FOOD TECHNOLOGY

UTILIZATION OF GEOTHERMAL ENERGY THROUGH THE PROCESS OF DRIED FOOD PREPARATION

CURRICULUM

Ankara, 2021

- This module is an individual learning material with the purpose of guiding course attendees in order to attain competence that is specified in the Framework Teaching Programs applied at occupational and technical schools/institutions.

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INTRODUCTION

Dear Trainee

Since the early ages human has tried various methods in order to consume food independent from the season or to preserve food in hot or cold conditions. Drying is one of the most widespread method.

This method has provided consumption of various food in various seasons and has also prevented them to become inconsumable due to factors such as harmful micro-organism growth and decay. Therefore, shelf life can be prolonged to 12 months by hot air application which provides removal of essential water for micro-organism growth and prevents decay and enzymatical spoiling. We are aware that any fruit is inconsumable in 3-10 days after it is removed from the branches. It is obvious that consumption date is much longer when same fruit is preserved by drying.

Drying is a temperature and mass transfer by carrying the water inside-out and evaporation from the surface. Dehydration is removing moisture from food products. Dehydration provides longer endurance for food. This method has been recognized since the primitive human. However, it has been industrialized in eighteenth century.

The major advantage of drying food is to overcome decay during storage. Moisture is removed by drying and microbial development with other reactions is prevented. Quality figures such as scent, nutrition value are also preserved by decreasing moisture amount in products. Product volume is decreased by drying; thus, transportation and storage stages are facilitated.

Food is subjected to some preliminary procedures. These procedures can be described as sorting, washing, chopping and salinization. Some products are also submersed into alkali solution or many food products are vulcanized.

The moisture within products are naturally removed which provides loss of weight. Dry food weight ratio is a major criteria in terms of keeping taste, and texture.

Dry food weight ratio studies are performed in authorized laboratories within the scope of physical analyses. Domestic and foreign standards are applied during these tests. Generally accepted test methods and test criteria are complied in order to obtain reliable and neutral results.

This module provides information on how to dry food with geothermal energy utilized system which is a sustainable energy source and related research has provided the data for the module. Dried food has become essential beyond a method due to advancing technology, increasing

population and the needs that come along. Although there are many methods meeting this need, preferring geothermal energy is significant with regard to preservation of nature and contribution to economy.

This module shall ensure you to learn how to perform preliminary procedures for drying, drying methods, proper storing of packed product.

Completing the utilization of geothermal energy through the process of dehydrated food preparation module will allow you to work in food drying facilities.

LEARNING ACTIVITY-1

AIM

You shall be aware of occupational health and safety. You shall be aware of risk factors regarding occupational health and safety. You shall learn to perform risk assessment and risk management for occupational safety.

RESEARCH

Do a preliminary research on occupational health and safety.

You shall study occupational health and safety procedures for food drying facilities.

1. What Is Occupational Health and Safety?

Occupational health and safety (OHS) is intensely used in business. OHS can be described as "systematic and scientific studies in order to protect from possible hazardous conditions at workplace during operation which may arise due to various reasons.

Occupational health and safety - OHS fact has been started to be handled mainly in European Union dating from 1980's. Occupational Health and Safety directive numbered 89/391/EEC has been accepted as framework directive and many individual directives have been published with regard to this framework. Occupational Health and Safety code numbered 6331 has been settled in 2012 in accordance with the European Union harmonization process.

The purpose of occupational health and safety studies is to ensure the safety of workers, production and business.

OHS is a teamwork. Workplaces with a certain number of employees have the obligation to establish an OHS board and meet at varying intervals depending on the hazard class (less dangerous: 1 in 3 months, dangerous 1 in 2 months, very dangerous once a month) and to discuss and decide on the OHS needs and nonconformities of the enterprise. In general, the workplace doctor determines the nonconformities related to occupational health, and the occupational safety expert determines the ones related to occupational safety and presents them to the OHS board. The board also includes employer representative and employee representatives varying according to the number of employees.

1.1. Risk Factors Regarding Occupational Health and Safety

Risk factors that will adversely affect the health of employees at workplaces can be listed as; physical, chemical, biological, electrical, ergonomic, psychosocial and so on.

1.1.1. Physical Risks

Physical risk factors

- Illumination
- Vibration
- Noise
- Thermal comfort conditions.

In addition to the special precautions described in each section, the following general precautions should also be implemented in order to eliminate or reduce the negative effects of physical risk factors.

- Collective protection should be prioritized without departing from personal protection.
- It is necessary to ensure that appropriate personal protective equipment is used even if all kinds of precautions are taken.
- Employees must be provided with the necessary occupational health and safety trainings and periodic health examinations.
- Occupational health and safety risk assessment covering the whole workplace should be ensured.

1.1.1.1. Illumination

Various health and safety risks may occur due to insufficient illumination of the working environment.

These are;

- Injuries due to tripping and falling,
- Eye disturbances,
- Biological and psychological disturbances such as employee unwellness, depression and fatigue.

1.1.1.2. Vibration

Vibration occurs as a result of the oscillating movements of the tools and machines used in the working environment or during the operation of tools which are not well balanced. In terms of affecting health and safety, vibration is divided into two groups as "hand-arm vibration" and "whole body vibration".

Measures to be taken against vibration exposure can be listed as:

- Choosing tools that do the job best and give the least vibration exposure,
- Planning the necessary maintenance works such as sharpening the tools, lubricating and adjusting the engine,
- Reducing the hours worked by the employee with the vibrating tool,
- Arranging the work so that vibrating and non-vibrating tools are used alternately,
- Arrangement of working style and workplace in accordance with ergonomic principles in order to minimize vibration stress,
- Supporting the vibrating tool handle or the place where the tool and worker is in contact with vibration-absorbing materials,
- Fingers and palms of the gloves are supported by vibration-absorbing materials.

1.1.1.3. Noise

Noise can be defined as unwanted disturbing sounds. The most negative effect of noise is that it causes hearing loss. A person who is constantly exposed to noise during work may experience occupational hearing loss. It has been determined that noise can cause various mental disorders with nervous and digestive system diseases as well as hearing loss.

Measures to be taken to eliminate or reduce noise exposure can be listed as;

- If possible, replacing the equipment causing the noise with the non-noiseless equipment, if not with the appropriate equipment that emits the least noise,
- Designing the workplace and work environment considering the exposure to noise,
- Moving the noise source into a separate compartment,
- Covering places such as walls, ceilings and floors where sound can transfer and reflect with sound absorbing material,
- Maintenance of work equipment at regular intervals,
- Limiting the employee's exposure to noise,
- Organizing working periods by giving adequate rest breaks.

1.1.1.4. Thermal Comfort

For the working environment that will ensure the comfort of the employees, all thermal comfort conditions created by environmental (such as humidity and heat sources in the workplace), work-related and personal factors (such as clothing, weight, age, metabolism) must be met. The high temperature of the environment may have negative effects on the employee such as excessive sleepiness, fatigue, low blood pressure, dizziness, decreased body resistance, excessive sweating, decreased work efficiency, red spots that cause itching, hypersensitivity, anxiety and concentration disorders.

The cold environment may have negative effects on the employee such as distraction, decrease in physical and mental efficiency, increase in body internal temperature, shivering, shaking, nutrition and energy requirement.

There are many ways to control thermal comfort in the workplace. Some of these are very easy to implement.

Some of the control measures can be listed as;

- **Environmental control;** checks of ventilation and air conditioning systems,
- **Control of the task;** control of the amount of work done by the employee, the clothes with the equipment used and the working time
- **Administrative controls;** work scheduling, planning, scheduling and control of rest times,
- **Engineering controls;** control of the measures taken as a result of engineering studies.

1.1.2. Biological Risks

Biological risk factors are organisms that are the products of living things or living things, including bacteria, viruses, fungi, parasites and their related toxins. Biological risk factors can enter into human body through respiration, digestion, skin absorption, eyes, wounds, mucous membranes, eardrum. As a result, it can adversely affect human health by causing mild or fatal allergic reactions and diseases that may lead to death.

In order to protect against biological risk factors, it should be ensured to:

- Ventilate the environment,
- Inform employees against biologic risk factors,
- Comply with hygiene rules,
- Immunize employees,
- Proper disposal of wastes,
- Observe health and safety signs.

1.1.3. Electrical Risks

Electrical energy plays a very important role in human life. However, it is also the reason why most of the occupational accidents occur. A significant part of the occupational accidents that occur in our country every year are the electric shocks caused by electric current.

Although electrical risks are encountered in all sectors, they are more common especially in electricity generation distribution facilities and metal industry.

Risk factors in working with electricity can be listed as;

- The control, maintenance and repair of the electrical installation is not carried out by persons with a vocational training certificate,
- The bare metal parts of the machines or tools are not grounded or the necessary insulation is not made,
- The impairment of grounding for the tools or machines that are considered to have been grounded over time or as a result of external factors, the employees are not given sufficient and appropriate PPE or they are not used,
- Failure to provide necessary training to the employees on occupational health and safety or the employees' failure to comply with the rules set in the workplace,
- Employees do not have the necessary training, knowledge and experience about electrical risks, have excessive self-confidence and do not show the necessary attention and care against electricity,
- Employees intervening in electrical failures without taking the necessary instructions or outside of their duties,
- Abrasions on the cables through which the electric current passes.

Measures to be taken against electrical risks are as follows:

- Machines and devices used in laboratories, workshops and factories must have separate stop mechanisms and switch mechanisms that can stop them all.
- No material should be left on the front of the electrical panels that can prevent access.
- Where power tools are required to be used, there should be sockets suitable for the plugs of the tools (grounded socket). In case of absence, the cables should not be plugged into sockets by cutting the plugs, and appropriate (grounded) extension cables should be used.
- Devices with broken on-off switches should be repaired. Switches must not be disabled.
- Electrical cables should be laid regularly, cables should not be left in the open, broken sockets and plugs should be replaced with new ones, fuses should be kept in a closed cabinet.

1.1.4. Ergonomic Risks

Ergonomics is a collection of natural and technical research and development studies of human-machine-environment harmony by examining human physical and psychological characteristics. Ergonomics, by definition, covers many different areas from hand lifting to thermal comfort and lighting. Ergonomic risk factors are frequently encountered in fields of

activities such as construction, mining, healthcare, logistics, furniture, textile industries and office work.

Ergonomic risk factors are listed below.

In material storage and hand lifting works;

- If the load is heavy, large, difficult to grasp, unstable and the contents are displacing, it may cause back and waist injuries, especially if it is in a position that requires bending and twisting.
- The loads carried by one side of the body can cause injuries along with back, shoulder and neck pain.
- Improper working postures during the transportation of the materials can cause back, neck and shoulder discomfort.
- Risks such as slipping, falling and stumbling can be encountered on uneven or slippery floors.

The use of hand tools;

- Vibration caused by hand tools can damage tendons, nerves and veins.
- Working with heavy tools, repetitive and uninterrupted use and improper working postures may cause musculoskeletal system disorders.

Machine and bench use:

- The working area of the machines and benches is not designed in accordance with the body size of the employee, incorrect positioning or misuse of buttons and pedals may cause musculoskeletal disorders.
- The use of machine pedals requires a special posture, which restricts the movement of the operator, especially when standing. Continuous pedal use with single foot can lead to unilateral strain and stress and back pain.

1.1.5. Psychosocial Risks

The likelihood of work design, work organization and social and environmental conditions in which work is carried out causing psychological, social or physical damage is called psychosocial risk.

Psychosocial risks can cause the following negative situations on employees:

- Stress,
- Psychological disorders such as work-related depression and burnout syndrome,
- Behavioral disorders such as increased smoking, consumption of tea and coffee, substance abuse, sleep disorders,

- Diseases that disrupt the working rhythm of internal organs and resulting physiological disorders.

Work environments are especially susceptible to stress factors. Work stress is a mood disorder that is a mixture of feelings such as guilt, anger and fear that significantly affects the well-being and production capacity of the employee.

The employee can be protected from psychosocial risks with the following measures:

- **Collective protection**; In order to protect the body, mind and social well-being of employees, it aims to identify and eliminate psychosocial risk sources, as well as establishing collective protection methods such as the establishment of social support units and counseling services.
- **Personal protection;** It includes increasing the awareness of employees through training and improving their ability to cope with stress. It may include relaxation techniques, time and problem-solving methods, counseling and planning on lifestyle. Programs that support personal protection are health monitoring and health value enhancement programs and the development and dissemination of healthy attitudes and behaviors in the workplace.

1.2. Risk Assessment and Risk Management for Occupational Safety

Risks in occupational health and safety can never be eliminated or reduced. Taking all precautions is not to eliminate or reduce the risk, but to prevent danger or dangerous situation. Any compromise made from the measures will return as either a work accident or an occupational disease.

Risk; in case of danger, is the realization of the danger, it is a possible outcome. It will not occur unless the conditions are developed, If risk occurs, damage happens, Risk is always an element of danger.

1.2.1. Forming Risk Assessment Teams and Instructing The Team

A separate team should be established for each part of the workplace. The team structure should be as follows.

- A Manager (team leader)
- Sufficient number of employees
- Occupational Safety Specialist
- Workplace Physician

The team members should be informed about the benefits of this work, how to do the work, etc.

Note: The team leader will act as a bridge that provides communication between technical support members and team members.

1.2.2. Specifying Labor

Team members make a list of the work they did during a shift, in other words, the jobs on this step. According to legislation, occupational accidents happen when doing a job. In this regard, it is important to list the works done. Each work done means a danger or dangerous situation.

1.2.3. Determination of Labor Risks

We have defined all the work done up to this stage, in other words, the dangers / dangerous situations. Now it is necessary to identify the risks within these hazards. Add a potential risk column to the list of final works done. Print it out and distribute it to team members. Team members should write down the risks they anticipate "in their own way" along with every work they perform.

At this stage, the Workplace Physician, Occupational Safety Specialist and, if deemed necessary, a sufficient number of technical personnel must be involved in the study. Lists of risks found by the workers shouldn’t be considered to be sufficient. It is necessary to determine all possible risks with technical support.

After making sure that all the risks have been identified, the precautions to be taken should be determined in order not to reveal each risk. Let's open another column in Excel spreadsheet and distribute the print-outs to team members. Let's ensure that the question of what precautions should be taken against each risk is answered by the workers.

1.2.4. Classification of Precautions

It is necessary to clarify and then classify all necessary precautions with the support of the workplace doctor and occupational safety specialist and, if deemed necessary, sufficient technical personnel. The classification result will be as follows;

Corrections that can be made with the present resources of the workplace, Corrections to be applied after procuring goods and / or services from outside, corrections that can be made with the investment project / plan, etc.

Creating Control Tables and Statistics. The obtained data must be supported by statistics and the "business risk prevention tree" must be entered into the business risk assessment form. In this way, almost all of occupational accidents and occupational diseases that may occur in each part of the workplace can be defined.

ASSESMENT-1

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

Read the following questions carefully and mark the correct option.

1. What is the name for the set of measures to be taken to create a safe working environment in order to prevent employees from suffering work accidents?

a. Occupational health and safety

b. Job

c. Sales and Marketing

d. Employee

e. Production

2. Which of the following does not occur due to the risks arising from hand tools?

a. Hearing loss

b. Hand-arm vibration

c. Exposure to acid vapor

d. Hand-arm injury

3. Which of the following is not a threat to occupational safety in buildings?

a. Plumbing

b. Electrical installations

c. Heating installations

d. Landscape arrangement

4. What is the main purpose of occupational health and safety?

a. It is to protect and watch over the safety of life and property of shopkeepers, merchants and employees.

b. To protect workers against work accidents and occupational diseases and to ensure their spiritual and body integrity.

c. To protect and watch over the life and property safety of the employer.

d. Improving the economic conditions of the employees.

5. Who are the parties to Occupational Health and Safety?

a. Employees only

b. Employers only

c. Government, Workers and Employers.

d. Government and Employers

6. In which of the following situations does the fire occur?

a. Heat only is enough for a fire to break out.

b. Presence of flammable material is enough for a fire to break out.

c. Flammable material and oxygen is enough.

d. Combustible material, oxygen and heat must be together for a fire to break out.

7. Which of the following is not a measure to be taken to avoid electrical accidents?

a. Using a voltage less than 65 volts,

b. Using isolation transformer (safety transformer).

c. Grounding the metal bodies of electrically operated tools and equipment.

d. Using high voltage.

8. Which of the following are the duties and responsibilities of the employees regarding Occupational Health and Safety at workplaces?

a. Operating a machine without protective equipment.

b. To comply with all measures taken on Worker's Health and Work Safety in the workplace.

c. Not using personal protective equipment.

d. To immediately intervene in a breakdown in the workplace without notifying the employer or employer representatives.

9. What is the most important event affecting the health and safety of employees in the workplace?

a. Workers diseases

b. Occupational accidents

c. Trafic accidents

d. Overtime of employees

10. Which of the following materials does not conduct electricity?

a. Steel rod

b. Wet wooden rod

c. Saltwater

d. Plastic rod

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-2

AIM

You will learn about the definition of dried food and the importance of drying food with Geothermal Energy.

You shall learn the definition of geothermal energy, geothermal energy resources in Turkey and in the world with their food drying facilities by these sources.

RESEARCH

What is being performed with renewable energy sources?

Discuss what can be established with geothermal energy by brainstorming with your friends in the classroom.

Research which food is conducive to the drying in the world and in Turkey.

2. Utilization and Importance of Geothermal Energy Through the Process of Dehydrated Food Preparation

Since the early ages human has tried various methods in order to consume food independent from the season or to preserve food in hot or cold conditions. Drying is one of the most widespread method. Drying is a temperature and mass transfer by carrying the water inside-out and evaporation from the surface.

Picture 2.1 Grapes on Hangers

Picture 2.2 Dried Fruits

Picture 2.3 Dried Vegetables

Picture 2.4 Dried Tropical Fruits

Picture 2.5 Dried Meat

Picture 2.6 Dried Fish

This method has ensured that different kinds of food can be consumed independent of the seasons. The purpose of this technique is to prevent the growth of decay factor microorganisms on food, and becoming inconsumable due to factors such as decay, etc. Therefore, shelf life can be prolonged to 12 months by hot air application which provides removal of essential water for micro-organism growth and prevents decay and enzymatical spoiling. We are aware that any fruit is inconsumable in 3-10 days after it is removed from the branches. It is obvious that consumption date is much longer when same fruit is preserved by drying.

Drying is an ancient technique used to preserve food and extend its shelf life. Although products can be stored for a long time by cooling, freezing, undergoing chemical processes, storing in an oxygen-free environment, and using ultraviolet and radioactive rays, drying is the method with a more solid ground. Dried foods keep their durability for a longer period. Because the amount of water it contains is low, microorganisms that will spoil the food cannot develop and multiply.

Bringing the amount of water in the product to low levels in the drying process prevents the product from spoiling, and the transportation and storage processes of the product become more efficient thanks to the reduction in mass and volume. It reduces shipping costs and storage costs per unit product weight. Dehydration using natural techniques is a practice that still continues in rural life. While sun drying is the most common method of preserving food in the countryside, mechanical drying in industrial production is a faster, more practical and versatile application on a commercial scale. Why is drying food so important? Because dried agricultural products are a very important resource that can be used all year round and can be consumed during drought and protect us from product waste. In the previous years, the drying process was generally carried out using sun in the open air. Today, it has been determined that drying under sun is not very healthy, it harms the product in terms of quality, energy and nutrient values according to researches, and different drying methods have been developed. Dried fruits have taken their place in both domestic and foreign markets because they are rich in nutritional value and also healthy.

Picture 2.7 Sun Dried Vegetables

The method of drying in open air under the sun may cause excessive drying of the product and a loss in the quality of the final dried product due since it is not completely possible to control the drying parameters such as temperature and air speed. Therefore, drying methods which use closed and controlled modern dryers come forward. Drying the product with hot air using tunnel or cabinet type dryers is one of the advanced modern drying methods. Modern drying methods increase the quality of the final product by shortening the required drying time, but it causes a

significant increase in the energy requirement used in drying process. For this reason, it becomes important to use renewable energy sources as energy sources in the drying process. Geothermal energy is one of the renewable energy sources used in drying applications. Geothermal energy provides the opportunity to be used in drying processes as a continuous energy source regardless of seasonal changes.

Considering that our country is very advantageous in terms of solar energy and geothermal energy among the renewable energy resources, it has become more important to expand the implementation of these resource considering their economic and strategic contributions. Dried fruits and vegetables are among the important domestic consumption and export items for our country. Therefore, there is a need for research into designs that can be controlled better than traditional drying management.

Drying of agricultural products in the open air, under the sun, carries risks such as dust, being damaged by flies and various insects, being eaten by birds, flying in the wind. The geothermal drying method is a powerful alternative to drying under the sun. The geothermal drying method differs from other modern drying methods that use electricity thanks to its low energy cost. Geothermal energy opens a new era in the drying of vegetables and fruits with its cheap and hygienic drying method.

With this module, you will learn the pre-treatments applied to foods to be dried with geothermal energy, drying methods, packaging the dried product and storing it in suitable storage conditions.

The main goals of food drying are:

- To protect food by reducing the water activity in foods,
- To achieve low transportation and storage costs by reducing weight and volume,
- Converting a food to an easier manner for storage, packaging, transportation and use,
- Transforming dried agricultural products into resources that can be accessed and consumed all year round,
- To extend shelf life and prevent waste by drying food.

2.1. What is geothermal?

Geothermal as a word; is a term that comes from the combination of the words "geo" meaning "ground" and "thermal" meaning "heat". We can express the Turkish equivalent of the word **geothermal** as ground heat / ground energy.

In scientific and technical terms; the hot water, steam and dry steam formed by the heat energy accumulated in the rocks in the depths of the earth are transported by fluids and stored in reservoirs, called geothermal resources.

2.2. What is geothermal energy?

Geothermal energy can be described as the heat transported to the surface by steam (fluid) temperature generated by the accumulated heat in various depths of the earth's crust, which is above the regional atmospheric average temperature and may contain more dissolved minerals, various salts and gases than the surrounding normal underground and surface waters.

Geothermal energy is generally obtained from the water that reach the surface from the depths of the earth via weak zones formed by cracks and fractures or from specially drilled boreholes. The source of geothermal energy can be observed as water, steam, hot rocks and magma in those layers close to the earth's surface. The fluid overheated by the heat source contains more melted minerals, various salts and gases than normal underground and surface waters. Geothermal energy is the most important source of energy among alternative energy sources compared to fossil fuels.

Geothermal energy is a renewable, sustainable, inexhaustible, cheap, reliable, environmentally friendly and domestic energy source.

2.3. Where does Turkey stand on geothermal energy utilization?

Turkey is among the richest countries in the world in terms of geothermal as a result of geological and geographical position since the country is located on an tectonically active zone. There are approximately 1,000 geothermal resources at different temperatures in the form of natural outlets spread all over our country.

According to the data by Ministry of Energy and Natural Resources (MENR), Turkey ranks first among European countries with 1,283 MW of installed geothermal power plant. Turkey ranks fourth in the world.

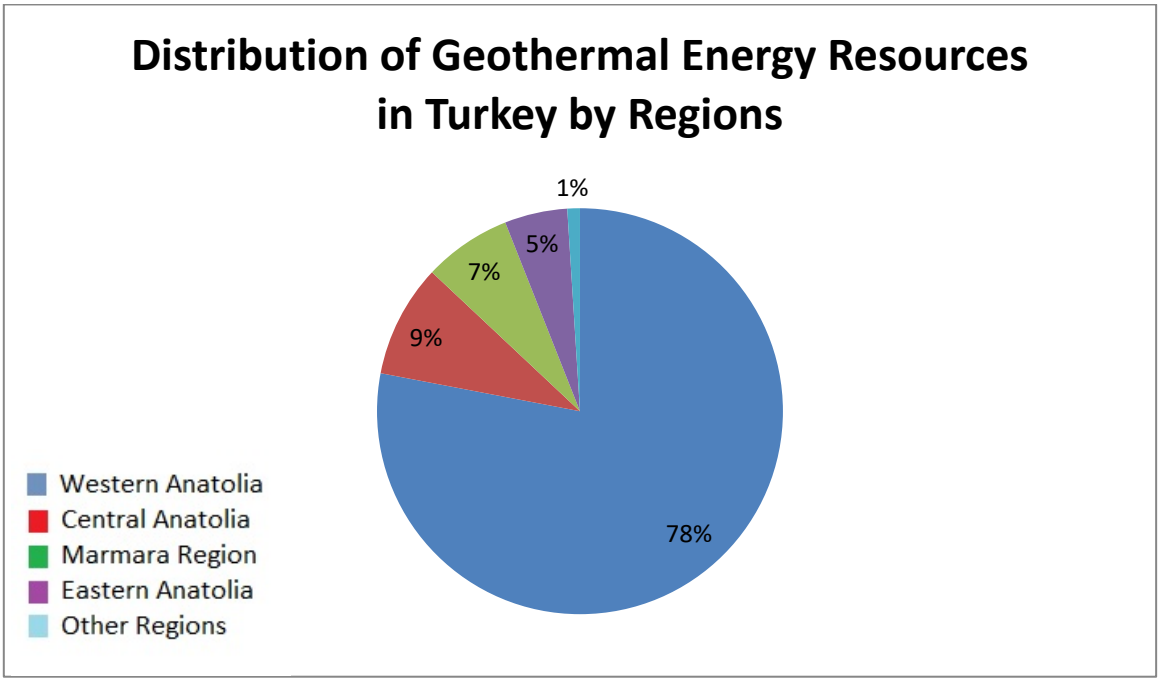


Diagram 1: Distribution of Geothermal Energy Sources in Turkey

Food drying plants with geothermal energy in Turkey are located in Kırşehir, Denizli (Sarayköy), Aydin, Afyonkarahisar, Balıkesir (Sındırgı), Ankara (Kızılcahamam), Manisa (Alaşehir).

2.3. Geothermal Energy in the World

Considering the general distribution of geothermal energy in the world, especially the regions with plate boundaries stand out. The Alpine-Himalayan zone, South and Southeast Asia (Pacific Ring of Fire) and American continent are seen as prominent regions in this regard.

As in our country, , the types of benefiting from this resource in other areas of the world rich in geothermal energy appear as domestic heating, greenhouse activities and most importantly electricity generation.

Since it is a continuous and renewable resource especially in developed countries, electricity generation is highly preferred. Some developed countries in the cold zone also benefit from geothermal energy in heating the roads, pavements and runways.

As in our country, , the types of benefiting from this resource in other areas of the world rich in geothermal energy appear as domestic heating, greenhouse activities and most importantly electricity generation.

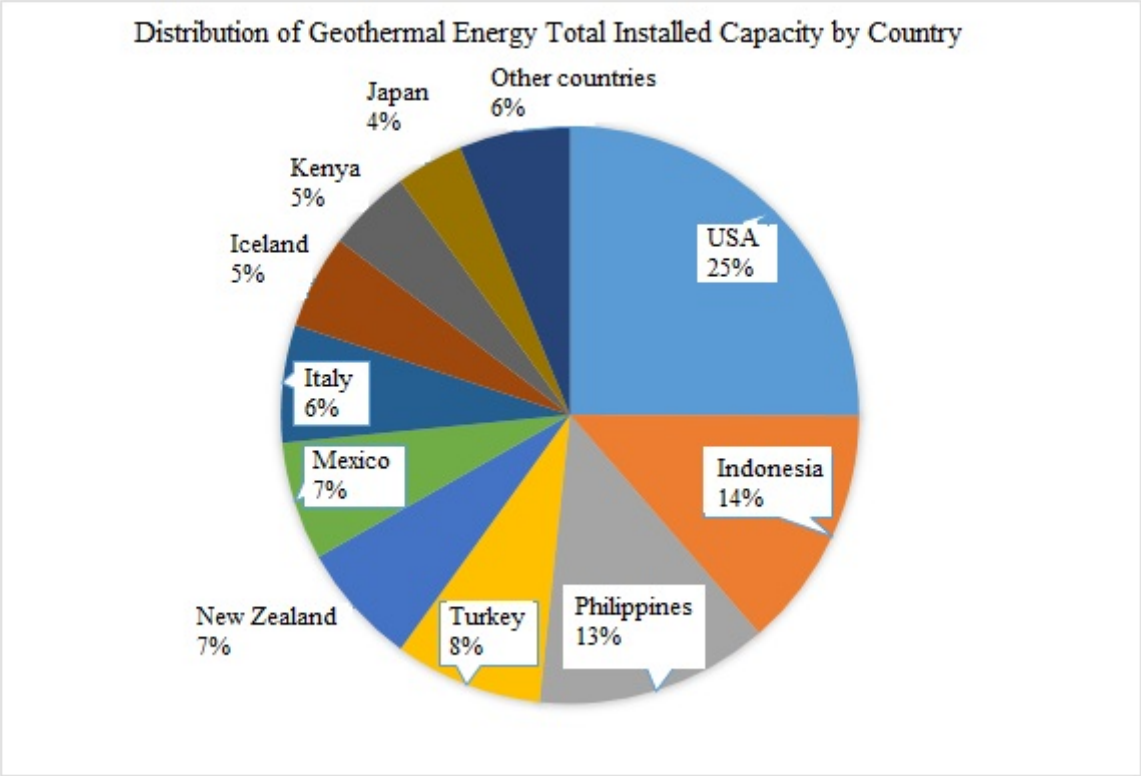


Diagram 2: Distribution of Geothermal Resources to Countries

Since it is a continuous and renewable resource especially in developed countries, electricity generation is highly preferred. Some developed countries in the cold zone also benefit from geothermal energy in heating the roads, pavements and runways. The world's largest geothermal power plants are Geysers Complex - USA, Lardello - Italy, Cerroprieto - Mexico, Hellisheidi - Iceland, Malaya - Philippines, Olkaria - Kenya, Makban - Philippines, Saltonsea - USA, Darajat - Indonesia.

The “Fruit and Vegetable Dehydration (drying) by Sustainable Geothermal Energy" project, prepared by Alaşehir Municipality, was chosen as the world champion in the competition held in the USA in 2019, in which 200 projects from 20 countries participated.

In summary, since it is continuous and renewable, **geothermal energy** is an important resource in the world and in our country. It is necessary to invest in geothermal for the future, especially for electricity generation in our country. This situation is also very important for the economic development of our country.

ASSESMENT-2

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. In which of the following statements is the definition of drying wrong?

a. Drying is a temperature and mass transfer by carrying the water inside-out and evaporation from the surface.

b. Drying; It is one of the storage methods applied to products with short storage period. Briefly, it can be defined as the dehumidification of a substance.

c. It is called keeping food under the sun until its color changes during the season and the water content is completely exhausted.

d. Drying is the process of removing most of the water present in foods and reducing the amount of water (water activity) to a level that prevents microorganism activities.

2. Which of the statements given below is not a reason for the drying of food?

a. Preserving food

b. Extending shelf life

c. Avoiding waste

d. Spreading the use of packaging

3. Which of the following is not one of our renewable energy sources?

a. Solar Energy

b. Nuclear Energy

c. Wind Energy

d. Geothermal Energy

4. Which of the following cannot be the main target in dried food?

a. To preserve food by reducing the water activity in foods.

b. To extend shelf life and prevent waste by drying food.

c. To achieve low transportation and storage costs by reducing weight and volume

d. Eating dried agricultural products with their tastes in season.

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-3

AIM

- You will learn drying methods according to food types and conditions.

RESEARCH

- Make a research on one of the drying methods.
- Evaluate the drying methods described below in the classroom environment at the end of the lesson and discuss them.

3. Dehydration Methods

Basically, there are two types of drying given below:

1) Natural drying

2) Mechanical drying.

3.1. Natural drying

In natural drying, natural sources such as the sun are used to dry food. It is also known as solar drying. Sun drying has been used to dry fish, meat and grains, and this technique has proven to produce high quality food. Sun drying is an inexpensive, easy and common method; however, it needs a long drying time and suitable weather conditions.

In the natural drying method, 6-9 weeks and further processes are required to reduce the water content of the grapes to 25-30%. Sun drying is a cheaper method compared to other methods, however;

Picture 3.1.Drying food with natural methods

- It is a time consuming slow process,
- Products are exposed to dust, sand, insect residues,

- Food is susceptible to ferment and a sour taste may occur,
- It is dependant on weather conditions.

3.2. Mechanical drying

Mechanical drying is another method of drying food through various mechanical systems. The hot air generated by the system is used for drying. Various types of mechanical drying systems are available on the market.

Picture 3.2 Mechanical Food Drying Machine

Advantages of mechanic drying

- The products stay away from dust, sand particles and insect residues,
- It is fast and independent of weather conditions,
- The drying process ends with hygienic and homogeneous results.

3.2. MECHANIC DRYING METHODS

3.2.1. Hot air conduction drying

Drying by hot air conduction principle is based on simply transferring the heated air to the dried material. Hot air is blown towards the food and the moisture diffusion process causes drying. This method is widely used in industrial production.

- Dryer heat pumps do not cause any danger to the environment such as pollution, explosion, burning or poisoning.
- The drying plant is installed simply and quickly with the fruit dryer heat pumps.
- Compared to other drying systems, by making a hygienic drying, a healthier and quicker drying occurs.
- Dried food does not give any other odor except its own odor. There is no oxidation, rotting, explosion or taste change.
- Food dryer heat pumps do not use any kinds of fossil fuels. In addition, it is 40% to 80% more economical than fossil fuel drying systems.

3.2.2. Freeze drying

Freeze drying is one of the best methods of drying in terms of the quality of the final product. Freeze drying process; consists of freezing, vacuum, sublimation and condensation operations and is based on the principle that the water in the product is directly transformed from solid to gas. Due to the removal of the water in the food and the fact that the process takes place at very low temperatures, possible reactions and microbiological activity are stopped, resulting in excellent quality final product.

Picture 3.3 Freeze Dried Foods (Apple, Strawberry)

Structural rigidity, which is the most important factor here, is provided by the frozen surface where sublimation occurs. This structural rigidity also prevents the dried material from deforming after drying. As a result, when water is added to the freeze-dried product again, thanks to its non-shrunken porous structure, it is provided to reach a structure that is very close to its pre-drying structure by rapidly absorbing water (rehydration). Another advantage of freeze dried food and biological materials is that there is little loss of taste and aroma during the drying process. Very low temperature and low relative humidity, very rapid local water loss, minimizes non-enzymatic tarnishing, degradation of proteins in the structure of the food and enzymatic reactions compared to other traditional drying methods. Despite these advantages, freeze drying is still a high cost drying process. Freeze dried products can preserve their aroma, character, structural integrity and taste and can be stored at ambient temperature for years. The large weight loss (useful for transport and storage) and the preservation of the original quality bring balance to the high initial investment cost of freeze drying, while not requiring cold for food storage.

Freeze Drying takes place by first freezing the product, then lowering the pressure in the environment and evaporating the water it contains before it becomes liquid. In the meantime, most of the chemical and physical properties of the product are preserved.

Instant coffees (instant coffee), milk powder obtained by this method, and fruits in some breakfast cereals are some of the examples.

Some medicines are sensitive to heat. Some fruits and vegetables lose their aroma and flavor when exposed to high temperatures. Freeze drying is an expensive and complex technique. Freeze drying is difficult to apply to all industrial and commercial drying needs.

3.2.3. Vacuum drying

Areas of usage: It is especially used for drying sensitive products. The low atmospheric pressure allows the drying temperature to be realized at lower levels. Vacuum drying can also be used for drying without oxygen or with different gases. As it is known, as the atmospheric pressure decreases, the boiling point of water decreases and the atmospheric pressure applied for the transition of water molecules to the gas phase is less at low levels. Thus allows the water to evaporate more easily. It can be used in pharmaceutical industry, chemical industry, fruit and vegetable drying fields.

Advantages: Low energy cost drying, the ability to dry sensitive products at lower temperatures while drying, the ability to dry without oxygen or with different gases, the ability to remove the liquid in the product separately while drying.

Picture 3.4 Vacuum Dryer Example

Principle: It is a machine where drying is faster with the lowering of the boiling point of water at low atmospheric pressure. Its principle is to reduce the atmospheric pressure with a vacuum pump in a strong cabinet and to dry the product with the heater, fan and rotary tray system inside. There are ovens that can be heated up to 180 degrees for drying.

The basic principle of vacuum drying is the removal of water by vacuum. There are four basic elements in the vacuum drying system: a vacuum chamber, vacuum generating device, vapor collection system and a supplier of heat required for water evaporation. Vacuum drying is an expensive drying method similar to freeze drying. It is used only for high cost products.

3.2.4. Fluid-bed drying

Fluid bed drying system is widely used in drying and cooling processes. In fluid bed drying systems, the product is moving on the bed with the effect of vibration and the effect of air. The word "fluid bed" comes from here. As a result of the interaction of the product with these two kinds of movements, the product not remaining stationary while drying helps to increase the heat transfer coefficient and at the same time to ensure a good mixture and achieve uniform drying. Temperature and air flow rate to be used in fluid bed drying processes are the parameters that should be determined first.

Picture 3.5 Fluid Bed Drying Machine Example

It is a drying technique in which fluidization occurs. Fluidization provides better surface area for heat and mass transfer. Fluid bed dryer is used in all industries, from heavy mining to food, fine chemicals and pharmaceuticals. It provides an effective method to dry relatively free flowing particles with a reasonably small particle size distribution.

3.2.5. Microwave drying

Different techniques have emerged in recent years to preserve food based on the developing technology and changing nutritional habits. Among these techniques, practical and easy-to-apply methods are preferred and widely used by consumers today such as microwave drying. Microwave drying provides a faster moisture transfer compared to traditional drying methods, as well as better preservation of the nutritional value of foods. However, not all products are suitable for microwave drying, and the wavelength and frequency range to be selected are very important in determining the final product quality. In addition, microwave drying increases the product cost due to reasons such as high initial investment cost, capacity problem, advanced technology and trained labor. However, microwave drying has an important area of use in

economically valuable products that cannot be dried by other methods, and when combined with different drying methods, it positively supports the product quality and increases energy efficiency.

Microwave is an innovative food drying technique that provides volumetric heat, which means heating from all sides. Batch heating facilitates faster drying and minimizes microbial load. Microwave drying is a fast technique that can be applied to certain foods, especially fruits and vegetables.

3.2.6. Vacuum assisted microwave drying

Microwave Vacuum Oven allows heat sensitive materials to be dried at low temperatures using low pressure. Alternatively, they can be dried faster at high temperatures with continuous frequency without fan circulation. This oven is also particularly useful for heating under controlled atmosphere. Since the inner chamber is completely enclosed, it may also be suitable for solvent removal depending on sufficient exhaust pipes provided for the furnace and room respectively, and ventilation conditions.

Vacuum assisted microwave drying provides a better drying process in terms of organoleptic qualities of dried products, drying time and rehydration quality. Vacuum assisted microwave drying is very suitable for drying sensitive fruits and similar products that are sensitive to temperature. This method generally results in lower energy costs and better product quality.

3.2.7. Microwave assisted fluid-bed drying

Microwave assistance improves the efficiency of the drying system. Fluid bed and microwave drying compensate for some of each other's disadvantages. The combination of the two methods makes it easier to achieve the targeted results; The homogeneity of the temperature between the particles depending on fluidization can be achieved by thorough mixing, and drying times can be reduced by using microwave energy.

LEARNING ACTIVITY-4

AIM

- You will recognize the types of dryers used in industrial food drying.

RESEARCH

- Make a research on one of the drying methods.
- Make a research on the facilities where the below described dryer types are used. Find out in which areas it is used more.

4. Dryer types

Industrial food drying is basically performing the work of evaporating moisture in the product by using electrical energy and heat process on a large scale, healthy and fast. The basic energy requirement is associated to obtaining the appropriate temperature to start the evaporation process and obtain the energy required to evaporate a certain percentage of the moisture. The process often takes place by direct contact of the product (cereals, vegetables, fruits, etc.) which has been subjected to air drying at a relatively low temperature (35 to 80 ° C). Therefore, low temperature geothermal resources are easily used as an energy source for the drying of agricultural products.

4.1. Air as dehydration fluid

In the drying process, air is used in various processes such as transporting the heat needed for moisture evaporation, removing the evaporating water out of the facility and cooling the dried product after the drying process is completed.

The temperature of the drying air varies according to the food to be dried. For instance, the recommended maximum temperature for drying grains is usually 43 ° C. Most grains will be damaged if they are exposed to a temperature of 52 ° C or higher. In the case of ground grains, temperatures above 60 ° C are not allowed.

Therefore, the duration of the drying process will vary depending on the maximum allowable temperature. In other words, the higher the temperature of the drying air, the shorter the time required to dry the product.

Higher temperature than allowed degrees during drying process can cause physical and chemical damage to the products. When considering grains (rice, corn, soybeans) this occurs as cracking and breaking.

Temperatures higher than permissible for fruits and vegetables will cause damage to the nutrients involved, deterioration of their texture and aroma, loss of color and quality loss.

To avoid such negative consequences, the following is required;

- Using lower temperatures for drying,
- To cool the products slowly after drying,
- Evaporation of moisture content only as needed (different for each product type),
- Using air with a certain humidity and temperature.

4.1.1. Geothermal Source

If a geothermal source will be used for drying, the following factors should be considered:

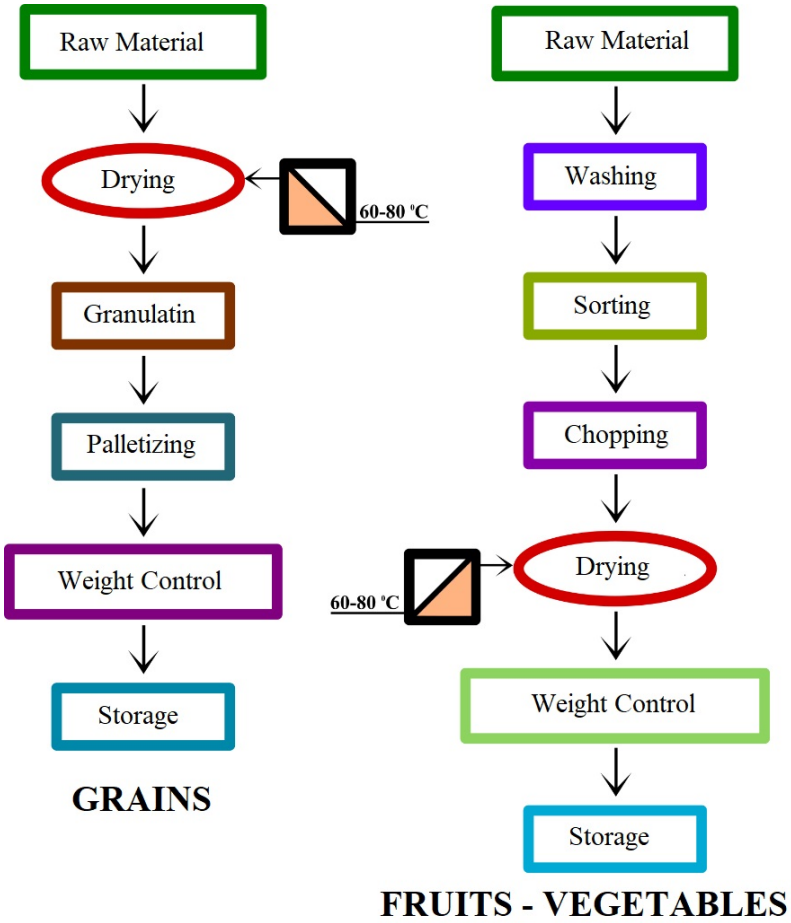
- The distance of the source to the facility,
- The temperature of the geothermal resource,
- Flow rate of the geothermal resource,
- Chemical structure of the geothermal resource,
- Integration possibility with other applications,
- The cost of the temperature difference used.

4.1.2. Designing Dryers

Thermal calculation largely depends on how heat is applied to the product to be dried.

For convective (hot air conductive dryers) dryers, the drying regime (parameters determining the time required for drying) is defined by the temperature, flow rate and relative humidity of the drying medium. In the drying process, the intensity of the heat flow for the heat input paths (contact, thermal radiation, high frequency current, etc.) is adjusted so that the temperature of the material does not exceed the specified limit value.

Drying of agricultural products generally involves convective drying. The calculation of the thermal heat of drying ovens depends not only on how the heat is supplied, but also on the type and construction of the furnace.



4.1.3. Heat Exchangers and Geothermal Energy

The main purpose of food drying is to be able to store food for a long time without spoiling, to reduce field losses by early harvest, to find buyers for agricultural products at higher prices and to obtain better quality products.

Industrial drying processes are performed via using electricity and use heat to operate the equipment. Basically, the heat source is directed to the product and adjusted to a suitable temperature to initiate the (moisture) evaporation process.

Often the heat comes into direct contact with the product (cereal, vegetable, fruit, etc.) which is subjected to relatively low temperature (35 to 80 ° C) warm air drying. Therefore, low temperature geothermal fluids can be used as energy source to heat air for drying.

A moderate temperature of 50–60 ° C with a relative humidity of about 40 percent is sufficient to dry other products. For example, the drying temperature of coffee beans should be around 50–60 ° C, and the temperature of rice should be below 40 ° C to prevent internal cracking. The drying temperature of some grains may approach 90 ° C.

The main reason for using heat exchangers in geothermal systems is to trap geothermal waters with their residues, where corrosion or calcification can be controlled by material selection or

cleaning will be relatively easy and economical. However, the application of the heat exchanger causes a reduction in temperature in addition to the existing temperature difference between the primary and secondary fluid.

In principle, air is used as a heating medium for drying. So, if there is a more complex system (for integrated geothermal projects where geothermal energy is used for many different purposes), the air will be heated by the secondary fluid (via the secondary heat exchanger); or it can also circulate as a secondary fluid in the heat exchanger by drawing the required heat energy from the geothermal water.

Food preparation and preservation is a very delicate process as it requires a high level of sanitary conditions. This process again makes the use of heat exchangers inevitable when geothermal energy is used.

Drying of agricultural products generally involves hot air conduction drying. The calculation of the thermal heat and structure of drying ovens depends not only on how the heat is supplied, but also on the type and construction of the furnace.

Hot air conduction dryers:

There are three basic ways to dry by hot air conduction:

- Drying by reheating of air (multi-zone dryers for drying heat-sensitive materials that do not allow the use of air at high starting temperatures),
- Drying by recirculating the used air (the air from the dryer is partially discharged to the atmosphere and partially mixed with fresh air, where the fresh air mass is equal to the mass of the exhaust air)

Combination (this drying process is mostly used in countercurrent flow multi-zone dryers).

4.2. Chamber dryers

This type of dryers operate cyclically / regularly and at atmospheric pressure. The basic part of the chamber dryer (Figure 2) is the rectangular section in which the material is placed. The material is in a fixed position during the drying cycle.

Picture 4.2 Chamber Dryer for Food

Loading and removing of the material is performed from only one side of the dryer. It can be performed via: trays, screens, hooks and wagons. Under normal circumstance its intended use is for lumber drying, insulation plates, ceramic and silicate objects, porous and fibrous materials. The application is suitable for small quantities of material and where precise regulation of the drying process is required. These dryers are characterized by low efficiency and longer drying period. Drying is due to the partial flow of air through shorter paths (through openings) in the upper layers rather than the uneven distribution of temperatures in the room. The downside of this type of dryer is the high need for manual work.

4.3. Tunnel dryers

This type of dryers have a continuous working principle. The main part of the dryer is the long drying chamber. The interconnected wagons move slowly on rails throughout the room. The tunnel is equipped with airtight doors at the entrance and exit. They are opened simultaneously and periodically so that the dryer can be loaded and unloaded with the material.

Picture 4.3 Tunnel Type Dryer

Drying air moves in the same or opposite direction according to the movement of the dried material. The distribution of air can be natural or forced, but the better effect is obtained with forced countercurrent motion. Tunnel dryers can operate with a single use of heated air, by redistribution or by reheating the air.

4.4. Conveyor dryers

Conveyor dryers are used to dry cotton, wool and other fibrous materials. These dryers have the principle of continuous operation using a reservoir in which the drying material is placed and moves on the loading lane (Figure 4). Drying is performed at temperatures where the air (or gas) is between 70 and 170 ° C. The circulation of the drying air is provided by using axial fans.

Picture 4.4 Conveyor Type Dryer

The dried material is collected into a reservoir made of strips or collected in another conveying device. These dryers are constructed with a line width of 2 to 2.2 m and a length of 40 m. The downside is the uneven drying across the height of the sheet, which is greatly reduced by mixing as it passes from one strip to the next. Another negative aspect is the pollution caused by the particles falling on the heat exchanger while passing through the protection grid.

4.5. Drum dryers

This type of dryer is suitable for drying beer and sugar residues, cereals, dairy food crops and other materials. The basic part is a horizontal or inclined cylindrical drum with 0.5 to 0.8 revolutions per minute, which enables the porous material to be moved and mixed (figure 5). The angle of the drum (for gradual movement of material from one end to the other) is usually 0.5 to 3 degrees. Different compartments are placed inside the drum depending on the material, contributing to a better drying of the material.

Picture 4.5 Drum Type Dryer

4.6. Pneumatic dryers

The basic part of these dryers is the chamber or tube in which the porous material is dried during pneumatic conveying (figure 6). The air velocity for the transport of the particles must be higher than the rate at which the particles are blown up (10 to 20% higher than the airborne velocity of the largest particles). It is kept in a frame of 10 to 40 m / s depending on the particle size. This situation requires additional electricity consumption. In principle, the operation of pneumatic dryers is continuous. Grains, chopped dairy products, vegetable leaves, etc. are used for drying.

Picture 4.6 Drum Type Dryer

ASSESMENT-3

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. Which of the following is not one of the advantages of mechanical drying?

a. The products stay away from dust, sand particles and insect residues.

b. It is fast and independent of weather conditions.

c. The drying process ends with hygienic and homogeneous results.

d. It is low cost and economical.

2. Which of the following is not one of the mechanical drying methods?

a. Freeze drying

b. Cabinet Type Dryer

c. Fluid-bed drying

d. Vacuum assisted microwave drying

3. What operations does the freeze drying process consist of?

a. Freezing

b. Vacuum

c. Condensation

d. All

4. Which of the following factors should not be taken into account where a geothermal resource will be applied for drying purposes?

a. The distance of the source to the facility

b. The temperature of the geothermal source

c. Contribution of geothermal source to residential heating

d. Chemical structure of the geothermal source

5. There are three basic ways to dry by hot air conduction. Which of the following is not one of the three basic ways?

a. Drying by reheating air

b. Drying by recirculating the used air

c. Combination

d. Vacuuming of food with hot air

6. Which of the following dryers is suitable for drying beer and sugar residues, cereals, dairy food crops and other materials?

a. Tunnel dryers

b. Drum dryers

c. Conveyor dryers

d. Chamber dryers

7. Which of the following is the most suitable dryer for cereals, chopped dairy products, vegetable leaves, etc.?

a. Tunnel dryers

b. Conveyor dryers

c. Drum dryers

d. Pneumatic dryers

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-5

AIM

- You will be able to distinguish foods used for dried food.

RESEARCH

- Make a research on which foods are mostly dried in our country.
- Make a research on which foods are mostly dried in food drying facilities with geothermal energy sources.

5. Necessary Qualifications For The Food To Be Dried

Picture 5.1 Dried Fruits

The most popular dehydrated food products internationally are:

• Fruits: Mango, pineapple, banana, avocado, papaya, plum and cashew nut

• Vegetables: Carrots, tomatoes, onions, garlic, and hot peppers

• Herbs: Aromatic (coriander, parsley, celery, mint etc.)

• Tea: Roselle flower, chamomile, orange flower, lemon tea and orange flowers

• Spices: Bay leaf, thyme, rosemary, thyme, etc.

Apple, fig, grape, peach, apricot, cabbage, red, pepper, garlic, cherry, plum, pear, banana, carrot, onion, pepper, potato, corn, green bean, tomato, eggplant, strawberry, pumpkin, mulberry, banana , mushrooms, pumpkin seeds; we can dry, store and safely eat many kinds of foods. In addition to being beneficial for human health, these foods carry many vitamins and strengthen the immune system that weakens during seasonal changes.

Picture 5.2 Fruits and Vegetables

Drying foods with high sugar content is more difficult than others. The reason is the tendency of such products to stick to each other. In addition, products that are considered to be produced as powder may have problems such as clumping later. Therefore, it is necessary to go down to the minimum possible moisture level in such products.

The properties that are required before drying foods are:

Picture 5.3 Harvested fruits

1. Ripe The fruits to be dried should be harvested in drying maturity. Although this is variable in some foods, ripe foods are preferred at this stage because they have reached their essence in terms of taste and vitamins. Its color and taste must be fully ripe so that dried foods can taste like the first day.

Picture.5.4. Harvest

2. Harvesting should be performed according to its procedure. It should be dried in the season when it is abundant. The foods to be dried should be dried freshly according to the season, organic grown food will also serve the purpose when it is not the season.

Picture 5.4 Rotten food

Picture 5.5 Fresh food

3. It should be free of scars and bruises. No matter how much the injured food is washed before drying, it is assumed that it is in contact with the insect, pest, and it is not suitable for use. -It must be firm. There should be no crushing on the products. Crushed products are unsuitable as they lose the liquid that must remain in essence before drying. There should be no insect bites. It should be free of rot. Rotten products cause great harm to human health. Foreign matter, stems, garbage, leaves, stones, etc. and bruised ones should be separated.

4. It should be washed both to clean and to purify the pesticide residues.

Picture 5.6 Avocados separated by size

5. They should be sorted according to their sizes. Food should be separated according to their sizes as well as their types. This is a factor with the temperature and time to be applied in the drying technique.

ASSESMENT-4

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. Which of the following is not required in foods before drying?

a. Ripe

b. They should be sorted according to their sizes.

c. Harvesting should be performed according to its procedure.

d. It should be free of scars and bruises.

2. Which of the following foods are suitable for drying?

a. Apple

b. Pear

c. Carrot

d. All

3. The foods to be dried should be dried ..... according to the season, organic grown food will also serve the purpose when it is not the season.

4. Drying foods with high ..... content is more difficult than others. The reason is the tendency of such products to stick to each other.

5. The fruits to be dried should be ..... in drying maturity.

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY–6

AIM

- You will be able to pre-treat foods in the dried food facility.

RESEARCH

- Discuss in the classroom about the possible problems that may occur in the pre-treatments applied in foods. List these negativities and make a research on what measures can be taken.
- Research at least one subject from the pre-procedures and explain it to your friends using visual materials in the classroom environment.

6. Pre-treatment of food drying

The main purpose of the drying process is to use energy as efficiently as possible while obtaining a quality end product. It is not possible for a single drying method to be sufficient for all products in terms of both economic and quality characteristics. In some cases, pretreatments such as dipping in a solution or steaming before drying both increase the quality of the final product and reduce the process cost as it may shorten the drying time of the product. As a result, besides the drying technology, correctly selected pre-treatment methods also have a significant effect on the final product quality when necessary. In order to obtain a good quality final product and to use energy as efficiently as possible, the parameters of the pre-treatment and drying method, which are selected in accordance with the market value of the raw material and the final product, should be selected carefully. The product to be dried is pre-treated according to the requested product type. The raw materials that are considered to be produced as chips are cut into rings in specially designed slicing machines and then dried.

Picture 6.1 Diced fruits

The raw materials that are intended to be produced in cubic form are passed through specially designed cube cutting machines and then baked.

Picture 6.2 Powdered broccoli

The powder is dried with the raw materials considered and can be ground in mills or it is possible to reach the final product much faster with Pneumatic Drying systems

6.1. Pre-treatment of fruits

Small fruits such as grapes and strawberries can be dried without cutting, but most vegetables and larger fruits such as mango, pineapple and apple must be peeled, sorted and cut into cubes to increase the drying surface and reduce the diffusion distance before drying.

Picture 6.3 Sorted and chopped foods

Blackening reactions in fruits and vegetables generally occur when the tissues encounter a stress or deterioration after harvest.

Since color is an important visual quality criterion for customers, preventing decay reactions is important for the food industry.

Dried fruits are obtained by reducing 80-95% of the water contained in the fresh fruit to 10-20%. After the drying process, dried fruits, in which all minerals except vitamin C are preserved and they protect the body primarily against free radicals with their high antioxidant potential. Dried fruits best suited to Turkish palate are dried apricots, prunes, dried figs, raisins, dried mulberries and dried nuts. In our country, these fruits are mostly consumed as compote.

Although it varies from fruit to fruit, the generally applied pre-treatments are processes such as sorting, classification, peeling, dividing-slicing-chopping and seed removal. In addition, some fruits, such as apples, are treated with a gentle boiling, plums and grapes dipping in an alkaline solution and apples, peaches, grapes and apricots getting sulfurized. In this section you will be informed about the alkaline solution immersion and sulfurization process.

The basic processes applied in the drying of different fruits are similar to each other and are as follows.

Washing

- Eliminating foreign substances
- Longitude
- Peeling according to the type of fruit

Dividing, slicing, chopping

- Seed extraction

In addition to these, pre-treatments such as boiling, dipping in alkaline solutions and sulfurization are performed when necessary.

6.1.1. Dipping or olive-oil alkaline solution

It has been customary since ancient times to dip some fruits (such as grapes, plums) into a suitable solution to accelerate drying. In the past, solutions prepared from wood ash and olive oil were used in the dipping process. Wood ash, which is actually a strong alkali material, has been replaced by alkaline compounds such as K_2CO_3 (potassium carbonate) and NaOH. The process of immersion in an alkali bath is called "dipping" in Turkey. Dipping process is applied mostly to grapes. It is applied in order to remove the wax layer that is naturally found outside of the grape, to accelerate the drying and to protect its color. As is known, Grape is not just the fruit with a natural wax layer on the skin. Some fruits such as cherries, plums, apples and pears also have a thin layer of wax on their peels.

Apart from this method, if the grapes are dried after being immersed in hot water at 93 ° C as a pre-treatment, a light colored raisin can be obtained even without the use of SO_2. By such a pre-treatment, the enzyme PPO (polyphenol oxidase) in the fruit can be inactivated and the enzymatic browning can be prevented and the mass transfer rate from the peel increases and the drying time is shortened.

6.1.2. Vulcanization and purpose

Since fruits to be dried are usually not boiled, enzymes remain active and the drying temperature often cannot render them inactive. If the moisture level is not at a level that prevents the enzymes from working during drying, enzymatic reactions may continue. These changes occur in two ways:

- Color browning related to enzymatic changes.
- Color browning related to non-enzymatic changes.

These problems appear to be a big problem in dried fruits. The substance commonly used in the prevention of browning, both enzymatic and non-enzymatic, is sulfur dioxide (SO_2). Sulfur dioxide is widely used in many areas with both antioxidant and protective effects. Sulfurization refers to the application of SO_2 to dried or to be dried fruit. Fruits are vulcanized before drying, during drying, after drying.

During sun drying apricots, peaches and pears are vulcanized before drying and for apples dried with artificial, hot air method vulcanization is performed both before and during drying. On the other hand, grapes are re-vulcanized during processing after drying in order to put them on the market.

Fruits are immersed in solutions (sulfite or sodium bisulfate solutions) or the solution is sprayed on the fruit for vulcanization.

6.1.2.1. Advantages of vulcanization

-It preserves the natural color of the fruit sensitive to enzymatic browning.

- It prevents the activities of microorganisms, especially yeasts and molds.
- Provides the protection of vitamins A and C.
- As it raises the temperature, it provides quicker drying.
- Protects from insect, pests, etc.

6.1.2.2. Disadvantages of vulcanization

- Causes corrosion in the product and equipment.
- Bad taste and aroma may occur in the product. This situation appears when the amount is excessive.
- Causes the breakdown of some vitamins such as vitamin B1.
- Excess is dangerous for health.

6.2. Pre-treatment of vegetables

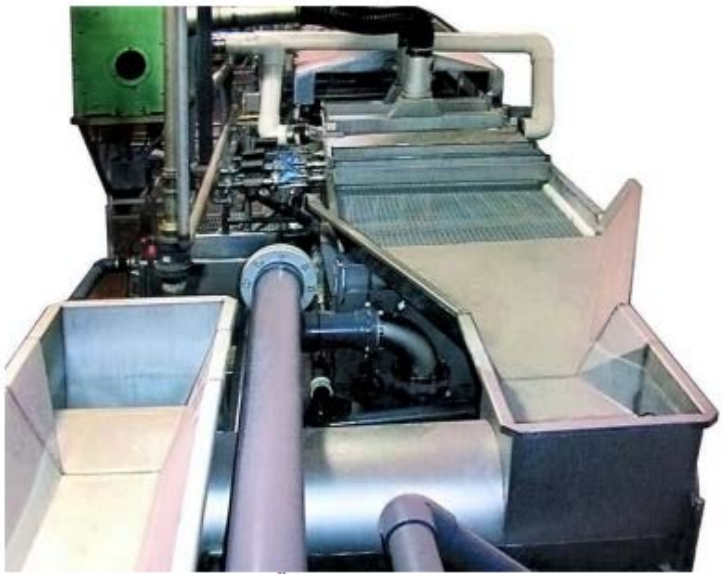
Similar pre-treatments are applied for drying vegetables as in other preservation methods. These pre-processes are sorting, washing, peeling, chopping, scalding, cooling and similar general processes. The most important pre-treatment among these pre-treatments is the boiling process. Although the boiling process has a protective advantage, it may cause the breakdown of foods, especially vitamins, and loss of color. Boiling temperature and time activate some enzymes. In particular, the peroxidase enzyme is one of the most heat-resistant enzymes and is considered an index of scalding. The higher the scalding temperature, the higher the enzyme's activation is achieved. Both the activation of the enzyme and the preservation of nutrients are possible with a controlled boiling.

PPO can be activated by scalding, or undesirable reactions can be initiated due to cell damage by insufficient scalding. Inappropriate heating conditions can accelerate degradation reactions as they cause the enzyme and substrate to come together which are separate.

6.2.1. Rinse

Picture 6.4 Rinsing machine

Vegetables that are transported to the factory in bulk or in crates should be washed in order to facilitate the heat treatment, to reduce the microorganism load and to remove foreign substances such as dust, soil, pesticides and sludge. The rinsing process is carried out in three stages depending on the type and feature of the product. These are pre-washing (softening), washing, rinsing. Machines operating according to various principles have been developed for washing vegetables.



Picture 6.5 Special purpose washing machine

The healthiest washing process is washing by moving it with different systems in water. Vegetables are washed effectively in water by moving in the water tank with the help of pallets or by giving pressurized air to the water in the tank. Another method of washing is washing with pressurized water.

In principle, always cold water and clean water are used in all washing processes.

6.2.2. Sorting

Picture 6.6 Sorting process

Cleaned vegetables must be sorted before drying. Damaged, crushed, moldy and rotten vegetables are either thrown away completely or the damaged parts are cut away.

Picture 6.7 Sorting conveyor with illumination and sitting order

Sorting is usually performed manually by hand. While the washed vegetables and fruits are moving on the conveyor belt, they are checked by the workers on both sides of the belt and the damaged, dents, rotten, moldy, raw or over-ripe ones are removed. Very small defects are cut with a knife and defective parts are discarded. However, even if defective, crushed, rotten part is small, vegetables and fruits with such defects should not be used because microorganisms will affect the quality of the raw material, product and human health.

6.2.3. Peeling

Vegetables are peeled because coat slows down the drying speed of some vegetables. The coats can be peeled before or after boiling, depending on the characteristics of the vegetable.

Peeling process can be implemented in 4 ways:

- Manual peeling
- Peeling by applying heat
- Freeze peeling
- By chemical substances

6.2.4. Chopping

In order to speed up the drying of the vegetables, the vegetables are either cut into two pieces, sliced or chopped without a certain shape. It depends on the type and content of the vegetables.

Picture 6.8 Chopped food

6.2.5. Boiling

Boiling is the first step towards drying vegetables. The most important problems encountered in drying and storing vegetables are loss of color, taste and browning. The reason for these problems is the continuation of enzyme activity and browning as a result of this activity. Boiling eliminates browning. In addition, drying will occur faster, as it makes the tissues that make up the vegetable cell membranes more permeable.

Tablo: Boiling periods for some vegetables

Boiling process:

Decreases microbial load. Reduces the drying time of some foods. Preserves fat-soluble vitamins during storage. Causes a decrease in water-soluble vitamins. Therefore, the necessary qualities of vegetables can be preserved by adding sodium bisulfate to the boiling water. This process cannot be applied to vegetables such as red onion, garlic, leek.

Boiling takes place in two ways:

- Scalding with boiling water
- Boiling by steam

6.2.5.1. Scalding with boiling water: Sorted and chopped products are taken into wire boxes or strainers after they are washed. More than 450 kg of vegetables are dipped into each gallon of water boiled in large containers with wire boxes or strainers . The soaking time of vegetables in boiling water is started when the vegetable is immersed in water and is removed after being kept in boiling water for the appropriate time for each vegetable. Blancher is also used for boiling. Vegetables are cooled with cold water and the products taken are placed on drying trays and dried.

6.2.5.2. Boiling by steam: It is the same as scalding with boiling water. Vegetables placed in wire boxes and strainers are hung around the boiled water in large pots. Vegetables are steamed for the appropriate amount of time for each vegetable, without being soaked in water. The boiled product is taken to drying trays after cooling with cold water. Drying takes place by using a dryer that bounces and dehumidifies with vibration and hot air. Thus, the chopped product is prevented from sticking to each other and the load of the dryer is reduced.

6.2.6. Salinization

Mold and yeast growth is an important problem in dried vegetables during the storage process. For this purpose, in the period after the drying of the vegetables, salt application (salting) is made before drying in order to control the microbial load. Because many bacteria cannot survive in salt concentrations above 6% or their bacterial activity decreases by salting. Salt is applied by direct sprinkling or by dipping in saline solutions or spraying. Like all chemicals used in drying, the salt used must have values in accordance with the Turkish Food Codex 2004/44, Table and Food Industry Salt Communiqué.

Picture 6.9 Food dried by salting

Salt is widely used on tomatoes before drying. Salt application is a pre-treatment commonly used for drying tomatoes. Tomatoes, which are harvested at full maturity, are brought to the drying location and divided into two with a knife on the stem towards the flower nose. Salt application should be made immediately after cutting, and the crust formation due to high temperature on the cutting surface should not be allowed. Generally, the salt application is performed by hand sprinkling the table salt on the half tomatoes laid on the exhibition areas. In granular salt application, an average of 5-6 kg of coarse salt is required per ton of tomato. In the salty product, the color will not be bright red as in the sulfur product, but the dirty brick red color. The product loses this redness in a very short time under normal storage conditions and becomes dark. Salted product is mostly consumed in Italy and in some European countries. It is difficult to reduce the moisture content in salted products. Fermentation and mold will occur if the product is too damp.

Pre-treat apples to dry.

Process Steps	Suggestions
• Put on your work clothes.	
• Disinfect your hands.	
• Put on your bonnet.	
• Follow the codes of cleanliness and hygiene in your work.	
• Pay attention to customer specification	
• Transfer apples to operation zone.	• Act according to business criteria.
• Wash the apples.	• Make sure that the washing water is clean.
• Sort the apples.	• Eliminate crushed, bruised, rotten ones.
• Classify apples.	• Pay attention to color, size and maturity.
• Peel.	• Peel with minimal waste
• Extract seeds.	• Use proper tool. • Do not cut hands.
• Slice.	• Do not exceed 1 cm with the slices. • Slice into 3 equal pieces. • Cut ¼.
• Lay on bedsteads.	• Act swift. • Be careful.
• Forward them to drying unit.	• Place 10 kg apples per square meter.
• Clean the equipment used.	• Make sure the drying unit is ready.
• Operate tools carefully by complying with the occupational safety principles. • Use your time well. • Follow the provided instructions.	• Use the cleaning agents and disinfectants provided by your plant. Work in accordance with the instructions when using chemicals. • Remember your information in the pre-treatment module.

• Take of your work clothes and hang them. • Take out your disposable materials and throw in the trash. • • Wash your hands after every operation. • Make final checks of your environment.	

ASSESSMENT AND EVALUATION -5

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. If the raw material to be processed is extremely dirty, which process is applied before the main washing?

a. Rinsing

b. Brush washing

c. Showering

d. Pre-Washing

2. Which of the following is not washing stage?

a. Pre-Washing

b. Drying

c. Washing

d. Rinsing

3. Which of the following is not the purpose of washing?

a. Removing impurities such as dust and soil

b. Removing pesticide residues

c. To soften the raw material

d. To decrease the microorganism load on the raw material surface

4. Which of the following is not one of the criteria for the sorting process?

a. Crushed

b. Rotten

c. Gross

d. Raw

5. Which of the following foods is not boiled and dried?

a. Beans

b. Carrot

c. White Cabbage

d. Mushroom

6. Which of the following foods has been given the wrong boiling time?

a. Beans 2-3 min

b. Carrot, 15 min

c. White Cabbage, 1.5-2 min

d. Peas, 3-4 min

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

CHECKLIST

Pre-treat cabbage to dry. Check your procedures according to the evaluation chart below.

Evaluation Criteria	Yes	No
1. Did you put on your work uniform?		
2. Did you put on bonnet?		
3. Did you take off your jewelry?		
4. Have you disinfected your hands?		
5. Did you receive the vegetable to be dried into operation?		
6. Did you remove the outer skin of the cabbage for the drying process?		
7. Did you remove the heart in cabbage for the drying process?		
8. Did you wash the cabbage?		
9. Did you clear the cabbage from foreign materials?		
10. Did you choose correct chopping style?		
11. Did you prepare the chopping machine?		
12. Did you prepare the chopping knives?		
13. Did you chop at correct sizes?		
14. Did you re-clean?		
15. Did you forward it to the drying unit?		
16. Did you pay attention to the use of tools and equipment?		
17. Were you elaborative and careful while doing your work?		

EVALUATION

At the end of the evaluation, review your "No" answers once again. If you have any hesitations about your answers, repeat the learning activity. If all your answers are "Yes", move on to the next Learning Activity.

LEARNING ACTIVITY-7

AIM

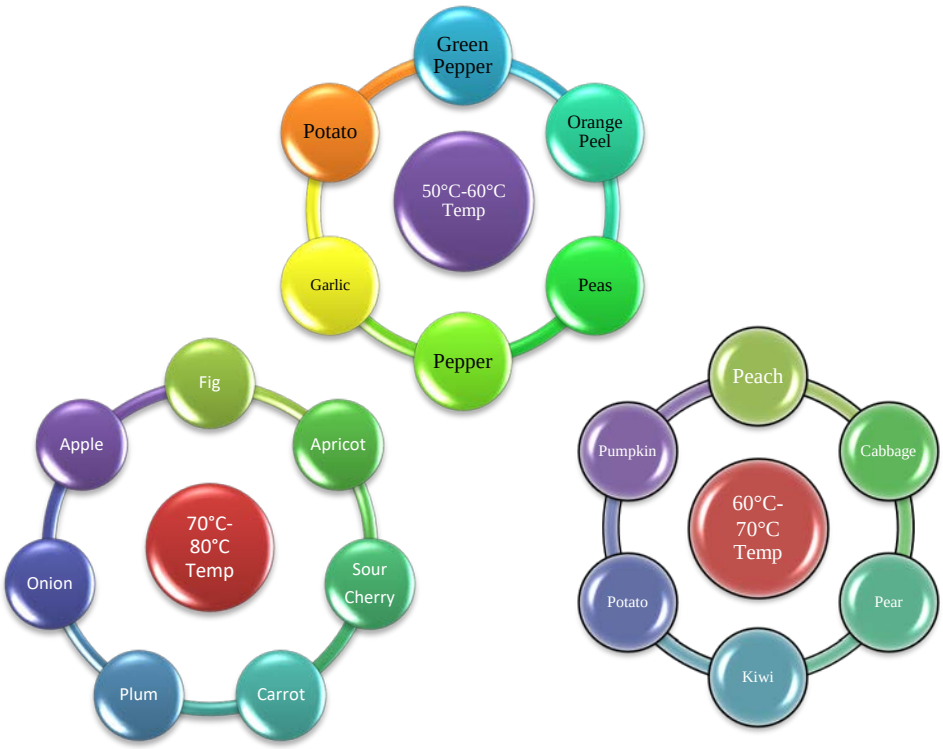
- You will learn the temperatures and periods applied in dry foods.

RESEARCH

- Make a research on the temperature values applied in facilities producing dried food.
- Make a research on a food that is not dried in your facility.

7. Determination of drying temperature and duration according to food types

Researchers have used different drying methods or their combinations to determine the most appropriate method in terms of drying time, energy consumption and product quality for different agricultural products. These combinations have been evaluated with the data obtained as a result of R&D studies. As previously mentioned, required qualities have effect on drying periods and temperatures. This is the reason why clear information cannot be obtained even when sources are scanned. The drying method and types of dryers used cause lack of clear information on this subject. If we need to give a general figure despite many factors, the information about the temperature of some foods can be found in the table below.



Since some foods and other agricultural products such as spices and herbs are heat sensitive, these are required to be processed at low temperatures. The driving force for mass transfer required to increase the rate of drying under these conditions can be increased by various strategies. Reducing the relative humidity of the warm air is one such approach, which increases the dehumidification capacity of the air, thus increasing the drying speed.

Some foods are dried at high temperatures. In addition to the advantages of drying at high temperatures, there are some disadvantages. Especially with thin-layer foods, burning at high temperatures and consequently nutritional value losses can be observed. The amount of moisture contained in the dried food varies according to the amount of water vapor in the environment. When the humidity of the environment is increased and decreased, the moisture change in the material holds different characteristics.

As stated in the pre-treatments applied to the food to be dried, the difference in the pre-treatments applied to the products affects the drying process in terms of temperature and duration. The information obtained as a result of another R&D study, different from the table shown above is as follows:

Apple	• If it is desired not to darken by slicing 4-5 mm thickness, it should be dipped in lemon juice. It can be dried at 50 C for 10-12 hours.
Banana	• Being sliced in 3-5 mm thickness, dries at 50 ° C for 10-12 hours.
Plum	• After dividing into two and removing the core, it is dried at 50 ° C for 13-15 hours.
Apricot	• After the seed is removed, it is dried at 60 ° C for 22-24 hours.
Tomatoes	• When split into two or four, it is dried at 60 ° C for 12-14 hours.
Strawberry	• After dividing into two, it is dried at 60 ° C for 10-12 hours.
Orange	• Being sliced in 5 mm thickness, dries at 50 ° C for 14-16 hours.
Pineapple	• Being diced or sliced round, dries at 50 ° C for 10-14 hours.

All of the above data are approximate, here the product amount, air circulation are very important. Not all drying systems can dry at these periods. The values specified in the table are general values. Many factors such as the ripening rate and size of foods are the factors that affect these values. In R&D studies, it was concluded that systems operate with geothermal energy has common drying temperature of 45-51 ° C in food drying . These temperature values are where there is no loss of many vitamins in foods.

ASSESSMENT AND EVALUATION -6

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. Which of the following is not a factor affecting the drying speed?

a. Temperature,

b. Chemical composition of the product

c. Rehydration

d. Aridity

2. Which of the following dries faster than the others?

a. Boiled products with higher water content

b. Products containing glucose

c. Products rich in starch and pectin

d. Products rich in oil

3. Which of the following affects the rehydration?

a. Ambiance temperature

b. Water temperature and holding duration

c. Holding container

d. Amount of product

4. Which of the following is not one of the factors affecting product quality during drying?

a. Rehydration

b. Drying temperature

c. Drying duration

d. Size of the product

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-8

AIM

- You will learn the technology of food drying using geothermal energy resources.

RESEARCH

- Make a research on facilities that produce dried food using geothermal energy sources.
- Research food that are dried using these sources.

8. Practicing drying methods

8.1. Heat Exchangers and Geothermal Energy

Air has several responsibilities as the drying liquid in the drying process, such as:

The evaporation of moisture, the heat required to carry the evaporated water out of the facility, and to cool the dried product after the drying process is over.

The temperature of the hot air has limited values according to the products in question. For example, the maximum recommended temperature for drying grains is usually 43˚C. Most grains will be damaged if exposed to a temperature of 52° C.

Consequently, the duration of the drying process will depend on the maximum allowed duration. Temperature, in other words, the higher the temperature of the drying air, the shorter the time is required to dry the product.

Higher temperature than allowed degrees during drying process can cause physical and chemical damage to the products. When considering grains (rice, corn, soybeans) this occurs as cracking and breaking. Temperatures higher than permissible for fruits and vegetables will cause damage to the nutrients involved, deterioration of their structure and aroma, loss of typical color and other quality losses.

8.2. Major Changes During Dehydration

Physical and chemical quality properties of food products may change due to heat and mass transfer during drying. In addition to physical changes such as shrinkage and swelling in foods, chemically and biochemically desired or undesirable changes in color, odor and texture occur.

Figure 8.1. Foods removed from the dryer

8.2.1. Physical changes

During drying, physical, chemical, biochemical and microbiological changes occur in foods causing quality loss, decrease in nutritional value and bad evaluation by consumers. With the spoilage of all foods, the amount of spoilage varies according to the type of food, its content, the environment during its storage and the drying process conditions. Physical, chemical, biochemical and microbiological changes occur during the drying of food. These are briefly discussed below.

8.2.1.1. Soluble matter migration

Water is not the only ingredient moving through the substance during drying. In living tissue, water is present in a solution containing many components. These components range from small molecular weight sugars to highly hydrated large molecules. During drying, some of the dissolved substances also change their locations in the substance. When the tissue is alive, water and some low molecular weight molecules in solution diffuse through the cell wall due to the semi-permeable structure of the cell wall. Moisture movement during drying is from the center to the surface and the cause of the flow is liquid or vapor flow or diffusion of free water molecules as mentioned before. Non-volatile soluble matter migration is not due to vapor movement and diffusion, but only by liquid solution movement. Therefore, dissolved material migration depends on the physical structure of the 53 fruits and vegetables as well as the drying conditions that affect the distribution of temperature and moisture within the material.

8.2.1.2. Incrustation

It is an event that occurs as a result of incorrect selection of the drying conditions and is caused by the high drying speed in the first stage of drying. Thus, the dry layer formed on the surface shrinks and forces on the substrates. However, since the substrates are still moist, they resist

the pressure applied from the top. In this case, the upper layers that do not have the opportunity to shrink as a result of drying, stretch and turn into a hard shell. Drying speed decreases suddenly with skin bonding. Incrustation may also occur due to soluble dry matter migration. This situation is observed especially in the drying of fruits rich in sugars. Since the water in the inner parts cannot pass this layer, the drying stops and the product remains dry and hard on the outside and wet inside.

8.2.1.3. Structural shrinkage

During the drying of fibrous structures such as fruits and vegetables, shrinkage of up to 40-50% occurs, especially in the initial stages of drying. Shrinkage is a factor that reduces the drying rate because the surface of the dried food shrinks and becomes hard and does not allow water to pass. In many foods, when drying at high temperatures, the amount of shrinkage increases because the amount of water transferred from the surface of the food per unit time increases. In order to reduce the effect of shrinkage, the food should be dried with a more humid air or at a lower temperature. In this way, the drying speed slows down and the amount of water transferred from the surface of the food per unit time is reduced. Thus, the amount of shrinkage also decreases. At the same time; it has been stated that when foods are dried with microwave, they show less shrinkage compared to drying with other drying methods. Shrinkage is the most important structural change that occurs during drying and usually occurs in the initial stages of drying. Shrinkage occurs as a result of the collapse of the structure in the food. However, preventing structural shrinkage in fruits and vegetables is also very difficult, and consequently structural shrinkage and collapse during drying are inevitable.

8.2.1.4. Bulk density changes

The weight per unit volume of any material is called its bulk density. The bulk density of the dried product is indicative of the conditions applied in its drying. In addition, bulk density is a quality fact of the dried product. Bulk density is an important value that provides information about the drying conditions of a product. There are advantages and disadvantages of having the same product at low bulk density or high bulk density. Those with low bulk density are preferred by the consumer. Because, purchased product appears much more at the same weight.. In addition, they have good rehydration abilities, which means they absorb faster and more water. The dried product is more similar to the original. Their packaging, storage and transportation costs are higher. In addition, since the spaces inside the product cause the surface area of the same amount of product to increase too much, the oxidation tendency is high, that is, the storage stability is low. Layer-by-layer dispersion can sometimes be observed in rehydration. Dry products with high density are especially preferred by manufacturers who process them into other products.

8.2.1.5. Size and shape changes during drying

Let's assume that a diced vegetable such as carrot is air dried. At the beginning of drying, the texture is in a "turgor" state. The fluid inside the cell is under pressure and the cell membrane is under tension. The surface of the vegetable slice is moist from the carrot juice. With drying, water evaporates from the surface and the concentration dissolved in the surface liquid increases accordingly. Depending on the concentration gradient formed in this way, the water in the more diluted solution in the interior moves over the permeable cell walls and moves towards the outer surface. Surface cells, which still contain fluid and are therefore in a stretched state, decrease in volume and flatten, depending on the fluid they lose. The outer surface is still wet and shrinks on incompressible inner surfaces. With the progress of drying, the cells on the outer surface are completely flattened and stretched. The corners of the carrot cube disappear and turn into a pillow shape.

8.2.2. Chemical changes

During drying, various chemical changes also occur besides the physical changes described above, . When a food item is dehydrated, one of the most important problems encountered is the color change called browning. Color browning occurs before drying, during drying or during storage. In the Aegean Region, tomatoes are dried in July and August and after drying, they start to be exported immediately. Considering that the temperature changes between 25 ° C-40 ° C in the shade and the containers are left out in the open during transportation, it is inevitable that color browning will occur in dried tomatoes. Color browning occurs before drying, during drying and during storage. Color browning can be the result of enzymatic or non-enzymatic reactions. However, browning in dried products occurs mostly in a non-enzymatic way. Color browning based on the oxidation of many substances, especially phenolic substances, is manifested by the action of oxidation enzymes in products that are dried without boiling, especially fruits. The temperature level of the air applied in drying is often not sufficient to inactivate the enzymes in the material. The moisture content of the product, the storage temperature, the composition of the food and the addition of bisulfates are effective in controlling non-enzymatic browning in foods. Although the effect of sulphureous compounds is greater in preventing non-enzymatic browning, salt and starch are also used with sulphates either together or alone.

8.2.3. Maintenance And Cleaning Of Drying Systems

At each product change, the furnaces are dismantled and the combs and trays used for drying are washed with special disinfectants preferred by the facility, rinsed and dried. It is then assembled by technical personnel and prepared for use for the new product.

Prepare the pre-treated apples for drying.

Process Steps	**Suggestions**
• Put on your work clothes.	
• Put on your bonnet.	
• Disinfect your hands.	
• Put on your work clothes.	
• Follow the codes of cleanliness and hygiene in your work.	
• Pay attention to customer specification.	
• Comply with the work organization.	
• Prepare the drying system for production.	• Make sure that the oven you will use is clean. • Set the oven temperature according to the type and quantity of the product.
• Deliver the product to be dried into the system.	• Prepare the bedsteads. • Put the product on the trays.
• Dry.	• Place the trays fulled with product in the oven.
• Take out the product from the ovens and cool it.	• If there are fans for cooling, place them inside the oven. • Start the fans. • If there is no fan, take the product from the oven and place it in their special carts. • Cool it for 30 minutes in the operating environment.
• Process through the procedures applied after drying.	• Sort the dried product using conveyor systems.

	• Classify them according to the dimensions with regards to the customer request.
• Use the tools carefully by following the work safety principles.	• Start the detector. • Separate clean product and metal contaminated products from each other. • Dispose of metal contaminated products.
• Use your time well.	
• Follow the provided instructions.	
• Take of your work clothes and hang them.	
• Take out your disposable materials and throw in the trash.	
• Clean your working environment.	

ASSESSMENT AND EVALUATION -7

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. Which of the following is not the physical changes that occur during the drying of food?

a. Soluble matter migration

b. Incrustation

c. Structural shrinkage

d. Vitamin loss

2. Which of the following is the physical change in the first stage of drying caused by the wrong selection of drying conditions in foods and the high drying speed?

a. Chemical changes

b. Bulk density changes

c. Structural shrinkage

d. Incrustation

3. Which of the following is chemical change in foods before drying, during drying or during storage?

a. Structural shrinkage

b. Browning

c. Incrustation

d. Vitamin loss

4. Which of the following is the correct order of operation in the production of dried food?

a. Food selection-pretreatment-drying-storage-packaging

b. Pre-treatment-drying-storage-packaging-food selection

c. Food selection-pretreatment-drying-packing-storage

d. Food selection-pretreatment-packing-storage-drying

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

CHECKLIST

Make cabbage flour by drying the white cabbage that you pre-treated. Check your procedures according to the evaluation chart below.

Evaluation Criteria	**Yes**	**No**
1. Did you put on your work uniform?		
2. Did you put on bonnet?		
3. Did you take off your jewelry?		
4. Have you disinfected your hands?		
5. Did you prepare the oven for drying?		
6. Did you lay on bedsteads with equal thickness?		
7. Did you take the cabbage to the drying area?		
8. Did you put the bedsteads in the oven?		
9. Did you dry in accordance with the necessary quality?		
10. Did you cool the cabbage at the end of the drying period?		
11. Did you eliminate foreign substances or unwanted objects?		
12. Did you turn it into flour by milling it?		
13. Did you re-filter the product that was turned into flour?		
14. Did you follow the codes of cleanliness and hygiene in your work?		
15. Did you pay attention to the use of tools and equipment?		
16. Were you elaborative and careful while doing your work?		
17. Did you complete the work within the provided duration?		
18. Did you clean your work environment?		
19. Did you keep a record of your work?		
20. Did you take of your work clothes?		

EVALUATION

At the end of the evaluation, review your "No" answers once again. If you have any hesitations about your answers, repeat the learning activity. If all your answers are "Yes", move on to the next activity.

LEARNING ACTIVITY-9

AIM

- You will learn how dried food is packaged and stored.

RESEARCH

- Make a research on dried food warehouses.
- Make a research on packing types for dried food.

9. Final process of dried food

9.1. Cooling dried vegetables

The purpose of dried foods is to remove the water that will trigger spoilage. Therefore, the dried product must be stored in a dry environment in order to prevent moisture from re-absorbing. Dried products must have been cooled for packaging. When dried products from the dryers are packaged immediately, their shelf life becomes shorter and the amount of moisture facilitating the reproduction of microorganisms increases. In order to prevent the formation of such undesirable properties, it must be cooled in suitable environments down to a certain temperature.

Picture 9.1 Dried food removed from the oven.

Cooling can be performed in two ways.

- With special fans located inside the oven

- It is cooled down to the desired temperature by taking it to the appropriate environment with special carts.

Cooling is implemented for approximately 30 minutes under normal circumstances within the ambient characteristics inside the facility.

The moisture ratio depends on the properties of the product.

- Moisture should reach a homogeneous level.

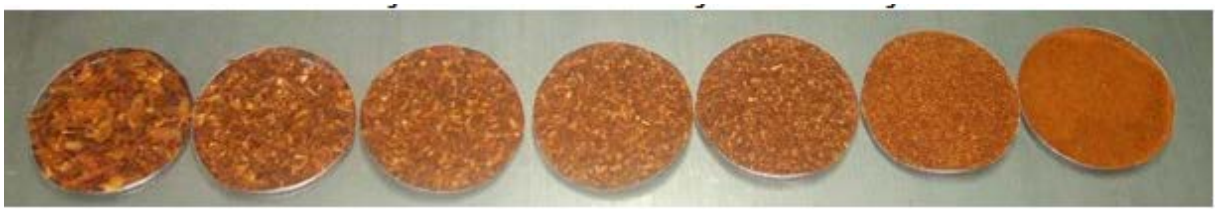
- The water content of each vegetable is different from each other. At the end of drying, the moisture content should be brought to the 8–10% rate specified in the standards.

Picture 9.2 Tomatoes on drying benches

Picture 9.3 Tomatoes about to dry

- The dried product should be sifted and classified according to its size and must be cleared of foreign substances. The sieve sizes used for sorting are different from each other.

Picture 9.4 Calibration Sieve



Picture 9.5 Calibrated dry tomatoes coming out of sieve

Picture 9.6 Circular Sieve

- It should be packaged in accordance with the nature of the food.
- It should be paid attention that the warehouses are cool, airy, dim, dry and protected.

In addition, a change in the color of foods is also considered as deterioration. Storing such products in an environment that is not exposed to light is necessary to prevent deterioration in the color of the food. There are temperatures at which microorganisms can develop optimally. Microorganisms that cause deterioration can grow in a wide temperature range. Therefore, it is necessary to store foods below 10 ° C in order to preserve their shelf life.

During drying, the particles formed in the form of crumbs must be separated with a shaker sieve. Also, foreign substances such as stems, leaves, bark, etc. are extracted. All these processes applied to dried products and the packaging that follows them must be carried out in a compartment with low humidity, so that the product doesn’t gain moisture again.

9.2. Packing

Picture 9.7 Plastic Package

Picture 9.8 Plastic Package

One of the factors that affect the quality of dry products is the packaging stage. Containers, covers or wraps made of special materials such as metal, glass, paper, plastic that protect food from external influences and facilitate its marketing and consumption are called food packaging. Packaging has been defined in Article 4 of the Turkish Food Codex Regulation as “Foodstuffs; wrapped and / or placed in containers using packaging material to contain, protect and inform ”.

General properties of packaging materials:

- Heat and light-proof,
- Protect the product from humidity,
- Suitable for storage,
- Qualities not be damaged during shipment.

The European Union takes a holistic approach to food safety with the slogan "From Field to Fork". The aim of this holistic approach is to ensure the highest level of food safety, animal health, animal welfare and plant health. In all stages of primary production, processing, packaging, transportation, storage and sales, it is aimed to ensure food safety by controlling, monitoring and operating the domestic market in the most effective way.

Table 9.1. Key Points of the EU Concept of Food Safety

When considering EU or Turkish legislation, it is essential to consider exactly which packaging products the relevant regulations cover. For example;While the regulations on "packaging and packaging waste" cover all packaging, including paper or plastic containers or disposable plates and glasses that are filled and used at points of sale, Regulations for “pre-packaged” products only cover packaging products that are packaged at a stage where the vendor is not present, whose quantity is predetermined and cannot be changed without opening or deforming the package.

The storage life of dry products also depends on the quality of the packaging. In the packaging system of dried foods, an excellent water vapor and gas impermeability is desired, especially due to the fat composition in the food. When fatty acids in food encounter oxygen, they cause oxidation, resulting in rancidity, color and taste changes. In fact, these reactions continue for a while after the packaging process is over. Therefore, such activities should be reduced.

Picture 9.9 Doypack packages (Openable packages)

Fruits dried to low moisture levels should be packed in sealable packaging. Dried fruits, which are stored for later processing, can be packaged in barrels, chests, cardboard boxes and tin boxes.

Picture 9.10 Household type vacuum packaging machine

Vacuum packaging is one of the most frequently used methods for preserving the quality of dried products and extending their shelf life. Vacuum packaging is the removal of air in a gas-impermeable package or gas-permeable on specific level package by vacuum. It is widely used in the dried fruit and vegetable industry.

Picture 9.11 Renewable Polymeric films and coatings

In addition, edible films used in the preservation of foods by the coating method are packaging that do not pollute the environment, since they are made of agricultural-origin, natural or biologically recycled materials. Edible film is formed of thin layers that can be eaten by the consumer and are an oxygen and moisture barrier for food, as well as providing solid passage, enveloping the whole food or taking part as a component between food components. According to this definition, edible films have functional properties such as protecting the food in terms of nutritional value and microbial quality during the presentation of food to the consumer. These films can be applied to foods to prevent moisture loss, slow down respiration, improve the mechanical properties of the product, maintain its shape, and carry antimicrobial, antioxidant, color and flavoring substances. Due to these advantages, positive results are obtained especially in dried products sensitive to moisture loss and oxygen (such as apricot, fig).

9.3. Labeling

The label should provide information to the consumer about the product. It should provide information such as company name, address, product name, batch number, net-gross amount, shelf life, production and expiry date, production permit, preparation and usage instructions, storage and storage conditions, contents, whether it has passed through a metal detector and whether it is allergen, etc.

Labels are printed via the computer and pasted on the appropriate place of the product by the personnel.

9.4. Storage

Storage is the preservation of the properties and quality of a product for a certain period of time. The ideal storage area for dried food should be cold, dark and dry. The coldness of the warehouse is provided by the coolers located in the storage. Thus, the shelf life of foods can be extended. Storage areas should be dark to prevent discoloration and vitamin loss in dry products. The dryness of the warehouses prevents the products from absorbing moisture and mold growth.

The purpose of storage is to preserve the initial quality as much as possible and to keep the storage conditions under control in order to minimize the changes that have negative effects on the quality.

Dried vegetables can generally be stored for one year at 0-4˚C in 50-60% relative humidity without any signs of deterioration. If this period is desired to be extended, appropriate storage conditions should be provided and attention should be paid to the final moisture content in dry vegetables.

Dried products warehouse maintenance and cleaning should be performed periodically. Therefore, the floors and walls of the warehouse should be covered with materials that are easy to clean. The walls, floors, shelves of dried product warehouses should be cleaned and disinfected once a month.

Package dried green beans.

Process Steps	Suggestions
• Put on your work clothes. Put on your bonnet.	
• Disinfect your hands.	
• Put on your work clothes.	
• Follow the codes of cleanliness and hygiene in your work.	
• Pay attention to customer specification..	
• Comply with the work organization..	
• Select the packaging material you will use.	• Make sure that it is suitable for the product.
• Prepare the packaging material.	• Make it suitable for filling.
• Attach the packaging material to the metal detector or filling machines.	• Use your time well. • Be careful and thorough. • Comply with hygiene rules.
• Turn on the filling machine and fill the package.	• Be careful and quick. • Pay attention to the amount of filling to be made in the packaging.
• Close the mouth of the package. • Put it on the outer packaging. • Measure the weight. • Seal the inner and outer packaging.	• Be careful with sealing. • Seal it tight. • Measure the weigh correctly.
• Prepare the labels in accordance with the product specifics. • Label them.	• Check the accuracy of the information on it. • Apply the label correctly without delay.
• Put it on pallets for storage. • Dispatch to the warehouse.	• Be careful.

• Clean the equipment used.	• Do the cleaning of the metal detector with the disinfectants approved by the facility.
• Use the tools carefully by following the work safety principles.	
• Use your time well.	
• Follow the provided instructions.	
• Take of your work clothes and hang them.	
• Take out your disposable materials and throw in the trash.	
• Clean your working environment.	

ASSESSMENT AND EVALUATION -8

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

Write (T) if the information given in the sentences below is true, and (F) if it is incorrect.

1. () The packaging is a supplement to the product.

2. () The packaging does not protect the product against counterfeiting.

3. () Packaging reduces the storage capacity of the product.

Read the following questions carefully and mark the correct option.

4. Which of the following is not one of the expected functions of the packaging?

a. Protection from moisture and atmospheric effects

b. Keeping the products together

c. Requires additional expense to be destroyed

d. Keeping the necessary information about the product inside

5. Which of the following is false?

a. When dried products from the dryers are packaged immediately their shelf life becomes longer and with the increasing amount of moisture the reproduction of microorganisms gets difficult.

b. The cooling process can be carried out with special fans inside the oven.

c. Dried products should pass through a metal detector maximum three times.

d. Dried products can be turned into flour according to customer request.

6. How many degrees Celsius are dried products stored at ?

a. 0 to 4° C

b. 4 to 10° C

c. 11İ to 15˚C

d. 3 to 7˚C

7. What should be the relative humidity of the tanks?

a. 20 to 30%

b. 50 to 60%

c. 10 to 15%

d. 30 to 35%

8. In which of the following products does color change occur during storage?

a. In vitamin and mineral products

b. In fatty and sugary products

c. In products with high water and protein ratios

d. In sugary and protein products

9. What is the reason for microbiological deterioration during storage?

a. Not reducing the water rate sufficiently

b. Reducing the water rate sufficiently

c. High drying temperature

d. Low storage temperature

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

CHECKLIST

As part of this activity, please rate yourself by placing an (X) in the Yes box for the skills you have gained from the behaviors listed below, and the No for the skills you cannot acquire.

Evaluation Criteria	Yes	No
1. Did you put on your work uniform?		
2. Did you put on bonnet?		
3. Did you take off your jewelry?		
4. Have you disinfected your hands?		
5. Did you choose the package material?		
6. Did you prepare the package for filling?		
7. Did you take the peas to the filling zone?		
8. Did you fill the package?		
9. Did you check the weight as requested?		
10. Did you close the package?		
11. Did you prepare the labels in accordance with the product specifics?		
12. Did you check the accuracy of the information?		
13. Did you label correctly?		
14. Did you locate it on pallets for storage?		
15. Did you store in accordance with food storage conditions?		
16. Did you follow the codes of cleanliness and hygiene in your work?		
17. Did you pay attention to the use of tools and equipment?		
18. Were you elaborative and careful while doing your work?		
20. Did you complete the work within the provided duration?		
21. Did you clean your work environment?		
22. Did you keep a record of your work?		
23. Did you take of your work clothes?		

EVALUATION

At the end of the evaluation, review your "No" answers once again. If you have any hesitations about your answers, repeat the learning activity. If all your answers are "Yes", move on to the next activity.

LEARNING ACTIVITY-10

AIM

- You will be able to evaluate the food drying module.

RESEARCH

- Make a research on different studies on dried food production.
- Discuss with your friends in the classroom, what the malfunctions are in the drying system we have made.

10. Evaluation of drying process

Today, globally increasing human population and its parallel good life expectancy put pressure on limited energy resources.

The main purpose of the drying process is to use energy as efficiently as possible while obtaining a quality end product. It is not possible for a single drying method to be sufficient for all products in terms of both economic and quality characteristics. In some cases, pretreatments such as dipping in a solution or steaming before drying both increase the quality of the final product and reduce the process cost as it may shorten the drying time of the product. The drying method selected in accordance with the raw material quality of the product and the market value after processing is necessary for companies to hold on to the market where the competitive environment is high ant to maintain their existence. During the selection of the appropriate drying technology in the industry, operating costs should be taken into consideration as well as the initial investment cost of the technology. As a result, besides the drying technology, correctly selected pre-treatment methods also have a significant effect on the final product quality when necessary. In order to obtain a good quality final product and to use energy as efficiently as possible, the parameters of the pre-treatment and drying method, which are selected in accordance with the market value of the raw material and the final product, should be selected carefully.

Many fruits and vegetables can be enjoyed in dried forms, and dried vegetables can be used in instant soup mixes and sauces. Fruit powders are widely used in the pudding and pastry industry. In addition, different products obtained by drying various herbs such as spices, yogurt powder and olive powder are also products acquired by using drying technology. In our country, which has an important place in the export of dried fruits and vegetables, it is important to pay

attention to the correct implementation of drying techniques, packaging in accordance with the product specifications and keeping the packaged product under the most appropriate conditions. Oxygen and water vapor impermeability of the packaging is important, especially in the storage of products, against adverse effects such as moisture absorption. Therefore, methods such as vacuum packaging or the addition of oxygen and moisture absorbers to activate the packaging material, and the use of edible film technologies should be developed.

ANSWER KEYS

ANSWER KEY - 1

1	A
2	A
3	D
4	B
5	C
6	D
7	B
8	B
9	B
10	D

ANSWER KEY - 2

1	C
2	D
3	D
4	D

ANSWER KEY - 3

1	D
2	B
3	D
4	C
5	D
6	B
7	D

ANSWER KEY - 4

1	B
2	D
3	FRESH
4	SUGAR
5	HARVEST

ANSWER KEY - 5

1	D
2	B
3	D
4	D
5	D
6	B

ANSWER KEY - 6

1	C
2	A
3	B
4	D

ANSWER KEY - 7

1	D
2	D
3	B
4	C

ANSWER KEY - 8

1	**D**
2	**Y**
3	**Y**
4	**C**
5	**A**
6	**A**
7	**B**
8	**D**
9	**A**

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