute humidity (X) of the product as a function of time, or by the variation in the drying speed (-dX / dt) as a function of time t or even the proposed curve by Krisher (-dX / dt) as a function of absolute humidity X (Krisher). [21]

II.8.1Drying kinetics

We study the drying kinetics of the different products by curves representing the evolution of the drying speed (mass of water evaporated per unit of time and surface area of evaporation of the material (kg of water / m2 s) as a function of These curves are generally obtained for different experimental conditions (temperatures, speed of the drying air, humidity, etc.).

The drying kinetics curves vary according to the product to be dried and contain from one to three main periods of the drying kinetics, everything depends on the product.

The experimental drying curve is obtained by following the variation in the absolute humidity of the product by successive weighings during drying until the absolute equilibrium humidity of the product is reached. For each product there is an optimum equilibrium moisture value for which the product does not deteriorate and retains its organoleptic and nutritional properties [20].

We should reach this optimum value at the end of the drying process which is

eq = 11% [22].

II.8.2Different periods of the drying kinetics of a wet product

TThe experiment making it possible to characterize the drying kinetics consists in subjecting a thin layer of a product to the action of an air current of fixed temperature, humidity and speed and in measuring the mass of the product as a function of time.

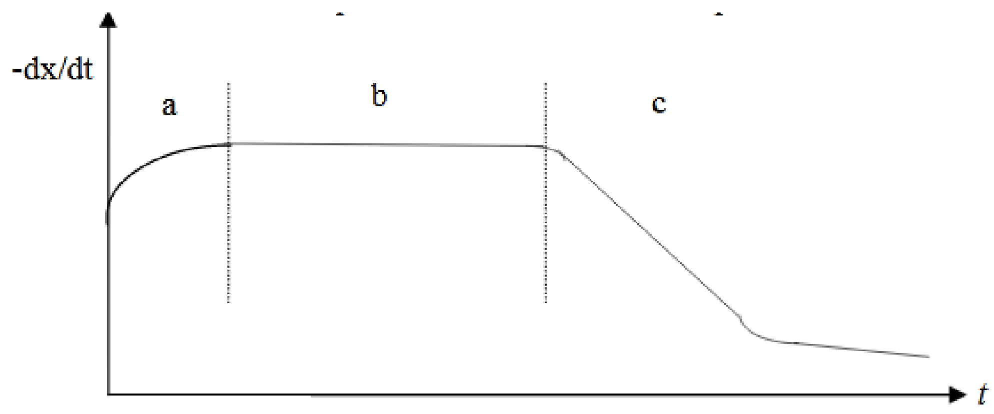


Figure II.2:drying periods

The curve above shows the variation in the drying speed as a function of time. Often we also construct the curve of the drying speed as a function of the humidity remaining in the material during drying. In[figure II.2]we distinguish three periods:

II.8.2.1Warm-up period (region a)

When a product with a surface temperature Ts and a partial water vapor pressure Ps is stirred by a current of hot air, heat and material exchanges take place between the product and the drying air. To be carried away in the form of vapor, the quantities of water contained in the product require a corresponding supply of vaporization energy, the excess heat supplied by the air causes the product to heat up further until reaching the wet bulb temperature characteristic of the drying environment. This period is generally very short compared to the overall drying time.

II.8.2.2Period at constant pace (region b)

This period of drying at constant speed corresponds to the evaporation of the surface liquid. The liquid rises to the surface under the action of the suction forces of the capillaries and it renews itself at a speed sufficient to form a continuous film and compensate for evaporation. The heat flux exchanged by convection between the air and the product is fully utilized for the evaporation of water, this period is identical to the isenthalpic drying of a water film and therefore depends mainly on the aeraulic conditions surrounding the product. to dry. When the surface moisture of the solid is not renewed at a rate sufficient to maintain a continuous film of the liquid on the surface, the rate ceases to be constant. For food and organic products, there is generally no drying period at a constant speed. This is because the cell walls disrupt the rapid migration of moisture to the outer surface of the product, the migration of solutes that clog the pores, and the hardening and shrinking of the product surface [20].

II.8.2.3Slowdown period (region c)

During this period the product surface is no longer saturated with water vapor and mass transfer is controlled by the complex mechanisms of water movement from the interior to the product surface. [19]

II.9THE DIFFERENT DRYING MODES

II.9.1Direct drying is also called convection drying or dehydration

This drying method is due to the fact that the drying air performs two simultaneous functions, the heat is delivered to the surface of the product, according to Newton's law, $(\varphi_{conv} = \alpha S_P\,(T_{\alpha,\alpha} T_{S,p}))$and the recovery of the water vapor emitted from the product.

II.9.2Indirect or conduction drying

The substance is in contact with a heat-conducting wall heated by a fluid for heat transfer (air water, gas , water vapour). The liquid evaporates under the influence of heat that is transmitted by conduction. Operating with a small stream of excess gas or agitation scrapes the resulting steam. Conductive heat transfer ensures the diffusion of energy into the product's inner layers according

$$\text{to. } (\varphi_{cond} = -\lambda S_p \frac{dT_p}{dx}) \qquad (II.8)$$

II.9.3Radiant drying

We know that any surface with a temperature greater than absolute zero emits radiation that can be transformed into heat and that the total energy emitted from the surface or the heat flux emitted from a unit area of this surface is proportional to the absolute surface temperature's fourth power. It follows from this that a greater or lesser part of the heat flux obtained by th is contained in many dryers.

II.9.4Vacuum drying

As the liquid boiling point increases as the pressure rises, the drying performed under vacuum eliminates the liquid to rapidly boil. Evaporation then speeds up the cycle that takes place, and how long the material stays in the dryer. This technique allows the drying of heat sensitive materials, which are difficult to process under normal pressure.

II. 9.5Drying by dielectric loss

Dielectric loss drying relies on electrical heating of non-conductive (dielectric) materials. It is obtained by placing the material to be dried in an alternating electric field at a very high frequency 1 to 30 MHz.

II.9.6Freeze drying

this moisture is frozen and extracted immediately from the solid phase to the vapor phase, without going through the liquid state, that is, by sublimation at a low temperature. Clearly, this costly drying method can only be applied to materials which can not withstand the normal drying methods due to their brittleness to heat.

II.10FREE AIR DRYING

Ancestral process used to this day, which consists of spreading out the items to be dried outdoors. This is an simple and inexpensive method but it can cause significant losses. A comparison table was drawn up detailing the benefits and disadvantages of drying outdoors and in a dryer. Researchers have switched to artificial drying to improve these conventional techniques.

Drying in a solar dryer	Drying in the open air
Benefits • Reduced drying time • Control of water contentdesired final. • Product protection againstultraviolet radiation. • Sheltered from bad weather,insects and fungi. • Control of the operation ofdrying. **Disadvantages** • Free energy • Energy consumptionconventional (electricity, gas,wood….) if hybrid system. • Relatively investmentimportant. • Skilled labor	**Benefits** • Simple and inexpensive process • Does not require material or skilled labor • Free and non-polluting source of solar energy • No energy expenditure • Gentle drying thanks to the alternation day and night • Little color change **Disadvantages** • Long drying time (possibility of mold). • Alteration of product quality by radiationsolar. • the efficiency of the process is low given the • many hazards (meteorology, product constituents • sensitive to ultraviolet radiation, insects,rodents, loss of vitamin, etc).

Table II.1: Advantages and disadvantages of drying in a solar dryer and drying in the open air .

II.11THE DIFFERENT TYPES OF SOLAR DRYERS

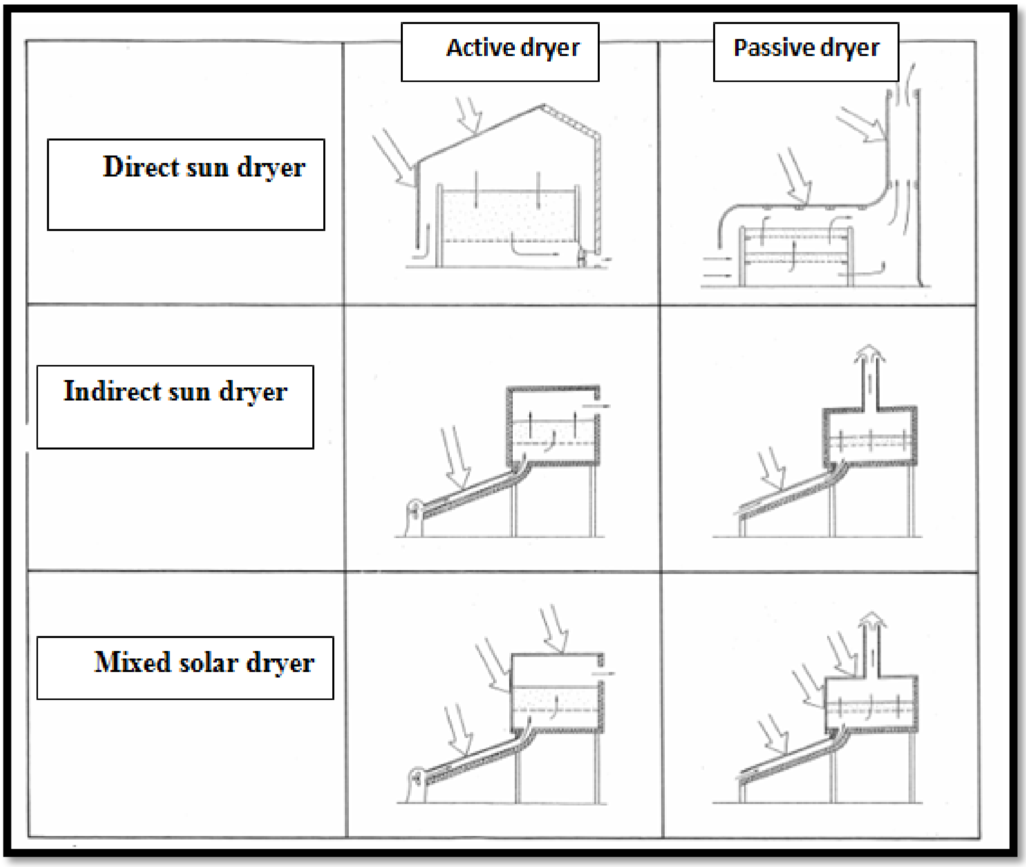


Figure II.3: The different types of solar dryers

There is a very wide variety of types of dryers, as great as the diversity of products to be dried. The flow rates of product to be dried and their residence time in the dryer differ from one product to another, likewise the drying operation can take a few minutes up to several tens of days.Generally for agro-food products, solar drying systems are classified according to the heating method (direct by convection, indirect by conduction, by infrared radiation), the heat input mode (direct or indirect) and the handling mode product (accessibility).There are two main classes of solar drier for agricultural products:

II.11.1Passive solar dryer or natural convection

Natural load drying uses solar energy, which heats the air in the coolant, giving it additional water vapor retention power. The hot air continues to rise up and leave through a chimney, bringing the moisture extracted from the drying goods.

II.11.2Active solar dryer or forced convection

A fan forces the drying liquid which allows increased evaporation ability in the dryer. The forced convection in general far exceeds the normal convection that is not yet authorized.

This type of solar dryer provides greater control of the drying process and improved drying time compared with passive dryer.

II.11.3Direct solar dryer

Sunlight directly hit the products. The direct solar dryer consists of one piece that functions as a drying chamber and a solar collector. The bottom of the drying chamber is painted black to increase the heat-absorbing ability, a clear plastic or polyethylene sheet is generally used as a roof but other expensive materials such as glass or special plastic can also be used. (Agricultural polyethylene). However, the direct interaction of solar radiation - product leads to deterioration of product quality and nutrient destruction [23].

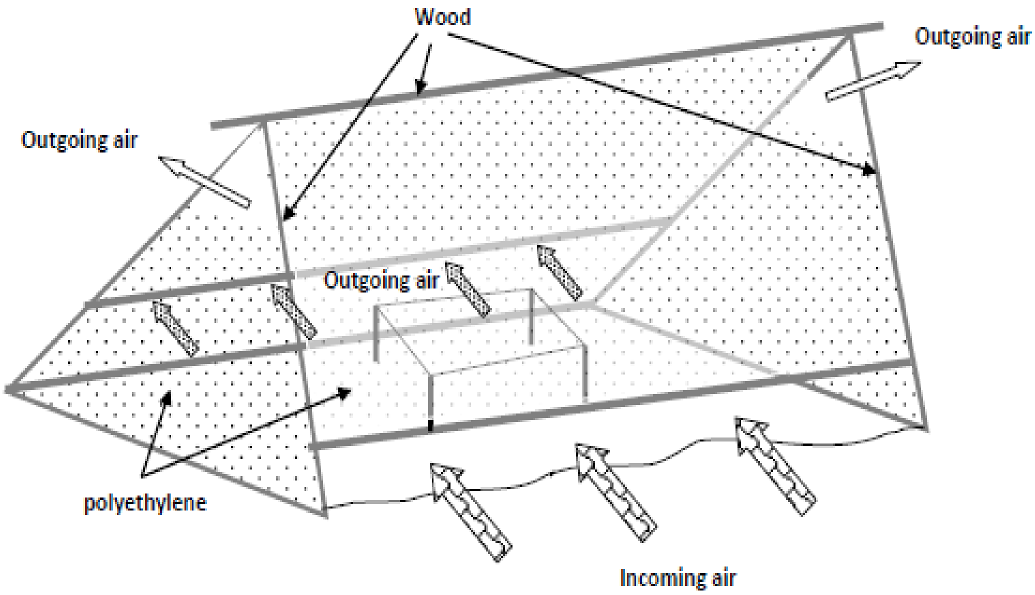


Figure II.4: Polyethylene direct sun drying tent

II.11.4Indirect solar dryer

The indirect solar dryer [Fig. II.4] mainly consists of two parts: an insulator that converts the solar radiation into heat as the drying air is heated up and rises by a natural or forced convection to the drying chamber containing the products to be dried where the heat transfer from the air to the product and mass transfer occurs From product to air during the coolant path. The latter leaves the drying chamber outside through a chimney, taking with it the moisture extracted from the products [24].

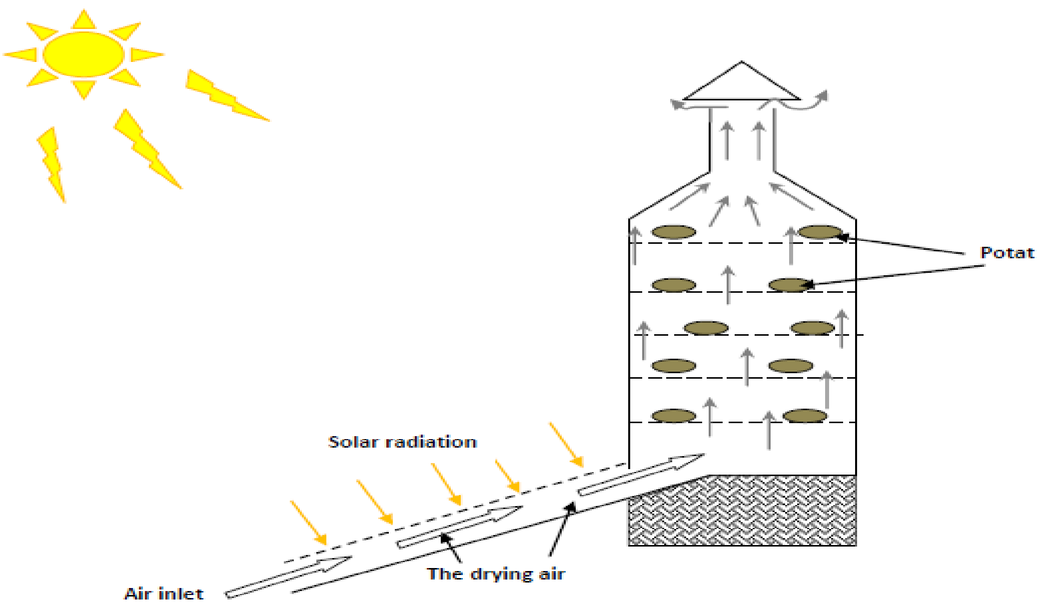


Figure II.5: Indirect solar dryer

II.11.5Mixed solar dryers

These dryers combine the devices of direct and indirect dryers. In this type of dryer, the combined action of direct sunlight on the product to be dried and the solar collector is to provide the heat necessary for the drying process. [19]

II.11.6Hybrid solar dryers

Active solar drying systems use solar and / or electric or fossil fuel heating systems and ventilators and / or motorized pumps for air circulation. The additional energy supply can be located in two different places in the dryer:

The make-up energy makes it possible to maintain a constant temperature inside the dryer whatever the climatic conditions. In this case, solar energy becomes secondary, it preheats the air.

The fan ensures the circulation of air. I ci solar energy remains the source of heat but the dryer has a greater capacity of evaporation thanks to better ventilation.

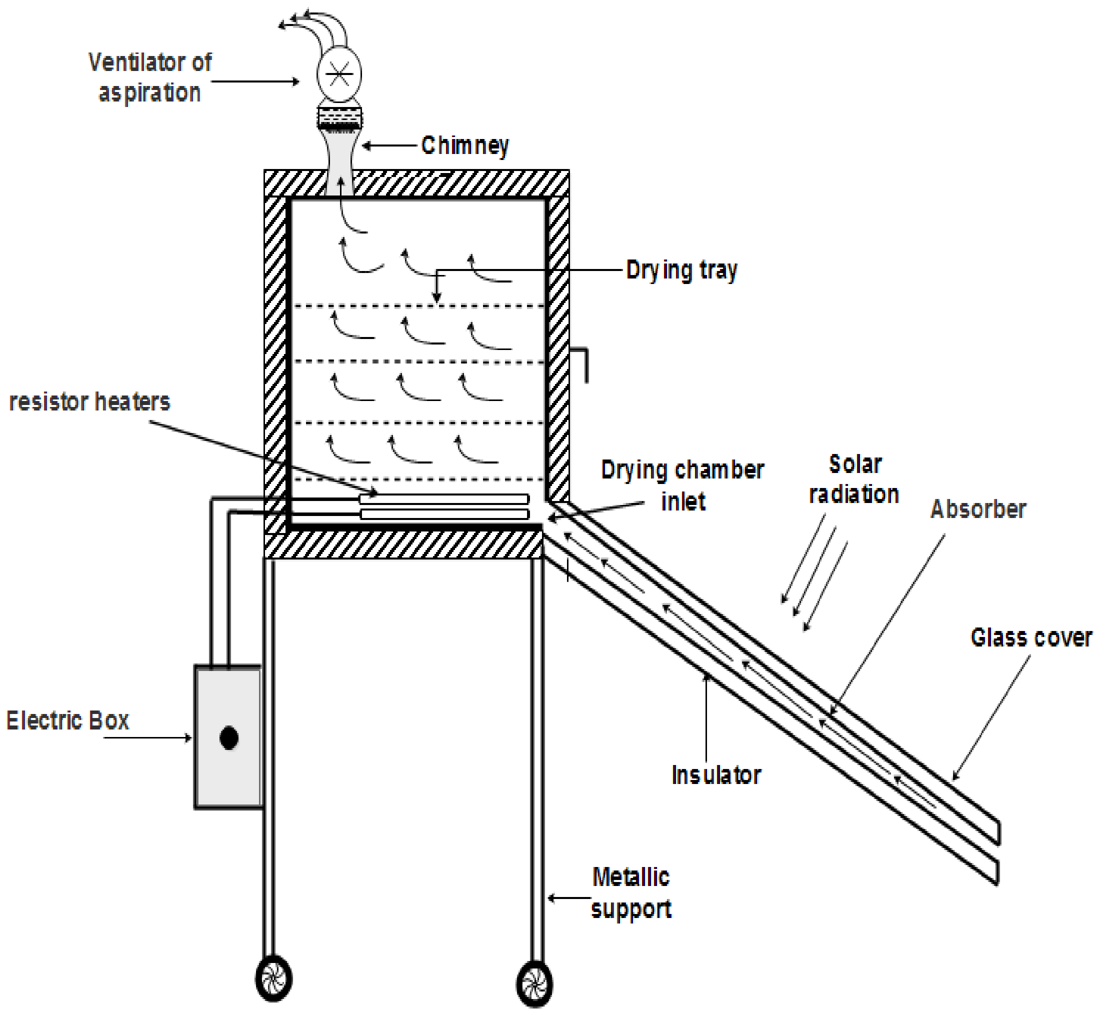


Figure II.6: Hybrid *solar dryer*

II.11.7Continuous solar dryer

There are several types of dryers that run continuously. Within this type of dryer, air and water motions can be complicated because water and air pass through but we can still be reduced to arrangements of primary spin units with parallel or specific currents (CC), opposite current (CC) and cross-current (C+)]. The common current is preferred by the combined current of the air generated.[20]

II.11.8Discontinuous solar dryer

Batch dryers are only suitable for handling small blocks of material that are not subjected to any movement during the drying process.

This method refers to simplicity of construction, while continuous drying requires running belts or cargo-carrying trolleys and hence some complexity. Air-drying by displacement with touch drying.[19]

Name of Solar Dryer	**Name of Designers**	**Findings**
Direct Solar Dryer	Mühlbauer	This is one of the simplest solar dryer of low capacity
	Ondier *et al.*	Solar radiation is the main source and overcome the discolorness of the crops
	Al-Juamily *et al.*	Temperature is the main factor on drying rate and in off shine hours the drying technology is affected
Indirect Solar Dryer	Goyal and Tiwari	Reverse flat plate collector was used and gave best result
	Sharma *et al.*	High quality drying products get by producing higher efficiency
	Sharma *et al.*	It is available for small farms and under bad weather it produces good quality products
	El-Sebaii *et al*.	The drying time is eminently decrease dand drying efficiency is good
Mixed Mode Solar Dryer	Exell and Kornsakoo	Get optimal value of drying sectors using computer modelling
	Simate	Contains separate collector sand this dryer is used for drying crops in wet season
	Zaman and Bala	The drying rate was highest and this kind of dryer is used for drying rough rice
	Zomorodian *et al.*	This dryer gives satisfactory result for best drying efficiency and moisture content

	Bala *et al.*	Artificial network is used and predicting the potentiality of the dryer
Natural Convection SolarDryer	Oosthuizen	It is a low cost solar dryer and gives vary satisfactory result
	Garg and Kumar	It is low cost and its performance is satisfactory
	Later Ezeike	Design of this dryer is very simple and gives high efficiency
Forced Convection SolarDryer	Midilli	Simple, available and locally found materials are used to make this type of dryer
	Sodha *et al.*	Save a large amount of fuel. Product quality is better than any other sand keeps products neat and clean
	Ratti and Mujumdar	In ambient temperature this kind of dryer is more appropriate for drying pistachio and sample is perfectly dried in this dryer
	Arata and Sharma	This dryer is suitable for prediction the temperature and moisture content under control and constant rate
	Pawar *et al.*	The parameter s of drying system are time dependent and it is performed to predict the drying rate

TableII 2: For Finding Different Type Solar Dryer

II.12.ÉVALUATION DES SECHOIRS SOLAIRES

To evaluate its technical performance, evaluating a dryer is important and offers a basis for comparison with other dryers, which may help manufacturers refine their designs.

II.12.1Physical characteristics of the dryer

*Type, shape and size of the dryer.

*Drying capacity / load density.

*Surface of the rack and number of screens.

*Appropriateness of loading and unloading of products.

II.12.2Thermal performance

*Drying time and drying speed.

*Temperature and humidity of the drying air.

*Drying air flow.

*Efficiency of the dryer.

II.12.3Quality of the dried product

*Organoleptic quality (color, flavor, taste, aroma, texture).

*Nutritional elements.

*Rehydration capacity.

II.12.4Cost of the dryer and amortization time

To extract the water, a certain amount of energy must be provided, the electricity of the fan or the energy used in the backup is charged, in addition to the personnel charging and unloading the goods and controlling the drying cycle.

To this is added the cost of fresh goods to be dried; The investment cost reflects the size of the entire dryer. Consumption time is the time required for this.

II.13. MODE OF HEAT AND MASS TRANSFER DURING THE DRYING

Drying [Fig II.6] is characterized by transfer of heat and mass (water in the form of vapour). Water is transferred by the diffusion phenomenon from the inside of the product to the product – air interface, and by the convection phenomenon from the.

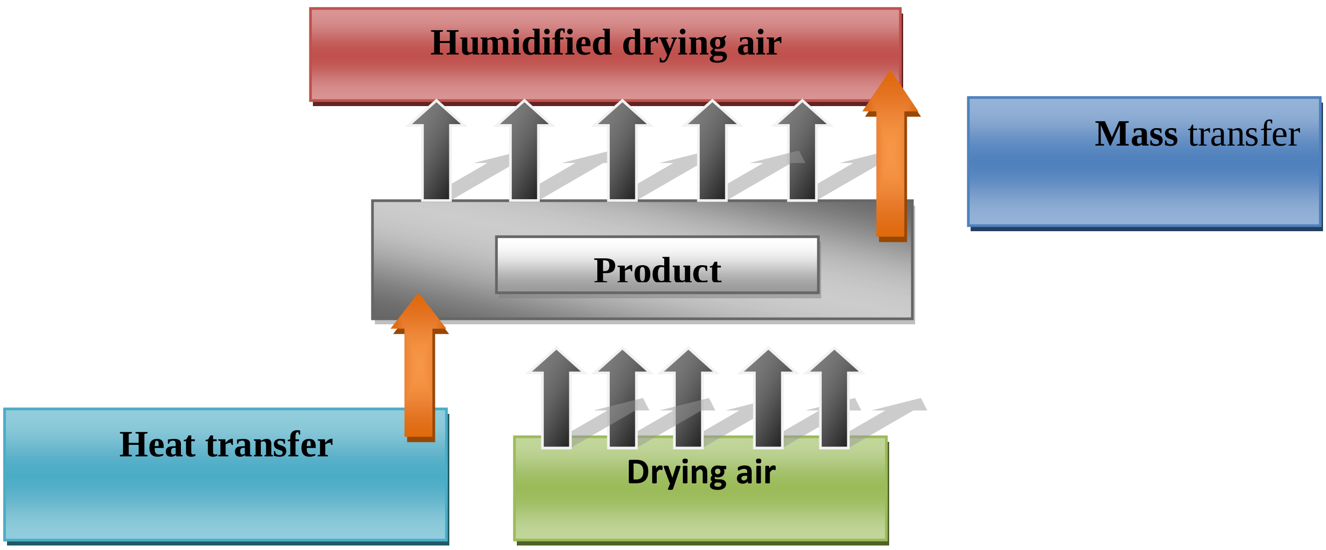


Figure II.7: Transfer mode during drying.

Providing the energy necessary for the activation and release of water molecules, this heat transfer takes place in two different stages:

*Transfer by convection

The drying air supplies the surface of the product with heat according to Newton's law:

$$\varphi_{conv} = \alpha S_{\mathrm{p}}\left(\mathrm{T}_{\mathrm{a,a}} - T_{s,p}\right) \qquad \text{(II. 9)}$$

*Transfer by conduction

The surface of the product heated by the drying air, this heat energy is transmitted to the internal layers of the product by conduction. This phenomenon is governed by Fourier's law:

$$\varphi_{\mathrm{cond}} = -\lambda S_{\mathrm{p}} \frac{\mathrm{dt_p}}{\mathrm{dx}} \qquad \text{(II. 10)}$$

II.14Advantages and Disadvantages of Solar Drying

Solar drying has advantages and disadvantages we will quote some parameters

Avantages

- It uses free energy: the sun.
- This type of traditional village drying has the advantage of being simple, requiring neither expensive installations nor energy sources, and therefore inexpensive.
- Keep the products and amortize the seasonal nature of certain agricultural or industrial activities.
- Reduce the mass and volume of food, reduce its size and facilitate its transport.
- Give a particular presentation, structure or functionality to the product (mashed potato flakes, freeze-dried coffee, etc.).
- Solar energy has reduced costs thanks to its high public support and low carbon emissions.
- Combined with energy storage and intelligent software solutions, solar energy becomes a reliable and less expensive source of energy.
- Solar cell systems have a long lifespan - around 25 years.

Disadvantages

- The risk of energy alteration of the form, texture and nutritional and organoleptic qualities of the product.
- Requires more time for drying.

- It remains expensive, despite falling costs in recent years.
- Sunlight varies by location and season. The forecasts are more uncertain than fossil fuels (but better than those of wind).
- Non-adjustable and low combination of production and demand
- The sun produces more in summer, while electricity is more necessary in winter.

II.15Conclusion

Solar drying has proved to be technically and economically valuable for several crops. It is, however, necessary to develop large-scale dryers that may be used throughout the year for different products to make them attractive to the farmers.

Protection against UV radiation, dust, insects, mold, and other sources of contamination, as well as temperature and relative humidity control, are needed to improve the quality of the product. Likewise, the storage conditions of solar-dried products should be tailored to the crop and the packaging optimized if a long shelf-life is required.

CHAPTER: III

MATERIALSANDMETHODS

III.1Introduction

In this study, an experimental investigation of the solar system consisting of several major components was performed; Solar air collector, drying room and air blower to achieve drying of some food products.

III.2 Materials and Methods

In this study , an experimental investigation on the solar system consists of many main components for the achievement of study objectives. The solar system primarily consists of solar air heater, drying cabin and inline air blower. The elements had been connected by insulated air ducts.

III.2.1Solar air collector

Resembling satellite reception dishes (fig III.1), the parabolic solar collector is a mirror which reflects the sun's rays at a point of convergence called the focal point, which is located in the receiver. The collector follows the movement of the sun to take advantage of maximum sunshine. The temperature can reach 960 ° C on the hearth but the dried product does not need intense heat to give optimal products.

Figure III.1: Solar air collector.

III.2.2 Drying cabin

It consists of a well-insulated box (refrigerator) with a spacing of 60 cm in length, 60 in width and 180 cm in height, and contains calories; Metal to set product to dry.

There are two openings with a diameter of 60 mm on the top and bottom to allow hot air to enter and exit through.

Figure III.3: Drying cabin

III.2.3RECEIVER

The receiving metal must have good conductivity, we have chosen iron with a thermal conductivity of around 80 W / k.m², it is a tube with an outside diameter of 17 cm and a length of 15 cm, it is provided with two holes the first hole for blown the cold air and the second for exit the hot air, contain interior has obstacles to let the air stay longer for the well heated (FigIII.3).

Figure III.3: The model of the future in action

III.2.4SOLAR DRYER

The indirect solar drier (FigIII.4) essentially consists of two parts: solar collector formed by a parabolic concentrator which converts solar radiation into thermal energy where the drying air is heated in a metal enclosure placed in the focal point.

L’air monte par convection forcée en utilisant un ventilateur jusqu'à la chambre de séchage qui contenant le produit à sécher où un transfert de chaleur de l'air vers le produit et un transfert de masse du produit vers l'air.

Figure III.4: model of the forced convection indirect solar dryer used

III.3Conclusion

A prototype of solar dryer assisted by parabolic concentrator was studied. This study allowed us to know the functioning and the performances of the presented system.

The use of parabolic concentrator leads to improve the performance of the drying process such as the drying temperature, increase in the product quantities to be dried and drying time.

The experience is to be considered largely positive regarding the understanding of the model and the knowledge of the method of construction of a solar drier assisted by a parabolic concentrator.

CHAPTER: IV

RESULTSANDDISCUSSIONS

IV.1Introduction

In this chapter we will describe the drying system used and some of them Results related to discussing the following curves: (for mint product).

*Variation in mass of water content as a function of time.

*Change in room temperature as a function of time.

*Receiver temperature change as a function of time.

*Solar irradiance change as a function of time.

In this experiment an indirect solar heat dryer was used

Forced: (parabolic capacitor).

The first experiment: in the case of the dryer on the vertical plate.

The second experiment: in the case of the dryer on the horizontal

Position.

IV.2 Results and discussions

IV.2.1Variation of water content as a function of time

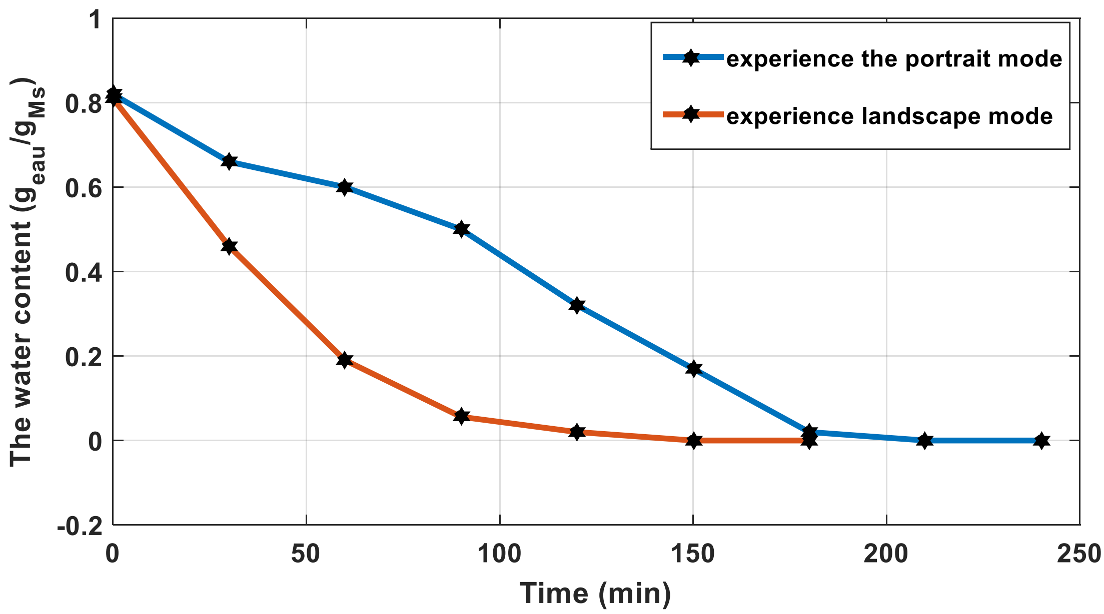


Figure IV.3: Figure IV.1: Variation of water content as a function of time

(Mint)

Figure IV.1 indicates a relative decrease in the water content, where its value is from 0.8 (geau / gMs) to zero. In both experiments, we noticed that the decrease in water content in the second case was faster than in the first case.

IV.2.2 Solar radiation change as a function of time

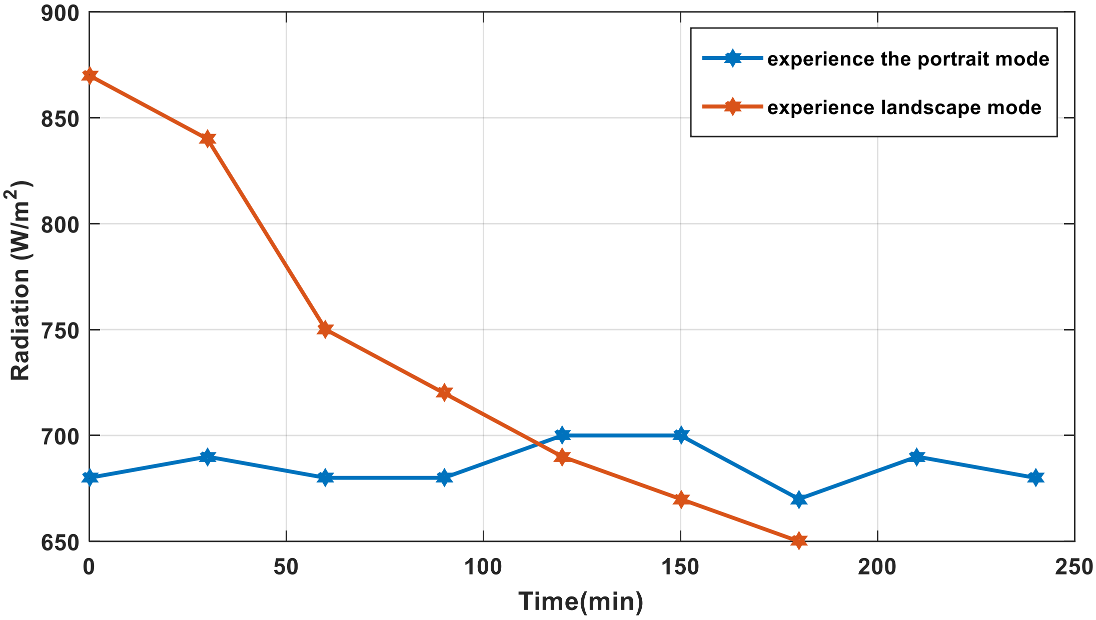


Figure IV.2: Solar radiation change as a function of time.

(Mint)

Figure IV.2: shows a relative decrease in the amount of solar radiation by virtue of clouds in the first case, where the radiation ratio ranges from 850 watts / m2 to 650 watts / m2. In the second case, there is a slight fluctuation in the amount of radiation, where the percentage of radiation ranges from 640 watts / m 2 to 700 W / m2.

IV.2.2 Receiver temperature change as a function of time

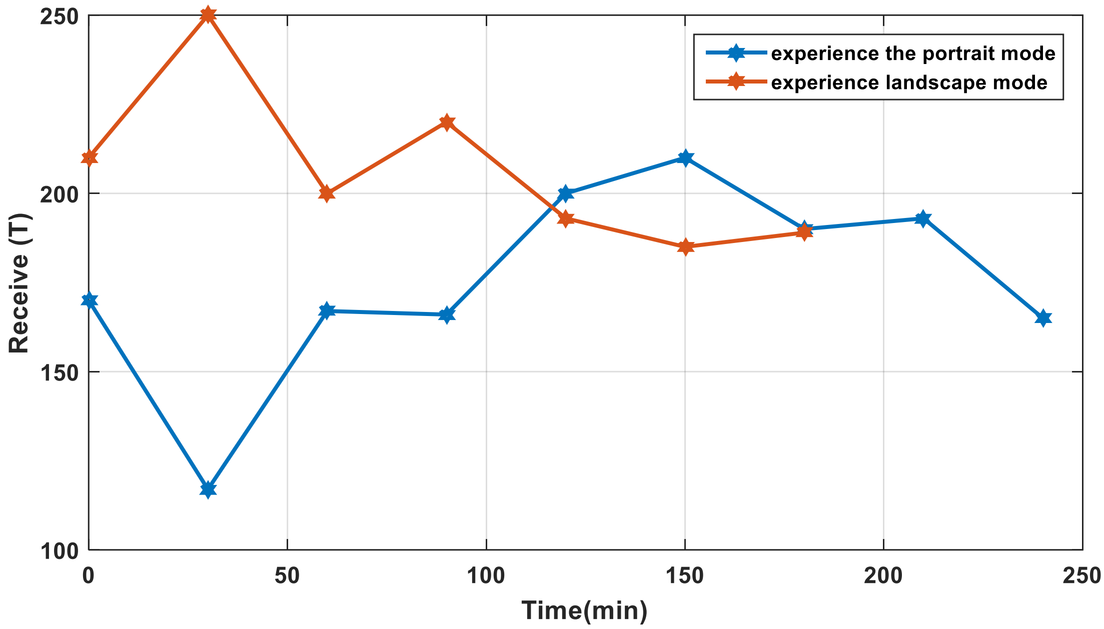


Figure IV.3: Receiver temperature change as a function of time

(Mint)

Figure.3: shows a decrease in the temperature of the receiver, as the receiver temperature starts from 170 degrees Celsius to a low of 130 degrees Celsius as a minimum during the first hour and then increases to the highest temperature at a .(maximum of 210 degrees Celsius (the first case

As for the second case, there is a relative rise in the first hour from 210 degrees Celsius to 250 degrees Celsius, and then it begins to decline to the lowest value at 190 degrees Celsius.

IV.2.2 Room temperature change as a function of time

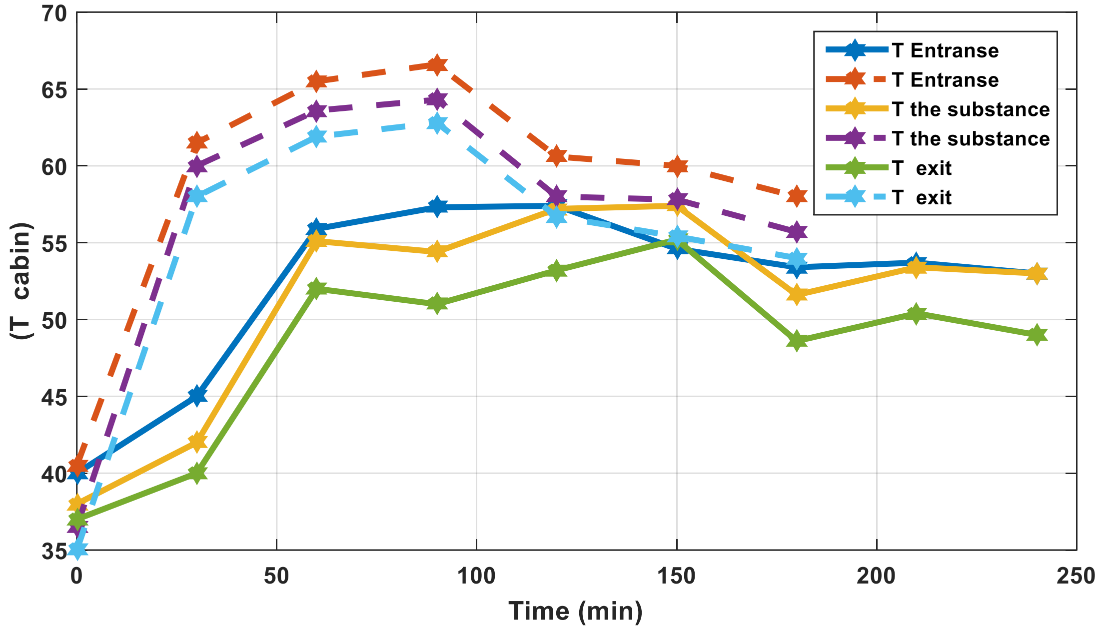


Figure IV.4: Room temperature change as a function of time

(Mint)

Figure IV.4: The fourth notes a relative increase in the temperature for each of the two cases, where the temperature in the drying room reached 57 degrees as a maximum value in the first case, while in the second case the room temperature reached 67 degrees as a maximum value.

After an hour and a half of drying, we notice a relative decrease in both cases, due to clouds.

IV.3 Conclusions

From the previous results we conclude that the product drying kinetics

The study is based on the following criteria:

*Product Type

*Product shape die cut

*The initial water content of the product

*The appropriate atmosphere for the operation

CONCLUSION

GENERAL

General conclusion

We are concerned with indirect solar drying by forced convection of hot air supplied by an identical capacitor into the drying chamber in this present work.

The drying by indirect solar thermal energy has been adopted for three agricultural food products; potato, red pepper and peas, the purpose of which is to be followed during the day and the curves of variations in drying speed, temperature and water content of these products.

These curves are established according to the following parameters:

- type of product.

- The product's cutting shape.

- initial water content of the product.

An effect was seen by examining the variation of these parameters

Temperature, water content and speed of drying of the product in such a way as to:

- The fastest commodity in the drying process is the potato.

• For potatoes:

This research leads us to believe that control of the parameters studied gives us an improvement in the speed of drying and thus the possibility of improving the efficiency of this process. So in order to sustain their natural cycle of production, and given their economic and medicinal effects, we suggest:

* Supply well-sized equipment based on a collection of drying products , especially over-produced products requiring such care.

Industrialization of solar drying processes to allow exports to expand, as well as the national economy.

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ANNEX


60.49


3.88
ANEMOMETER


30.1
40.5 °C
POWER
ESC
HOLD
REC
FUNCTION (>2S)
ENTER
Setting (>5S)
RS232
OUTPUT


REC
CH1
204.4
CH2
17.3
CH3
34.5
CH4
44.2
CH5
CH6
CH7
CH8
POWER
ESC
TYPE
PAGE
Offset

Abstract

In this work, we are interested in solar drying of certain agro-food products, the mostproduction in the el-oued region such as potato, red pepper and pea, using an indirect solardryer. forced convection ,where the dryer used, the hot air which is provided by a parabolicconcentrator oriented by means of a system of manual tracking of the sun, towards the dryingchamber. this concentration model leads to temperature levels between 300-700 C The objective of this work is, on the one hand, the study of the drying kinetics of these threeproducts and, on the other hand, the influence of the operating parameters on the drying timeThe experimental results shows that:

the potato: the drying temperature ranging from (43-57), for the duration of 3hand the red pepper: the drying temperature ranging from (40-56), for the duration of 6 hoursand the pea: the drying temperature from (30-55), for the duration of 5hFinally, the interest of the drying process of these products is: the preservation of these products without used cold room.Key words: Solar drying, forced convection, solar dryer, parabolic concentrator, trackingsystem, red pepper, potato, kinetic drying pea, temperature.

Résumé

Dans ce travail, nous nous intéressons au séchage solaire des certains produits agro-alimentaires ,le plus production dans la région d'el-oued comme la pomme de terre, le pimentrouge et le petit pois et ce en utilisant un séchoir solaire indirect a convection forcée, où le séchoir utilisé, l’air chaud qui est assuré par un concentrateur parabolique orienté à l’aide d’un système de poursuite manuel du soleil, vers la chambre de séchage , ce modèle de concentration conduit à des niveaux de températures compris entre 300C° et 700C°. Le objectif de ce travail est , d'une part l'étude de la cinétique de séchage de ces trois produits et d'autre part l'influence des paramètres opératoires sur la durée de séchage. Les résultats expérimentaux montre que : la pomme de terre: la température de séchage allant de (43-57), pour la durée de 3h et le piment rouge: la température de séchage allant de (40-56), pour la durée de 6h et le petit pois: la température de séchage allant de (30-55), pour la durée de 5h. Enfin, l'intérêt du processus de séchage de ces produits est : la conservation de ces produits sans utilisé chambre froid. Mots Clés : Séchage solaire, séchoir solaire, convection forcée, concentrateur parabolique, système poursuite manuel, piment rouge, pomme de terre, petit pois cinétique de séchage,température.

الملخص:

فيهذاالعملنصباهتمامناعلىعمليةتجفيفلعدةمنتوجاتغذائيةزراعيةالكثرانتاجافيمنطقةالواديكالبطاطاوالفلفلالاحمروكذاالجلبانةحيثاستعملنافيهذهالتجاربمجففشمسيقسريغيرمباشرحيثفيهذاالاخيريؤمنالحرارةلغرفةالتجفيفبواسطةمركزشمسيمكافئتصلدرجةالحرارةالتييلتقطهاعلىمستوىالنقطةالبؤريةمن 300–700 درجةمئوية .

الهدفالرئيسيمنهذهالتجاربهودراسةحركيةالتجفيفمنجهةوالعواملالمطبقةعلىالمنتوجاتمنجهةأخرىالنتائجالمتحصلعليهافيهذهالدراسةالتطبيقيةلهذهالمنتوجاتكانتكالتالي : تتراوحدرجةالحرارةالمطلوبةمناجلتجفيفالبطاطامن 43–57 درجةمئويةفيظرف 03 ساعاتوالفلفلالاحمرمن 40 –56 درجةمئويةفيظرف 06 ساعاتوالجلبانةمن 30–55 درجةمئويةفيظرف 05 ساعات . الفائدةمنعمليةالتجفيفلهذهالمنتجاتهوالمحافظةعليهابدوناستعمالغرفةالتبريدالكلماتالمفتاحية: التجفيفالشمسي ‘المجففالشمسي‘التحميلالقسري ‘مركزمكافئ ‘نظاممتابعةيدوي ‘البطاطا ‘الفلفلالاحمر ‘ الجلبانة‘حركيةالتجفيف ‘الحرارة.