RQF LEVEL 3

FOPBK303

FOOD PROCESSING

Basic Knowledge in Food Processing

TRAINEE'S MANUAL

October 2024

BASIC KNOWLEDGE IN FOOD PROCESSING

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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TABLE OF CONTENT

ACRONYMS

AGR: Agriculture

ASF: Animal source foods

BK: Basic Knowledge of food processing

Bp: Boiling point

CBC: Competence Based Curriculum

EDTA:Ethylene diamine tetra acetic acid

FAO: Food and Agriculture Organization

FOP: Food Processing

Fp: Freezing point

Ltd: Limited

MAP: Modified atmosphere packaging

Mp: Melting point

pH: Potential of Hydrogen

PPE: Personal Protective Equipment

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

TQUM: TVET Quality Management project

TVET: Technical and Vocational Education and Training

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in food processing specifically for the module of **"Basic Knowledge in Food Processing".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainee's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: FOPBK303-BASIC KNOWLEDGE IN FOOD PROCESSING

Learning Outcome 1: Apply basics of thermodynamic.
Learning Outcome 2: Apply basics knowledge of food chemistry.
Learning Outcome 3: Describe micro-organisms in food.


MODE OF HEAT TRANSFFFOR

Indicative contents

1.1 Description of physical quantities

1.2 Identification uses of physical quantities

1.3 Description of Heat transfer mechanisms

1.4 Differentiation of the types of food

1.5 Description of the physical properties of different types of food

Key Competencies for Learning Outcome 1: Apply basics of thermodynamic

Knowledge	Skills	Attitudes
• Description of the types of physical quantities • Identification of heat transfer modes • Description of food types and their physical properties	• Measuring physical quantities	• Be accurate • Be Confidence • Be Self-Efficacy • Be Precise and accuracy • Patience and Perseverance • Collaboration and Teamwork

Duration: 10hrs

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe properly types of physical quantities and their uses.
2. Distinguish appropriately modes of heat transfer mechanisms.
3. Describe adequately the physical properties of the different types of food.
4. Measure accurately physical quantities used in food processing

Resources

Equipment	Tools	Materials
● Heat exchangers ● Pumps ● Engines and Turbines ● Refrigerator and air conditioners	● Tape measure ● Balance ● Thermometer ● Chronometer ● Graduated cylinder ● Densimeter ● Calorimeter ● Moist meter ● Monometers	● Sugar ● Milk ● Meat ● Fruits ● Wheat flour ● Water

Indicative content 1.1&1.2: Description of physical quantities

Duration: 4hrs

Theoretical Activity 1.1.1: Description of physical quantities and their uses

Tasks:

1: You are requested to answer the following questions related to description of physical quantities:

i. Describe fundamental and derived quantities.
ii. Give 3 examples of fundamental and derived quantities
iii. Give the symbols and units of fundamental and derived quantities
iv. State the uses of physical quantities

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: For more clarification, read the key readings 1.1.1

Key readings 1.1.1: Description of physical quantities

- **Physical quantities**

A physical quantity is a property of an object or system that can be quantified means that it can be measured and expressed in numbers. They are extensive if they depend on the mass or size of the object and intensive if they do not. A quantity is a measurable property of an object or system.

Physical quantities can be classified into two main types such as fundamental physical quantities and derived physical quantities

✓ **Fundamental physical quantity**

Fundamental quantities are the most basic quantities that cannot be defined in terms of any other quantities. There are seven fundamental quantities in physics:

- **Length:** the distance between two points, measured in meters (m) in the International System of Units (SI)
- **Mass**: the amount of matter in an object, measured in kilograms (kg) in the SI.
- **Time**: the duration of an event, measured in seconds (s) in the SI.

Electric current: is the flow of electric charge through a conductor. It is measured in amperes (A) in the SI.

- **Temperature**: the measure of how hot or cold something is, measured

in kelvins (K) in the SI.

- **Amount of substance (moles)**: is a measure of the number of elementary entities in a substance. It is measured in moles (mol) in the SI.
- **Luminous intensity**: is the measure of the luminous flux emitted by a light source in a particular direction. It is measured in candelas (cd) in the SI.

✓ **Derived physical quantities**

Derived quantities are physical quantities that can be defined in terms of two or more fundamental quantities. They are calculated using mathematical operations such as addition, subtraction, multiplication, and division.

There are many examples of derived quantities, including:

- **Area** is a two-dimensional measure of the size of a surface. It is measured in square meters (m2) in the International System of Units (SI). Area can be calculated by multiplying the length and width of a surface.
- **Volume** is a three-dimensional measure of the space occupied by an object. It is measured in cubic meters (m3) in the SI. Volume can be calculated by multiplying the length, width, and height of an object.
- **Density** is a measure of how much mass is contained in a given volume. It is calculated by dividing the mass of an object by its volume. Density is measured in kilograms per cubic meter (kg/m3) in the SI.
- **Speed** is a measure of how fast an object is moving. It is calculated by dividing the distance travelled by the time taken to travel that distance. Speed is measured in meters per second (m/s) in the SI.
- **Acceleration** is a measure of how quickly an object's speed is changing. It is calculated by dividing the change in speed by the time taken for the change in speed to occur. Acceleration is measured in meters per second squared (m/s2) in the SI.
- Force is a push or pull on an object. It is calculated by multiplying the mass of an object by its acceleration. Force is measured in Newton (N) in the SI.
- **Work** is the transfer of energy from one object to another. It is calculated by multiplying the force applied to an object by the distance the object moves in the direction of the force. Work is measured in joules (J) in the SI.
- **Power** is the rate at which work is done. It is calculated by dividing the work done by the time taken to do the work. Power is measured in watts (W) in the SI.
- **Energy** is the ability to do work. It comes in many different forms, such

as kinetic energy, potential energy, and thermal energy. Energy is measured in joules (J) in the SI.

- **Identification of physical quantities uses**

  Physical quantities are used in a wide variety of ways, including:

  - ✓ **To describe the physical world around us**. For example, we can use physical quantities to describe the size, mass, and motion of objects, as well as the temperature, pressure, and energy of systems.
  - ✓ **To design and build machines and structures**. Engineers use physical quantities to calculate the forces and stresses on machines and structures, and to ensure that they are strong enough to withstand these forces.
  - ✓ **To diagnose and treat diseases**. Doctors use physical quantities to measure blood pressure, heart rate, and other vital signs, as well as to diagnose and treat diseases such as cancer and diabetes.
  - ✓ **To study the fundamental laws of nature**. Physicists use physical quantities to study the behaviour of matter and energy at the atomic and subatomic level, and to develop theories about the universe. Physical quantities are important to understand the properties of materials.

Practical Activity 1.1.2: Measuring physical quantities

Task:

You are requested to go in food processing workshop to measure physical quantities.

1: Apply safety precautions.

2: Select tools and equipment for measuring physical quantities.

3: Measure physical quantities used in food processing.

4: Present your work to the trainer and whole class.

5: Read key reading 1.1.2

6: Perform the task provided in application of learning 1.1.

Key readings 1.1.2: Measuring physical quantities

- **Procedure for measuring physical quantities**
  - ✓ Clearly identify the physical property you want to measure, such as length, mass, time, temperature, or force.
  - ✓ Select an appropriate measuring Instrument
  - ✓ Calibrate the measuring Instrument
  - ✓ Perform the measurement
  - ✓ Record or write down the measurement results

Application of learning 1.1&1.2.

INEZA Company ltd located near the school is designing new bakery products. Those new bakery products require precise measurements of various physical quantities, such as mass and volume of ingredients and adjustment of temperature and time for baking. Go to INEZA Company ltd to measure those physical quantities.

Indicative content 1.3: Description of Heat transfer mechanisms

Duration: 2hr

Theoretical Activity 1.3.1: Description of Heat transfer mechanisms

Tasks:

1: You are asked to answer the following questions related to description of heat transfer mechanisms:

i. Define the term “heat”.
ii. How is the temperature converted from one scale to another, such as Celsius, Kelvin, Fahrenheit and Reaumur?
iii. Explain the heat transfer mechanisms

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class

4: For more clarification, read the key readings 1.3.1

Key readings 1.3.1.: Description of Heat transfer mechanisms

- **Main heat transfer mechanisms**

✓ **Conduction**

Conduction is the transfer of heat energy between objects that are in direct contact. It occurs when the faster-moving particles of a hotter object collide with the slower-moving particles of a cooler object, transferring some of their energy. Conduction is the fastest mode of heat transfer.

Examples of conduction include:

- A metal spoon heating up in a hot cup of coffee.
- The skin on your hand getting hot when you touch a hot stove.
- The heat from your body warming up your bedsheets.

✓ **Convection**

Convection is the transfer of heat energy through the movement of a fluid. It occurs when the hot fluid rises and the cooler fluid sinks. The hot fluid transfers its heat energy to the cooler fluid as they mix together. Convection is the second fastest mode of heat transfer.

Examples of convection include:

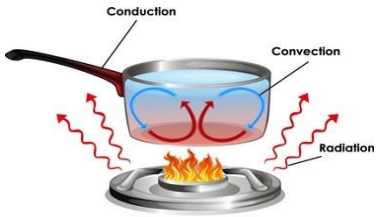
- A pot of boiling water heating up the air around it.
- The hot air from a radiator rising to the ceiling and then spreading out.
- The wind blowing over the ocean, transferring heat energy from the water to the air.

✓ **Radiation**

Radiation is the transfer of heat energy through electromagnetic waves. It does not require any contact between the objects that are exchanging heat energy. Radiation is the slowest mode of heat transfer.

Examples of radiation include:

- The heat from the sun warming up the Earth's surface.
- A fire radiating heat to the people and objects around it.
- A toaster radiating heat to the bread inside it.



Heat Transfer

- **Difference between heat and temperature**

✓ **Heat**

Heat is the transfer of thermal energy from one physical system to another system or from one region in a physical system to another region? Heat always flows from a hotter body to a colder body. It can be also the transfer or flow due to the difference in temperature between the two objects. The direction of energy flow is from the substance of higher temperature to the substance of lower temperature. Heat is measured in units of energy, usually calories or joules.

✓ **Temperature**

Temperature is the measure of hotness or coldness of matter. Temperature is measured in degrees on the Celsius (C) or Fahrenheit (F) scale, or in kelvins (K).

- **Conversion of temperature from one scale to another**

Temperature is converted from: Celsius to Kelvin scale, Celsius to Fahrenheit scale., Fahrenheit to Kelvin, Reaumur to Fahrenheit and Fahrenheit to Reaumur.

✓ **Relationship between Celsius and Kelvin scale**

To convert temperature from degree Celsius (°c) to Kelvin temperature (K), we add 273 to degrees' temperature i.e.

1.K = °C + 273

To convert kelvin (K) temperature to degrees celsius (°C) temperature, we subtract 273 from kelvin temperature i.e.

1.°C = K – 273

- ✓ **Relationship between Celsius and Fahrenheit**

To convert Fahrenheit into Celsius, we subtract 32 and then multiply by 5 / 9 i.e.

1.°C = (°F - 32) × 5/9

To convert Celsius to Fahrenheit, we multiply by 9 /5 then add 32 i.e.

1.°F = (°C × 9/5) + 32

- ✓ **Relationship between Fahrenheit and Kelvin**

To convert Fahrenheit to Kelvin,

1.°F = (K - 273) × 9/5 + 32

- ✓ **Kelvin to Fahrenheit**

To convert Kelvin to Fahrenheit,

1.K = (°F - 32) × 5/9 + 273

- ✓ **Relationship between Fahrenheit and Reaumur**

To convert Fahrenheit to Reaumur,

1.°R = (°F - 32) × 4/9

2.°F = (°R × 9/4) + 32

- ✓ **Reaumur to Fahrenheit**

To convert Reaumur to Fahrenheit,

1.°F = (°R × 9/4) + 32

2.°R = (°F - 32) × 4/9

Examples:

Convert 20 degrees Celsius to Kelvin:

1.K = 20 + 273 = 293

Convert 32 degrees Fahrenheit to Celsius:

1.°C = (32 - 32) × 5/9 = 0

Convert 100 degrees Celsius to Fahrenheit:

6.°F = (100 × 9/5) + 32 = 212

Convert 40 degrees Reaumur to Fahrenheit:

1.°F = (40 × 9/4) + 32 = 104

Convert 80 degrees Fahrenheit to Reaumur:

1.°R = (80 - 32) × 4/9 = 32

Indicative content: 1.4 Differentiation of the types of food

Duration: 2hrs

Theoretical Activity 1.4.1: Differentiation of food types

Tasks:

1. You are requested to answer the following questions related to food types differentiation

   i. Explain different types of food.
   ii. What is the roles of different types of food?

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: For more clarification, read the key readings 1.4.1

Key readings 1.3.1.: Differentiation of the Types of Food

Food is any substance consumed to provide nutritional support for an organism. Food is usually of plant or animal origin and contains essential nutrients such as carbohydrates, fats, proteins, vitamins, or minerals. The substance is ingested by an organism and assimilated by the organism's cells to provide energy, maintain life, or stimulate growth.

- **The types of food**

✓ **Cereals**

Cereals are grains that are harvested and processed. They are starch food containing high amount of carbohydrate, also known as energy yielding food that produces an edible grain (fruit or seed).

Example: Wheat, Barley, Sorghum, Millet, Maize, Rice

Cereal varieties cultivated in Rwanda:

The following cereal varieties are cultivated in Rwanda:

The following cereal varieties are cultivated in Rwanda:

Varieties	Scientific name

Maize	Zea mays
Sorghum	Sorghum bicolour
Rice	Oryza sativa
Millet	Eleusine coracana
Wheat	Triticum vulgare

Importance of cereals in human diet:

- **Reduced risk of heart disease:** Cereals are a good source of fiber, which can help to lower cholesterol levels and reduce the risk of heart disease.
- **Improved digestion:** Cereals are a good source of fiber, which can help to improve digestion and prevent constipation.
- **Weight management:** Cereals are a low-calorie food that is high in fiber. This makes them a good choice for people who are trying to lose weight or maintain a healthy weight.
- **Diabetes management:** Cereals are a low-glycemic food, which means that they do not cause a sharp spike in blood sugar levels after eating. This makes them a good choice for people with diabetes.

✓ **Legumes**

Legumes are seeds of plants that grow in pods. Legumes is a plant in the family Fabaceae (or Leguminosae), or the fruit or seed of such a plant. When used as a dry grain, the seed is also called a pulse.

They are a good source of protein, fiber, vitamins, and minerals. Some common legumes include beans, lentils, peas, and peanuts.

✓ **Vegetables**

Vegetables are edible plants or parts of plants. They are consumed by humans or other animals as food or it refer to all edible plant matter, including the flowers, fruits, stems, leaves, roots, and seeds.

Vegetables can be eaten either raw or cooked and play an important role in human nutrition, being mostly low in fat and carbohydrates, but high in vitamins, minerals and dietary fibre.

Example of vegetables: Cabbage, Carrot, Beetroot, Lettuce, Green bean, Pea, Tomato, Onion, Garlic, elephant garlic, spinach

✓ **Fruits**

Fruits are the sweet and fleshy products of a tree or other plant that contain seed and can be eaten as food. They are a good source of vitamins, minerals, and fiber.

Fruit" normally means the seed-associated fleshy structures (or produce) of plants that typically are sweet or sour and edible in the raw state, such as apples, bananas, grapes, lemons, oranges, and strawberries

✓ **Tubers and roots**

Tubers and roots are edible underground parts of plants. They are staple energy giving food second to cereals also provide high amount of carbohydrate.

The principal root and tuber crops of the tropics are:

- Cassava (*Manihot esculenta* Crantz),
- Yam (*Dioscorea* spp.),
- Sweet potato (*Ipomoea batatas* L.),
- Potato (*Solanum* spp.) and
- Edible aroids (*Colocasia* spp. and *Xanthosoma sagittifolium*).

The Role of Roots and Tubers in Nutrition

- Root and tuber crops are second only in importance to cereals as a global source of carbohydrates.
- They also provide some minerals and essential vitamins, although a proportion of the minerals and vitamins may be lost during processing as, for example, in the case of cassava.

General characteristics of roots & tubers compared with cereals (FAO, 1983)

Characteristics of roots & tubers compared with cereals (FAO, 1983)

Cereals and oil seeds	Roots and tubers
Low moisture content, typically 10% to 15%	High moisture content, typically 70% to 80%
Small unit size, typically less than 1 gram	Large unit size, typically 100 grams to 15 kg
Very low respiration rate with very low generation of heat. Heat production is typically 0.05 megajoule/ton/day for dry grain	High respiration rate. Heat production is typically 0.5 to 10 megajoules/ton/day at 0°C to 5 to 70 megajoules/ton/day at 20ºC
Hard texture	Soft texture, easily bruised
Stable, natural shelf life is several	Perishable, natural shelf life

years	is a few days to few months
Losses usually caused by moulds, insects and rodents	Losses usually caused by rotting (bacteria and fungi), senescence, sprouting and bruising

Difference between roots and tubers

Tubers differ from root crops in three ways:

- Tubers are enlarged stems rather than enlarged roots.
- Cut up a tuber, and each section will grow a plant; root crops cannot do this.
- Tubers contain more starch than root crops

✓ **Foods of Animal origin (Milk, Meat, fish, honey)**

Foods of animal origin are foods that come from animals. Animal source foods (ASF) include many food items that come from an animal source such as fish, meat, milk, eggs, honey, cheese and yogurt. They are a good source of protein, vitamins, and minerals.

Indicative content 1.5: Description of the physical properties of different types of food

Duration: 2hr

Theoretical Activity 1.5.1: Description of physical properties of different types of food

Tasks:

1: You are requested to answer the following questions related to description of physical properties of different types of food.

i. Describe the physical properties of food types.
ii. Enumerate four main colour pigments

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class

4: For more clarification, read the **key readings 1.5.1**

Key readings 1.5.1.: Description of physical properties of different types of food

Food materials possess physical properties. Physical properties are those properties that can be observed or measured without changing the chemical makeup of the material.

✓ **Density and Specific Gravity**

- **Density:** Density is a measure of how much mass is contained in a given volume. It is a physical property that affects many other properties of food, such as texture, flow ability, and shelf life.

Formula to calculate the density:

$$\rho = \frac{m}{V}$$

where ρ is the density, m is the mass, and V is the volume

The density of a material varies with temperature and pressure. Increasing the temperature of a substance (with a few exceptions) decreases its density by

increasing its volume while increasing the pressure on an object decreases the volume of the object and thus increases its density.

- ✓ **Specific gravity** is a similar measure to density but it is unit-less. It is calculated by dividing the density of the material by the density of water (1 g/cm^3).

Therefore, the specific gravity of a material ends up being the same value as the density without adding the unit.

- ✓ **Viscosity**

Viscosity is a measure of a fluid's resistance to flow. It is a physical property that affects many food processes, such as mixing, pumping, and spreading. Viscosity depends on a fluid's state, such as its temperature, pressure, and rate of deformation.

Viscosity is measured with various types of **viscometers** and **rheometers**.

A **rheometer** is used for fluids that cannot be defined by a single value of viscosity and therefore require more parameters to be set and measured than is the case for a viscometer.

Example: Water (low viscosity) and honey (high viscosity).

- ✓ **Colour**

Color is a visual property of food that is caused by the interaction of light with the food's surface. It is a physical property that affects food quality and consumer appeal.

The color of food is caused by the presence of different pigments. Pigments are natural chemicals that absorb certain wavelengths of light and reflect others. The wavelengths of light that are reflected give the food its color.

Colors come from four main pigments:

- Chlorophyll, in green vegetables
- Carotenoids making carrots orange and tomatoes red
- Anthocyanin responsible for the red, purple, blue and even black colour of radishes, aubergines, artichokes, grapes, black rice and blackberries
- Flavonols giving many kinds of fruit and vegetables their yellow hue.

All pigments deteriorate once fruit or vegetables have been harvested or when they are cooked, thus speeding up the natural chemical and climatic transformation such as dry, humid, cold or hot

- ✓ **Moisture content**

Water content or Moisture content is the amount of water present in a food. It

is a physical property that affects many food properties, such as texture, shelf life, and flavor. This determines how much water is available for microbial growth. The lower the water activity, the less chance for microbial spoilage. This is not the same as water content. Foods with the same water content may have different water activity.

This is measured by direct or indirect methods. The direct method removes moisture from the product by oven drying, desiccation, distillation, extraction and other physicochemical techniques. Its quantity is found by weighing. This method is accurate but time consuming.

- ✓ **Solubility**

Solubility is the ability of a substance to dissolve in another substance. It is a physical property that affects many food processes, such as mixing and extraction. It has ability of a substance (solute) to dissolve in a given amount of solvent at a specified temperature.

The solubility mainly depends on the composition of solute and solvent like:

- pH
- The presence of other dissolved substances
- Temperature
- Pressure

- ✓ **Taste**

Taste is the sensory perception of food caused by chemical compounds in the food interacting with taste receptors on the tongue. It is a sensory property that affects consumer preference. Taste receptors in the mouth sense the five taste modalities: sweetness, sourness, saltiness, bitterness, and savoriness.

- ✓ **Hygroscopicity**

Hygroscopicity is the ability of a substance to attract and absorb water vapor from the air. It is a physical property that affects many food properties, such as texture, shelf life, and caking. The total amount of water, which can be taken up by the hygroscopic material will be a function of the temperature and humidity of the atmosphere in which it is located

- ✓ **Freezing, Melting and Boiling Point**

- Freezing point (Fp) is the temperature at which a liquid turns to solid when it is cooled.
- Melting point (Mp) is the temperature at which a solid melt

- Boiling point (Bp) is the temperature at which a liquid turns to vapor.

A good reference to use to compare these temperature points against, is water.

- ✓ The freezing and melting point of water is 0 ºC (32 ºF) and it and has a boiling point of 100 ºC or 212 ºF.
- ✓ Adding solids to water, such as sugars and salts will increase the boiling point. Therefore, getting burned with a hot syrup will cause much more injury than getting burned from hot water.
- ✓ Adding solids to water causes freezing point to drop. That means more energy has to be removed from the liquid to cause freezing

These physical properties affect many food processes, such as cooking and freezing**.**

- ✓ **Volatility**

Volatility is the tendency of a substance to evaporate or vaporize. It is a physical property that affects many food properties, such as flavor and aroma.

Most aroma molecules are volatile organic compounds. These compounds come from, e.g., the ripening of plants, the development of oils or during natural processes such as fermentation

The volatile compounds are likely to form during long exposure to high temperatures in the reaction of sugars with amino groups of either amino acids or peptides/proteins, which is called the Maillard reaction.

Points to Remember

- Physical quantities should always be accurate for standard food processing.
- While adjusting tools and equipment for standard food processing, it is strictly recommended to follow manufacturer's instructions
- When you are selecting tools and equipment for standard food processing, select tools and equipment that meet the selection criteria.
- Adjust the weighing balance regularly to ensure that it is providing accurate readings
- Adjust the thermometer regularly to ensure that it is providing accurate results
- Adjust the watch regularly to ensure that it is providing accurate time
- Use Fundamental quantities and physical quantities correctly.

Learning outcome 1 end assessment

Theoretical assessment

1. The following terms are examples of fundamental physical quantities except:

a) Area
b) Volume
C) Density
d) Relative humidity
e) Speed
f) Acceleration
g) Work
h) Power
i) Energy

2.Circle the wrong term in the following terms refer to the change of state of matter between solid, liquid, and gas phases except:

a) Freezing Point
b) Melting Point
c) Moisture content
d) Boiling Point
e) Humidity

3. Match the **Column B** containing the modes of heat transfer with their corresponding meaning in **Column C.** Write the answer in the provided space (**Column A**)

Column A	**Column B**	**Column C**
…….	1. Conduction	A. Is the transfer of heat through a fluid by means of motion in the fluid.
……	2. Convection	B. Is the transfer of heat through electromagnetic waves.
……	3. Radiation	C. Is the transfer of heat from one substance to another that is in direct

		contact with it.
		D. Is a transfer of heat from liquid to gas
		E. Is energy transfer from one substance to another
		F. Is a transfer of heat from liquid , gas and solid.

4. Fill in blank space the correct word between **density, volatility, viscosity pertaining** in physical properties of different types of food.

a) ……is a measure of a fluid's resistance to flow. It is a physical property that affects many food processes, such as mixing, pumping, and spreading.

b) …….is the tendency of a substance to evaporate or vaporize. It is a physical property that affects many food properties, such as flavor and aroma.

c)…… is a measure of how much mass is contained in a given volume? It is a physical property that affects many other properties

Practical assessment

Dairy farmer, committed to maintaining high-quality milk production, has contacted you, as food processing assistant technician. During a recent milking, they observed some changes, in the milk, including volume, temperature, and consistency (watery).

You are requested help the Dairy farmer by measuring those physical quantities.

References

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Indicative contents

2.1 Description of food components

2.2 Differentiation of solute and solvent

2.3 Identification of the types of solution

2.4 preparation of solution

2.5 Description of acid and base

2.6 Identification of food additives

Key Competencies for Learning Outcome 2: Apply basics knowledge of food chemistry

Knowledge	Skills	Attitudes
• Compositions of food • Characteristics of solute and solvent • Classification of solution based on their nature • Properties of acids and bases • Definition and types of food additives • Apply formula related to solution preparation	• Preparing the solutions	• Be Careful • Be Attentive • Be Accuracy • Be professional • Be precise • Patience • Perseverance

Duration: 20hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe appropriately food components
2. Differentiate properly solute from solvent
3. Identify effectively the types of solution
4. Prepare properly the solution
5. Describe clearly acids and bases
6. Identify correctly food additives

Resources

Equipment	Tools	Materials
• Analytical balances • Spectrophotometers • Chromatographs • Dryers	• Measuring cylinder • Test tube, • Conical flask • Baguette • Burette • Pipette • Wash bottle • pH meter • Beaker • Scientific calculator	• Indicator (litmus phenolphthalein • NaOH, • HCl, • H_2SO_4 • Distilled water • Buffer solution • Food additives

Indicative content 2.1: Description of Food Components

Duration: 5hrs

Theoretical Activity 2.1.1: Description of food components

Tasks:

1:You are asked to answer the following questions related to description of physical properties of different types of food.

i. The definitions and sources of all food components
ii. The functions of food components.
iii. Classification of food components.

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class
4: Read the key reading 2.1.1

Key readings 2.1.1: Description of food components

- **Carbohydrates**

  Carbohydrates are the main source of energy for the body which are cheap and readily available from food. There are three different kinds of carbohydrates. They include starch, sugar, and fiber. We do not get calories from fiber because our bodies do not break down fiber during digestion.

  ✓ **Classification of Carbohydrates**
  - **Monosaccharides:** these are the simplest form of carbohydrates containing simple sugar molecule. Example: Glucose, Fructose.
  - **Disaccharides**: These carbohydrates composed of two units of Monosaccharides. Example: Sucrose, Lactose and Maltose.
  - **Polysaccharides:** these are the complex sugars containing numerous units of monosaccharide molecules. Example: Glycogen, Cellulose and Pectin.

  ✓ **Sources of carbohydrate**
  - All sugars, honey, whole grains, cereals, grains, rice, fruits, milk, yogurt, beans, roots and tubers such as potatoes, etc.

  ✓ **Functions of Carbohydrates**

  Carbohydrates are an essential macronutrient that plays a number of important roles in the body, including:

- **Energy production:** Carbohydrates are the body's main source of energy. When carbohydrates are broken down, they release glucose, which is used by cells for fuel.
- **Protein sparing:** Carbohydrates help to spare protein from being used for energy. This is important because protein is essential for building and repairing tissues.
- **Blood sugar regulation:** Carbohydrates help to regulate blood sugar levels by releasing glucose into the bloodstream slowly over time. This helps to prevent blood sugar levels from spiking or crashing.
- **Gut health:** Some carbohydrates, such as fiber, are not digested by the body and instead travel to the large intestine, where they promote the growth of beneficial bacteria. This is important for gut health and digestion.

- **Proteins**

Protein are very large molecules composed of basic units called amino acids joined by peptide linkage. Proteins contain carbon, hydrogen, oxygen, nitrogen, and Potentially sulphur, phosphorus, iron.

Amino acids are classified as essential and non-essential amino acids.

✓ **Essential amino acids**

Essential amino acids are amino acids that the body cannot produce on its own and must be obtained from food. There are nine essential amino acids for humans:

- Histidine
- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine

✓ **Non-essential amino acids**

Non-essential amino acids are amino acids that the body can produce on its own. However, some non-essential amino acids may become essential in certain circumstances, such as during illness, pregnancy, or infancy. These are called conditionally essential amino acids.

Some examples of non-essential amino acids include:

- Alanine
- Arginine
- Asparagine

- Aspartic acid
- Cysteine
- Glutamic acid
- Glutamine
- Glycine
- Proline
- Serine
- Tyrosine

✓ **Sources of protein:**

- **Animal-based sources of protein**: meat, fish, offal (organ meats), milk products and eggs
- **Plant-based sources of proteins**: beans, legumes and pulses, nuts, seeds, peanut and nut butters and soy.

✓ **Protein structure**

- **Primary structure:** Primary structure is a sequence of amino acids in a long chain.
- **Secondary structure:** Secondary structure is formed by folding and twisting into Spring like coiling - Alpha helix of the amino acid chain.
- **Tertiary structure:** Tertiary structure is formed when the twists and folds of the secondary structure fold again to form a larger three dimensional structure.
- **Quaternary structure:** Quaternary structure is a protein consisting of more than one folded amino acid chain.

✓ **Function of proteins:**

- Proteins have a wide range of functions in the body, including:
- Proteins help in synthesis of enzymes, plasma proteins and hormones in the body
- Proteins help in growth and repair of body tissues
- Proteins are secondary sources of energy during deficiency of carbohydrates and fat.
- Proteins help in forming of haemoglobin
- Proteins help in antibody formation

- **Lipids**

Lipids are a diverse group of organic compounds that are insoluble in water. Lipids are fats and oil.

✓ **Sources of lipids**

- Animal products: Meat, poultry, fish, eggs, dairy products
- Plant products: Nuts, seeds, avocados, olive oil, vegetable oil
- Processed foods: Margarine, salad dressing, baked goods

✓ **Classification of lipids based on their structure:**

- **Simple lipids** are composed of only two fatty acids. Example: triglycerides
- **Complex lipids** contain a fatty acid component and another group of molecules, such as a phosphate group, a sugar group, or a nitrogen group. Example: phospholipids, glycolipids, and sphingolipids.
- **Steroids** are a type of lipid with a four-ring structure. Example: Steroids include cholesterol, which is a major component of cell membranes, and hormones such as testosterone and estrogen.

✓ **Functions of lipids**

- Supplies energy
- Improve the palatability of food (flavor and taste)
- Supports body organs like liver and kidneys
- Provides insulation and thermoregulation against cold
- Provides essential fatty acids which helps in growth, promotion and maintenance of skin integrity
- Helps in formation of hormones in the body
- Helps in transportation of fat soluble vitamins

- **Minerals**

These are the inorganic compounds in micro quantities which are essential for many vital functions of the body. The minerals constituent of the body amounts to 4.3 to 4.4 %, largely in the skeleton.

✓ **General Functions of Minerals**

- As constituents of hard tissue. (eg.) calcium and phosphorus in bone and teeth.
- As constituents of soft tissue. (eg.) Sulphur and phosphorus.
- Building and repairing tissues
- Regulating blood sugar levels
- Transmitting nerve signals
- Contracting muscles
- Supporting the immune system

✓ **Classification of minerals**

Minerals are classified into two main groups: macrominerals and microminerals. Macrominerals are needed in larger amounts than microminerals.

The seven macrominerals are:

- **Calcium:** It takes function in formation and maintenance of bones and teeth**,** coagulation (thickening) of blood and muscle contraction. Calcium takes sources in milk and its products, green leafy vegetables, bones of meat, fish, pumpkin, coconut, dry fruits, and cereals.
- **Chloride:** It takes roles in maintaining fluid balance, regulating blood

pressure, supporting immune function and Supporting muscle and nerve function

- **Magnesium:** Constituent of bones and teeth, coenzymes in general metabolism, smooth muscle action. Dairy products (excluding butter) fresh green vegetables, meat, nuts, sea food and legumes are good sources of magnesium.
- **Phosphorus:** It takes function in Building and repairing bones and teeth, producing energy, regulating muscle contractions, supporting nerve function and transporting nutrients throughout the body. Phosphorus sources are whole grain cereals and flours, legumes, oatmeal, cheese, nuts, fish
- **Potassium:** is an essential mineral that plays a vital role in many bodily functions, maintaining fluid balance, regulating blood pressure, supporting muscle and nerve function, promoting digestion, supporting immune function, excreting waste products from the body. It takes sources in fresh vegetables, citrus fruits, milk and guava.
- **Sodium:** Sodium is essential for many body activities such as maintaining fluid balance, supporting muscle and nerve function. It is taken in the diet as salt. It takes Sources in Common salt, sodium chloride is also found in certain foods like fish, meat, eggs and seasoned
- **Sulphur:** It takes role in detoxifying the body and regulating metabolism

Microminerals are needed in smaller amounts than macrominerals.

Examples include Iron, zinc, copper, selenium, manganese, iodine, chromium and molybdenum

- **Water**

Water is a major food component, making up 50-70% of the human body. Most natural foods contain water up to 70% of their weight or greater unless they are dehydrated, and fruits and vegetables contain water up to 95% or greater.

It is essential for all bodily functions, including:

- Transporting nutrients and oxygen to cells
- Removing waste products from cells
- Regulating body temperature
- Lubricating joints
- Protecting organs and tissues

✓ **Types of water in food**

There are two main types of water in food: free water and bound water.

- **Free water** is water that is not chemically bound to other molecules in

food. Free water is also the type of water that is most available for microbial growth.

- **Bound water** is water that is chemically bound to other molecules in food, such as proteins and carbohydrates. Bound water is not as available for microbial growth as free water.

- **Vitamins**

Vitamins are complex chemical substances required by body in very small amounts. Vitamins in food are for the protection and regulation of body functions.

Vitamins are divided in to two major groups:

✓ **Fat-soluble vitamins** dissolve in fat and are stored in the body's liver, fatty tissue, and muscles. These vitamins include vitamins A, D, E, and K.

✓ **Water-soluble vitamins** dissolve in water and are not stored in the body. These vitamins must be consumed on a daily basis. Water-soluble vitamins include vitamin C and the B vitamins.

Each vitamin plays a specific role in the body. For example:

- **Vitamin A** is important for vision, immune function, and cell growth and development. Green leafy vegetables and yellow orange fruits and vegetables like mango, papaya, pumpkins and carrots are good sources of β-carotene, Butter, whole milk, egg, liver and fish are richest sources
- **Vitamin B1 (thiamin)** is important for energy metabolism and nerve function. Sources are whole grain cereals, wheat, vegetables and potatoes, green leafy vegetables. Meat, fish, liver and eggs.
- **Vitamin B2 (riboflavin)** is important for energy metabolism, cell growth and development, and vision. Riboflavin is found in eggs, nuts, dairy products, meats, wheat germ, wild rice, mushrooms, soya beans, green leafy vegetables and whole grain and enriched cereals and bread.
- **Vitamin B3 (niacin)** is important for energy metabolism, cell growth and development, and nervous system function. Found in appreciable amounts in liver, yeast, meat, legumes, peanuts and whole cereals.
- **Vitamin B6 (pyridoxine)** is important for protein metabolism, energy metabolism, and red blood cell production. Sources are whole grains, legumes, bananas, potato, liver, kidney and other meats, fortified breads and cereals. Sunflower seeds, soya beans, and yeast are the richest sources of pyridoxine among plant foods.
- **Vitamin B12 (cobalamin)** is important for red blood cell production, nerve function, and DNA synthesis.
- **Vitamin C** is important for immune function, collagen production, and wound healing. Sources are citrus fruits (guava, lemon, orange, tomato), green leafy vegetables.

- **Vitamin D** is important for bone health, immune function, and cell growth and development. sources are milk, butter, cheese, egg, fish and fish liver oils, and foods which have been fortified by addition of vitamin D.
- **Vitamin E** is an antioxidant that helps to protect cells from damage. Sources are milk, oils, eggs, leafy vegetables, papaya, grains, nuts.

  Vitamin K is important for blood clotting and bone health. Sources are green leafy vegetables, cereals, fruits. Synthesized by bacteria in gut.

Indicative content 2.2: Differentiation of solute and solvent

Duration: 3 hours

Theoretical Activity 2.2.1: Explaining the difference between the solute and solvent

Tasks:

1. You are asked to describe characteristics of solute and solvent by answering the following questions:

   i. Define solute and solvent.
   ii. Differentiate solute from solvent.

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: Read the **key reading 2.2.1**

Key readings 2.1.1: Explaining the difference between the solute and solvent

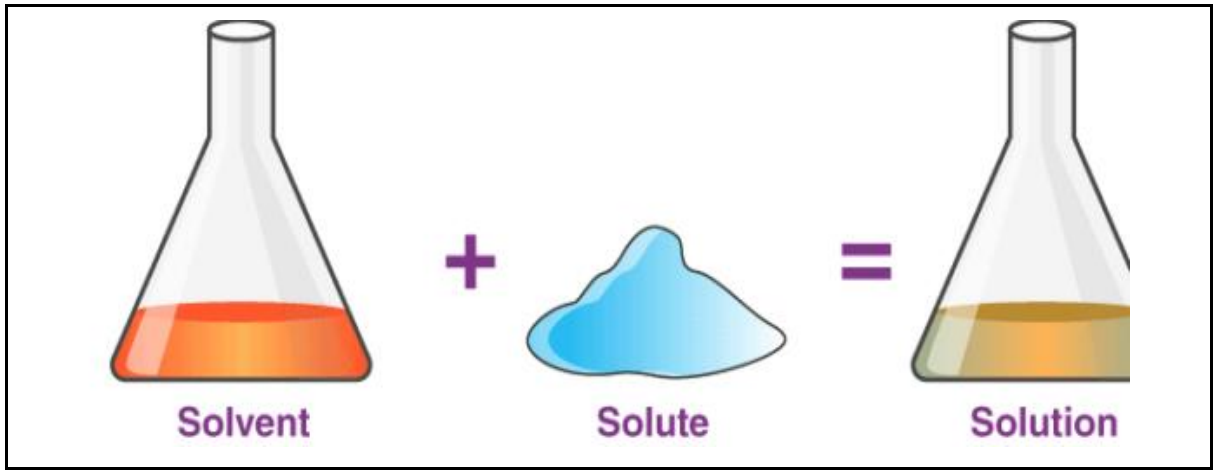
- **Definitions**

✓ **A solute** is a substance that is dissolved in another substance, called the solvent. For example, in a salt-water solution, the salt is the solute and the water is the solvent.

✓ **The solvent** is the substance that dissolves the solute. For example, in a sugar water solution, the water is the solvent and the sugar is the solute.

Comparison of solute and solvent:

Characteristic	Solute	Solvent
Amount	Present in a smaller amount	Present in a larger amount
State of matter	Can be solid, liquid, or gas	Can be solid, liquid, or gas
Function	Dissolved in the solvent to form a solution	Dissolves the solute to form a solution



Points to Remember

- Always select tools and equipment for preparation of solutions
- Prepare tools and equipment for preparation of solution
- Solutions based on the physical state of the solute and solvent are: Solid solution, Liquid solution, Gaseous solution, Saturated solution, Unsaturated solution, Supersaturated solution.

Indicative content 2.3: Identification of the types of solution

Duration: 3 hrs

Theoretical Activity 2.3.1: Identification of the types of solution

Tasks:

1: You are asked to classify solutions Based on: physical state, nature of mixture and Solute/solvent proportion by answering the following questions:

i) Define the term solution

ii) What are the characteristics of solution?

iii) Classify the solutions based on their nature

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: Read the **key reading 2.3.1**

Key readings 2.3.1: Identification of the types of solution

A solution is a homogeneous mixture of two or more substances of solute and solvent.

- **Characteristics of solutions**
  - ✓ A solution is a homogeneous mixture of two or more substances.
  - ✓ The particles of solute in a solution cannot be seen by the naked eye.
  - ✓ A solution does not allow beams of light to scatter.
  - ✓ A solution is stable.
  - ✓ The solute from a solution cannot be separated by filtration (or mechanically).
  - ✓ A solution is composed of only one phase
  - ✓ It is composed of only one phase
- **Classification of solutions:**
  - ✓ **Based on the physical state of the solute and solvent:**
    - **Solid solution:** A solution in which the solute and solvent are both solids. For example, alloys such as brass and bronze are solid solutions.

- **Liquid solution:** A solution in which the solute and solvent are both liquids. For example, salt water is a liquid solution.
- **Gaseous solution:** A solution in which the solute and solvent are both gases. For example, air is a gaseous solution.

✓ **Based on nature of mixture:**

- **Homogeneous solution:** A solution in which the solute and solvent are mixed to form uniform composition, properties and cannot be distinguished from each other.
- **Heterogeneous solution:** A solution in which the solute and solvent are mixed and cannot form uniform composition, properties can be distinguished from each other. For example, a mixture of sand and water is a heterogeneous solution.

✓ **Based on the concentration of the solute/solvent:**

- **Unsaturated solution:** A solution that contains as much solute as can dissolve in the given solvent at a given temperature. Example: A teaspoon of sugar dissolved in a glass of water
- **Saturated solution:** A solution that contains less solute that can dissolve at given temperature. Example: A sugar solution where no more sugar will dissolve at a given temperature.
- **Supersaturated solution:** The solution contains more solute than it can normally dissolve at a given temperature. Example: A supersaturated solution of sugar, which can be created by dissolving a large amount of sugar in hot water and then slowly cooling the solution

Indicative content 2.4: Preparation of solution

Duration: 5 hrs

Practical Activity 2.4.1: Preparation of solution

Task:

Referring to the previous theoretical activity, you are asked to go in food processing workshop to prepare the solution.

1: Apply safety precautions
2: Select all requirements needed to prepare the solution
3: Prepare the solution
4: Present your work to the trainer
5: Read **the key reading 2.4.1.**
6: Perform the task provided in application of learning 2.4

Key readings 2.4.1: Preparation of solution

The process of preparing a solution involves dissolving a known amount of solute in a solvent to form a homogeneous mixture. The concentration of a solution can be expressed in various ways, but the most common unit is molarity (M), which represents the number of moles of solute per liter of solution.

✓ **Example of calculation of molarity:**

You have 5.0 grams of sodium chloride (NaCl) and 100 mL of water. Calculate the molarity of the solution you prepared by dissolving the NaCl in the water.

Solution:

Molarity is defined as the number of moles of solute per liter of solution. The formula for molarity is:

Molarity (M) = moles of solute / liters of solution

moles of NaCl = mass of NaCl / molar mass of NaCl

The molar mass of NaCl is 58.44 g/mol.

Substituting the given values, we get:

moles of NaCl = 5.0 grams / 58.44 g/mol = 0.0855 mol

volume of water in liters = 100 mL / 1000 mL/L = 0.100 L

Molarity (M) = 0.0855 mol / 0.100 L = 0.855 M.

✓ **Procedures of solution preparation:**

- Weigh the calculated mass of solute using an analytical balance.

- Select a solvent that will dissolve the solute effectively.
- Transfer the measured solute to a clean dry beaker or volumetric flask.
- Add a small amount of solvent.
- Stir the mixture gently by using stirring rod until the solute dissolves completely.
- Add more solvent gradually until the desired volume of solution is reached.
- Label and store the solution properly.

Example

Describe in details how you can prepare the following solution: 50 ML of NaOH, 10%.

Answer:

% Concentration = (Mass of solute / Volume of solution) x 100%

Mass of NaOH = $(\mathbf{10}\ \boldsymbol{x}\ \mathbf{50}\ \boldsymbol{ml})/\mathbf{100}$ = **5g** of **NaOH**

✓ **Procedure:**

1. Weigh 5g of NaOH accurately using glass watch, spatula and analytical balance.

2. Dissolve it in a volumetric flask of 50 ML containing already little water and mix using a baguette and shake till you get homogeneous mixture (you should take care since it is an exothermic reaction).

3. Top up using distilled water and shake again and cover your solution.

4. Label your solution: NaOH10%; 50 mL and the date of preparation.

✓ Both dissolving and diluting are methods of preparing solutions:

- **Dissolving (dissolution):** involves mixing a solid solute with a liquid solvent to form a homogeneous solution. The solute particles disperse evenly throughout the solvent, forming a new substance with uniform properties.
- **Diluting (dilution):** on the other hand, involves adding more solvent to an existing solution to decrease the concentration of the solute. The solute particles remain dispersed in the increased solvent volume, resulting in a less concentrated solution.

Formula related to dilution: $M_1V_1 = M_2V_2$

Where **M_1, V_1** are molarity and volume before dilution and **M_2, V_2** are molarity and volume after dilution.

Example: Calculate the volume of **15M** H_2SO_4 that would be required to prepare 150cm^3 of **2M** H_2SO_4.

Answer: Using $M_1V_1 = M_2V_2$, then 15 x V_1 = 2 x 150

V1 = 20cm^3

Volume of 15M H_2SO_4 required 20 cm^3

Describe in details how you can prepare the following solution: 50 ML of NaOH, 10%.

Answer:

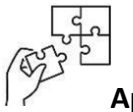
Mass of NaOH = $(\mathbf{10\ x\ 50\ ml})/\mathbf{100}$ = 5g of NaOH

✓ **Procedure:**

- Weigh 5g of NaOH accurately using glass watch, spatula and analytical balance.
- Dissolve it in a volumetric flask of 50 ML containing already little water and mix using a baguette and shake till you get homogeneous mixture (you should take care since it is an exothermic reaction).
- Top up using distilled water and shake again and cover your solution.
- Label your solution: NaOH10%; 50 mL and the date of preparation.

Points to Remember

- Equipment used in food chemistry workshop should always be accurate.
- While adjusting tools and equipment used in food chemistry workshop, it is strictly recommended to follow instructions
- When you are selecting tools and equipment used in food chemistry workshop select tools and equipment that meet the selection criteria.
- Adjust the weighing balance regularly to ensure that it is providing accurate readings.
- Always respect procedures of preparation of solution correctly.
- Before starting respect rules and regulation of how prepare solutions and take personnel protective equipment



Application of learning 2.4

AKEZA Company ltd is Food Company located near Burega School. The AKEZA Company Laboratory has a problem of preparation of irrelevant solution of 0.1 M acetic acid (CH3COOH) for use in an experiment to study the effect of pH on the texture of bread. As an assistant technician in food processing, solve this problem by preparing relevant solution of 0.1 M CH_3COOH.

Indicative content 2.5: Description of acid and base

Duration: 4 hrs

Theoretical Activity 2.5.1: Description of acid and base

Tasks:

1: You are asked to describe acid and base by answering the following questions:

i. Define these terms: acid and base according to Arrhenius
ii. What are the physical properties of acid and base?
iii. List the applications of acid and base

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: Read the **key reading 2.5.1**

Key readings 2.5.1: Description of acid and base

- **Definition of acid and base according to Arrhenius**

Acid is a substance which when dissolved in water dissociates to give hydrogen ion(s) (H+) as the only positively charged ions.

✓ **Examples of acids and the ions they produce on dissociation include:**

- The formation of the H+ cation in water is responsible for all the properties of an acid.

Note: Hydrochloric acid is also found naturally in our stomachs.

- A base is a substance which when dissolved in water dissociates to give hydroxide ion(s) (OH–) as the only negatively charged ions.

✓ **Examples of dissociation bases give the following ions:**

- An amphoteric is substance that behaves as an acid when it reacts with a base, and as a base when it reacts with an acid.

Example: aluminum hydroxide (Al(OH)3)

- A salt, in chemistry, is any ionic compound made by combining an acid with a base. A reaction between an acid and a base is called a neutralization reaction and can be represented as:

acid + base → H2O + salt

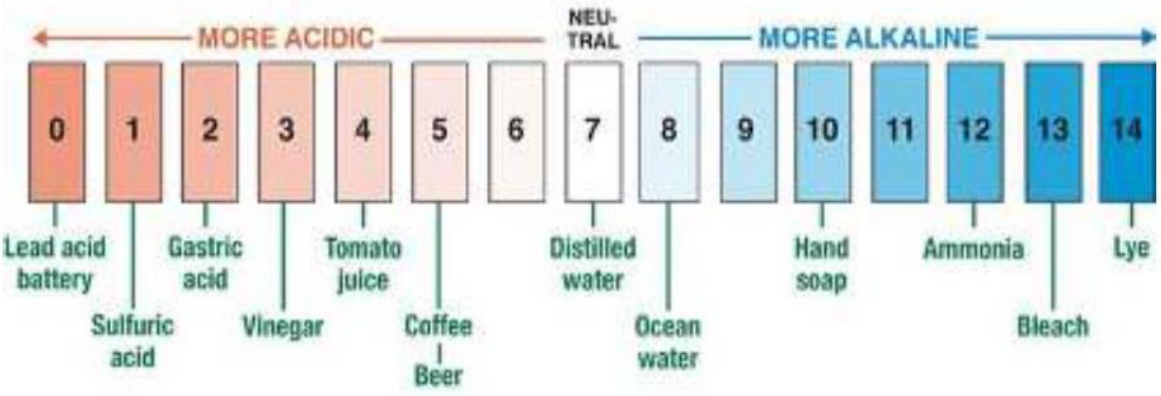
Example: HCl + NaOH → NaCl + H2O

- **The pH of a solution**

The pH of a solution is a measure of the acidity or alkalinity of the solution
The pH scale measures how acidic or basic a substance is.

✓ **It has numbers ranging from 0 to 14 as showed ahead:**

- The pH scale measures how acidic or basic a substance is. It has numbers ranging from 0 to 14.
- A pH of 7 shows that a solution is neutral while a pH below 7 shows that a



solution is acidic. A pH higher than 7 indicates that a solution is basic.

Substances such as rainwater and lemon juice have pH values which range between 4 and 7 and are said to be weak acids. Solutions of hydrochloric acid and sulphuric acid have pH values, which range between 0 and 4. These solutions are said to be strong acids.

- A pH value of 7 implies the solution is neither acidic nor basic and it is hence said to be neutral. Distilled water is neutral hence has a pH of 7.
- Ammonia solution and calcium hydroxide solution have pH values between 7 and 10 and are said to be weak bases.
  An example of a naturally occurring weak base is a wood ash.
- Sodium hydroxide and potassium hydroxide solutions have pH values above 10 and are said to be strong bases. As the pH values increase from 7 to 14, the strength of the bases also increases.

- **Physical properties of acid and base**
  - ✓ **Physical properties of acids:**

- Sour taste: Acids have a characteristic sour taste.
- Ability to change litmus paper color: Acids turn blue litmus paper red.
- Ability to conduct electricity
- Corrosiveness: Acids can corrode metals.
- Solubility in water: Acids are generally soluble in water.
- React with bases to form salt and water.

✓ **Physical properties of bases:**

- Bitter taste: Bases have a characteristic bitter taste
- Ability to change litmus paper color: Bases turn red litmus paper blue.
- Ability to conduct electricity: Bases are electrolytes, meaning they can conduct electricity in solution.
- Slippery feel: Bases have a slippery feel.
- Solubility in water: Bases are generally soluble in water.
- They react with acid to form salt and water

- **Use of acid and base**

✓ **Some applications of acids**

- Hydrochloric acid is produced in the human stomach to aid in the process of digestion.
- Sulphuric acid is used in car batteries, manufacture of plastics, pesticides, detergents and pharmaceutical products. It is also used in the manufacturing of some fertilisers.
- Ethanoic acid in vinegar is used as a food seasoning.
- Carbonic acid is added in soft drinks to enhance taste.
- Nitric acid is used in the manufacture of nitrogenous fertilisers, explosives an in the manufacture of dyes and paints.
- Phosphoric acid is used in the manufacture of phosphate fertilisers and making anti-rust paint.

✓ **Some applications of bases**

- Ammonia solution is used in the manufacture of fertilisers and detergents.
- Sodium hydroxide is used in the manufacture of soaps and detergents.
- Ammonium hydroxide is used to make cleaning agents such as oven cleaners.
- Magnesium hydroxide is used in the treatment of indigestion.

Calcium hydroxide is used as garden lime to reduce soil acidity and in the manufacture of cement and toothpaste.

Indicative content 2.6: Identification of food additives

Duration: 3 hrs

Theoretical Activity 2.6.1: Description of food additives

Tasks:

1: You are asked to explain by answering the following questions:

i. Define the term food additive.
ii. What are the types of food additives?
iii. Explain the application of food additives

2: Write the answers to papers / flipchart, blackboard or whiteboard
3: Present the finding / answers to the whole class
4: Read the **key reading 2.6.1**

Key readings 2.6.1: Description of food additives

- **Food additives**
  Food additives are substances intentionally added to food to modify their characteristics, such as flavor, texture, appearance, shelf life, or nutritional value.

✓ **General categories of food additives:**

- **Nutritional additives:** These additives are added to food to enhance its nutritional value, such as vitamins, minerals, and essential fatty acids. Examples of nutritional additives include folic acid, iron, and omega-3 fatty acids.
- **Processing agents:** These additives are used to modify the characteristics of food during processing, such as emulsifiers, thickeners, and stabilizers. Examples of processing agents include lecithin, xanthan gum, and carrageenan.
  - ❖ Emulsifiers or stabilizers: These additives help to stabilize mixtures of food for example to prevent separating of oil and water use emulsifiers, Examples of emulsifiers include lecithin, soy lecithin
  - ❖ Thickening and gelling agents: These additives increase the viscosity or consistency of food. Example of thickening and gelling agents include gelatin

- **Preservatives:** These additives help to extend the shelf life of food by preventing the growth of bacteria and other spoilage-causing microorganisms. Examples of preservatives include sodium benzoate, potassium sorbate, and propionic acid.
- **Sensory agents:** These additives are used to improve the sensory characteristics of food, such as flavorings, colorings, and sweeteners. Examples of sensory agents include vanilla extract, artificial sweeteners, and annatto.
  - **Flavourings:** These additives enhance the taste or aroma of food. They can be natural extracts, synthetic compounds, or a combination of both. Examples of flavorings include vanilla extract, artificial sweeteners, and monosodium glutamate (MSG).
  - **Colourings:** These additives add or intensify the color of food. They can be natural pigments, such as carotenoids from fruits and vegetables, or synthetic compounds. Examples of colorings include annatto, beta-carotene, and tartrazine.
  - **Sweeteners:** Sweeteners are substances that add sweetness to food. They can be natural or synthetic. Examples of sweeteners used in food additives include sugar, honey, and artificial sweeteners like aspartame and sucralose.

✓ **Classification of additive based on E-number**

Examples:

- E160b: Annatto
- E200: Sorbic Acid
- E210: Benzoic Acid
- E223: Sodium Metabisulphite
- E300: Ascorbic Acid (Vitamin C)
- E330: Citric Acid
- E951: Aspartame
- E440: Pectin
- E500: Sodium Carbonate
- E621: Monosodium Glutamate
- E1404: Oxidized Starch.

✓ **Composition of food additives:**

The composition of food additives varies greatly depending on the specific additive and its intended use. However, some of the most common components of food additives include:

- **Acids**: Acids are often used as preservatives, flavorings, or acidifying agents. Examples of acids used in food additives include citric acid, lactic acid, and acetic acid.
- **Alkalis**: Alkalis are often used as neutralizing agents, emulsifiers, or leavening agents. Examples of alkalis used in food additives include sodium hydroxide, potassium hydroxide, and baking soda.
- **Carriers:** Carriers are substances that are used to dissolve or disperse other ingredients in a food additive. Examples of carriers include water, propylene glycol, and glycerin.
- **Chelating agents**: Chelating agents are substances that bind to metal ions to prevent them from reacting with other substances. They are often used in food additives to prevent discoloration or spoilage. Examples of chelating agents used in food additives include EDTA and citric acid.
- **Colors**: Colors are substances that add or intensify the color of food. They can be natural or synthetic. Examples of colors used in food additives include annatto, beta-carotene, and tartrazine.
- **Emulsifiers**: Emulsifiers are substances that help to stabilize mixtures of oil and water, preventing them from separating. They are often used in food additives to create a smooth, creamy texture. Examples of emulsifiers used in food additives include lecithin, soy lecithin, and xanthan gum.
- **Flavorings:** Flavorings are substances that enhance the taste or aroma of food. They can be natural or synthetic. Examples of flavorings used in food additives include vanilla extract, artificial sweeteners, and monosodium glutamate (MSG).
- **Preservatives:** Preservatives are substances that help to extend the shelf life of food by preventing the growth of bacteria and other spoilage-causing microorganisms. Examples of preservatives used in food additives include sodium benzoate, potassium sorbate, and propionic acid.
- **Sweeteners**: Sweeteners are substances that add sweetness to food. They can be natural or synthetic. Examples of sweeteners used in food additives include sugar, honey, and artificial sweeteners like aspartame and sucralose.
- **Texturizers:** Texturizers are substances that affect the texture of food. They can be used to make food thicker, thinner, smoother, or rougher. Examples of texturizers used in food additives include carrageenan, guar gum, and xanthan gum.
- **Vitamins and minerals**: Vitamins and minerals are essential nutrients that are often added to food to improve its nutritional value. Examples of vitamins and minerals used in food additives include folic acid, iron, and omega-3 fatty acids.

✓ **Use of food additives:**

- Preservation: Food additives can extend the shelf life of food by preventing the growth of bacteria and other spoilage-causing microorganisms.
- Flavour enhancement: Food additives can be used to enhance the taste or aroma of food.
- Appearance: Food additives can be used to improve the appearance of food.
- Nutritional enrichment: Food additives can be used to add vitamins, minerals, and other nutrients to food.

Technical functions: Food additives can be used for a variety of technical functions, such as emulsifying oil and water, stabilizing mixtures, and preventing browning. These functions can help to improve the quality and consistency of food products.

Points to Remember

- Equipment used in food chemistry workshop should always be accurate.
- While adjusting tools and equipment used in food chemistry workshop, it is strictly recommended to follow instructions.
- When you are selecting tools and equipment used in food chemistry workshop select tools and equipment that meet the selection criteria.
- Adjust the weighing balance regularly to ensure that it is providing accurate readings.
- Always respect procedures of solution preparation correctly.
- Before starting respect rules and regulation of how prepare solutions and take personnel protective equipment.

Learning outcome 2 end assessment

Theoretical assessment

1. Answer by True or False for this statement

In a tea solution, the sugar is the solute and the water is the solvent.

2. The following are four general categories of food additives except:

i) Nutritional additives
ii) Processing agents
iii) Carbohydrates
iii) Sensory agents
iv) Preservatives

3.Match the **Column B** containing the modes of heat transfer with their corresponding meaning in **Column C.** Write the answer in the provided space (**Column A**)

Column A	**Column B**	**Column C**
……	1. dissolution	A. involves adding more solvent to an existing solution to decrease the concentration of the solute
……	2. dilution	b. involves mixing a solid solute with a liquid solvent to form a homogeneous solution. The solute particles disperse evenly throughout the solvent, forming a new substance with uniform properties
…….	3.Morality	C. defined as the number of moles of solute per liter of solution.
		D. The process of preparing a solution involves dissolving a known amount of solute in a solvent to form a homogeneous mixture.

4.Fill in blank space the correct word between **preservatives, flavourings, emulsifiers** pertaining with Composition of food additives.

a) …….. are substances that help to extend the shelf life of food by preventing the growth of bacteria and other spoilage-causing microorganisms.
b) ……. These additives enhance the taste or aroma of food
c) …… are substances that help to stabilize mixtures of oil and water, preventing them from separating.

Practical assessment

In laboratory of food, industry there is a problem in solution preparation because they use concentrated hydrochloric acid. The specialist tells them to use diluted hydrochloric acid to avoid that problem caused by concentrated HCl. As an assistant technician in Food processing, you are requested to go in food laboratory to prepare a diluted solution of 0.1M hydrochloric acid (HCl) from a concentrated solution of 12M HCl for an experiment.

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Indicative contents
3.1 Classification of food microorganisms
3.2 Identification of factors influencing microbial growth in food
3.3 Differentiation of harmful and beneficial microorganisms in food

Key Competencies for Learning Outcome 3: Describe micro-organisms in food

Knowledge	Skills	Attitudes
• Identification of food microorganisms' types • Identification of factors affecting microbial growth in food • Differentiation between harmful and beneficial microorganisms • Explaining the functions of beneficial microorganisms Identification of the sources of food Microorganisms	• None	• Attentive • Curiosity • Respect • Understanding

Duration: 10 hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly types of food microorganisms
2. Identify properly factors influencing microbial growth in food
3. . Differentiate appropriately harmful and beneficial microorganisms
4. Explain clearly the functions of beneficial microorganisms
5. Identify correctly the sources of food microorganisms

Resources

Equipment	Tools	Materials
• Microscopes • Culturing equipment • Microscopy stains • Spectrophotometers • Mass spectrometry • Biochemical test kits	• Scientific calculator	• Culture media • Reagents and strains • Sterile swabs • Dilution tubes • Media and agar additives: nutrients supplements. • Control materials: positive and

		negative

Indicative content 3.1: Classification of food microorganisms

Duration: 4

Theoretical Activity 3.1.1: Characterization of food microorganisms

Tasks:

1: You are requested to answer the following questions related to

Definition and characteristics of food microorganisms.

i) Definition of food microorganisms.

ii) The characteristics of food microorganisms

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class

4: Read the **key reading 3.1.1**

Key readings 3.1.1: Characterization of food microorganisms

- **Food microorganisms**

Food microorganisms are the small living organisms found in food that they cannot seen by naked eyes, only be seen under microscope.

✓ **Classification of food microorganisms**

Microorganisms are classified on the basis of different characteristics: morphological, chemical, genetic, metabolic and cultural characteristics.

- **Morphological Classification:** Microorganisms are classified based on their shape, size, and arrangement, using techniques like microscopy and staining methods. This classification includes bacteria (rods, cocci, spirals), archaea (irregular shapes), fungi (hyphae and yeasts), and protozoa (diverse shapes).
- **Chemical Classification:** Microorganisms are classified based on their unique chemical composition, particularly the types of lipids, cell walls, and flagella. This classification helps identify different groups like Gram-positive and Gram-negative bacteria, which have distinct cell wall structures.
- **Genetic Classification:** Microorganisms are classified based on their genetic makeup, primarily using ribosomal RNA (rRNA) gene sequencing. This classification helps identify closely related species and understand evolutionary relationships between different groups of microorganisms.

- **Metabolic Classification:** Microorganisms are classified based on their metabolic processes, including the way they obtain energy and nutrients. This classification includes phototrophs (use light energy), chemotrophs (use chemical energy), autotrophs (synthesize organic compounds), and heterotrophs (obtain organic compounds from other sources).
- **Cultural Classification:** Microorganisms are classified based on their growth patterns and requirements, using different types of culture media and growth conditions. This classification helps identify specific species and their environmental preferences.

✓ **Types of food microorganisms**

There are six main types of microorganisms that can be found in food:

- **Bacteria:** Bacteria are the most common type of microorganism found in food. They can be either beneficial or harmful. Some bacteria, such as lactic acid bacteria, are used in the production of yogurt, cheese, and other fermented foods. Other bacteria, such as Salmonella, can cause foodborne illness.
- **Viruses:** Viruses are much smaller than bacteria and can only be seen with an electron microscope. They are not as common as bacteria in food, but they can cause serious foodborne illnesses, such as norovirus and hepatitis A.
- **Protozoa:** Protozoa are single-celled organisms that are slightly larger than bacteria. They are not as common as bacteria or viruses in food, but they can cause foodborne illnesses, such as giardiasis and cryptosporidiosis.
- **Algae:** Algae are plant-like organisms that are found in water and soil. They are not as common as bacteria, viruses, or protozoa in food, but they can cause foodborne illnesses, such as algal bloom poisoning.
- **Fungi:** Fungi are eukaryotic organisms that are more complex than bacteria. They can be either beneficial or harmful. Some fungi, such as yeast, are used in the production of bread, beer, and wine. Other fungi, such as molds, can cause foodborne illnesses, such as mycotoxicosis.
- **Archaea:** Archaea are a type of single-celled organism that is similar to bacteria but with some key differences. They are not as common as bacteria in food, but they can cause foodborne illnesses, such as halophilic archaea poisoning.

✓ **Sources of food microorganisms**

The common sources of food microorganisms include the following:

- **Soil and water:** Microorganisms can be found in soil and water, and they can be transferred to food through direct contact. For example, vegetables grown in contaminated soil can be contaminated with bacteria, viruses, and parasites.

- **Animals:** Animals can harbor microorganisms that can be transferred to food through contact or through fecal contamination. For example, raw meat can be contaminated with bacteria, such as Salmonella and Campylobacter, from the animal's intestines.
- **Food handlers:** Food handlers can contaminate food with microorganisms from their hands, skin, or respiratory secretions. For example, a food handler who is sick with norovirus can contaminate food if they do not wash their hands properly.
- **Equipment and surfaces:** Microorganisms can grow on equipment and surfaces, and they can be transferred to food through contact. For example, a cutting board that has not been properly sanitized can contaminate food with bacteria, such as Salmonella and Listeria.
- **Packaging:** Microorganisms can contaminate food through contact with packaging materials. For example, food packaged in a contaminated container can be contaminated with bacteria, such as Salmonella and Listeria.
- **Insects and rodents:** Insects and rodents can carry microorganisms that can contaminate food. For example, flies can spread bacteria, such as Salmonella and E. coli, to food.
- **Air:** Microorganisms can be found in the air, and they can be transferred to food through aerosolization. For example, a sneeze or cough from a sick person can contaminate food with viruses, such as norovirus and influenza.

Points to Remember

- Microorganisms are classified in variety ways including morphological, Chemical, Genetic, Metabolic, and Cultural Classification.
- Select six main types of microorganisms that can found in food.
- Types of food microorganisms are : Bacteria, Viruses, Protozoa, Algae, Fungi, Archae.
- Select the common sources of food microorganisms found in food.
- Sources of food microorganisms are : Soil and water, Animals, Food handlers, Equipment and surfaces, Packaging, Insects and rodents,air.

Indicative content 3.2: Identification of factors influencing microbial growth in food

Duration: 4 hrs

Theoretical Activity 3.2.1: Identification of factors influencing microbial growth in food

Tasks:

1. You are asked to answer the following question:

   i) Give the factors affecting microbial growth in food

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class

4: Read the **key reading 3.2.1**

Key readings 3.2.1: Identification of factors affecting microbial growth in food

- **Factors affecting microbial growth in food**

Properties inherent to food that affect the growth of microorganisms are known as intrinsic factors, whilst the extrinsic factors are parameters external to food that determine the microbial activities in food.

✓ **Intrinsic factors affecting microbial growth in food**

- **Moisture content:** Water activity (aw) represents the free water available for microbial growth. Most microorganisms require a minimum aw of 0.60 to grow, with some requiring higher levels. Lowering aw, such as through drying or adding solutes, can inhibit microbial growth.
- **pH:** The pH of food is a measure of its acidity or alkalinity. Most microorganisms have a preferred pH range for optimal growth. For instance, bacteria generally prefer neutral pH, while molds thrive in acidic environments. Adjusting the pH can control microbial growth.
- **Osmotic pressure:** Osmotic pressure refers to the pressure exerted by dissolved substances in a solution. High osmotic pressure can draw water out of microorganisms, dehydrating them and inhibiting their growth. Adding solutes, such as sugar or salt, can increase osmotic pressure and control microbial growth.
- **Availability of oxygen (Oxygen requirements**): Microorganisms have different oxygen requirements, with some being aerobic (requiring oxygen) and others anaerobic (not requiring oxygen). Aerobic

microorganisms can grow in the presence of oxygen, while anaerobic microorganisms can grow in the absence of oxygen. Modified atmosphere packaging (MAP) involves replacing air with a mixture of gases to create an environment that favors specific microorganisms

- **Nature of food:** The nutrient profile of a food influences the types and extent of microbial growth. Foods rich in nutrients, such as proteins, carbohydrates, and fats, provide the necessary building blocks for microbial growth. The presence of specific nutrients can also favor the growth of certain microorganisms.
- **Antimicrobial substances:** Some foods naturally contain or are deliberately added with antimicrobial substances that inhibit or kill microorganisms. These include organic acids (e.g., acetic acid in vinegar), essential oils (e.g., cinnamon oil), and enzymes (e.g., lysozyme in egg white).
- **Biological structures:** The physical structure of food can influence microbial growth. Intact tissues, such as the skin of fruits and vegetables, provide a barrier to microbial invasion, while damaged or cut surfaces increase the risk of contamination.

✓ **Extrinsic factors affecting microbial growth in food include:**

- **Temperature:** Controlling storage and processing temperatures can significantly impact microbial growth. Refrigerating or freezing food can slow down microbial growth, while heating food to a high enough temperature can kill most microorganisms.
- **Atmosphere:** The composition of gases surrounding food can affect microbial growth. Modified atmosphere packaging (MAP) involves replacing air with a mixture of gases, such as nitrogen, carbon dioxide, and oxygen, to extend shelf life by reducing microbial growth.
- **Relative humidity:** Relative humidity measures the amount of water vapor in the air. High relative humidity can increase microbial growth, while low relative humidity can inhibit growth.
- **Time:** The longer food is stored, the more time microorganisms have to grow and multiply. Proper storage practices, such as refrigeration or freezing, can slow down microbial growth.
- **Initial microbial load:** The initial number of microorganisms present on food influences the rate of microbial growth. Proper food handling and hygiene practices can reduce the initial microbial load.
- **Interactions among microorganisms:** Different microorganisms can interact with each other in various ways, such as competition, symbiosis, and antagonism. These interactions can influence the overall microbial growth rate and community composition.

Points to Remember

- Select accurate tools and equipment pertaining with physical factors affecting microbial growth in food.
- Physical factors always affecting microbial growth in food are: temperature, Moisture content, Ph, Osmotic pressure, oxygen.
- Nutritional (biochemical) factors are: nature of food, Antimicrobial substances, Biological structure

Indicative content 3.3: Differentiation of Harmful and beneficial microorganisms in food

Duration: 3hrs

Theoretical Activity 3.3.1: Differentiation of Harmful and beneficial microorganisms in food

Tasks:

1: You are asked to explain the types and sources of food microorganisms by answering the following questions:

i. What do you understand by the terms "harmful and beneficial microorganisms"?
ii. What are the functions of beneficial microorganisms?

2: Write the answers to papers / flipchart, blackboard or whiteboard

3: Present the finding / answers to the whole class

4: Read the **key reading 3.3.1**

Key readings 3.3.1.: Differentiation of harmful and beneficial microorganisms in food.

- **Harmful microorganisms**

There are a number of microorganisms that are responsible for food spoilage, diseases and infections. Harmful microorganisms in food can cause foodborne illnesses, which are illnesses that result from the consumption of food contaminated with harmful bacteria, viruses, or parasites. These illnesses can range from mild to severe, and can even lead to death.

Bacteria are the most dangerous of all microorganisms and are responsible for several infectious diseases such as tuberculosis, cholera, diphtheria, etc. Viruses are also responsible for certain fatal diseases such as AIDS, influenza, etc. Fungi are also harmful and can lead to certain skin infections and allergies.

- **Beneficial microorganisms**

Beneficial microorganisms in food are those that provide a positive benefit, such as improving the nutritional value of food, protecting against harmful microorganisms, or enhancing the flavor and texture of food.

Useful microorganisms include bacteria such as Lactobacillus, Streptococcus

thermophiles, fungi and protozoa.

✓ **Uses of beneficial microorganisms**

- **Production of fermented foods:** Beneficial microorganisms are used in the production of a variety of fermented foods, such as yogurt, cheese, sauerkraut, and kimchi. These microorganisms help to preserve the food, improve its flavor and texture, and enhance its nutritional value.
- **Improvement of nutritional value:** Some beneficial microorganisms can produce vitamins and minerals that are essential for human health. For example, Bifidobacteria can produce vitamin K, while some lactic acid bacteria can produce vitamin B12.
- **Protection against harmful microorganisms:** Some beneficial microorganisms can produce substances that inhibit the growth of harmful microorganisms. For example, Lactobacillus produces lactic acid, which can create an acidic environment that is unfavorable for the growth of harmful bacteria.
- **Enhancement of flavor and texture:** Beneficial microorganisms can contribute to the flavor and texture of food. For example, yeast produces carbon dioxide, which gives bread its characteristic light and airy texture. Mold can also contribute to the flavor of cheese, such as blue cheese.
- **Pest control**
- **Bioremediation**
- **Biodegradation**

Points to Remember

- Always select microorganisms according to their roles either beneficial or harmful.
- Beneficial microorganisms are: Fungi, yeast, Bacteria such as Lactobacillus, Streptococcus thermophiles.
- Harmful microorganisms are: E. coli, Salmonella, Staphylococcus aureus, and Mycobacterium tuberculosis., viruses, parasites

Learning outcome 3 end assessment

Theoretical assessment

1. Which is not a source of food microorganisms in the following words?

a) Soil
b) water
c) Animals
d) Time
e) Food handlers
f) Equipment and surfaces
g) Packaging
h) Insects and rodents
i) Air

2. Read the following statements and answer by **True** if it is Right otherwise **False**.

a) Beneficial microorganisms can be used to improve the flavor, texture, and nutritional value of food.
b) Beneficial microorganisms can be used to preserve food and prevent spoilage.
c) Beneficial microorganisms can be used to produce antibiotics and other medicines.
d) Beneficial microorganisms can be used to biodegrade pollutants and clean up the environment.
e) Beneficial microorganisms can be used to produce biofuels.

3. The following terms below are Nutritional (biochemical) factors except:

a) Nature of food
b) Osmotic pressure
c) Antimicrobial substances
d) Biological structures

4. Match the **Column B** containing the factors affecting microbial growth in food with their meanings in the **Column C**. Write the answer in the provided space (**Column A**).

Column A	Column B	Column C
1 = ……	**1.** Water activity (aw)	**A.** The presence of microorganisms that compete with harmful microorganisms for resources
2 = …..	**2.** pH	**B.** Factors that prevent

		microorganisms from reaching food, such as packaging.
3 = …..	**3.** Temperature	**C.** Substances that inhibit or kill microorganisms.
4 = …..	**4.** Oxygen	**D.** The length of time that food is stored at a temperature that allows microbial growth.
5 = …..	**5.** Nutrients	**E.** The presence or absence of oxygen.
6 = …..	**6.** Time	**F.** The availability of nutrients for microbial growth.
7 = ….	**7.**Antimicrobials	**G.** The acidity or alkalinity of food.
		H. The temperature at which food is stored or cooked
		I. The availability of water for microbial growth.

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