MOUNTAIN TOP UNIVERSITY

E-Courseware

COLLEGE OF BASIC AND APPLIED SCIENCES

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COURSE GUIDE

COURSE TITLE: Physical and Colloidal Properties of Food Materials

COURSE CODE: FST 203

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COURSE OBJECTIVES

GENERAL INTRODUCTION AND COURSE OBJECTIVES

This course aims at introducing the students the physical and colloidal properties of food. The Geometric properties of food such as shape, uniformity of shape, freedom from surface irregularities, size and weight of food unit, specific surface of food units, colour properties, textural properties, Aero and hydro dynamic properties and frictional properties will be considered. How the basic constituents of food resist processing stresses and the interaction of the biochemical constituents of food with water will also be delved into.

COURSE CONTENTS

LECTURE ONE

PHYSICAL PROPERTIES OF FOOD MATERIALS

1.0 Introduction

Physical characteristics of raw, unprocessed, as well as processed food materials include particle size and shape, particle and bulk density, porosity, and surface area. The size and shape of a raw food material can vary widely. The variation in shape of a product may require additional parameters to define its size.

Objectives

At the end of this lecture, students should be able to:

1. explain in details the various concepts as stated above;
2. explain what an economic activity is; and
3. distinguish between what is production and what is not production.

Pre-Test

1. Define production
2. What is the difference between a function and an equation?
3. What do you understand by the phrase 'economic activity'?

CONTENT

1.1 Description of the shape of irregular objects

Irregular objects can be described using terms such as follows:

Shape	Description
Round	Approaching spheroid
Oblate	Flattened at the stem end and apex
Oblong	Vertical diameter greater than the horizontal diameter
Conic	Tapered toward the apex
Ovate	Egg-shaped and broad at the stem end
Oblate	Inverted oblate
Lopsided	Axis connecting stem and apex slanted
Elliptical	Approaching ellipsoid
Truncate	Having both ends squared or flattened
Unequal	One half larger than the other
Ribbed	In cross section, sides are more or less angular
Regular	Horizontal section approaches a circle
Irregular	Horizontal cross section departs materially from a circle

1.2 Methods used to measure or characterize the shape and size characteristics of foods and food products.

Various methods are used to measure or characterize the shape and size characteristics of foods and food products. In several cases, actual measurements are made to estimate the major dimensions and cross sections of the product. Tracings or projections are made to compare the shapes to listed standards. Mohsenin (1970) illustrates the use of standard charts in the describing and defining of the shape of a product.

Various formulas and methods have been devised to estimate cross sections and other characteristics of the materials.

i. **Roundness**, as defined by Mohsenin (1970), "is a measure of the sharpness of the corners of the solid." Curray (1951) and Mohsenin (1970) provided the following equations for estimating roundness under different conditions of geometry and appli-cation:

$$Roundness = \frac{A_P}{A_c} \quad (1.01)$$

where: A_p = largest projected area of object in natural rest position

A_c = area of smallest circumscribing circle

$$Roundness = \frac{\Sigma r}{NR} \quad (1.02)$$

where: r = radius of curvature as defined in figure 1.01

R = radius of maximum inscribed circle

N = total number of corners summed in numerator

$$Roundness\ ratio = \frac{R}{r} \quad (1.03)$$

where R in this case is the mean radius of the object and r is the radius of curvature of the sharpest corner. It should be noted that, in the last definition (2.03), the use of the radius of curvature of a single corner determines the roundness or flatness of an object. Roundness values will differ for each of the above methods. Thus, the method for roundness determination should always be noted.

ii. **Sphericity** expresses the characteristic shape of a solid object relative to that of a sphere of the same volume (Mohsenin, 1970). Curray (1951) suggested the following equation for estimating the sphericity of an object:

$$Sphericity = \frac{D_i}{D_c} \quad (1.04)$$

where: D_i = diameter of largest inscribed circle

D_c = diameter of smallest circumscribed

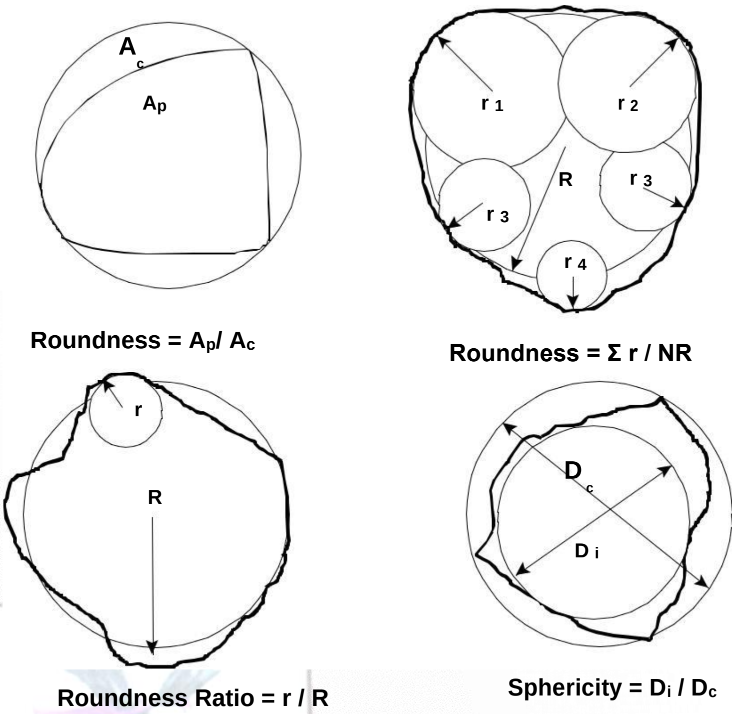

Figure 1. Roundness and sphericity as defined by geologists to describe shape of grains and pebbles (Curray, 1951, and Mohsenin, 1970).

1.3 Density (ρ)

The density of a material is the amount of that material occupying a certain space and is expressed in units of mass per unit volume. Materials consisting of particles or grains with interstitial air spaces have different values of particle density and bulk density. Materials without internal air spaces, such as fluids and solids, have equal particle and bulk density.

- **i.** **Particle density** is the mass divided by the volume of the particle alone.
- **ii.** **Bulk density** is the mass of a group of individual particles divided by the space occupied by the entire mass, including the air space.

1.4 Porosity

This is the percentage of air between the particles compared to a unit volume of particles. Porosity allows gases, such as air, and liquids to flow through a mass of particles referred to as a **packed bed** in drying and distillation operations. Beds with low porosity (low percentage air space) are more resistant to fluid flow and thus are more difficult to dry, heat, or cool. With high porosity, air flows easily through the bed, drying is fast, and the power required by fans and pumps is low.

1.5 Volume

Classification of Factors of Production:

A frequently used method of measuring the **volume** of non-porous objects such as vegetables and fruits is the use of platform scales or a top loading balance to determine the volume of a displaced liquid such as water. The liquid volume is computed by determining the mass of the displaced water and dividing by the known density of the water. The mass of the displaced water is the scale's reading with the object sub-merged minus the mass of the container and water. For objects that float, it is necessary to force the object entirely into the water with a thin stiff rod. If the object is heavier than water, it must be suspended in the water by a rod or other support to in-sure that the added mass of the object is not measured. The following expression is used to calculate the volume of displaced water:

$$\text{Volume } (m^3) = \frac{\text{mass of displaced water (kg)}}{\text{density of water } (kg/m^3)} \qquad (1.05)$$

1.6 Specific gravity

The **specific gravity** is defined as the ratio of the mass of that product to the mass of an equal volume of water at 4°C, the temperature at which water density is greatest. A reference temperature other than 4°C may be used if that temperature is explicitly specified with the specific gravity value. Specific gravity may be calculated from the following expression:

$$\text{Specific gravity} = \frac{\text{mass in air} \times \text{specific gravity of water}}{\text{mass of displaced water}} \qquad (1.06)$$

1.7 Surface area

Surface area is difficult to measure for irregular-shaped objects and thus is often determined indirectly or computed by assuming a specific shape. Several methods have been developed to measure the surface area of items. Surface area is most easily measured for items that very closely resemble common geometric shapes. A frequently used method is the projection method, which uses photographs or projected images to obtain an outline of the object. Once the object outline is obtained, segments can be defined by drawing parallel lines and calculating the area enclosed in each segment. Another method involves tracing an object. The area en-closed in the tracing may be determined by the use of a planimeter, development of segments as defined above, or other methods.

Surface area is useful in estimating the amount of wax applied to fruit, amount of packaging film to wrap fruit, and rate of heating, cooling, freezing, and drying. For granular materials, porosity is closely related to surface area. Particle surface area is important in heating and cooling operations since heat transfer is proportional to surface area.

1.8 Surface Activity

Many foods are a mixture of multi-phase materials (i.e., a mix of solid, liquid, and gas). The boundary between these phases, the interface, plays a significant role in the properties of the food. Examples of a **foam**, a gas in a liquid, are whipped creams and toppings. An **emulsion**, a liquid in a liquid, example is mayonnaise. A **solid foam** example is the meringue on pies. Both oil and water, which do not readily mix, exist in many foods. Milk and cream (oil-in-water) and butter and margarine (water-in-oil) are examples of emulsions. Uniform distribution of oil and water throughout a food mate-rial incorporates the use of surface properties. Surface properties are important in unit operations such as spray drying, aeration, hydrogenation, and fermentation. A know-ledge of surface properties is also important in cleaning operations. Emulsifying agents and detergents clean because they reduce the surface tension to more readily remove solids (dirt). These liquids wet solid surfaces and dissolve water- soluble and fat-soluble components. Detergents reduce surface tension to break apart large particles and promote spreading over the surface. Detergents allow mechanical force such as sprays or bulk turbulent flow in cleaned-in-place systems to be more effective.

1.9 Surface tension

The forces acting on the surface of a liquid tending to minimize its area are known as **surface tension**. The surface tension of water is twice as high as for cooking oils. Thus, water tends to form spherical droplets on clean surfaces. Materials when mixed with water to reduce its surface tension are referred to as surface active, i.e., surfactants. The addition of low concentrations of surfactants decreases the surface tension of water significantly. Wetability and solubility of powders affect their mixing with liquids. The liquid's surface properties control the rate of wetting and dissolution of the powder's particles. Wetting properties of milk powder during spray drying are affected by particle size, surface tension, presence of wetting agents, and the form and location of fat molecules. Although data on the surface properties of food materials are not quantified as extensively as other properties, it is no less important; and empirical, qualitative data are often used as the only information available.

Post-Test

1. With examples, what do you understand by production activity and non-production activity?
2. Explain the four factors of production.
3. An economic activity is whatever an individual spends time on. True or false?
4. Differentiate among the various time periods for the firm.

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- Production and Cost Analysis: Part II, Chapter 10,www2.gsu.edu/~ecorlcx/Colander-ch10-Production&CostsII.ppt
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LECTURE TWO
MOISTURE IN FOODS

1.0 Introduction

This lecture focuses on cost concepts and the characteristics of the costs. Fundamentally, it is important to note that economic efficiency of any firm is determined by its ability to minimize costs and maximize profits. Also. It is important to know that cost is a function of Output. As output of a firm changes the cost pattern also undergoes change.

Objectives

At the end of this lecture, students should be able to:

1. identify various cost concepts and their characteristics; and
2. graph the major production costs.

Pre-Test

1. Define opportunity cost.
2. Explain the various production costs you know.

CONTENT

1.1 Moisture content

Foods are composed of nothing in greater amount than water. Fresh fruit, vegetables, and milk contain over 80% water. The amount of water in a food is denoted by its moisture content.

1.2 Effect of Moisture Content on Storability of Foods

A food's storability is directly related to moisture content, along with temperature and oxygen availability. High amounts of available moisture lead to mold growth and microbial activity. Fruit must be dried below 30% and agricultural grains below 12% for good long-term storage.

1.3 Forms / Phases of Water

Moisture is present in foods in either solid form (ice), liquid (water), or vapor (humidity in air). The properties of water in each of these forms are significantly different. For example, the dielectric constant of water is 25 times higher than that of ice. Microwave heating is highly affected by a material's dielectric constant. Thus, heating of a frozen food in a microwave takes place significantly more slowly than heating of the same unfrozen food. The change in form or phase of water is accompanied by an exchange in energy. Thus, externally produced thermal energy is required to add sufficient heat to change the form from solid to liquid or liquid to vapor. Similarly, as water turns into ice heat energy is released by the food. These phase changes affect the other food constituents and properties such as density and thermal conductivity. Moisture affects many other physical properties. Since the physical properties of water differ from the other constituents and since water is a major constituent of food, it there-fore has a major influence on a food's properties.

1.4 Hygroscopic Nature of Foods

Foods, being biological materials, have an affinity for moisture. This interaction of food with water is known as its hygroscopic nature. The moisture content of a hygroscopic material such as food is in direct relation to the humidity of the surrounding air.

2.5 Equilibrium moisture content (*EMC*)

The moisture content of a hygroscopic material such as food is in direct relation to the humidity of the surrounding air. A hygroscopic material left sufficiently long will eventually reach a unique moisture content known as the **equilibrium moisture content** (*EMC*) for that relative humidity (*rh*) and temperature condition. The *rh-EMC* relationship is non- linear; it is a sigmoid shaped curve. At air relative humidities below 10% and above 90% there is a large change in *EMC* for small relative humidity changes. Each biological material has a unique and different *rh-EMC* relationship. The *EMC* is important in predicting the drying potential of air or storage potential of grain. Materials with moisture contents below their *EMC* will tend to increase in moisture if there is adequate air flow. Materials with moisture contents above their *EMC* will tend to decrease in moisture. The term *EMC* is commonly used in dealing with lower moisture materials, i.e., below 30%, such as agricultural grains and seeds. Agricultural grains, seeds, and nuts need to be kept at low moisture, below 12%, if they are to be stored for long periods in warm temperatures.

2.6 Effect of Moisture on the Weight of Food

The moisture in food has a direct influence on its weight, and weight of material is related to its value in dollars. If the weight of fruit in a packing house decreases by 5% due to moisture lost to the air, the owner has lost 5% of his product, which is 5% of gross income. Moisture in fruit has significant monetary value. Moisture in any food has the same value as the going unit price of the food. For example, if apples are sell-ing for $2.00 per kg and part of the weight is lost in storage due to low humidity air, the lost water has the value of $2.00 per kg! For every 1,000 kg of $2.00/kg product shipped having 5% moisture loss, the owner will be paid $100 less than the cost of the product that was placed into storage. Minimizing weight loss is important in maintain-ing amount of product as well as its quality.

Post-Test

1. With the aid of diagram, explain fixed cost, variable cost, total cost, average cost, and marginal cost.
2. Differentiate between the following:
   - Private cost and social cost
   - Money cost and real cost
   - Accounting cost and economic cost

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