RQF LEVEL 5

FOPAP503

FOOD PROCESSING

Analysis of Physicochemical Properties of Food

TRAINEE'S MANUAL

October, 2024

ANALYSIS OF PHYSICOCHEMICAL PROPERTIES OF FOOD

RTB | RWANDA TVET BOARD

KOICA Korea International Cooperation Agency

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ACRONYMS

EDTA: Ethylene diamine tetracetic acid

FOP: Food Processing

GDP: Gross Domestic Product

GMP: Good Manufacturing Practices

KOH: Potassium hydroxide

NaOH: Sodium hydroxide

pH: Potential of hydrogen

PPE: Personal Protective Equipment

RPL: Recognition of Prior Learning

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

SOP: Standard Operating Procedure

TQUM: TVET Quality Management

TVET: Technical and Vocational Education and Training

UV: Ultraviolet

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in Food Processing specifically for the module of **"Analysis of Physicochemical Properties of Food".** 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: FOPAP503 ANALYSIS OF PHYSICOCHEMICAL PROPERTIES OF FOOD

Learning Outcome 1: Prepare sample for physicochemical properties analysis
Learning Outcome 2: Test physical properties of food
Learning Outcome 3: Test chemical properties of food.

Learning Outcome 1: Prepare Sample for Physicochemical Properties Analysis

Indicative contents
1.1 Describing physical properties of food **1.2 Describing chemical properties of food** **1.3 Collecting sample for food analysis** **1.4.Preparing sample for analysis**

Key Competencies for Learning Outcome 1: Prepare samples for physicochemical properties analysis

Knowledge	Skills	Attitudes
• Description of physical properties of food • Description of chemical properties of food • Identification of laboratory reagents • Identification Physicochemical laboratory rules and regulations • Description of sampling methods • Description of Preparation of sample • Description of sources of experimental errors	• Sampling • Preparing sample	• Being responsible when preparing sample • Being careful when taking sample • Being attentive when preparing reagent • Being accurate when preparing sample and reagent

Duration: 10 hrs

Learning outcome 1 objectives:

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

1. Describe adequately the physical properties of the food
2. Describe effectively the chemical properties of the food
3. Describe properly the sampling methods of food
4. Take sample properly according to sampling methods and safety precautions
5. Identify properly physicochemical laboratory rules and regulations
6. Prepare correctly sample according to analytical method
7. Describe properly the sources of experimental errors according to analytical method

Resources

Equipment	**Tools**	**Materials**
• Ice box • Centrifuge • Grinder • Dryer • Desiccator • PPE	• Spatulas • Precision balance • Glass wares	• Food samples • Sample packaging materials • Gloves • Reagents

Indicative content 1.1: Describing physical properties of food

Duration: 2 hrs

Theoretical Activity 1.1.1: Description of physical properties of food

Tasks:

1. You are requested to answer this question:
   I. Basing on your understanding, describe physical properties of food
2. Write the answer on papers, flip chart, Blackboard or white board.
3. Present the findings/answers to the whole class.
4. For more clarification, read the key readings 1.1.1

Key readings 1.1.1.: Description of physical properties of food

Physical properties of food

The following are physical properties of food:

- **Freezing point**

It is temperature at which a substance undergoes a phase change from a liquid state to a solid-state. For example, water freezes at 0°C.

- **Melting point**

It is temperature where a substance can change from its solid state to a liquid state: For example, the melting point of butter is around 32-35°C.

- **Boiling point**

It is the temperature at which a liquid undergoes a phase change and turns into a vapor. For example, Water boils at 100°C at standard atmospheric pressure.

- **Water activity**

It is a measurement of the availability of water for biological reactions. It determines the ability of micro-organisms to grow. If water activity decreases, micro-organisms with the ability to grow will also decrease. Values range from 0 (completely dry) to 1 (pure water). Lower water activity typically inhibits microbial growth.

- **Viscosity**

It is measure of a fluid's resistance to flow. It is resistance of a fluid (liquid or gas) to a change in shape, or movement of neighbouring portions relative to one another. Viscosity denotes opposition to flow. High viscosity means thicker liquids (like honey), while low viscosity means thinner liquids (like water).

- **Heat transfer of solid, semi-solids and liquid foods:**

- ✓ Solid Foods: Heat transfer is typically slower, mainly through conduction.
- ✓ Semi-Solid Foods: Heat transfer involves both conduction and convection.
- ✓ Liquid Foods: Heat transfer is generally faster due to convection currents.

- **Size and thickness**

Thickness is defined as a bulky characteristic of a product as sensed in mouth or by feeling and seeing e.g. during pouring of the product. While The serving size definition refers to a measured amount of food or beverage. The serving size is included on the nutrition facts label found on food and beverage items.

It is important for cooking times and heat distribution. Larger or thicker pieces generally take longer to cook.

- **Density and specific gravity**
  - ✓ **Density:** it is the property of matter represented by a ratio of mass to a unit volume of matter.
  - ✓ **Specific gravity**: it is also called relative density, is a measure of density with respect to the density of pure water.
- **Shape**

  The shape of food products plays a significant role in influencing consumer perceptions and satisfaction.
- **Volume**

  A food's volume is a function of a couple of things: its fiber content and the balance of carbohydrates, protein and fat in the food. High-fiber foods that also contain a large amount of water are considered to be high-volume foods. It is also **t**he amount of space a food occupies. Changes in volume can affect texture and cooking behavior.
- **Colour**

  Consistent and accurate measurements of the colour and visual appearance of food products is extremely important.
- **Porosity**

  Porosity is a measure of the pores or void (i.e. "empty") spaces in a material. The percent of open spaces or voids within a volume of material. The porosity of material describes the material's capacity to hold water. Permeability is a physical property of food and is defined as the rate of water movement through interconnected pores within food material.
- **Deformation**

  A change in shape due to the application of force is known as deformation. Even small forces are known to cause some deformation.
- **Solubility**

Solubility is the ability of a solid, liquid, or gaseous chemical substance (referred to as the solute) to dissolve in solvent (usually a liquid) and form a solution. The ability of a substance to dissolve in a solvent. For example, sugar is soluble in water, while oil is not.

Points to Remember

- Physical properties of food are Freezing point, Melting point, Boiling point, Water activity, Heat transfer, Appearance (color, size, volume, porosity, shape, and deformation), Flavor, Aroma, Taste, Temperature, Density, Viscosity, Texture, and solubility.

Application of learning 1.1

ISHEMA Company Ltd plans to develop a new product derived from fruits and requires a skilled technician to identify and define the physical parameters that will ensure its quality. You are asked to help ISHEMA Company Ltd to describe physical properties of that product.

Indicative content 1.2: Describing chemical properties of food

Duration: 2 hrs

Theoretical Activity 1.2.1: Description of chemical properties of food

Tasks:

1. Answer the following question related to description chemical properties of food Basing on your understanding, describe chemical properties of food.
2. Provide the answers to asked questions by writing them on papers, flip chart, Blackboard or white board.
3. Present the findings/answers to the whole class.
4. For more clarification, read the key readings 1.2.1

Key readings 1.2.1.: Description chemical properties of food

- **Chemical properties of foods**
    - ✓ **Moisture content**: The amount of water in a food product, which affects texture, shelf life, and microbial stability.
    - ✓ **Protein properties**: Includes amino acid composition, solubility, and functionality like gelling and emulsifying.
    - ✓ **Fat/oil properties:** Fats and oils are composed of molecules known as triglycerides, which are esters composed of three fatty acid units linked to glycerol. It Includes fatty acid composition, melting point, oxidation stability, and flavor impact.
    - ✓ **Starch properties**: Includes gelatinization temperature, viscosity, and its role in thickening and texture.
    - ✓ **Sugar properties:** Includes solubility, sweetness, and its role in caramelization and texture. They are the natural building blocks of carbohydrates. The monosaccharides are glucose, fructose, and galactose, as well as the disaccharides sucrose, lactose, and maltose, are the most frequent sugars present in foods. Sugars provide a variety of functions in foods, including sweetness, texture, color, flavor formation, freezing point depression, preservation, and fermentation.
    - ✓ **Fibers Properties:** Includes solubility, viscosity, and its impact on texture and digestive health.
    - ✓ **pH:** The term pH stands for potential hydrogen. It represents the relative basicity or acidity of a substance to other substances based on the

amount of hydrogen present in the solution. Its value ranges from 1 to 14

- ✓ **Acidity**: The concentration of acidic components in a food. It influences taste and preservation**.**
- ✓ **Aroma and flavour compounds:** are the volatile chemical components that enable you to get more enjoyment while eating. For example: esters contribute to fruity flavors.
- ✓ **Pigment compounds:** are the compounds in food that gives them their color. It is Natural colorants in foods, like carotenoids in carrots or anthocyanins in blueberries.
- ✓ **Bioactive compounds:** Bioactive compounds have actions in the body that may promote good health. They are being studied in the prevention of cancer, heart disease, and other diseases. Examples of bioactive compounds include lycopene, resveratrol, lignan, tannins, and indoles.
- ✓ **Classes of foods**
  - By Origin: Plant-based (fruits, vegetables) and animal-based (meat, dairy).
  - By Nutrient Content: Macronutrients (carbohydrates, proteins, fats) and micronutrients (vitamins, minerals).

Points to Remember

- Chemical properties of food are moisture content, protein properties, fat properties, starch properties, sugar properties, fiber's properties, acidity, ph, aroma pigment compound**,** bioactive compounds.

Application of learning 1.2.

ISHEMA Company Ltd plans to develop a new product derived from fruits and requires a skilled technician to identify and define the chemical parameters that will ensure its quality. You are asked to help ISHEMA Company Ltd to describe chemical properties of that product.

Indicative content 1.3: Collecting sample for food analysis

Duration: 3 hrs

Theoretical Activity 1.3.1: Description of sampling methods

Tasks:

1. Answer the following question related to description of sampling
   i. Define the following terms:
      a. Sample
      b. Sampling protocol
      c. Characteristic
      d. Homogeneity
      e. Sampling error
      f. Batch
      g. Unit
   ii. Give the purpose of sampling
   iii. Outline the major sources of variability in nutrients composition
   iv. Identify the physicochemical laboratory safety and regulations
   v. Explain the following sampling methods
      a. Probability sampling
      b. Non-probability sampling
2. Provide the answers to asked questions by writing them on papers, flip chart, Blackboard or white board.
3. Present the findings/answers to the whole class.
4. For more clarification, read the key readings 1.3.1

Key readings 1.3.1: Description of sampling methods

Introduction to sampling

Food sampling is a process of drawing a sample/ a small portion of food which is a representative of a population/lot of a food for testing, analysing, intended to show the nature and quality of the whole specimen.

1. Purpose of Sampling

Sampling is crucial in food analysis for several reasons:

- **Representativeness**: To obtain a sample that accurately reflects the characteristics of the entire batch or lot.
- **Quality Control**: To assess the quality, safety, and compliance of food products.
- **Nutritional Analysis**: To determine the nutrient content and ensure it meets labelling and regulatory standards.
- **Detection of Contaminants**: To identify any contaminants or adulterants present in the food product.

2. **Definition of Basic Terms**

2.1. Sample

A portion or subset of a larger quantity of food that is selected for analysis. The sample should be representative of the whole batch or lot to ensure accurate results. For example, a few randomly chosen cans from a production line.

2.2. Sampling Protocol

The set of procedures and guidelines followed during the sampling process to ensure that the sample is representative and the analysis is accurate. It includes the methods of collection, handling, and storage of samples. For instance, a protocol may specify how many samples to take, how to collect them, and how to store them before analysis.

2.3. Characteristic

An attribute or property of the food that is being studied, such as color, texture, flavor, or nutrient content. Characteristics help in evaluating the quality and suitability of the food product.

The key characteristics of a sample are:

2.3.1. **Representativeness**: The sample should be representative of the larger population from which it is drawn, so that the findings can be generalized to the broader population.

2.3.2. **Random Selection:** Samples are typically selected randomly, using techniques like random sampling or probability sampling, to ensure each member of the population has an equal chance of being included.

2.3.3. **Sample Size:** The size of the sample is important, as it affects the reliability and precision of the research findings. Larger samples generally provide more accurate and generalizable results.

2.3.4. **Diversity:** A diverse sample that reflects the heterogeneity of the population can help ensure the findings are applicable to different subgroups within the population.

2.3.5. **Accessibility:** The sample should be accessible and available for data collection, without significant barriers or biases in the selection process.

2.3.6. **Independence:** The units or individuals within the sample should be independent of one another, so that the data collected from each unit can be considered statistically independent.

Overall, the characteristics of a good sample are critical for ensuring the validity and generalizability of the research findings to the broader population of interest.

2.4. **Homogeneity**: The degree to which the sample is uniform in composition and properties. Homogeneity is important to ensure that the sample accurately represents the entire batch or lot. For example, a homogenous sample of flour should have consistent particle size and composition throughout.

2.5. **Sampling Error**: A sampling error is a statistical error that occurs when an analyst does not select a sample that represents the entire population of data. As a result, the results found in the sample do not represent the results that would be obtained from the entire population. Sampling error can arise due to improper sampling techniques, unrepresentative samples, or variability within the batch. Reducing sampling error involves following rigorous sampling protocols and ensuring proper sample handling.

2.6. **Batch**: is a method of manufacturing where the products are made as specified groups or amounts, within a time frame. A specific quantity of food produced during a single production cycle or process, often treated as a unit for quality control. For example, a batch of yogurt might be produced in a single day and stored together.

2.7. **Unit:** the members of the population from which measurements are taken during sampling. The smallest indivisible portion of the batch that is sampled. For instance, in a batch of cereal, individual boxes or bags might be considered units. The choice of unit affects how samples are taken and analyzed.

3. Major Sources of Variability in Nutrient Composition

Understanding sources of variability in nutrient composition is crucial for accurate food analysis. Here are key factors that can affect nutrient levels:

3.1. Geographical factors

Impact: The location where food is grown or produced can influence its nutrient composition due to variations in soil, climate, and agricultural practices.

Example: Tomatoes grown in different regions may have different levels of lycopene and vitamin C due to soil composition and climate conditions.

3.2. Seasonal factors

Impact: Nutrient levels can vary with the season due to changes in weather, temperature, and daylight, which affect plant growth and development.

Example: Fruits and vegetables might have higher sugar content in the summer compared to winter due to increased photosynthesis and warmer temperatures.

3.3. Physiological State and Maturity

Impact: The stage of growth or ripeness of the food can significantly affect its nutrient levels. Nutrients can increase or decrease as the food matures.

Example: Bananas have higher levels of starch when unripe and convert to sugars as they ripen.

3.4. Cultivars and Breeds

Impact: Different varieties or breeds of the same food item can have varying nutrient compositions due to genetic differences.

Example: Different cultivars of apples may vary in their levels of antioxidants, such as quercetin and vitamin C.

4. Description of Physicochemical Laboratory Safety and Regulations

4.1. Personal Protective Equipment (PPE)

- **Includes**: Lab coats, gloves, safety goggles, and masks.
- **Purpose**: To protect against chemical spills, splashes, and other hazards.

4.2. Handling and Storage

- **Chemicals**: Store chemicals according to safety data sheets (SDS) and regulations, using appropriate containers and labeling.
- **Samples**: Properly label and store samples to prevent contamination and degradation.

4.3. Waste Disposal

Regulations: Follow local regulations for disposing of hazardous and non-hazardous waste. Use designated containers for different types of waste.

4.4. Equipment Maintenance

Protocols: Regularly calibrate and maintain laboratory equipment to ensure accurate results. Follow manufacturer guidelines for use and maintenance.

4.5. Emergency Procedures

Includes: Knowledge of emergency exits, first aid procedures, and spill containment methods. Ensure that emergency contact numbers and safety equipment are accessible.

4.6. Training and Compliance

Requirements: Ensure that all laboratory personnel are trained in safety protocols and comply with relevant regulations and standards.

5. Tools and Equipment for Collecting Samples for Physicochemical Analysis

5.1.Sampling Tools

- Sterile containers (glass/plastic bottles, bags)
- Spatulas, scoops, spoons (stainless steel or inert material)
- Pipettes, syringes (for liquids)
- Funnels, tweezers, and forceps

5.2. Specialized Sampling Equipment

- Core samplers (for solid/semi-solid food)
- Grain probes (for bulk dry materials)
- Liquid samplers (for large containers)
- Thief and vacuum samplers (for powders, liquids, and slurries)

5.3. Storage and Preservation

- Coolers, insulated boxes, ice packs
- Vacuum-sealed bags, desiccators
- Amber bottles (for light-sensitive samples)

5.4. Safety and Hygiene

- Disposable gloves, masks, lab coats
- Disinfectants (for tool sterilization)

5.5. Documentation and Identification

- Sampling forms, waterproof labels
- Temperature loggers (for temperature monitoring)

6. Sampling Methods

6.1. Probability Sampling

Probability sampling deals with the selection of a representative sample from a population based on chance with the elimination of human bias. The probability of including any item in the sample is known and sampling error can be calculated.

The following are the most common probability sampling techniques

6.1.1. Simple Random Sampling

Every unit in the population has an equal chance of being selected.

Example: Drawing names from a hat to select a sample of products from a batch.

6.1.2. Cluster Sampling

The population is divided into clusters, and a random sample of clusters is selected. All or a subset of units within chosen clusters are then sampled.

Example: Selecting random farms (clusters) and then sampling all crops from those farms.

6.1.3. Systematic Sampling

Selecting units at regular intervals from a list or sequence.

Example: Every 10th can from a production line is selected for testing.

6.1.4. Multistage Sampling

A combination of sampling methods used in stages. It often involves selecting clusters and then performing random sampling within those clusters.

Example: First sampling different regions, then selecting specific farms within those regions, and finally sampling specific products from those farms.

6.1.5. Judgmental Sampling

Samples are chosen based on the judgment or expertise of the sampler, often to focus on specific aspects or high-risk areas.

Example: Selecting samples from areas of a production line that are known to be problematic.

6.2. Non-Probability Sampling

Non-probability sampling is a method in which not all population members have an equal chance of participating in the study, unlike probability sampling

6.2.1. Convenience Sampling

It is non probability sampling which samples are taken from the easiest or most accessible sources.

Example: Sampling food products from the most readily available store shelves without regard to representativeness.

6.2.2. Purposive Sampling

It is non probability sampling which samples are selected based on specific characteristics or purposes.

Example: Sampling only organic foods to assess nutrient content in organic versus conventional products.

6.2.3. Quota Sampling

It is non probability sampling which sample is selected to meet certain quotas or proportions of characteristics.

Example: Ensuring that the sample includes a certain percentage of different types of foods, such as fruits, vegetables, and grains.

Practical Activity 1.3.2: Applying Sampling methods

Task:

1. Referring to Key reading 1.3.2, you are requested to go in food chemistry laboratory to take food sample for analyze of physicochemical properties.
2. Apply safety precautions.
3. Take food sample to analyze physicochemical properties of food.
4. Present your work to the trainer and whole class. Ask clarification where necessary
5. Perform the task provided in application of learning 1.3

Key readings 1.3.2 Application of sampling methods

1. Practical Considerations for Sampling

- **Sample Size**: Ensure that the sample size is adequate to represent the whole batch accurately and to meet the analytical requirements.
- **Sample Collection**: Use clean and appropriate tools to avoid contamination. Follow the sampling protocol strictly.
- **Storage and Transport**: Properly store and transport samples to maintain their integrity until analysis. For example, some samples may need to be kept at specific temperatures.

  Examples

  ✓ **Sampling for Microbial Analysis**: If you're analyzing a batch of cheese for microbial contamination, the sampling protocol might involve taking several samples from different parts of the batch and mixing them to ensure a representative sample.

  ✓ **Nutritional Analysis**: For analyzing the nutrient content of a batch of cereal, individual boxes may be sampled to ensure the results reflect the entire production run.

2. General Stages of sampling

a. **Define the Population**: Clearly identify the entire group you want to study. This population should be well-defined and relevant to your research question.

b. **Determine the Sampling Frame**: Develop a list or other representation of the population from which the sample will be drawn. This frame should ideally include every member of the population to ensure accuracy.
c. **Choose the Sampling Method**: Decide on the sampling technique based on the research goals, population characteristics, and resources available. Common methods include:
d. **Determine Sample Size**: Decide how many individuals or units will be included in the sample. The sample size should be large enough to provide reliable estimates but manageable within the constraints of time and resources.
e. **Collect the Sample**: Implement the chosen sampling method to gather the sample from the sampling frame. Ensure that the process is consistent and minimizes any potential biases.
f. **Analyze the Sample**: Use appropriate statistical techniques to analyze the sample data. This involves checking for accuracy, reliability, and validity of the results.
g. **Draw Conclusions and Make Inferences**: Based on the analysis, draw conclusions about the population. Make sure to consider the potential margin of error and how representative the sample
h. **Report Findings**: Present the results of the analysis, including methodology, sample size, and any limitations of the study. Transparency about the sampling process and potential biases helps ensure the credibility of the findings

Points to Remember

- Food sampling is a process of drawing a sample/ a small portion of food which is a representative of a population/lot of a food for testing, analysing, intended to show the nature and quality of the whole specimen.
- Purpose of sampling is: Representativeness, quality control, nutritional analysis and detection of contaminants
- Sampling Methods are probability sampling and non-probability sampling.
- General Stages of sampling are: define the Population, determine the sampling frame, determine sample size, collect the sample, analyze the sample, draw conclusions and make inferences and report findings.

Application of learning 1.3

You are asked to go in Food chemistry laboratory and you are requested to take food sample for analysis of physicochemical properties of food.

Indicative content 1.4: Preparing sample for physicochemical food analysis

Duration: 3 hrs

Practical Activity 1.4.1: Preparing food sample for analysis

Task:

1. Referring to Key reading 1.4.1, you are requested to go to food chemistry laboratory to prepare food sample to use while analysing physicochemical properties.
2. Apply safety precautions.
3. Prepare food sample for analyse of physicochemical properties
4. Present your work to the trainer and whole class. Ask clarification where necessary
5. Perform the task provided in application of learning 1.4

Key readings 1.4.1. Preparing food sample for analysis

- **Sample preparation**

Sample preparation is a critical step in ensuring accurate and reliable results in food analysis. Here's a detailed overview:

1. **Purpose of Sample Preparation**
    a. **Consistency**: To ensure that the sample is representative and consistent, allowing for accurate analysis.
    b. **Suitability**: To make the sample suitable for the specific analytical methods being used.
    c. **Accuracy**: To eliminate or minimize factors that could interfere with the analysis, ensuring the results are accurate and reliable.
2. **Pre-Treatment of Sample for Analysis**

    2.1.Cleaning of the Sample

    - **Purpose**: To remove any surface contaminants, debris, or residues that could affect the analysis.
    - **Methods**: Washing with appropriate solvents or water, using brushes or other cleaning tools as necessary.

    2.2.Homogenization

    - **Purpose**: To achieve uniformity in the sample, ensuring that all portions of the sample have the same composition.

- **Methods**: Grinding, blending, or mixing. For instance, a food sample might be blended to create a uniform mixture before analysis.

2.3. Dilution, Evaporation, Liquid-Liquid Extraction for Liquid Samples

- **Dilution**: Reducing the concentration of the sample to bring it within the range of the analytical method.
  - ✓ **Example**: Diluting a juice sample to measure specific nutrient concentrations.
- **Evaporation**: Removing solvents to concentrate the sample or prepare it for further analysis.
  - ✓ Evaporating water from a food extract to concentrate the solutes.
- **Liquid-Liquid Extraction**: Separating compounds based on their solubility in different liquids.
  - ✓ **Example**: Using organic solvents to extract fats from a food sample.

2. **Prevention of Changes in Sample**

2.1. Enzymatic Inactivation

- **Purpose**: To prevent enzymatic activity that could alter the sample's composition.
- **Methods**:

1. **Freezing**: Quickly freezing samples to halt enzyme activity.
2. **Drying**: Removing moisture to prevent microbial and enzymatic activity.
3. **Heat Treatment**: Applying heat to deactivate enzymes.
4. **Chemical Preservatives**: Adding preservatives that inhibit enzyme activity.

2.2 Chemical (Lipid Protection)

- **Purpose**: To prevent chemical changes such as oxidation.
- **Methods**:

1. **Storage under Nitrogen or Inert Gas**: Reducing oxygen exposure to prevent oxidation.
2. **Dark Rooms and Covered Bottles**: Protecting samples from light that can induce chemical changes.
3. **Refrigerated Temperatures**: Slowing down chemical reactions by lowering temperature.
4. **Addition of Antioxidants**: Adding substances that prevent oxidation of lipids and other components.

2.3 Microbial Growth and Contamination

- **Purpose**: To prevent microbial activity that can alter the sample.
- **Methods**:

1. **Freezing**: Halting microbial growth by lowering temperatures.
2. **Drying**: Removing moisture to inhibit microbial growth.

3. **Heat Treatment**: Using heat to kill microbes.
4. **Chemical Preservatives**: Adding preservatives that inhibit microbial growth.

2.4 Physical Changes

- **Purpose**: To prevent changes due to physical factors like temperature.

2.4.1 Controlling Temperature:

Keeping the sample at stable temperatures to avoid physical changes such as melting or crystallization.

3 Sample Identification

3.3 Product Name

Clearly label the sample with the name of the product being analyzed.

3.4 Time of Sampling

Record the exact time when the sample was taken to track any time-related changes or factors.

3.5 Location Sample Was Taken From

Document the specific location to ensure traceability and account for location-related variability.

3.6 Person Who Took the Sample

Note the name or identifier of the person who collected the sample to ensure accountability and for potential follow-up.

4 Description of Sources of Experimental Error

4.3 Personal Errors (Blunders)

- **Definition**: Mistakes made by individuals due to oversight or lack of attention.
- ✓ **Examples**: Misreading measurements, incorrect sample handling, or data entry errors.

4.4 Random Errors

- **Definition**: Variations in results due to unpredictable factors that are inherent in any measurement process.
- ✓ **Examples**: Variability in sample composition, fluctuations in measurement instruments, or slight differences in environmental conditions.

4.5 Systematic Errors

- **Definition**: Consistent, repeatable errors that occur due to flaws in the measurement system or method.
- ✓ **Examples**: Calibration issues with equipment, methodological flaws, or consistent bias in measurement techniques.

Points to Remember

- Sample preparation is a critical step in ensuring accurate and reliable results in food analysis. Its purpose includes ensuring consistency, suitability, and accuracy
- Pre-treatment of sample for analysis involves cleaning of the sample, homogenization, dilution, evaporation, liquid-liquid extraction for liquid samples
- Prevention of changes in sample involves, enzymatic inactivation, chemical (lipid protection), microbial growth and contamination, and physical changes
- Sample identification considers product name, time of sampling, location sample was taken from, and person who took the sample
- Experimental error includes personal errors (blunders), random errors, systematic errors

Application of learning 1.4

You are asked to go in food chemistry laboratory and you are requested to prepare food sample for analysis of physicochemical properties of food.

Learning outcome 1 end assessment

Theoretical assessment

I. Circle the letter corresponding to the right answer

1. The melting point of substance should be defined as:
   A. The temperature at which a substance turns from a solid to a liquid.
   B. The temperature at which a substance turns from a liquid to a solid.
   C. The temperature at which a liquid turns into vapor.
   D. The measurement of water availability for biological reactions.
2. Water activities in food products is:
   A. The temperature at which a substance boils.
   B. The availability of water for biological reactions and microbial growth.
   C. The resistance of a fluid to flow.
   D. The ratio of mass to unit volume of matter.
3. Viscosity of food should define as:
   A. The temperature at which a liquid boils.
   B. The density of a substance relative to water.
   C. The resistance of a fluid to flow or change shape.
   D. The amount of water present in a substance.
4. Method of heat transfer within solid food is**:**
   A. Convection
   B. Radiation
   C. Conduction
   D. Evaporation
5. Specific gravity defined as:
   A. The property of matter represented by a ratio of mass to unit volume.
   B. The measurement of the amount of water available for microbial growth.
   C. The ratio of the density of a substance to the density of pure water.
   D. The resistance of a liquid to flow.
6. Sampling method involves dividing the population into subgroups and then randomly sampling from each subgroup is:
   A. Simple Random Sampling
   B. Systematic Sampling
   C. Stratified Sampling
   D. Cluster Sampling
7. Food proteins is defined as:
   A. Proteins are primarily important for energy storage in cells.
   B. Proteins are crucial for biological functions and cell structure.
   C. Proteins are mainly composed of triglycerides.
   D. Proteins are primarily used for thickening agents in food.
8. The purpose of sample preparation in food analysis is:
   A. To change the food's color for better analysis.
   B. To ensure the sample is representative of the defined whole and compatible with instrumental analysis.
   C. To increase the water activity of the sample.

D. To reduce the viscosity of the sample.

9. Role bioactive compound is:
    A. ability to dissolve in solvents.
    B. Promoting good health and disease prevention.
    C. Their impact on the freezing point of foods.
    D. Ability to change the texture of food.

Practical assessment

IGISUBIZO Company exports different food products including juices and pastries products, the company requires to take sample for analysing physicochemical properties of those food. The production manager of the company requests you to assist in taking sample for further analysis. This task must be completed within 1 hour.

END

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Learning Outcome 2: Test Physical Properties of Food

Indicative contents
2.1 Testing organoleptic properties of food
2.2 Testing rheological properties of food
2.3 Measuring density in food
2.4. Measuring temperature in food

Key Competencies for Learning Outcome 2: Test physical properties of food

Knowledge	Skills	Attitudes
• Description of food organoleptic properties testing methods • Description of food rheology testing technique • Description of food density measuring methods • Description of food temperature measuring methods	• Applying food organoleptic properties testing methods • Applying Rheometry techniques • Applying food gravimetric density measuring techniques • Applying temperature measuring methods in food	• Being responsible in food organoleptic properties testing methods • Being careful when measuring temperature in food • Having team working spirit when measuring density in food.

Duration:30hrs

Learning outcome 2 objectives:

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

1. Describe clearly food organoleptic properties testing methods of food products
2. Apply effectively food organoleptic properties testing methods in food products
3. Describe correctly food rheology testing technique of food products
4. Apply effectively Rheometry technique in food products
5. Describe clearly food density measuring methods of foods products
6. Apply exactly food gravimetric density measuring techniques as required
7. Describe correctly food temperature measuring methods of food products
8. Apply exactly temperature measuring methods in food products

Resources

Equipment	**Tools**	**Materials**
• Rotational rheometer • Capillary rheometer • Oscillator rheometer	• Thermometers • Pycnometer • Glassware	• Hedonic Scorecard • Papers • Different food samples

Indicative content 2.1: Testing organoleptic properties of food

Duration: 6hrs

Theoretical Activity 2.1.1: Description of food organoleptic properties testing methods

Tasks:

1. Answer the following questions related to food rheology testing technique
   a) What is the purpose of testing organoleptic properties of food?
   b) Describe food organoleptic properties testing methods?
2. Provide the answers to asked questions by writing them on papers, flip chart, Blackboard or white board.
3. Present your findings/answers to the whole class
4. Ask for clarification if any
5. For more clarification, read the key readings 2.1.1

Key readings 2.1.1.: Description of food organoleptic properties testing methods

Food organoleptic testing

Organoleptic evaluation of food involves a scientific approach to assess the product's sensory attributes across the senses: taste, smell, sight, and touch.

1. Purpose of testing organoleptic properties of food

Organoleptic testing is a critical process in the food industry that evaluates the sensory characteristics of food products. This type of testing focuses on how consumers perceive food through their senses, including taste, smell, sight, and touch.

The primary purpose of organoleptic testing is to ensure that food products meet quality standards and consumer expectations includes ensuring quality assurance and control, aligning with consumer preferences, facilitating product development and innovation, determining shelf life effectively, and maintaining regulatory compliance within the industry.

2. Description of food organoleptic properties testing methods

Organoleptic testing methods are essential for evaluating the sensory characteristics of food products. These methods can be broadly categorized into qualitative and quantitative methods, each serving distinct purposes in assessing how food is perceived by consumers through their senses: taste, smell, sight, touch, and sound.

2.1 Qualitative Method

Qualitative method focus on understanding the sensory attributes of food without necessarily quantifying them. These methods often involve subjective assessments based on personal perceptions and experiences.

- **Paired comparison**

The paired comparison test is a qualitative sensory evaluation method used in food laboratories to determine preferences or differences between two food products based on specific attributes. This method is particularly useful when the goal is to assess which of two samples has a more pronounced characteristic, such as sweetness, saltiness, or overall preference.

2.2 Quantitative Methods

In food laboratories, quantitative methods are essential for evaluating and analyzing food products. These methods provide objective data that can be used to make informed decisions regarding product quality, consumer preferences, and marketability. Below is a detailed examination of four key quantitative methods: Descriptive Analysis, Hedonic Testing, Ranking Testing, and Triangle Testing.

- **Descriptive Analysis**

Descriptive analysis is a systematic approach used to describe the sensory characteristics of food products. This method involves trained panels who evaluate various attributes such as flavor, aroma, texture, and appearance. Descriptive analysis provides detailed insights into how a product is perceived by consumers and helps in product development and quality control.

- **Hedonic Testing**

Hedonic testing focuses on measuring consumer preferences and acceptability of food products. This method assesses how much consumers like or dislike a product based on their personal preferences. Hedonic testing is crucial for understanding consumer behavior and guiding marketing strategies.

- **Ranking Testing**

Ranking testing involves asking participants to rank multiple samples based on specific criteria (e.g., sweetness, overall preference). This method provides comparative data that can highlight differences among products. Ranking tests help identify which products stand out in terms of specific qualities or overall preference without requiring extensive descriptive data.

- **Triangle Test**

The triangle test is a discrimination test used to determine whether there are perceptible differences between two products. It involves presenting three samples, two identical and one different, to participants who must identify the odd sample out.Triangle tests are particularly useful in quality control processes where subtle changes in formulations need assessment.

Practical Activity 2.1.2: Applying food organoleptic properties testing methods

Task:

1. Referring to Key reading 2.1.2, go in food chemistry laboratory and apply food organoleptic properties testing methods (qualitative and quantitative methods).
2. Apply safety precautions (wear PPE).
3. Apply food organoleptic properties testing methods (qualitative and quantitative methods).
4. Present your work to the trainer and whole class. Ask for clarification where necessary
5. Perform the task provided in application of learning 2.1

Key readings 2.1.2. Application of food organoleptic properties testing methods

Food organoleptic testing methods

The food organoleptic testing methods are qualitative and quantitative methods Qualitative method identifies the presence or absence of a particular substance in a sample while quantitative method measures the amount or concentration of a substance in a sample.

1. Qualitative Method

Qualitative methods in organoleptic testing focus on understanding the sensory attributes of food through descriptive analysis rather than numerical scoring. These methods are essential for capturing the nuances of flavor, aroma, texture, and appearance that quantitative measures may overlook. The goal is to gather detailed insights into how consumers perceive food products, which can inform product development and quality control.

The procedures of qualitative method are:

1.1 Define Objectives and Parameters

Before conducting qualitative tests, it is crucial to define the objectives clearly. Determine what specific organoleptic properties you wish to evaluate, these could include taste (sweetness, bitterness), aroma (fruity, floral), texture (crunchy, creamy), and visual appeal (color, presentation). Establishing clear parameters will guide the testing process and ensure focused evaluations.

1.2 Select a Panel of Evaluators

Choosing the right panellists is vital for qualitative testing. Ideally, select individuals who have experience or training in sensory evaluation or those who represent your target consumer demographic. A diverse panel can provide a broader range of perceptions and insights. Typically, a group of 8-12 trained evaluators is sufficient for qualitative assessments.

1.3 Prepare Samples

Prepare food samples under controlled conditions to minimize variability. Ensure that all samples are presented uniformly regarding size, temperature, and serving method. Randomize sample presentation order to avoid bias from previous samples influencing evaluators' perceptions.

1.4 Conduct Sensory Evaluation Sessions

Organize sensory evaluation sessions where panellists can assess the food samples in a distraction-free environment. During these sessions:

- **Descriptive Analysis**: Encourage panellists to describe their sensory experiences using specific terms related to taste, aroma, texture, and appearance. This can be facilitated through guided discussions or individual evaluations.
- **Focus Groups:** Conduct focus group discussions where participants share their impressions openly. This allows for deeper exploration of preferences and aversions.
- **Free Choice Profiling:** Allow panellists to create their own descriptors based on their experiences with the samples without predefined categories.

1.5 Record Observations

Document all observations meticulously during the evaluation sessions. Use audio recordings or written notes to capture panellists' comments about each sample's sensory attributes. This qualitative data will serve as valuable feedback for product development.

1.6 Analyze Data

After collecting qualitative data, analyze it by identifying common themes and patterns in the responses. Look for frequently mentioned descriptors or sentiments that indicate overall preferences or concerns regarding specific attributes of the food products.

1.7 Report Findings

Compile a comprehensive report summarizing the findings from your qualitative analysis. Include direct quotes from panelists that illustrate key points about sensory perceptions. This report should provide actionable insights for product improvement or marketing strategies based on consumer preferences.

2. Quantitative Methods

Quantitative methods in organoleptic testing involve the systematic measurement of sensory attributes of food products. These methods provide numerical data that can be statistically analyzed, allowing for objective comparisons and evaluations. The goal is to quantify sensory characteristics such as taste, aroma, texture, and appearance, enabling manufacturers to make informed decisions based on consumer preferences and product quality.

The procedures of quantitative method are:

2.1 Define Sensory Attributes

Before conducting any tests, it is essential to define the specific sensory attributes that will be measured. Common attributes include:

- **Appearance:** Color, clarity, and overall visual appeal.
- **Aroma:** Intensity and quality of smell.
- **Taste:** Sweetness, bitterness, sourness, saltiness, and umami.
- **Texture:** Mouthfeel characteristics such as crunchiness or creaminess.
- **Aftertaste:** Persistence of flavors after swallowing.

Clearly defining these attributes helps establish a framework for testing.

2.2 Select a Suitable Quantitative Method

Several quantitative methods can be employed in organoleptic testing. Some commonly used methods include:

- **Descriptive Analysis**: Trained panels evaluate specific attributes using standardized scales (e.g., intensity scales from 0 to 10). This method provides detailed profiles of sensory characteristics.
- **Hedonic Scaling**: Consumers rate their liking or preference for a product on a scale (e.g., 1 to 9), where higher scores indicate greater preference. This method is useful for understanding consumer acceptance.
- **Triangle Tests:** In this method, participants are presented with three samples—two identical and one different—and asked to identify the odd sample. This test quantifies differences between products.
- **Paired Comparison Tests**: Participants compare two samples directly and indicate which one they prefer or which has a stronger attribute. This method provides clear comparative data.

2.3 Recruit Panelists

For quantitative testing, it is crucial to recruit appropriate panelists. Depending on the method chosen:

- For descriptive analysis or triangle tests, trained panelists with experience in sensory evaluation should be selected.
- For hedonic scaling or paired comparison tests, a diverse group of untrained consumers can provide insights into general preferences.

Panellist selection should consider factors such as demographics and familiarity with the product category being tested.

2.4 Prepare Samples

Samples must be prepared consistently to ensure valid results. Key considerations include:

- Use identical serving sizes for each sample.
- Control environmental factors (lighting, temperature) during testing.
- Randomize sample presentation order to minimize bias.
- Proper preparation ensures that any differences observed are due solely to sensory properties rather than extraneous variables.

2.5 Conduct the Testing

During the testing session:

- Provide panelists with clear instructions regarding how to evaluate each attribute based on the chosen method.
- Ensure that panelists have access to water or neutral palate cleansers between samples if necessary.

- Collect data systematically using forms or digital tools designed for sensory evaluation.
- Data collection should be organized so that results can easily be analyzed later.

2.6 Analyze Data

Once data is collected:

- Use statistical software (e.g., SPSS, R) to analyze results quantitatively.
- For descriptive analysis, calculate means and standard deviations for each attribute evaluated by trained panelists.
- For hedonic scaling data, determine average liking scores and conduct statistical tests (e.g., ANOVA) to assess significant differences among products.
- For triangle tests or paired comparisons, use chi-square tests or similar statistical analyses to determine whether there are significant preferences among samples.

2.7 Interpret Results

Interpreting results involves understanding what the numerical data indicates about consumer preferences and product quality:

- Identify which attributes scored highest or lowest across samples.
- Determine if there are significant differences between products based on statistical analysis.
- Make recommendations for product adjustments based on findings (e.g., reformulating recipes).

Points to Remember

- The primary purpose of organoleptic testing is to ensure food products meet quality standards and consumer expectations.
- Organoleptic evaluation of food is a scientific approach to assess the product's sensory attributes across the senses: taste, smell, sight, and touch.
- Organoleptic testing methods are qualitative and quantitative
- Qualitative method used is paired comparison while quantitative methods include descriptive analysis, hedonic testing, ranking testing, and triangle test.

Application of learning 2.1.

You are asked to go in food laboratory, and perform food organoleptic properties testing methods.

Indicative content 2.2: Testing rheological properties of food

Duration: 8hrs

Theoretical Activity 2.2.1: Description of food rheology testing technique

Tasks:

1. Answer the following questions related to food rheology testing technique
    a) What is the purpose of food rheology testing technique?
    b) What is rheometry? Explain the types of rheometers?
2. Provide the answers to asked questions by writing them on papers, flip chart, Blackboard or white board.
3. Present your findings/answers to the whole class
4. For more clarification, read the key readings 2.2.1

Key readings 2.2.1.: Description of food rheology testing technique

1. Introduction to rheology

Testing the rheological properties of food is vital for ensuring that products meet consumer expectations regarding texture and flow behavior while also facilitating efficient production processes.

Rheology is a branch of physics that studies the flow and deformation of materials, particularly focusing on how substances respond to applied forces. In the context of food science, understanding the rheological properties of food is crucial for predicting how these materials will behave during processing, storage, and consumption. Rheometry is the technique used to measure these properties, providing insights into viscosity, elasticity, and flow behavior.

2. Purpose of food rheology testing

Food rheology testing involves the use of various techniques to measure the flow, deformation, and texture properties of food materials. The goal is to quantify how food behaves under different physical conditions, such as during processing, storage, or consumption. Rheological properties such as viscosity, elasticity, and plasticity are crucial for determining texture, mouthfeel, stability, and consistency in food products.

3. Food rheology testing technique

The technique used in testing food rheology is rheometry.

3.1. How Rheometers Work

A rheometer is an instrument specifically designed to measure the rheological properties of materials by applying controlled stress or strain and measuring the resulting deformation. The fundamental parameters measured include:

- **Stress**: The force applied per unit area.
- **Strain:** The deformation resulting from applied stress.
- **Shear Rate:** The rate at which adjacent layers of fluid move with respect to each other.

Rheometers can operate in various modes, including rotational (shear) mode and oscillatory mode. In rotational mode, the sample is subjected to continuous shear stress, while in oscillatory mode, a sinusoidal strain is applied to assess viscoelastic behavior.

3.2.Types of Rheometers

There are several types of rheometers used in food testing:

- **Rotational Rheometer**: This type measures viscosity by rotating one part against another while the sample is held between them. It can be operated in either rate-controlled or stress-controlled modes.
- **Capillary Rheometer:** This simpler form measures viscosity by forcing a fluid through a capillary tube and timing how long it takes specific volume to pass through.
- **Dynamic Shear Rheometer**: This instrument applies sinusoidal loading to determine viscoelastic properties without damaging the material.

Practical Activity 2.1.2 Applying Rheometry Technique

Task:

1. Referring to Key reading 2.2.2, go in food chemistry laboratory and apply rheometry technique
2. Apply safety precautions (wear PPE).
3. Apply rheometry technique
4. Present your work to the trainer and whole class. Ask for clarification where necessary
5. Perform the task provided in application of learning 2.2

Key readings 2.2.2. Application of Rheometry

1. Introduction to Rheometry technique

Rheometry is the experimental technique used to measure the rheological properties of materials, particularly their flow and deformation behavior under various forces. It focuses on how materials respond to stress, strain, or shear, providing insights into their viscosity, elasticity, and other mechanical properties.

2. Application of Rheometry

2.1 Prepare the Sample

- **Select the Material**: Rheometry can be applied to a wide range of materials like liquids, gels, doughs, creams, and polymers.
- **Conditioning the Sample**: Depending on the material, conditioning might include temperature control (e.g., heating or cooling), mixing, or resting the sample to ensure it is ready for testing.
- **Measure the Right Quantity**: Different rheometers require specific sample sizes, typically small for rotational or oscillatory rheometers.

2.2 Choose the Right Rheometer

- **Rotational Rheometers**: Measure flow properties like viscosity and shear stress by rotating a tool (like a cone or plate) in contact with the sample.
- **Oscillatory Rheometers**: Apply oscillating stresses or strains to measure viscoelastic properties, useful for solid-like behavior in materials like gels or doughs.
- **Capillary Rheometers**: Measure the flow behavior of high-viscosity materials (e.g., molten polymers) by forcing the sample through a narrow capillary.

2.3 Set Up the Rheometer

- **Select the Measuring Geometry**: Depending on the rheometer type, choose the appropriate geometry (cone-plate, parallel plate, or concentric cylinder) for the test:
- **Cone-Plate**: For measuring low-viscosity liquids.
- **Parallel Plate**: For viscous liquids, pastes, or gels.
- **Concentric Cylinder**: For liquids that may be prone to slipping, like oils.
- **Adjust the Shear Rate/Stress:** Depending on the experiment, the shear rate or stress can be set to mimic real-life conditions, such as stirring, pumping, or spreading.

2.4 Define Test Parameters

- **Shear Rate/Strain Rate**: Set how quickly the sample will be deformed (important for simulating real-world forces like mixing or flowing).
- **Temperature:** Many rheometers have built-in temperature control to simulate real-life conditions (e.g., food products at cooking or refrigeration temperatures).
- **Time:** Some tests measure how a material's properties change over time (e.g., during gelation or curing).

2.5 Run the Rheological Test

- **Continuous Shear Test**: Measures the flow behavior of materials under constant shear to get data on viscosity and flow curves. This is important for materials that are subjected to steady-state conditions.
- **Oscillatory Test**: Measures viscoelastic properties by applying sinusoidal stress or strain. It can determine properties like elasticity, storage modulus (G'), and loss modulus (G").
- **Creep and Recovery Test:** This test involves applying a constant stress and observing the material's deformation over time, followed by removing the stress and monitoring the recovery behavior.
- **Temperature Sweep:** Rheometry tests can be conducted at different temperatures to understand how the material behaves under thermal stress.

2.6 Analyze the Results

- **Viscosity Curves:** A plot of viscosity versus shear rate can indicate if the material is Newtonian (constant viscosity) or non-Newtonian (shear thinning or shear thickening).
- **Flow Curves:** Show the relationship between shear stress and shear rate, helping to understand how the material flows under different conditions.
- **Elastic and Viscous Moduli (G' and G"):** From oscillatory tests, you can analyze how elastic (solid-like) or viscous (liquid-like) a material is at different frequencies or temperatures.

- **Yield Stress**: Indicates the minimum stress required to make the material flow, critical for products like sauces or pastes.

2.7 Apply Insights to Product Design or Processing

- **Optimize Formulation**: If testing a food product, rheology data can help adjust the formulation to achieve the desired texture, mouthfeel, or stability.
- **Design Processing Conditions:** Flow behavior data can be used to adjust the speed, temperature, or pressure in manufacturing processes such as extrusion, mixing, or filling.
- **Ensure Quality Control:** Use rheological properties as benchmarks for product consistency during batch production.

Points to Remember

- Rheology is a branch of physics that studies the flow and deformation of materials, particularly focusing on how substances respond to applied forces
- Food rheology testing involves the use of various techniques to measure the flow, deformation, and texture properties of food materials.
- The technique used in testing food rheology is rheometry.
- Instrument used in rheometry is rheometer
- Types of rheometers are rotational rheometer, dynamic shear rheometer and capillary rheometer
- Rheometry is applied by preparing the sample, selecting the right test method, configuring the rheometer with appropriate conditions (shear rate, temperature), and running tests that reveal key properties like viscosity, elasticity, or flow behavior.

Application of learning 2.2.

You are asked to go in food laboratory and perform food rheology testing technique

Indicative content 2.3: Measuring density in food

Duration: 8hrs

Theoretical Activity 2.3.1: Description of food density measuring methods

Tasks:

1. Answer the following questions related to food density measuring methods
   a) What is the purpose of measuring density in food?
   b) Describe food density measuring methods?
2. Provide the answers to asked questions by writing them on papers, flip chart, blackboard or white board.
3. Present your findings/answers to the whole class
4. For more clarification, read the key readings 2.3.1

Key readings 2.3.1.: Description of food density measuring methods

1. Purpose of Measuring Density in Food

Measuring density in food serves several important purposes that are crucial for quality control, consistency, and safety. Here's a detailed breakdown of these purposes:

✓ **Quality Control**

Density measurement is a key parameter in assessing the quality of both raw materials and finished products. Variations in density can indicate changes in composition or the presence of impurities. For example, if a food product has been adulterated with cheaper alternatives, its measured density will differ from that of the pure substance. This can help manufacturers ensure that they are using high-quality ingredients and maintaining product integrity.

✓ **Consistency and Homogeneity**

In food production, achieving consistency across batches is vital for consumer satisfaction and brand reliability. Density measurements can help ensure that products are homogeneous; this means that each batch has uniform characteristics. For instance, if there are internal air bubbles or inconsistencies within a product, it could lead to variations in texture or taste, potentially affecting consumer experience.

✓ **Nutritional Information**

Density can also play a role in determining nutritional content. Since density relates mass to volume, knowing the density of a food item can assist in calculating its caloric density (calories per unit volume). This information is particularly useful for dietary planning and labelling.

- ✓ **Process Optimization**

Understanding the density of ingredients can aid in optimizing processing conditions such as mixing, cooking, and packaging. For example, knowing how dense an ingredient is may influence how it should be handled during production to achieve desired textures or flavors.

- ✓ **Safety Considerations**

Certain food safety protocols require monitoring physical properties like density to detect spoilage or contamination. Changes in density might indicate microbial growth or other undesirable changes that could compromise food safety.

- ✓ **Regulatory Compliance**

Food products often need to meet specific regulatory standards regarding composition and labelling. Accurate measurement of density helps ensure compliance with these regulations by providing objective data on product characteristics.

2. Methods used in measuring food density

While measuring food density we use gravimetric method.

The gravimetric method is a technique used to determine the concentration of a substance by measuring its mass. This method can be divided into two primary approaches: hydrometry and pycnometry.

2.1 Hydrometric Method

The hydrometric method involves the use of a hydrometer, which is an instrument that measures the specific gravity (or relative density) of liquids. The principle behind this method is based on Archimedes' principle, which states that an object submerged in a fluid experiences an upward buoyant force equal to the weight of the fluid displaced by the object.

- **Operation**: A hydrometer consists of a calibrated glass tube with a weighted bulb at one end. When placed in a liquid, it floats at a level determined by the density of that liquid. The depth to which it sinks correlates with the specific gravity; thus, reading the scale on the hydrometer provides direct information about the liquid's density.
- **Limitations:** One limitation of this method is that it requires sufficient sample volume for accurate readings since the hydrometer must float freely without touching the sides of its container.

2.2 Pycnometric Method

The pycnometric method employs a pycnometer: a specialized flask designed for measuring fluid densities with high precision.

- **Operation:** A pycnometer typically has a close-fitting stopper with a capillary tube that allows excess liquid to escape when filled. To determine density using this device:
  - ✓ The empty pycnometer is weighed.
  - ✓ It is then filled with a liquid (usually water) and weighed again.
  - ✓ The volume of water displaced can be calculated based on its known density at a specific temperature.
  - ✓ Finally, when measuring another liquid's density, similar steps are followed to calculate its specific gravity relative to water.

Practical Activity 2.3.2: Applying food gravimetric density measuring techniques

Task:

1. Referring to Key reading 2.3.2, go in food chemistry laboratory and apply food gravimetric density measuring techniques
2. Apply safety precautions (wear PPE).
3. Apply food gravimetric density measuring techniques
4. Present your work to the trainer and whole class. Ask for clarification where necessary
5. Perform the task provided in application of learning 2.3

Key readings 2.3.2. Application of food gravimetric density measuring techniques

1. **Application of Hydrometric Method**

1.1.Preparation of Sample

Ensure that your food sample is homogeneous and representative of what you want to measure. If necessary, cut it into smaller pieces or grind it to achieve uniformity. This step is crucial because variations within the sample can lead to inaccurate density measurements.

1.2.Measure Mass in Air

Using the precision balance scale, weigh your food sample in air (let us denote this mass as mair). Record this value carefully.

1.3.Measure Volume Displacement

- Fill your graduated cylinder or volumetric flask with a known volume of water (let us denote this initial volume as Vinitial).
- Carefully submerge your food sample into the water without letting it touch the sides or bottom of the container, which could affect accuracy.
- Record the new water level after submerging the sample (let's denote this new volume as Vfinal).
- Calculate the volume displaced by subtracting Vinitial from Vfinal:
  - Vdisplaced=Vfinal−Vinitial

1.4.Calculate Density

Now that you have both mass and volume measurements, you can calculate the density (ρ) of your food sample using the formula:

ρ=mairV/displaced

Where:

- mair is the mass measured in air,
- Vdisplaced is the volume displaced by your food sample.

This calculation gives you a gravimetric density measurement expressed typically in grams per cubic centimeter (g/cm³).

1.5.Consider Temperature Effects

It's important to note that temperature can affect both mass and volume measurements due to thermal expansion or contraction of materials involved (both solid and liquid). Therefore, ensure that all measurements are taken at a controlled temperature or record temperatures during measurement for reference.

1. Application of Pycnometric Method

The pycnometric method, particularly helium pycnometry, is an analytical technique used to measure the volume and density of solid samples. In a food laboratory, this method can be applied to various food products, especially those that are powdered or granular, such as spices, flour, or powdered dairy products. The primary goal is to determine the skeletal density of these materials, which can provide insights into their quality and composition.

1.1.Preparing Samples for Analysis

Before conducting pycnometric measurements, it is crucial to prepare the samples properly:

- **Sample Selection**: Choose representative samples from different batches of the food product to ensure accurate results.
- **Sample Size**: Ensure that the sample size is appropriate for the gas pycnometer being used; typically, a few grams are sufficient.
- **Drying Samples**: If necessary, dry the samples to remove moisture content that could affect density readings.

1.2.Setting Up the Gas Pycnometer

Once the samples are prepared:

- **Calibration:** Calibrate the gas pycnometer according to manufacturer instructions to ensure accurate measurements.
- **Chamber Setup**: Place the sample in one chamber of the gas pycnometer while ensuring that both chambers are sealed properly.

1.3.Conducting Measurements

To perform the measurement:

- **Filling with Gas:** Fill the first chamber with an inert gas (usually helium) until it reaches a specific pressure.
- **Recording Data**: Measure and record both the volume of gas required to fill the chamber and any changes in pressure as gas flows into a reference chamber of known volume.

Using Boyle's law (P1V1 = P2V2), where P represents pressure and V represents volume, calculate the volume of the sample based on these recorded values.

1.4.Calculating Density

With both mass and volume known:

- **Density Calculation**: Calculate density using the formula:

Density=Mass/Volume

This will yield skeletal density values that exclude any contributions from open pores within solid food matrices.

1.5.Analyzing Results

After obtaining density measurements:

- **Quality Control**: Compare densities across different batches or against theoretical values to assess quality control parameters such as porosity or potential adulteration.

- **Research Applications**: Use data for research purposes related to texture analysis or shelf-life studies.

1.6.Reporting Findings

Finally:

- **Documentation:** Document all findings meticulously in reports for traceability and compliance with industry standards.
- **Recommendations**: Provide recommendations based on density results regarding product formulation or processing adjustments if necessary.

Points to Remember

- Gravimetric methods are Hydrometric method and pycnometric method
- Procedures of gravimetric methods are preparation of sample, measure mass in air, measure volume displacement, calculate density and analyzing results

Application of learning 2.3.

You are asked to go in food laboratory and perform food gravimetric density measuring methods.

Indicative content 2.4: Measuring temperature in food

Duration: 8hrs

Theoretical Activity 2.4.1: Description of food temperature measuring methods

Tasks:

1. Answer the following questions related to food temperature measuring methods
   a) What is the purpose of measuring temperature of food?
   b) Describe food temperature measuring methods
2. Provide the answers to asked questions by writing them on papers, flip chart, blackboard or white board.
3. Present your findings/answers to the whole class
4. Ask for clarification if any
5. For more clarification, read the key readings 2.4.1

Key readings 2.4.1.: Description of food temperature measuring methods

1. Purpose of measuring temperature of food

The primary purpose of measuring the temperature of food is to ensure that it has reached a safe internal temperature sufficient to destroy harmful bacteria and pathogens that can cause foodborne illnesses. This is critical for several reasons:

✓ **Food Safety**

Cooking food to the appropriate temperature kills pathogenic microorganisms that can lead to food poisoning. Different types of foods have specific safe minimum internal temperatures that must be achieved. For example, poultry should reach at least 165°F, while ground meats should reach at least 160°F. By using a food thermometer, one can accurately determine if these temperatures have been met.

✓ **Preventing Foodborne Illness**

The danger zone for perishable foods lies between 40°F and 140°F, where bacteria multiply rapidly. Foods left in this range for more than two hours (or one hour if above 90°F) are no longer safe to consume. Measuring the temperature helps ensure that food does not remain in this danger zone for too long.

✓ **Quality Control**

Beyond safety, measuring temperature also affects the quality and doneness of the food. Different cooking methods and desired outcomes require specific temperatures for optimal texture, flavor, and juiciness. For instance, steaks may be cooked to different levels of doneness (rare, medium-rare, well-done), which are defined by their respective internal temperatures.

✓ **Consistency in Cooking**

Using a thermometer allows cooks to replicate successful dishes consistently by ensuring that each preparation reaches the same internal temperature every time.

✓ **Monitoring Holding Temperatures**

After cooking, it is important to keep food at safe temperatures until served. Foods should be held below 41°F or above 140°F to prevent bacterial growth during service or storage.

2. Food Temperature Measuring Methods

There are two primary methods: direct contact methods and non-contact methods. Each method has its own advantages and applications, depending on the context in which they are used.

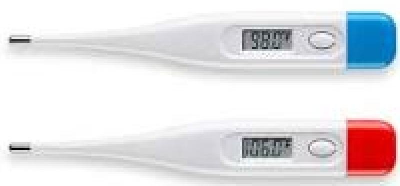
2.1 Direct Contact Methods

Direct contact methods involve physically touching the food item with a temperature sensor. These methods are generally more accurate because they measure the temperature at the point of contact. Here are some common direct contact methods:

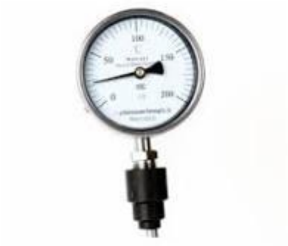
- **Thermometers**

  Types of thermometers

✓ **Digital Thermometers:** These devices have a metal probe that is inserted into the food. They provide quick readings and often have features like backlit displays and hold functions.

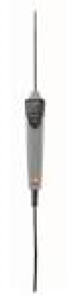


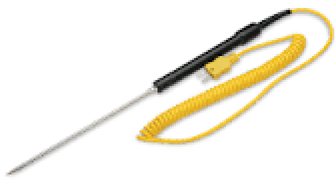
✓ **Bimetallic Stem Thermometers:** These thermometers consist of a metal probe with a dial display. The probe is inserted into the food, and the dial shows the temperature based on the expansion of metals.



- ✓ **Penetration Probes**

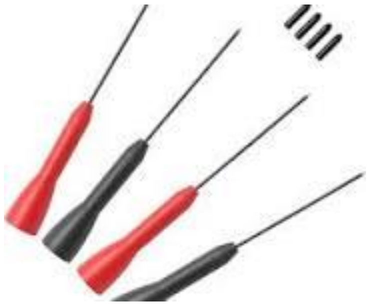
  Penetration probes are designed to measure the internal temperature of solid foods, such as meats, casseroles, and baked goods. They typically have a thicker shaft compared to other types of probes, which allows them to penetrate dense materials without damaging them excessively.





- ✓ **Needle Probes**

  Needle probes are another type of direct contact thermometer used primarily for thin foods or liquids. They are generally more slender than penetration probes and allow for quick readings without significant disruption to the food item.



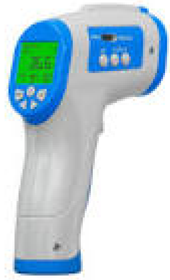
2.2 Non-Contact Methods

Non-contact methods measure temperature without needing to touch the food directly. This can be particularly useful in situations where hygiene is critical or when dealing with hot surfaces or liquids. Common non-contact methods include:

- **Infrared Thermometers**

Infrared thermometers detect thermal radiation emitted from an object and convert it into a temperature reading without any physical contact. They are widely used in kitchens for measuring surface temperatures quickly.

The key specifications include distance-to-spot ratio (D:S), which indicates how far away you can measure while still getting an accurate reading, and emissivity settings, which adjust for different materials' heat radiation properties.



Practical Activity 2.4.2: Applying temperature measuring methods in food

Task:

1. Referring to Key reading 2.4.2, go in food chemistry laboratory and apply temperature measuring methods in food
2. Apply safety precautions (wear PPE).
3. Apply temperature measuring methods in food
4. Present your work to the trainer and whole class. Ask for clarification where necessary
5. Perform the task provided in application of learning 2.4

Key readings 2.4.2. Application of temperature measuring methods in food

1. Introduction

When it comes to measuring food temperatures, ensuring accuracy is crucial for food safety and quality. There are two primary methods for measuring food temperature: direct contact methods and non-contact methods. Each has its own applications.

2.1 Direct Contact Method

Direct contact temperature measurement involves placing the sensor of the thermometer directly in contact with the food item. This method is commonly used in various settings such as kitchens, restaurants, and food processing facilities.

- **Application of Direct Contact Thermometers**

✓ **Calibrate the Thermometer:** Before use, ensure that your thermometer is calibrated correctly by placing it in ice water (should read 32°F or 0°C) or boiling water (should read 212°F or 100°C).

- ✓ **Insert the Probe**: For meats, insert the probe into the thickest part without touching bone or fat, which can give inaccurate readings.
- ✓ **Wait for Stabilization**: Allow a few seconds for the reading to stabilize before recording the temperature.
- ✓ **Clean After Use**: Sanitize the probe after each use to prevent cross-contamination.

2.2 Non-Contact Methods

Non-contact temperature measurement uses infrared technology to measure surface temperatures without needing physical contact with the food item. This method is beneficial when dealing with large quantities of food or when speed is essential.

- **Application of Non-Contact Thermometers**
- ✓ **Ensure Proper Calibration:** Similar to direct contact thermometers, ensure your infrared thermometer is calibrated according to manufacturer instructions.
- ✓ **Maintain Distance Guidelines:** Follow manufacturer guidelines regarding distance from the food item; typically, this will be a few inches away from the surface being measured.
- ✓ **Aim at Surface Area**: Point the thermometer at the area you wish to measure; ensure that there are no obstructions between the thermometer and food surface.
- ✓ **Record Temperature Quickly**: Infrared thermometers provide instant readings; record them promptly for accuracy.
- ✓ **Consider Surface Conditions:** Be aware that reflective surfaces may affect readings; if necessary, use a piece of tape on shiny surfaces before measuring.

Points to Remember

- There are two primary food temperature measurement methods: direct contact methods and non-contact methods.
- Procedure of direct contact method are calibrating the thermometer, insert the probe, wait for stabilization and clean after use
- Procedure of non-contact method are ensuring proper calibration, maintain distance guidelines, aim at surface area, record temperature quickly and consider surface conditions

Application of learning 2.4.

You are asked to go in food laboratory and perform temperature measuring methods

Learning outcome 2 end assessment

Theoretical assessment

I. Read the following statement on food organoleptic properties testing methods and circle the letter corresponding to the correct answer

1. How can organoleptic testing methods help in quality control of food products?

   a. By providing exact nutritional values
   b. By ensuring that sensory characteristics meet consumer expectations
   c. By detecting the presence of pathogens
   d. By analysing food packaging materials

2. During organoleptic testing, the hedonic scale is used to:

   a. Determine the shelf life of a product
   b. Measure how much a consumer likes or dislikes a product
   c. Assess the chemical composition of the food
   d. Compare the food's nutritional content

3. What type of test is commonly used to evaluate the aroma of a food product?

   a. Descriptive sensory analysis
   b. Paired difference test
   c. Visual examination
   d. Conductivity test

4. In a paired comparison test, participants are asked to:

   a. Choose between two samples based on a specific sensory attribute
   b. Rank multiple samples in order of preference
   c. Identify the sample that is most different from the others
   d. Evaluate all organoleptic properties of a product

5. Why is organoleptic testing crucial for new product development in the food industry?

   a. To determine chemical stability
   b. To assess consumer preferences and ensure product appeal
   c. To evaluate environmental sustainability
   d. To analyze supply chain efficiency

II. Read the statement related to testing the rheological properties of food, and answer by True if the statement is correct and False if the statement is wrong

1. Rheological properties of food refer to the study of its flow and deformation behavior.

2. Viscosity is a measure of how easily a food flows, and it is a key rheological property

3. Rheological testing is only relevant for liquid foods, not for semi-solid or solid foods.

4. Rheological properties do not change with temperature, making it unnecessary to control temperature during testing.

5. Elasticity, viscosity, and plasticity are examples of rheological properties that can be measured in food.

6. Rheological tests are unnecessary for determining the shelf life of a food product.

Practical assessment

IMENA Dairy, located in Busasamana Sector of Rubavu District in the Western Province, specializes in producing various products from raw milk. The facility includes both a processing room and a storage room. The company requires testing of the organoleptic and rheological properties of their products, as well as measurements of density and temperature. You are requested to assist IMENA Dairy and perform these tests and measurements. The task will be completed within 3 hours.

END

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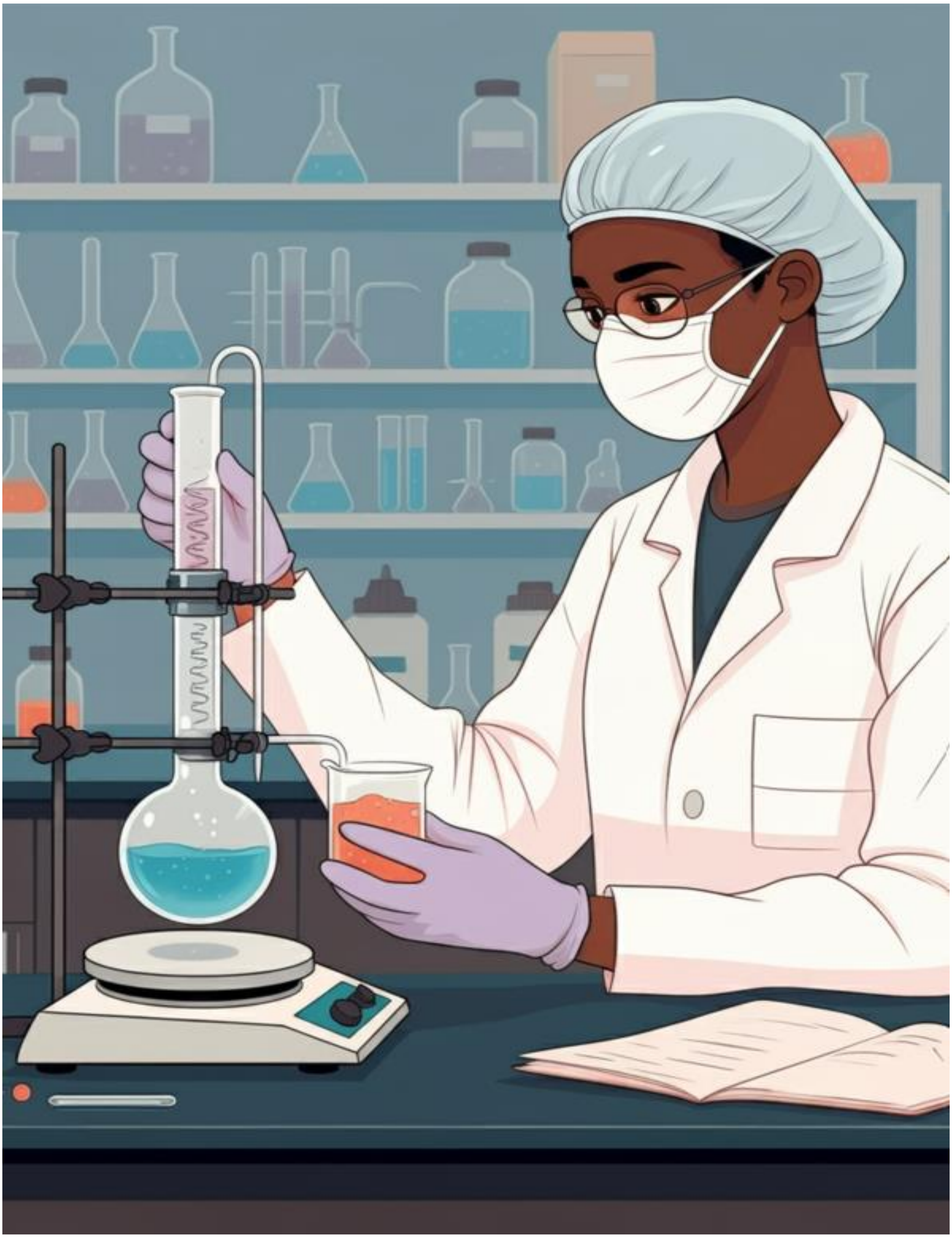
Learning Outcome 3: Test Chemical Properties of Food



Indicative contents
3.1. Determining proximate composition of food **3.2. Determining Titratable acidity in food** **3.3 Determining Total soluble solids (Brix) in food** **3.4 Determining vitamin in food** **3.5 Determining mineral content in food**

Key Competencies for Learning Outcome 3: Test chemical properties of food

Knowledge	Skills	Attitudes
• Description of the purpose of food proximate composition analysis • Description of analytical methods • Interpretations of results	• Determining Moisture content in food • Determining Ash content in food • Determining Proteins content in food • Determining Fat content in food • Determining Titratable acidity in food • Determining Total soluble solids (Brix) in food • Determining Vitamin A and c in food • Determining Calcium and Magnesium content in food • Interpreting the results	• Being careful and accuracy during testing chemical properties of food • Being decision maker during interpretation of result

Duration: 30 hrs

Learning outcome 3 objectives:

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

1. Determine properly Proximate composition according to the method and protocol
2. Determine exactly Vitamin A and C in food according to the method and protocol
3. Determine perfectly Calcium and Magnesium content in food according to the method and protocol
4. Determine effectively Titratable acidity in food according to the method and protocol
5. Determine exactly Total soluble solids (Brix) in food according to the method and protocol
6. Interpret correctly the results referring to food specifications

Resources

Equipment	Tools	Materials
• Karl Fischer titration Apparatus • Drying oven • Freezer • Kjeldahl apparatus • Precision balance • Soxhlet extractor • Computer • UV Spectrophotometer • Tissue Homogenizer Analytical Balance • Blender • Water bath • Hot plate • Furnace • Centrifuge • vortex mixer	• Moisture meter • Crucibles • Tongues • Spatula • Refractometer • Glassware • Pipette with desiccant • pH meter capable of measuring pH ranging 1.0 to 14.0 • Glass funnel suitable for use with a fluted filter paper • Glass rod • Centrifuge tube	• Sulfuric acid • Sodium sulfate • NaOH, Boric acid • Hydrochloric acid • KOH • Phenolphthalein indicator, Eriochrome Black T • EDTA • Calcium chloride • Ascorbic acid reference standard, 2, 6 • Dichloroindophenol • Metaphosphoric acid pellets

• Desiccator		• Standard Buffer (Fisher, pH 4, 7, & 10) • Filter paper (Whatman No. 541) • Deionised water • Nitric Acid, 1N • Stock standard for minerals.

Indicative content 3.1: Determination of proximate composition in food

Duration: 15 hrs

Practical Activity 3.1.1: Determining moisture content in food

Task:

1. Referring to Key reading 3.1.1, you are requested to go in food chemistry laboratory to determine moisture content in food
2. Apply safety precautions.
3. Follow carefully the demonstration of trainer
4. Determine moisture content in food
5. Present your work to the trainer and whole class. Ask clarification where necessary
6. Read the key reading 3.1.1 in the manual

Key readings 3.1.1: Determining moisture content in food

1. **Introduction**

1.1. Purpose of Food Proximate Composition Analysis

Food proximate composition analysis is a critical assessment that provides a detailed breakdown of the fundamental components of food products. The primary purposes of this analysis include:

Nutritional Assessment: Proximate composition analysis helps determine the nutritional value of food items by quantifying macronutrients such as proteins, carbohydrates, and fats. This information is essential for dietary planning, food labelling, and nutritional education.

Quality Control: Proximate analysis allows manufacturers to monitor the composition of raw materials and finished products, ensuring they meet specified standards and regulations.
Regulatory Compliance: Analyzing food for its proximate components ensures compliance with local and international food safety standards and labelling laws.

Research and Development: understanding the composition of various food products aids in the development of new products and formulations.
Consumer Information: Providing consumers with information about the proximate composition of foods supports informed decision-making regarding dietary choices. This transparency can enhance consumer trust and satisfaction.

Cultural and Sensory Studies: In sensory evaluation and cultural studies, proximate analysis can provide insights into how different compositions affect flavor, texture, and overall acceptability of foods.

1.2. Food Proximate Composition

Food proximate composition analysis refers to the breakdown and quantification of the major components of food. This analysis typically encompasses the following key components:

Moisture Content: This measures the amount of water present in the food item. Moisture content is crucial as it affects the shelf life, texture, and overall quality of food products.
Ash Content: Ash content represents the inorganic residue remaining after the organic matter has been burned away. It provides information about the mineral content of the food and is indicative of the food's overall quality and processing.
Protein: This measurement indicates the amount of protein available in the food, which is essential for understanding its nutritional value.
Fat: This measures the total fat content in food, including both saturated and unsaturated fats. Fat content is important for energy content and flavor.

2. Determination of moisture content

Moisture content in food refers to the amount of water present in a food item, typically expressed as a percentage of the total weight. It plays a critical role in determining the texture, flavor, shelf life, and nutritional value of food products

2.1.Determination of moisture content in food by using physical method (Moisture meter)

A moisture meter is an electronic device that measures the moisture content of food products.

There are two main types of moisture meters

- **Capacitive Moisture Meters**: Measure changes in capacitance due to the presence of moisture.
- **Resistance Moisture Meters**: Measure the electrical resistance of the sample, which varies with moisture content.

Procedure for Using a Moisture Meter

- **Calibration:** Before use, calibrate the moisture meter according to the manufacturer's instructions. Calibration may involve using known moisture content standards.
- **Sample Preparation:** Ensure the food sample is representative and uniform. For solid foods, cutting them into smaller pieces may help achieve accurate readings.
- **Measurement:** Place the probe or sensor of the moisture meter into the food sample. For some meters, you may need to press the probe against the surface of the food. Allow the meter a few seconds to stabilize and provide a reading.
- **Reading the Results:** The moisture meter will display the moisture content as a percentage. Record the reading for analysis.
- **Repeat:** To ensure accuracy, take multiple measurements from different parts of the sample and calculate an average moisture content

2.2. Determination of moisture content in food by using Karl Fischer titration

Determining moisture content in food using Karl Fischer titration is a precise and reliable method, particularly suitable for samples with low moisture levels. Here's an overview of the process:

Karl Fischer titration is a chemical analysis method that quantifies water content in a sample by using a reagent that reacts specifically with water. The method is highly accurate and can detect moisture levels as low as 0.01%.

Equipment and Materials used

- **Karl Fischer Titrator**: A specialized instrument for performing the titration.
- **Karl Fischer Reagent**: A solution containing iodine, sulfur dioxide, and an organic solvent.
- **Sample Holder**: A container for the food sample.
- **Solvent:** Depending on the sample, a suitable solvent may be needed for dissolution (e.g., methanol).

Procedure:

- **Preparation:** Calibrate the Karl Fischer titrator according to the manufacturer's instructions. Weigh a known quantity of the food sample (typically 1-5 grams).If necessary, dissolve the sample in an appropriate solvent (like methanol) to ensure a homogeneous mixture.
- **Titration:** Transfer the sample into the titration cell of the Karl Fischer titrator. Add the Karl Fischer reagent to the sample. The reagent will react with the water present in the sample, leading to a change in the solution.
- **Monitoring:** The titrator will monitor the reaction. As water is consumed, the titrator measures the amount of reagent needed to reach the endpoint, indicated by a change in voltage or potential.
- **Calculation:** The moisture content is calculated based on the volume of reagent used. The titrator usually provides a direct reading of moisture content in percentage form.

$$\%Moisture = \frac{volume\ of\ reagent\ used\ x\ equivalent\ factor}{weight\ of\ sample} x\ 100$$

2.3.Determination of moisture content in food by using gravimetric Methods (Oven drying, Vacuum oven drying, Freeze drying)

Determining moisture content in food using gravimetric methods involves measuring the weight loss of a sample as it is dried. Here is an overview of three common gravimetric methods: oven drying, vacuum oven drying, and freeze drying.

2.3.1 Oven Drying

Procedure:

- **Sample Preparation**: Weigh a clean, dry container (e.g., a porcelain dish).
- **Weigh Sample**: Add a known weight of the food sample to the container and record the total weight.
- **Drying:** Place the container in an oven set at a specified temperature (usually around 105°C) for a predetermined time.
- **Cooling:** After drying, remove the container and allow it to cool in a desiccator to prevent moisture absorption.
- **Final Weighing**: Weigh the cooled container with the dried sample.
- **Calculations:** Calculate moisture content using the formula:

$$\%Moisture = \frac{wi - wf}{wi} x\ 100$$

Where Wi is the initial weight of the sample and container, and Wf is the final weight of the container with the dried sample.

2.3.2.Vacuum Oven Drying

Procedure:

- **Sample Preparation**: Similar to oven drying, start with a clean, dry container.
- **Weigh Sample:** Add the food sample and record the weight.
- **Vacuum Drying**: Place the container in a vacuum oven, which is set to a lower temperature (typically 60-80°C) under vacuum to minimize oxidation and degradation.
- **Cooling:** After drying, allow it to cool in a desiccator.
- **Final Weighing:** Weigh the cooled container with the dried sample.

Calculations: Use the same formula as in oven drying to calculate moisture content.

2.3.3.Freeze Drying (Lyophilization)

Procedure:

- **Sample Preparation:** Weigh the sample and place it in a freeze dryer.
- **Freezing:** Freeze the sample quickly, usually at -40°C or lower.
- **Sublimation:** The vacuum chamber is then created, and heat is applied to promote sublimation of the ice directly to vapor, removing moisture without passing through the liquid phase.
- **Final Weighing:** Once the process is complete, weigh the dried sample.
- **Calculations:** Again, use the same moisture content formula.

Considerations

- **Accuracy:** Vacuum oven and freeze drying generally provide more accurate moisture measurements for heat-sensitive materials.
- **Time:** Freeze drying is usually more time-consuming than the other methods.
- **Sample Characteristics:** Different foods may require specific conditions for optimal moisture removal.

Conclusion

These gravimetric methods are widely used in food analysis to determine moisture content, which is critical for quality control, shelf life, and nutritional labeling. Choose the method based on the specific characteristics of the food sample and the required precision

Interpretation of Results

The calculated moisture content percentage provides insight into several aspects:

- **Quality Assessment**: High moisture content can indicate poor quality or spoilage potential due to microbial growth.
- **Shelf-Life Prediction**: Foods with lower moisture content generally have longer shelf lives as they are less prone to spoilage.
- **Nutritional Analysis**: Understanding moisture levels helps in calculating other nutritional parameters such as protein and fat content on a dry basis.
- **High moisture** content may indicate spoilage potential or reduced shelf life.
- **Low moisture** levels are often desirable for products like dried fruits or jerky.

In addition, comparing results against standard values for specific food types can help determine if a product meets regulatory requirements or industry standards.

Recommendations for Accurate Results

- **Calibration and Maintenance:** Regularly calibrate your balance and ensure that your vacuum oven is functioning correctly to maintain consistent temperature and pressure.
- **Sample Size Consistency**: Use uniform sample sizes across different tests to ensure comparability.
- **Avoid Contamination**: Handle samples with care to prevent contamination or moisture absorption during weighing processes.
- **Replicates:** Conduct multiple replicates for each sample to account for variability and improve accuracy.
- **Documentation**: Keep detailed records of all measurements, conditions used during testing, and any deviations from standard protocols.
- **Temperature Considerations:** Be cautious about selecting appropriate temperatures; higher temperatures may lead to decomposition or loss of volatile compounds in sensitive foods.

- **Use Appropriate Containers**: Select containers that do not react with or absorb moisture from samples during drying.

Practical Activity 3.1.2: Determining ash content in food

Task:

1. Referring to Key reading 3.1.2, you are requested to go in food chemistry laboratory to determine ash content in food
2. Apply safety precautions.
3. Determine ash content in food
4. Present your work to the trainer and whole class. Ask clarification where necessary

Key readings 3.1.2 Determining ash content in food

1. Introduction

Ash content is a critical parameter in various fields, including food science, pharmaceuticals, and materials science. It represents the inorganic residue remaining after the combustion of organic matter. The determination of ash content can be performed using two primary methods: dry ashing and wet ashing. Each method has its own principles, procedures, advantages, and limitations.

2. Dry Ashing Method

2.1 Principle

Dry ashing involves the incineration of a sample at high temperatures (typically between 500°C to 600°C) in a furnace or muffle oven. This process oxidizes organic material, leaving behind inorganic ash.

- **Procedure**
  a. Weigh a clean, dry crucible.
  b. Accurately weigh the sample and place it in the crucible.
  c. Heat the crucible in a muffle furnace at specified temperatures for several hours until all organic material is burned off.
  d. Allow the crucible to cool in a desiccator to prevent moisture absorption.
  e. Weigh the crucible with ash to determine the mass of ash produced.

2.2 Calculation

The ash content can be calculated using the formula:

$$\% \text{ Ash (dry basis)} = \frac{M_{ASH}}{M_{DRY}} \times 100$$

Where MASH refers to the mass of the ashed sample, and MDRY refer to the original masses of the dried and wet samples.

2.3 **Interpretation of Results**

Higher ash content may indicate higher mineral or inorganic substance levels in the sample. This can be relevant for assessing quality or nutritional value in food products.

3. Wet Ashing Method

3.1 Principle

Wet ashing employs chemical reagents (usually strong acids like nitric acid or sulfuric acid) to digest organic material at lower temperatures compared to dry ashing. This method is particularly useful for samples that are sensitive to high temperatures.

3.2 Procedure

a. Weigh a clean container (e.g., flask).
b. Add a known volume of concentrated acid to the container along with the sample.
c. Heat gently on a hot plate or use microwave digestion until complete digestion occurs.
d. After digestion, transfer the solution to a volumetric flask and dilute it to a known volume with distilled water.

3.3 Calculation

The total ash content can be determined by further analysis (e.g., atomic absorption spectroscopy) if needed, but typically it is expressed based on residual solids after evaporation.

$$\% \text{ Ash (wet basis)} = \frac{M_{ASH}}{M_{WET}} \times 100$$

3.4 Interpretation of Results

Similar to dry ashing, wet ashing results provide insights into mineral composition but may also allow for more detailed analysis of specific elements present due to subsequent analytical techniques.

3.5 Comparison Between Dry and Wet Ashing

- **Temperature Control**: Dry ashing requires high temperatures which may not be suitable for all samples; wet ashing allows for lower temperature processing.
- **Time Efficiency**: Dry ashing can take longer due to prolonged heating times; wet ashing can often be completed more quickly depending on conditions.
- **Sample Type Suitability**: Some samples may decompose or lose volatile components during dry ashing; wet ashing is often better for complex matrices where complete digestion is required.

Practical Activity 3.1.3: Determining protein content in food

Task:

1. Referring to Key reading 3.1.3, you are requested to go to food chemistry laboratory to determine protein content in food
2. Apply safety precautions.
3. Determine protein content in food
4. Present your work to the trainer and whole class. Ask clarification where necessary

Key readings 3.1.3. Determining protein content in food

1. **Direct Methods**

1.1 Determination of Protein content by Kjeldahl Method

In the Kjeldahl procedure, proteins and other organic food components in a sample are digested with sulfuric acid in the presence of catalysts. The total organic nitrogen is converted to ammonium sulfate. The digest is neutralized with alkali and distilled into a boric acid solution. The borate anions formed are titrated with standardized acid, which is converted to nitrogen in the sample. The result of the analysis represents the crude protein content of the food since nitrogen also comes from non-protein components (note that the Kjeldahl method also measures nitrogen in any ammonia and ammonium sulfate). Original Method in 1883, Johann Kjeldahl developed the basic process of today's Kjeldahl method to analyze organic nitrogen.

- **General Procedures and Reactions**

Step 1. Sample Preparation

Solid foods are ground to pass a 20-mesh screen. Samples for analysis should be homogeneous. No other special preparations are required.

Step 2.Digestion

Place sample (accurately weighed) in a Kjeldahl flask. Add acid and catalyst; digest until clear to get complete breakdown of all organic matter. Nonvolatile ammonium sulfate is formed from the reaction of nitrogen and sulfuric acid. This step consists of heating a substance with sulphuric acid, which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate

In this step potassium sulphate is added to increase boiling point of the medium (from 337^0C-373^0C)

Chemical decomposition of the sample is complete when the initially very dark-coloured medium has become clear and colouress

Nitrogen containing sample $\xrightarrow{\text{cat +Heat + } H_2SO4}$ **$(NH4)_2SO4 + H_2O + CO_2$**

Catalyst: K_2SO_4, $CUSO_4$, Selenium powder

During digestion, protein nitrogen is liberated to form ammonium ions; sulfuric acid oxidizes organic matter and combines with ammonium formed; carbon and hydrogen elements are converted to carbon dioxide and water.

Step 3. Neutralization and Distillation

The digest is diluted with water. Alkali-containing sodium thiosulfate is added to neutralize the sulfuric acid. The ammonia formed is distilled into a boric acid solution containing the indicators methylene blue and methyl.

$(NH4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na2SO_4 + 2H_2O$

$NH_3 + H_3BO_3$ (boric acid) $\rightarrow NH_4^+ + H_2BO_3^-$ (borate ion)

Step 4. Titration

Borate anion (proportional to the amount of nitrogen) is titrated with standardized HC.

$H_2BO_3^- + H+ \rightarrow H3BO3$

Step 5. Calculations

Calculate of percentage of Nitrogen in the sample and deduct the quantity from it of crude protein according to the formulas.

Moles of HCl = moles of NH3

= moles of N in the sample

A reagent blank should be run to subtract reagent nitrogen from the sample nitrogen.

$$\%N = N_{HCl} \times \frac{\text{Corrected acid volume}}{\text{g of sample}} \times \frac{14 \text{ g N}}{\text{mol}} \times 100$$

Protein content= %N×FM

FC= Factor of correction
FD= Factor of dilution
FM= Factor of multiplication

1.2 Determination of protein content by Dumas Method

Dumas method, also known as nitrogen combustion, is a classic technique used to determine the total nitrogen content in organic substances, including proteins. It is based on the principle of converting all nitrogen in the sample into elemental nitrogen gas, which is then measured quantitatively.

1.2.1. Procedure:

Sample Preparation:

a. Weigh a known amount of the sample accurately.
b. Ensure the sample is dry and free from any contaminants that might interfere with the analysis.

Combustion:

a. Place the sample in a combustion chamber, typically filled with oxygen.
b. Heat the chamber to a high temperature (around 800-900°C) to combust the sample completely.
c. The organic matter is oxidized, and the nitrogen compounds are converted to nitrogen gas (N2).

Gas Purification:

Pass the resulting gas mixture through a series of purification steps to remove any interfering gases, such as carbon dioxide and water vapor.

Nitrogen Measurement:

Determine the volume or concentration of nitrogen gas using a suitable analytical technique. This can be done using gas chromatography, mass spectrometry, or other methods.

Calculation:

a. Calculate the total nitrogen content based on the measured amount of nitrogen gas and the sample weight.
b. Convert the nitrogen content to protein content using a conversion factor (typically 6.25). This factor assumes that most proteins contain approximately 16% nitrogen.

1.2.2. Interpretation of Results

When interpreting results from either method**:**

- **Nutritional Implications:** Understanding protein content helps assess dietary needs; higher protein levels indicate better nutritional value for muscle maintenance and growth.
- **Quality Control Standards:** Results should be compared against regulatory standards or industry benchmarks for specific food products.

Limitations and Considerations:

- Both methods measure total nitrogen but do not differentiate between types of proteins or non-protein nitrogen sources.
- Sample preparation must be consistent to avoid variability in results.

In conclusion, both Kjeldahl and Dumas methods are essential tools for determining protein content in food products accurately and efficiently while providing valuable information for nutritional assessment and quality control.

✓ **Recommendations for Use**

When choosing between these two methods for determining protein content in food:

- **Kjeldahl Method**: Recommended for routine analysis where accuracy and reliability are paramount but time constraints are less critical.
- **Dumas Method**: Ideal for laboratories requiring rapid results or those looking to minimize chemical waste and environmental impact.

In practice, it is essential to consider factors such as sample type, available equipment, required turnaround time for results, and regulatory requirements when selecting a method for protein determination.

Practical Activity 3.1.4: Determine fat content in food

Task:

1.Referring to Key reading 3.1..4, you are requested to go to food chemistry laboratory to determine fat content in food

2. Apply safety precautions.

3. Determine fat content in food

4. Present your work to the trainer and whole class. Ask clarification where necessary

5. Perform the task provided in application of learning 3.1

Key readings 3.1.3 Determining fat content in food

1. **Semi-Continuous Methods**

1.1 Soxhlet Extraction

Soxhlet extraction is a widely used method for extracting lipids from solid samples. It involves the continuous extraction of lipids using a solvent, making it suitable for a variety of food, environmental, and biological samples.

Procedure

Step 1: Sample Preparation

- Weigh, to the nearest mg, about 2 g of predried sample into a predried extraction thimble, with porosity permitting a rapid flow of ethyl ether.
- Cover sample in thimble with glass wool.
- Weigh predried boiling flask
- Put anhydrous ether in boiling flask. The anhydrous ether is prepared by washing commercial ethyl ether with two or three portions of H_2O, adding NaOH or KOH, and letting stand until most of H_2O is absorbed from the ether.

Step 2: Assembly: Soxhlet apparatus: The apparatus consists of a boiling flask, Soxhlet extractor, and condenser.

Step 3: Extraction: The solvent is heated, vaporized, and condensed, extracting the fat from the sample. The rate of five or six drops per second by condensation for about 4 h, or for 16 h at a rate of two or three drops per second by heating solvent in boiling flask.

Step 4: Solvent Evaporation: The solvent is removed, leaving behind the extracted fat.

- **Petroleum ether:** A common solvent used for fat extraction.

Step 5: Drying and Weighing

- The extracted fat is dried to remove any residual solvent.
- The mass of the fat is determined.

Step 6: Calculation

The fat content is calculated as a percentage of the dry sample weight.

% Fat on dry weight basis = <u>g of fat in sample</u> ×100 g of dried sample

2. **Non-Solvent Wet Extraction**

2.1 Babcock Method

The Babcock method is a traditional technique used to determine the fat content in milk and dairy products. It involves the use of a special type of centrifuge and sulfuric acid to separate the fat from the other components of the milk.

Procedure;

- **Sample Preparation:** Measure a specific volume of milk into a Babcock test bottle.
- **Acid Addition:** Add a measured amount of concentrated sulfuric acid to the milk sample. The acid causes the proteins and other components of the milk to coagulate.
- **Centrifugation:** The Babcock test bottle in a centrifuge and spin it at high speed. This forces the fat to separate from the coagulated proteins and other components.
- **Reading:** The fat layer rises to the top of the test bottle and can be read using a calibrated scale on the neck of the bottle. The reading indicates the fat content of the milk as a percentage.

2.2 Gerber Method

The Gerber method is a traditional technique used to determine the fat content in milk and dairy products. It involves the use of a special type of centrifuge and sulfuric acid to separate the fat from the other components of the milk.

2.2.1 Procedure

- **Sample Preparation**: A specific volume (usually 10 mL) of milk or cream is placed into a Gerber flask.
- **Addition of Reagents**: An equal volume (10 mL) of sulfuric acid is added followed by 1 mL of amyl alcohol.
- **Mixing:** The flask is swirled gently to mix all components thoroughly.
- **Centrifugation Sample Preparation**: A specific volume (usually 10 mL) of milk or cream is placed into a Gerber flask.
- **Addition of Reagents**: An equal volume (10 mL) of sulfuric acid is added followed by 1 mL of amyl: The flask is then placed in a centrifuge for separation.
- **Reading Results**: After centrifugation, the fat layer forms at the top and can be read directly from calibrated markings on the flask.

2.2.2 Interpretation of Results

- A higher percentage indicates a higher fat content in food products.

- Results can vary based on factors such as type of food matrix, extraction time, and choice of solvent.

2.2.3 Recommendations for Accurate Results

- **Use High-Quality Solvents:** Ensure that solvents are pure and free from contaminants that could interfere with fat extraction.
- **Optimize Extraction Time:** Conduct preliminary tests to determine optimal extraction time for different food matrices as some may require longer periods than others.
- **Temperature Control:** Maintain consistent temperature during extraction to prevent degradation of sensitive compounds.
- **Replicate Measurements:** Perform multiple extractions on separate aliquots to ensure reproducibility and accuracy in results.
- **Calibration Standards:** Use known standards for calibration purposes when quantifying fat content.
- **Environmental Considerations:** Although these methods do not use organic solvents, proper disposal protocols should still be followed for any waste generated during testing.
- **Training Personnel**: Ensure that personnel conducting these tests are adequately trained in both methods to minimize variability in results.

Points to Remember

- The two main types of moisture meters are capacitive moisture meters and resistance moisture meters
- The procedures of moisture meters are calibration, sample preparation, measurement and reading the results
- The procedures of determination of moisture content in food by using karl fischer titration are sample preparation, titration, monitoring and calculation
- Gravimetric methods used in determination of moisture content in food are oven drying, vacuum oven drying and freeze drying.
- The two primary methods used in determination of ash content in food are dry ashing and wet ashing.
- The two direct methods of determination of protein content are kjeldahl method and dumas method
- The procedures of kjeldahl method are sample preparation, digestion, neutralization and distillation, titration and calculations.
- The procedures of dumasl method are sample preparation, combustion, gas purification, nitrogen measurement and calculation

- The two methods used in determination of fat content in food are semi-continuous methods and non-solvent wet extraction
- The procedures of determination of fat content in food by using semi-continuous method (soxhlet extraction) are sample preparation, extraction, solvent evaporation, drying, weighing and calculation
- The two methods of determination of fat content in food by using non-solvent wet extraction are babcock method and gerber method

Application of learning 3.1.

You are asked to go in food chemistry laboratory and determine proximate composition of food.

Indicative content 3.2: Determination of Titratable acidity in food

Duration: 3 hrs

Practical Activity 3.2.1: Determining Titratable acidity in food

Task:

1. Referring to Key reading 3.2.1, you are requested to go to food chemistry laboratory to determine Titratable acidity in food
2. Apply safety precautions.
3. Determine Titratable acidity in food
4. Present your work to the trainer and whole class. Ask clarification where necessary
5. Perform the task provided in application of learning 3.2

Key readings 3.2.1. Determining Titratable acidity in food

1. Introduction

Titratable acidity is a measure of the total acid content in a food sample. It is determined by neutralizing the acidic components with a standard alkaline solution. The titration method is commonly used to assess the acidity of various food products, including fruits, vegetables, dairy products, and beverages.

Common Indicators: Phenolphthalein: Turns pink in alkaline solutions.
Bromothymol blue: Turns blue in alkaline solutions

2. **Titration Procedure**

2.1 Sample Preparation

- Prepare a representative sample of the food to be analyzed. This might involve blending, homogenizing, or diluting the sample.
- Ensure the sample is free from any interfering substances that might affect the titration.

2.2 Titrant Preparation

Prepare a standard alkaline solution, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), with a known concentration.

2.3 Titration Setup

- Place a known volume of the food sample in a suitable container, such as a conical flask.
- Add a few drops of a suitable indicator, such as phenolphthalein or bromothymol blue.

2.4 Titration

- Slowly add the standard alkaline solution from a burette to the sample, stirring continuously.
- The endpoint of the titration is reached when the indicator changes color, indicating that the acid has been neutralized.

Calculate the titratable acidity based on the volume of the standard alkaline solution used and its concentration. The result is typically expressed as a percentage of acid, such as citric acid or lactic acid.

3. **Interpreting Results**

- The result gives you an indication of how acidic your food sample is relative to its weight.
- Higher values indicate higher acidity levels which can affect taste and preservation properties.

4. **Factors Affecting Titratable Acidity:**

- **Food type:** Different food products have varying levels of natural acidity.
- **Processing methods:** Processing techniques like fermentation, pasteurization, and canning can affect the acidity of food.
- **Storage conditions:** Storage temperature and time can influence the development of acidity in food.

5. **Recommendations**

- **Quality control:** Monitoring titratable acidity is important for ensuring food quality and safety.
- **Flavor evaluation:** Acidity contributes to the flavor profile of many foods.
- **Process control:** Titratable acidity can be used to monitor and control fermentation processes.
- **Shelf-life prediction:** Acidity can affect the shelf life of food products.

Points to Remember

- Titratable acidity is a measure of the total acid content in a food sample. It is determined by neutralizing the acidic components with a standard alkaline solution.
- The procedures of determination of titratable acidity are sample preparation, titrant preparation, titration setup, titration and calculation

Application of learning 3.2.

You are asked to go in food chemistry laboratory and determine titratable acidity in food.

Indicative content 3.3: Determination of Total soluble solids (Brix) in food

Duration: 3 hrs

Practical Activity 3.3.1: Determining Total soluble solids (Brix) in food

Task:

1. Referring to Key reading 3.3.1, you are requested to go to food chemistry laboratory to determine Total soluble solids (Brix) in food
2. Apply safety precautions.
3. Determine Total soluble solids (Brix) in food
4. Present your work to the trainer and whole class. Ask clarification where necessary
5. Perform the task provided in application of learning 3.3

Key readings 3.3.1 Determining Total soluble solids (Brix) in food

1. Introduction

Refractometry is a widely used method for determining the total soluble solids (TSS) content in food and beverages. TSS, often expressed in degrees Brix (°Brix), is a measure of the concentration of soluble solids, primarily sugars, in a liquid.

2. Principle of Refractometry

Refractometry is based on the principle that the refractive index of a liquid changes with its concentration. When light passes from one medium (e.g., air) to another with a different refractive index (e.g., a liquid), it bends. The degree of bending, called the angle of refraction, is related to the concentration of soluble solids in the liquid.

2.1 Refractometer Types

- **Handheld refractometers:** These are portable devices that are easy to use and ideal for field testing or small-scale applications.
- **Digital refractometers:** These instruments provide more accurate and precise measurements and are often used in laboratories and quality control settings.

2.2 Procedure for Using a Refractometer

2.2.1 Hand held Refractometer

- Collect a refractometer and should be handled carefully
- Ensure the refractometer prism surface is clean and dry.
- Place a small amount of fresh juice (a couple of drops is sufficient) onto the prism of the refractometer.
- Look through the eyepiece while pointing the prism in the direction of good light (not directly at the sun).
- Focus and take the reading of where the base of the blue colour sits on the scale and record the % percentage sugar (°Brix).
- Clean the refractometer immediately with a damp tissue, and dry thoroughly

2.2.2 LCD Digital model refractometer

Use: Push the button to get the soluble solids reading in percent

The following procedure will allow you to use refractometer

- Collect a refractometer and should be handled carefully
- Ensure the refractometer prism surface is clean and dry.
- Place a small amount of fresh juice (a couple of drops is sufficient) onto the prism of the refractometer.
- Push the button to get the soluble solids reading in percent and record
- Clean the refractometer immediately with a damp tissue, and dry thoroughly

3. Interpreting Results

The results obtained from a refractometer will give you a direct reading in °Bx:

- A higher °Bx value indicates a higher concentration of sugars and thus greater sweetness.
- Different foods have typical Brix ranges; for example:
- Ripe strawberries might have around 8-12 °Bx,
- Apples can range from 10-16 °Bx,
- Grapes used for winemaking often exceed 20 °Bx.

4. Factors Affecting Brix Measurement

- **Temperature:** The temperature of the sample can affect the refractive index. Most refractometers have built-in temperature compensation to account for this.
- **Suspended Solids:** Suspended particles can interfere with the measurement. It is essential to have a clear sample.
- **Color:** Highly colored samples may affect the accuracy of the measurement. In such cases, a digital refractometer with a light source may be necessary.

5. **Applications of Brix Measurement:**

   - **Fruit and vegetable processing:** Monitoring the sugar content of fruits and vegetables during processing.
   - **Beverage production:** Ensuring the correct sugar content in beverages like juices, syrups, and sodas.
   - **Jam and jelly making:** Determining the appropriate sugar concentration for preserving fruits and vegetables.
   - **Honey analysis:** Measuring the sugar content of honey.
   - **Winemaking:** Monitoring the sugar content during fermentation.

6. **Advantages of Refractometry:**

   - **Fast and easy:** Refractometry is a rapid and simple method for measuring Brix.
   - **Non-destructive:** It does not require destroying the sample.
   - **Portable:** Handheld refractometers are convenient for field testing.

7. **Disadvantages of Refractometry:**

   - **Sensitivity:** Refractometers may not be as sensitive for very low Brix values.
   - **Interference:** Suspended particles and color can interfere with the measurement

Points to Remember

- The two types of refractometers are handheld refractometers and digital refractometers

Application of learning 3.3.

You are asked to go in food chemistry laboratory and determine brix content in food.

Indicative content 3.4: Determination of Vitamin in food

Duration: 6 hrs

Practical Activity 3.4.1: Determining Vitamin A in food

Task:

1. Referring to Key reading 3.4.1, you are requested to go to food chemistry laboratory to determine Vitamin A in in food
2. Apply safety precautions.
3. Determine Vitamin A in food
4. Present your work to the trainer and whole class. Ask clarification where necessary

Key readings 3.4.1: Determining Vitamin A in food

1. UV spectrophotometry method

Vitamin A is a fat-soluble vitamin that plays a crucial role in various physiological functions, including vision, immune function, and skin health. Its determination in food products is essential for nutritional labeling and quality control. One effective method for quantifying Vitamin A is UV spectrophotometry, which leverages the absorbance properties of Vitamin A compounds at specific wavelengths.

2. Principle of UV Spectrophotometry

UV spectrophotometry is based on the principle that different substances absorb ultraviolet light at characteristic wavelengths. For Vitamin A (specifically retinol), the maximum absorbance occurs around 325 nm. When a sample containing Vitamin A is exposed to UV light, it absorbs light at this wavelength, and the amount of light absorbed can be correlated to the concentration of Vitamin A in the sample using Beer-Lambert Law:

($A = \varepsilon cl$)

Where:

A= absorbance (no units)

ε= molar absorptivity ($L \cdot mol^{-1} \cdot cm^{-1}$)

c= concentration (mol/L)

l= path length of the cuvette (cm)

3. **Procedures**

3.1 Sample Preparation

- **Extraction**: The first step involves extracting Vitamin A from food samples. This usually requires homogenizing the food matrix and using organic solvents such as hexane or ethanol to solubilize the vitamin.
- **Filtration:** After extraction, the solution may contain particulates that need to be removed through filtration.
- **Concentration:** The extract can be concentrated, if necessary, by evaporating some solvent under controlled conditions.

3.2 Calibration Curve Preparation

To quantify Vitamin A in unknown samples, a calibration curve must be established using known concentrations of retinol standards:

- Prepare a series of dilutions of retinol in an appropriate solvent.
- Measure their absorbance at 325 nm using a UV spectrophotometer.
- Plot absorbance against concentration to create a linear regression model.
- The equation derived from this plot will allow for calculating unknown concentrations based on their measured absorbance.

3.3 Measurement Procedure

- Set up the UV spectrophotometer and calibrate it according to manufacturer instructions.
- Measure the absorbance of the prepared sample extract at 325 nm.
- Use the calibration curve equation to determine the concentration of Vitamin A in your sample.

4. **Interpretation of Results**

Once you have calculated the concentration from your measurements:

- **Comparison with Standards:** Compare your results with established dietary reference intakes (DRIs) for Vitamin A to assess whether your food sample meets nutritional requirements.
- **Statistical Analysis:** If analyzing multiple samples, statistical methods such as ANOVA may be employed to determine significant differences between groups or treatments.
- **Quality Control:** Ensure that all procedures follow good laboratory practices, including running blanks and replicates for accuracy and precision.

5. **Recommendations for Accurate Measurement**

- Ensure all glassware and equipment are clean and free from contaminants that could interfere with measurements.
- Use appropriate controls and standards throughout your analysis.
- Regularly calibrate your spectrophotometer according to manufacturer guidelines.
- Consider potential interferences from other compounds present in complex food matrices; additional purification steps may be required if significant interference is observed.

Practical Activity 3.4.2: Determining Vitamin C in food

Task:

1. Referring to Key reading 3.4.2, you are requested to go to food chemistry laboratory to determine Vitamin C in food
2. Apply safety precautions.
3. Determine Vitamin C in food
4. Present your work to the trainer and whole class. Ask clarification where necessary
5. Perform the task provided in application of learning 3.4

Key readings 3.4.2. Determining Vitamin C in food

1. Introduction

Vitamin C, also known as ascorbic acid, is an essential nutrient that plays a critical role in various biological functions, including collagen synthesis, antioxidant activity, and immune function. It is water-soluble and must be obtained through dietary sources such as fruits and vegetables. Accurate determination of vitamin C content in food is crucial for nutritional labeling, dietary studies, and quality control.

2. Iodometric Titration Method Overview

Iodometric titration is a redox titration method used to quantify the amount of vitamin C in a sample. The principle behind this method relies on the reaction between ascorbic acid and iodine. In this process, iodine (I2) acts as an oxidizing agent that reacts with the reducing agent (ascorbic acid), leading to a color change that indicates the endpoint of the titration.

3. **Step-by-Step Procedure for Iodometric Titration**

3.1 Sample Preparation

- Weigh a specific amount of the food sample (e.g., fruit juice or vegetable extract).
- Dilute the sample with distilled water to ensure that it is within a suitable concentration range for titration.
- If necessary, filter the solution to remove any particulate matter.

3.2 Preparation of Reagents

- Prepare a standard iodine solution (usually 0.01 M) by dissolving potassium iodate (KIO3) in distilled water.
- Prepare a starch indicator solution by dissolving starch in boiling water; this will turn blue-black when iodine is present.

3.3 Titration Process

- Add a few drops of starch indicator to the diluted sample solution.
- Slowly add the iodine solution from a burette while continuously stirring until you observe a persistent blue-black color.
- The appearance of this color indicates that all ascorbic acid has reacted with iodine, marking the endpoint of the titration.

3.4 Calculating Vitamin C Content

- Record the volume of iodine solution used at the endpoint.
- Use stoichiometry to calculate the concentration of vitamin C in your sample using the formula:
  - Cascorbic=(VI2×CI2Vsample) ×Molar Mass ascorbic
  - Where:

Vl2=volume of iodine used(L)

Cl2=concentration of iodine solution(mol/L)

Vsample=volume of food sample taken for analysis(L)

Molar Mass(ascorbic)=176.12g/mol

4. **Interpretation of Results**
   - The calculated concentration can be expressed in mg/100g or mg/mL depending on how you wish to report your findings.
   - Compare your results against established dietary reference values or recommended daily allowances for vitamin C to assess whether your food sample meets nutritional standards.
5. **Recommendations for Accurate Measurement**
   - Ensure all glassware is clean and free from contaminants that could interfere with results.
   - Perform multiple titrations for each sample to obtain an average value

for increased accuracy.

- Store samples properly before analysis to prevent degradation of Vitamin C due to exposure to light and air.
- Use freshly prepared reagents whenever possible, particularly for iodine solutions, which can degrade over time.

6. Conclusion

The iodometric titration method provides an effective means for determining vitamin C levels in various food products. By following precise steps and calculations, one can accurately assess nutritional content and ensure compliance with health guidelines.

Points to Remember

- Vitamin A is a fat-soluble vitamin that plays a crucial role in various physiological functions, including vision, immune function, and skin health.
- The procedures of determining vitamin A in food are sample preparation, calibration curve preparation and measurement procedure
- Vitamin C, also known as ascorbic acid, is an essential nutrient that plays a critical role in various biological functions, including collagen synthesis, antioxidant activity, and immune function.
- The procedures of determination of vitamin c by iodometric titration are sample preparation, preparation of reagents, titration process and calculating vitamin c content.

Application of learning 3.4.

You are asked to go in food chemistry laboratory and determine vitamin A and vitamin C in food.

Indicative content 3.5: Determination of Mineral content in food

Duration: 3hrs

Practical Activity 3.5.1: Determining Calcium and Magnesium content in food

Task:

1: Referring to Key reading 3.5.1, you are requested to go to food chemistry laboratory to determine Calcium and Magnesium content in food

2: Apply safety precautions.

3: Determine Calcium and Magnesium content in food

4: Present your work to the trainer and whole class. Ask clarification where necessary

5: Perform the task provided in application of learning 3.5

Key readings 3.5.1. Determining Calcium and Magnesium content in food

- **Complex metric / Chelatometric Titration Method**

Complexometric titration is a method used to determine the concentration of metal ions, including calcium and magnesium, in a sample. It involves the formation of a colored complex between the metal ion and a chelating agent.

- **Chelating Agents**
    - **EDTA (Ethylenediaminetetraacetic acid):** A common chelating agent that forms stable complexes with many metal ions, including calcium and magnesium.
    - **EGTA (Ethylene glycol-bis (β-aminoethyl ether)-N, N, N', N'-tetra acetic acid):** A more selective chelating agent for calcium over magnesium.

- **Procedure**

3.1 Sample Preparation

1. Prepare a clear solution of the food sample containing calcium and magnesium. This might involve ashing, acid digestion, or extraction.
2. Ensure the sample is free from any interfering substances that might

react with the chelating agent.

3.2 Buffer Preparation

Prepare a buffer solution to maintain a specific pH range that is optimal for the formation of the metal-chelator complex. The pH depends on the specific chelating agent used.

3.3 Titration

1. Add a known volume of the sample solution to a titration vessel.
2. Add a few drops of a suitable indicator, such as Eriochrome Black T or Murexide.
3. Titrate the sample with a standard solution of the chelating agent (e.g., EDTA) until the indicator changes color, indicating the endpoint of the titration.

3.4 Calculation

Calculate the concentration of calcium and magnesium in the sample based on the volume of the chelating agent used and the stoichiometry of the reaction.

- **Interpretation of Results**
- Compare your calculated concentrations against standard values for calcium and magnesium content in food.
- Assess whether your results meet dietary recommendations or regulatory standards.
- **Recommendations for Accurate Results**
- Ensure all glassware is clean and free from contaminants that may interfere with results.
- Use freshly prepared buffers and indicators as their effectiveness can diminish over time.
- Conduct blank titrations without any sample to account for any potential errors due to reagents or equipment.
- Maintain consistent temperature conditions during titration since temperature can affect reaction rates and equilibrium.
- **Advantages of Complexometric Titration**

- **Sensitivity:** The method can be sensitive and accurate for determining low levels of calcium and magnesium.
- **Specificity:** By using selective chelating agents, it is possible to differentiate between calcium and magnesium.

- **Versatility:** The method can be applied to a wide range of food samples.

- **Disadvantages of Complexometric Titration**

- **Interferences:** Certain substances, such as iron and aluminum, can interfere with the titration by forming complexes with the chelating agent.
- **Indicator Selection:** Choosing the appropriate indicator is crucial for accurate results.
- **Sample Preparation:** Sample preparation can be time-consuming and may require specialized techniques.

Points to Remember

- Complexometric titration is a method used to determine the concentration of metal ions, including calcium and magnesium, in a sample. It involves the formation of a colored complex between the metal ion and a chelating agent.
- The procedures of determining calcium and magnesium content in food are sample
  preparation, buffer preparation, titration and calculation.

Application of learning 3.5.

You are asked to go in food chemistry laboratory and you are requested to analyse Calcium and Magnesium content in food.

Learning outcome 3 end assessment

Theoretical assessment

I. Read the following statement on testing chemical properties of food then circle the letter corresponding to the correct answer.

1. What is the reagent used in Karl Fischer titration
   a) Iodine
   b) Potassium permanganate
   c) Sodium hydroxide
   d) Hydrochloric acid
2. Which of the following is a gravimetric method for determining moisture content?
   a) Karl Fischer titration
   b) Capacitive moisture meter
   c) Oven drying
   d) Refractometry
3. Ash content in food refers to:
   a) The inorganic residue remaining after organic matter is removed
   b) The total amount of water in a food
   c) The amount of carbohydrates in a food
   d) The amount of protein in a food
4. Which of the following is not a step involved in the Kjeldahl method?
   a) Digestion
   b) Neutralization and distillation
   c) Titration
   d) Precipitation
5. What is the most commonly solvent used for Soxhlet extraction in fat determination?
   a) Water
   b) Ethanol
   c) Petroleum ether
   d) Methanol

II. Read the statement related to test chemical properties of food, Answer by True if the statement is correct and False if the statement is wrong

1. Centrifugation is an important step in the Gerber method to separate fat from the liquid mixture. ………….
2. A pH indicator, such as phenolphthalein, is often used during titration to detect the endpoint of the reaction. ……………
3. The UV spectrophotometry method for vitamin A determination is non-destructive, meaning the sample can be reused after analysis. ………………..

4. Iodometric titration can be used to determine both the oxidized and reduced forms of vitamin C in food. ………………
5. Refractometers can be used to measure the total soluble solids in beverages such as fruit juices, wines, and soft drinks**. ………………**

Practical assessment

AGAHOZO company export different food products including juices and pastries, the company requires to analyse chemical properties of those food. The quality management officer of the company asks you to assist AGAHOZO Company to perform these tests. This task must be completed within 8 hours

END

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