UNIT 8: PROPERTIES OF FOOD

Structure

8.1 INTRODUCTION

In the previous unit, we learnt that foods are generally complex materials. The food components are in the form of solids, in solutions or in the form of colloids - sols or emulsions. The properties of these components determine the quality of food.

The quality of a food product, you would realize, is also usually assessed by means of human sensory organs, the evaluation being called ‘sensory’ or ‘subjective’ or ‘organoleptic’. Here, in this unit, we shall study about various sensory attributes of food. What characteristics make a food attractive and appealing? How does appearance and colour of a food affect our choice? Does smell has a role to play in making a food choice? Do mouth-feel and finger-feel contribute to food acceptance? All these attributes of a food product come under what we refer to as quality of foods. In this unit, we will learn about these quality attributes of food.

Objectives

After studying this unit, you will be able to:

- describe the quality attributes of food
- understand the characteristics influencing food choices and
- discuss what is rheology and its usefulness in foods.

8.2 INTRODUCTION OF QUALITY ATTRIBUTES OF FOOD

In India, seasonal fruits and vegetables are grown in plenty, and are available in their respective seasons in abundance. While choosing these fruits/vegetables what are the factors that we look in for? Yes, colour, wholesomeness, gloss, degree of ripeness, smell, taste, textured defects etc. are some of the factors on the basis of which we select or choose an item. These factors in sum can be thought of as "quality". *Quality has been defined as a 'degree of excellence and includes such things as taste, appearance and nutritional content. It is the composite of characteristics that have significance and which help in making the product acceptable. '*

When we select foods and when we eat, we use all our physical senses, including sight, touch, smell, taste and even hearing. When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be 'sensory' or 'subjective' or 'organoleptic'. Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food.

Each time a food is eaten, a judgement is made. A wide range of vocabulary is used to describe sensory characteristics of food products, such as odour, taste, appearance, texture. These sensory characteristics of food products are highlighted in Table 8.1.

Table 8.1: Vocabulary used to describe sensory characteristics of food products

Odour	Taste	Appearance	Texture
Floral	Sweet	Heavy	Brittle
Rotten	Cool	Flat	Rubbery
Perfumed	Bitter	Fizzy	Short
Acrid	Zesty	Crystalline	Gritty
Musty	Warm	Wet	Clammy
Fragrant	Hot	Cuboid	Soft
Scented	Tangy	Fragile	Stodgy
Pungent	Sour	Dull	Bubbly
	Sharp		Sandy
	Rich		Tacky
	Salty		Tender
			Waxy
Odour and *taste* work together to produce a *flavour*. Following words may be used to describe either odour or taste of food products: Bland, Rancid, Tart, Acidic, Strong, Citrus, Milky, Spicy, Tainted, Weak, Savoury.		Following words may be used to describe either *appearance* or *texture* of food products: Firm, Flaky, Crisp, Fluffy, Dry, Crumbly, Lumpy, Smooth, Hard, Mushy, Sticky, Soft, Gummy, Chewy	

Food quality, as such, can be divided into three main categories i.e.

i. Appearance factors

ii. Textural factors

iii. Flavour factors

Let us see what these categories include.

(i) Appearance can be judged by the eye. Appearance factors include such things as size, colour, uniformity, absence of any defect, shape, wholesomeness, different forms of damage, gloss, transparency and consistency. For e.g. scrambled egg with a very dry surface is not acceptable. Fudge with a glossy surface is rated high. Similarly, quality of a fish can be ascertained by the brightness of the eyes of fish. In addition to giving pleasure, the colour of a food is associated with other attributes, such as ripeness of fruits like banana, tomato, mango, papaya etc. can be assessed by the colour. Burnt toast or chapati is likely to be rejected in anticipation of scorched bitter taste. Therefore, colour is

used as an index of maturity for a number of foods. It is also associated with the flavour and texture and in some foods, with its nutritive value (e.g. Carotene or Pro-Vitamin A). Appearance covers not only colour but also the shape, size, greasiness, transparency, brightness and so on, all of which must match consumer's expectations of that food or product. Therefore, the foods have to pass the sight test first before they can be screened by other sensory organs. In many instances we can see consistency and so it is considered a textural quality attribute. For example, 'a thin boiled chocolate syrup, a thick or thin tomato sauce'. Similarly, size can be used as an indirect indicator of other attributes, such as maturity, e.g. small peas etc. are less mature and more tender than big ones. Also, size helps in obtaining a more uniformly sized product, prevents wastage and gives rapid production and a high product quality.

(ii) Texture may be assessed through touch or mouthfeel. When the food is placed in the mouth, the surface of the tongue and other sensitive skin reacts to the feel of the surface of the food. Textural factors, therefore, include assessment through handfeel and mouthfeel such as firmness, softness, juiciness, chewiness and grittiness. The texture of a food is often a major determinant of how little or well we like a food. The range of textures in foods is very great, and a deviation from an optimum or typical texture is a quality defect. We expect chewing gum to be chewy, crackers and potato chips to be crisp and steak to be compressible and shearable between the teeth. While buying bread, we squeeze bread as a measure of texture which indicates the degree of freshness. Refractometer is used for measuring texture.

(iii) Flavour factors include both sensations perceived by the tongue, which include sweet, salty, sour and bitter tastes and aromas perceived by the tongue and nose, respectively. Flavour is a combination of both taste and smell (aroma or odour), and is largely subjective, and therefore, hard to measure. *Bland, rancid, tart, acidic, strong, citrus, mild, spicy, tainted, weak and savoury are a few words that are used to describe either odour or taste of food products as highlighted* in table 8.1.

Flavour is also influenced by colour and texture. We associate certain flavours with certain colours. For example, cherry, raspberry and strawberry flavours, although are colourless compounds, we associate them with colour because in nature they occur in food of a typical colour. Similarly, texture can be also mislead evaluation of flavour. To site an example, when you are asked to judge two identical samples of gravies or soups differing in their consistencies, it is very likely that the thicker gravy would be accepted better because of its richer flavour, although it has been thickened with a tasteless starch or gum, which in no way would have contributed to the flavour of the product. This can be entirely psychological. The line between psychological and physiological reactions is not always easy to draw. Our taste buds respond in a complex fashion, which is not yet fully understood.

Flavour can be measured either by using sophisticated instruments such as gas chromatography that measures specific volatile compounds responsible for that particular flavour or through sensory methods. Acidity can be measured by titrating with alkali or using a pH meter. Although, when it comes to consumer quality acceptance, there is still no substitute for the measurements made by having people taste products.

Check your Progress Exercise 1

1. Fill in the blanks:

(i) Some of the factors that we consider while selecting food products are----------, ----------, ----------, ----------, and ---------- .

(ii) A degree of excellence and includes things such as taste, appearance and nutritional content is referred to as ----------.

(iii) When sensory organs are used to assess the quality of a food product, the evaluation is said to be----------or----------or----------

(iv) The quality of a food can be categorized into ----------, ---------- and ---------- .

(v) One of the major determinants of liking or disliking of a food is ----------.

2. Given below is a list of words that are used to describe sensory characteristics of foods. Classify them according to the odour, taste, appearance and texture properties.

a) Zesty ----------
b) Gritty ----------
c) Cuboid----------
d) Acrid ----------
e) Stodgy ----------
f) Rich ----------
g) Floral ----------
h) Fizzy ----------
i) Clammy----------
j) Bubbly----------

With the basic understanding about quality attributes of food, we will next review few of these attributes in more detail starting with 'taste'- a basic characteristic of foods.

8.3 GUSTATION - THE SENSE OF TASTE

The word 'taste' means not only a sensory response to the soluble materials in the mouth but also aesthetic appreciation. It has been noted many times that among human senses, taste has been called the "poor relation". Perhaps, it is because taste contributes so few important qualities to the sum of human experience, when compared to vision or audition. From the view point of the food processor and food scientist, the sense of taste commands interest because of its role in food recognition, selection and acceptance, in addition to its pleasure giving function.

We have described the organs involved in taste perception in the Course on Applied Physiology, Unit 10. It would be a good idea to look up the unit now. This will help you understand the role of taste in food recognition, selection and acceptance.

You already know that taste is sensed by taste buds located on the tongue. Taste sensations which taste buds register are categorized as - sweet, sour, salt and bitter. Sweet and salty tastes are sensed more intensely on the tip of the tongue. Sour and bitter more intensely on the hard palate. Are you aware of the chemicals responsible for the four basic tastes and what are the factors affecting taste quality? The next sub-section introduces you to these concepts.

8.3.1 Chemicals Responsible for the Four Basic Tastes i.e. Sweet, Salt, Sour and Bitter

The chemicals responsible for imparting the sweetness, classic salt taste and bitter and sour taste are summarized herewith.

A. Sweet Taste

Sweetness is one of the most important taste sensations for humans and for many animal species as well.

Substances which elicit 'sweet' sensation are primarily the organic compounds like sugars - mono and disaccharides, glucose, fructose, sucrose, various alcohols mainly ethanol, sorbitol, glycerol, non-nutritive sweetners such as saccharine, cyclamate, aspartame.

Among them, sugars are the main sources of sweetness in foods. But not all sugars are equally sweet. Fructose gives the most intensely sweet sensation followed by sucrose, glucose, maltose, galactose and lactose respectively. Alongwith imparting sweetness to foods, you have learnt earlier about the other functional properties of sucrose in foods that make it useful as a bulking agent, texture modifier, mouthfeel modifier and a preservative. Sucrose additionally offers an important energy source for many food fermentations.

The threshold value for sucrose is 0.342%, glucose is 1.442% and saccharine is 0.00047%. What do we mean by threshold? *The concentration required for identification is known as threshold for that particular substance*.

Next let us learn about the salty taste.

B. Salty taste

Various ions both *cations* and *anions* are responsible for the salty taste. These include: K (Potassium), Na (Sodium), Li (Lithium), Cl, Br (Bromine), I (Iodine), F(Fluorine), SO_4 (Sulphate), NO_3 (Nitrate). As you move from Li to NO_3, the molecular weight increases and saltiness decreases. Threshold values for some salts are given herewith:

NaCl (Sodium chloride)	0.175%
LiCl (Lithium Chloride)	0.016%
NaBr (Sodium Bromide)	0.247%
NaI (Sodium Iodide)	0.42%

'Salty' taste is due to ions of salts. Classic salty taste is represented by Sodium Chloride (NaCl).

C. Bitter Taste

Bitterness is an inherent property of a substance. It is due to substances such as alkaloids present in food. For example, tannins present in tea, coffee, fruits and vegetables. Tannins are desirable in tea and coffee to some extent but not in fruits and vegetables. Apple juice, if left outside, gives a bitter taste due to the tannins present in it. Some electrolytes are also bitter e.g. magnesium (Mg), ammonia (NH_3) and other nitro compounds. More the number of nitro compounds, higher will be the bitterness perceived. Various amides are also bitter for example, benzamide and glycosides. Quinine, (found in grapes and citrus fruits) naringin (grape fruit), lemonin (citrus fruits), thromine, bromide, caffeine (coffee), Mg, NH_4, Ca, picric acid and various nitro groups are the compounds responsible for the bitter taste. Certain phenyl groups are also responsible for bitter taste, urea also gives bitter taste.

Debittering of these citrus fruits can be done by using advanced techniques such as super critical fluid extraction. What is this technique? CO_2 at super critical pressure and temperature causes extraction of these bitter components from these substances.

D. Sour Taste

Sour taste is usually due to the presence of acids such as acetic acid, citric acid, benzoic acid. Upon dissociation, the acids give H ions which impart acidity. More the H ion concentration higher is the acidity and more is the intensity of sourness. Fruits and vegetables are sour due to the acids present in them for example, tartaric acid in grapes and citric acid in lemon. Acids may be strong or weak depending upon their dissociation ability. Stronger the acid more will be the dissociation and higher will be the acidity, which imparts sourness to a particular substance. Of the two acids, HCl and acetic acid (CH_3COOH), acetic acid is more sour than HCl inspite of the fact that HCl is stronger. This indicates that there are other factors also along with the dissociation governing the intensity of sourness. All these factors influence the *reaction time* which is defined as the *time interval between tasting of a substance and identification of the taste by the brain.* The solution is first tasted, the impulse is transmitted to the brain and then identification takes place or in other words, reaction time interval between initial stimulation of the receptors and the final response.

The reaction time to perceive the acidic taste is indirectly proportional to the concentration of the acid. More the concentration, lesser is the time required. Individual variations are there in perception due to difference in the pH of the saliva. Low pH saliva will give a better perception of sour taste.

After understanding the four tastes, let us look at the factors affecting taste quality.

8.3.2 Factors Affecting Taste Quality

You may have experienced that the four primary tastes i.e., sweet, sour, salty and bitter are not sensed with an equal ease. There are many factors which influence the sensitivity. What are these factors? Read and find out.

1. *Concentration* - There is a specific range at which the tasteful substances should be used. The concentration required for identification is known as the *threshold* for that particular substance. Within this range, the perception of taste increases with an increase in concentration. Below and above this concentration, taste is not adequately perceived.

   Threshold may be defined in terms of absolute threshold or recognition/detection threshold or terminal threshold. Absolute threshold is the *minimum detectable concentration*. It is not a sharply defined concentration. It is the *stimulus magnitude at which the subject can identify different tastes*. Recognition/Detection Threshold, on the other hand, is *the concentration at which the subject can identify a specific taste*. It is always higher than absolute threshold. *Terminal threshold* is the maximum concentration beyond which taste is not perceived or a change in sensation is not perceived, how much high the concentration is.

   Range starts from recognition threshold to terminal threshold. For sweet taste, this range is very wide, for salty and sour the range is narrow, and is very narrow for the bitter taste. Most acceptable concentration for different tastes is included herewith:

   For sweet: 7-9%, in all desserts and beverages. A high concentration is used in jams and jellies, where it acts as a preservative.

   For sour – 0.28%

   For salty – eg., NaCl in cheese and butter – 2%

   For bitter- 0.0002%

2. *Taste interactions*- Foods contain a mixture of substances which elicit all four sensations. Modification of one sensation takes place in the presence of other. For

example, addition of sugar to tea extract or lemon to tea extract i.e. bitterness is suppressed by sweet or sour.

Out of the two sensations, the stronger one may repress the effect of other. For example, salt in sub-threshold concentration reduces the tartness of acid, salt is added to sweet fruits to modify the sweet taste or to make it more acceptable. Sugar or lemon added to the tea, which otherwise is very bitter, modifies the bitter taste.

3. *Adaptation* – A low concentration solution will not give any sensation after tasting a higher concentration solution due to the adaption of the tongue for higher concentration. For example, normal water will taste flat because our tongue is adapted to this type of water but when we take hard water, it appears salty. Mineral water/ground water containing many minerals and ions gives a salty taste. Distilled water containing no ions tastes slightly sweet. Tea taken after sugar appears flat i.e. does not gives a bitter perception.
4. *Time*- Time is another factor which affects sensation. Salt on tongue is sensed in a fraction of a second; whereas, bitter things may require longer time, say one full second. Once perceived, it however, keeps on lingering. Table 8.2 gives the reaction time for different tastes.

Table 8.2: Reaction time for different tastes

Tastes	Reaction Time in Seconds
Sweet	0.44
Salty	0.3
Sour	0.53
Bitter (Max)	1.08

From our discussion above, we hope you have gathered some insight into the role of taste in food acceptance and the factors which influence this attribute. To help you recapitulate what you have learnt so far, we have included some exercises to Check Your Progress Exercise 2. Answer them and check your responses with the answers given at the end of this unit.

Check Your Progress Exercise 2

1. Fill in the blanks:

(i) Taste is called as a poor relation as it contributes to ----------

(ii) Taste sensations can be categorized as ----------, ----------, ---------- and ---------- .

(iii) ---------- are the substances that elicit sweet sensation.

(iv) The detection threshold for quinine is ---------- .

2. Which are the areas where various taste sensations are perceived?

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3. Explain the following terms:

(a) Threshold

(b) Reaction time

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4. List the factors that affect the taste quality.

Next, we move on to the texture in foods.

8.4 TEXTURE IN FOODS

According to Matz (1962), texture can be defined as *the mingled experience derived from the sensation of skin in the mouth after ingestion of food or beverage*. What we sense as texture in foods, derives from the physical characteristics of these materials. **We generally concern ourselves with hardness of tough meat, softness of tender jellies,**

chewiness of steak, thickness of sauces, elasticity of bread, sticky surface of caramel, roughness of salt crystals etc. to realize how many characteristics provide textural stimuli in foods. In other words, *texture is a composite property involving many physical properties in a complex relationship* or in a more general way, *texture can be defined as a way in which various constituents and structural components are arranged and combined into a micro and macro structure and the external manifestation of the structure in terms of flow.* The formation texture influences:

(1) Consumer acceptability,

(2) Type of packaging, and

(3) Processing method (Power required).

We learnt earlier that texture is observed in terms of tactile sensations i.e. fingerfeel and mouthfeel. *Finger feel* is sensed before ingestion, by pressing and touching, e.g. to detect the freshness or staleness of bread by handfeel. On the other hand, once you ingest the food the mixed feeling derived mainly due to the activation of palate and teeth, is the *mouthfeel*. During chewing, various kinds of forces are applied which tell us about the texture of the food. The forces are compression, cutting, tensile strength and shearing. These same kinds of forces are imitated in the objective evaluation of textural properties. *The term 'mouthfeel' can therefore be defined as the mingled experience arising from the sensation of the skin and the mouth during and after ingestion.*

You may be wondering why a study of the food texture is important. The study of food texture is important for three reasons:

1. To evaluate the resistance of product against mechanical action such as in mechanical harvesting of fruits and vegetables,
2. To determine the flow properties of a product (what is referred to as rheology) during processing, handling and storage, and
3. To establish the mechanical behaviour of food when consumed.

Next, how do we measure food texture? Food texture can be evaluated by mechanical test or instrumental methods. This is called as *objective evaluation*. When we use the human

sensory organs as analytical tools, we call it the sensory or subjective evaluation. For the purpose of measurement, however, classification in terms of physical properties has been proposed by Szczesmiac in 1963. This system groups the characteristics as mechanical (hardness, cohesiveness, viscosity, elasticity, adhesiveness), geometrical (particle size, shape and orientation) and others (moisture content, fat content) as highlighted in Table 8.3.

Table 8.3: Different Textural Parameters and their popular classification (Szczezmiac Classification (1963)

S. No	Primary Parameters	Secondary	Popular Nomenclature
1. *Mechanical Characteristics*			
a.	Hardness		Softness Firm → hard
b.	Cohesiveness	Brittleness Chewiness Gumminess	Crumbly – Crunchy – Brittle Tender – Chewy – Tough Mealy – Pasty – Gummy
c.	Viscosity		Thin → Viscous
d.	Elasticity		Plastic → Elasticity
e.	Adhesiveness		Sticky → Tacky – Gooye
2. *Geometrical Characteristics*			
a.	Particle size and shape		Gritty Grainy Coarse
b.	Particle shape and orientation		Fibrous – Cellular – Crystalline
3. *Other Characteristics*			
a.	Moisture Content		Dry-Moist-Wet-Watery
b.	Fat content	Oiliness	Oily Greasy

Hardness, cohesiveness, viscosity, elasticity and adhesiveness are the mechanical characteristics. What do these characteristics stand for? These characteristics are described in physical terms herewith for your convenience.

Hardness: It is defined as *the force necessary to affect a given deformation*. When judged by human senses, it is the force required to penetrate a food with molar teeth. Solids and some semi-solids have this property. For example, Cream cheese is low in hardness and raw candy is very hard.

Cohesiveness: It derives from the *strength of internal bonds holding the body of the substance together*. Cohesiveness, being the primary characteristic includes - brittleness, chewiness and gumminess – as the secondary characteristics. What are these characteristics? Let us know. *Brittleness* is judged by the taster as the ease with which the food can be cracked, then shattered or crumbled. *Chewiness* can be defined as the resistance of a product to compression and shearing action of teeth or the energy needed to masticate a solid food and *gumminess* can be understood to include the resistance offered by food when teeth/tongue are withdrawn after first penetrating the food i.e. the energy required to disintegrate a semi-solid food prior to swallowing.

Viscosity: It is measured as *the rate of flow per unit force*. The resistance of liquids to flowing is readily observed and is usually conveniently measured. For example, in the mouth, it is sensed as 'body' or thickness by small variation of resistance against the sensitive touch receptors of lips, cheeks, palate and tongue.

Elasticity: It is defined as *the rate at which a deformed material goes back to its original shape*. Elasticity is difficult to measure independently of other parameters. It is a part of chewiness.

Adhesiveness: It is measured as the work necessary to overcome the attractive forces between surfaces of material and surfaces that contact it. In eating, this property is sensed between food surfaces and mouth/throat tissues. For example, oil allows little adhesion, while peanut butter much.

All these textural characteristics discussed above are the working basis for food researchers, quality control experts and engineers busy in developing instruments to

measure texture. In this section, we will study about objective evaluation of food texture. How is the food texture measured? What are the different methods and instruments used for measuring texture of different foods?

8.4.1 Objective Measurement and Evaluation of Food Texture

Kinesthetic characteristics deal with the sense of feel, just like the characteristics of appearance deal with the sense of sight.

Objective methods of textures measurement involve simulating and measuring the sensations which the consumer experiences through the sense of feel with the fingers and more precisely in the mouth.

Many of these instruments used to measure texture, involve measurement of resistance to the force applied which is measured in terms of grams/kilograms force. This force may be applied in a number of ways or through a combination of two or more of the methods highlighted herewith. Basically four types of forces are encountered, which include:

Four Types of basic forces

1. *Compression:* This refers to *the squeezing of the test material so that it still remains as a single undivided unit but may occupy less volume*. Figure 8.1 illustrates this type of squeezing. For e.g. finger test and pressure test to measure the juiciness, firmness etc.

Figure 8.1: Compression

2. *Cutting* – This occurs when the force is applied in such a way that the test unit is divided so that the portions in the original position in relation to each other, as you can see from the figure 8.2.

Figure 8.2: Cutting

3. Shearing – This results from *the application of force where the test material is separated to two or more parts as shown in the figure 8.3, with one part sliding beyond the other part* e.g. separating dough into two parts.

Figure 8.3: Shearing

4. Tensile strength – This is the application of force away from the material rather than towards the material, when a force is applied to pull the test material apart. This is illustrated in the figure 8.4. There may be one force or combination of two forces, such as shear pressure.

Shear Pressure – Both shearing and compression. The food is first compressed, then sheared for example tenderometer, chewing action of teeth etc.

Figure 8.4: Tensile Strength

Earlier we learnt that the textural properties include mechanical properties of hardness, cohesiveness, adhesiveness, chewiness, crispness, gumminess, viscosity and elasticity etc. A number of instruments are available to evaluate the texture of various foods. A brief discussion on these instruments follow.

Considering the various textural characteristics of food, you will find that different instruments are used to measure their different mechanical characteristics. A few

examples are: (i) the tenderness of meat is tested by measurement of structure of meat with a *penetrometer.* This measurement gives an idea of how easy or difficult it is for the teeth to bite into a piece of meat. Another device used to measure tenderness is *Warner Braztler Shear*. This measures the force needed to cut the meat in simple shear usually across the fibres and estimate the force needed to chew the meat.

(ii) The texture of fruits and vegetables can be measured as follows:

a) *Punctured testing* is used to evaluate firmness of fruits. It measures the amount of force required to penetrate the sample to a specific depth.

b) A *shear press* is used to study tenderness of fruits and vegetables. This consists of a rectangular box with evenly spaced slits at bottom. A series of blades is moved through a sample of food. As the blades move, food is compressed, sheared and extruded through the openings in box.

(iii) The texture of doughs and batters determine the quality of finished product. Consistency of batters is determined by *"Line-spread apparatus"*, which indicates the nature of dispersion of incorporated air. Consistency and stability of doughs are measured with a *"farinograph*", which measures the force required to turn mixer blade at a constant speed during mixing of the dough. A *"mixograph*" also gives information similar to farinographs.

(iv) Texture of baked products - pastries, cookies and crackers is determined by *"shortometer*". It measures the force required to break the products. A "*compressimeter"* is used to evaluate the firmness of breadcrumbs or softness of baked products. The force requires to break through a sample of baked product can be measured using "Warner-Braztler Shear".

Textures, as perceived by human beings, is a composite of characteristics to arrive at a textural profile. Different new instruments have been developed to evaluate more than one characteristic constituting texture of a food. One such multiple measuring devices – Instron – texture measuring system, can measure many properties at the same time e.g.

firmness, grittiness, case hardening etc. by the use of force and time curves. In this, force and time are varied simultaneously. For surface hardening a steep rise is obtained in the curve. For a less firm product, there will be a gradual rise. For gritty particles, a number of sharp peaks depths are observed.

Some characteristics of food depend on *rheological properties*. What are these properties? What do we mean by rheology of food? The next section presents a discussion on food rheology.

8.4.2 Rheology of Foods

Rheology is *the study of stress and strain* or in other words*, it is the study of flow and deformation of materials, both liquids and solids, under stress and strain conditions*. Primarily, rheology deals with three aspects –Elasticity, Plasticity and Viscosity.

The flow characteristics of a food are actually quite complex. For example, if a bread dough is stretched, but not too far, it will spring back; to the extent that it does, the dough is elastic. Elasticity is a characteristic of importance in baked products too. Such as crumb of bread and cake, especially so when they are fresh.

Elastic deformation is reversible but plastic is not. A material that exhibits plastic flow resists changing position until a minimum force is applied. This is a desirable characteristic in cake frosting. A soft frosting is desired, but it should stay in place but not flow down the sides of the cake.

Solids do not flow; however, some solids can be deformed by force and recover when the force is removed. This is elasticity and gels like those of pectin, gelatin and starch baked custard etc. are examples of elastic solids. There a number of objectives tests to determine the firmness of gels. A material that is plastic resists flow until a force is applied but unlike elastic flow, plastic flow is irreversible.

What is *viscosity*? Viscosity is resistance to flow of a liquid. It is a measure of the resistance of a fluid to deformation under shear stress. It is commonly perceived as "thickness", or resistance to pouring. Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. Thus, water is "thin", having a low viscosity, while vegetable oil is "thick" having a high viscosity. While studying about viscosity you will come across terms such as newtonian fluid and non-newtonian fluids. What do we mean by this? A Newtonian fluid is one in which the viscosity does not depend on the shear rate—no matter what shear is applied, the viscosity stays the same. Examples of newtonian liquids are mineral oil, water and molasses. In many applications, however, this is not the case and, as the fluid is sheared at greater rates, the viscosity will change. These types of liquids are known as non-newtonian and there are many classifications. Examples are toothpaste and whipped cream.

Various methods for textural or rheological measurement are used. We will not go into the details of these methods here in this unit, but certainly highlight a few method used to measure rheological parameters.

The first type of rheological model highlighted here is Dash pot model.

1. *Dash Pot Model:* This method establishes relation between the pressure gradient and the volume rate of flow. Here, the piston measurement is used to measure the consistency of the product present in the cylinder. If the load required is more, consistency is thick. It consists of a piston sliding in the cylinder filled with oil as shown in the figure 8.5. Here, the load is connected with piston, as you can see from the figure 8.5, which provides the force for piston movement. If the viscosity is high, more load is required to obtain a constant movement. Oil can be replaced by the food material for which the measurements are to be taken. The initial period of no deformation is there. The piston starts moving only after a critical load is applied. After sometime, the deformation remains constant. This model can be used only for fluid test products.

Figure 8.5: Dash Pot Model

2. Spring Model

The spring model depicts elasticity. A force is applied in terms of load onto the spring as illustrated in the figure 8.6. When the force is applied, deformation is produced which will remain constant for sometime and the spring will immediately regain its shape after removal of a load.

Figure 8.6: Spring Model

This is ideal for the elastic materials. In case of food, the spring is replaced with food material or elastic food, for which the deformation is to be measured. For example, extensiometer for measuring the dough elasticity and extensibility.

3. *Spring clip model:* The spring clip model differs from the spring model in a way that the force applied is comparatively slower. This also depicts elasticity or plasticity of a material. The force is controlled by pulley arrangement as shown in the figure 8.7. It is used for measuring the breaking strength of dough. Initially, for sometime, it resists the flow. Once started with the deformation and after completion of deformation, it becomes still.

Figure 8.7: Spring Clip Model

4. Shear Pin Model: In this type, a shearing force is applied using a pin to shear the food product, as illustrated in the figure 8.8. We are rupturing the element of the food product by using pin.

Figure 8.8: Shear Pin Model

Check Your Progress Exercise 3

1. Define the following terms:

(i) Texture

(ii) Mouthfeel

(iii) Hardness

(iv) Cohesiveness

(v) Elasticity

(vi) Adhesiveness

(vii) Chewiness

(viii) Rheology

---

2. Fill in the blanks:

(i) Objective methods of texture measurement involve---------- and ---------- sensations.

(ii) The four basic types of forces encountered while evaluating food texture are ----------, ----------, ---------- and ---------- .

(iii) ---------- is an instrument used to evaluate multiple characteristics of food texture.

(iv) Rheological parameters can be measured by ----------, ---------- and ---------- .

(v) Few examples of elastic solids are ---------- .

3. Name a few instruments that are used to measure the texture of:

(i) Meat

(ii) Fruits and Vegetables

(iii) Doughs and Batters

(iv) Baked products

8.5 COLOUR

Colour is an important quality attribute in food although they do not necessarily influence their nutritional, flavour or functional quality. Consumer preferences are strongly influenced by the colour of the food. Colour is defined as *the characteristic of light that is measured in terms of intensity and wavelength*. Why is colour an important

characteristic of food? What are its functions? How can we measure colour in foods? These are a few aspects covered in this section. We begin by first understanding the functions of colour in foods.

8.5.1 Functions of Colour in Foods

Earlier, in section 9.2 we very briefly introduced you to the colour properties of food and its role in food. Let us now look at the different functions of colour in details, which are enumerated herewith:

1. The maturity of many fruits and vegetables is closely associated with colour development or changes in colour. Colour is also indicative of the freshness of the product. Changes in colour take place on storage that may lead to reduced or increased consumer acceptance e.g. in tomatoes- green- yellow- red. So *colour acts as a ripening index in fruits and vegetables.*
2. *Composition Aspects*- Colour indicates the composition of the food. For example, in egg yolk, the intensity of yellow colour tells us about the pigment content.
3. *Grades* are assigned to the food products on the basis of their colour. For example, tomatoes are graded according to their size and colour. Different prices are allocated for different grades. This is important for canning industry where they assign different grades to the canned tomatoes.
4. The *end point determination* during food processing is also done on the basis of the colour of the final product. For example, golden brown colour of the fried products.
5. Distinct colours are associated with different flavours e.g. pink colour to strawberry flavour, yellow to mango flavour and orange to orange flavour etc.
6. It has been seen that the flavour scores of an inferior grade (poor quality) juice can be improved by colouring it to resemble the juice of better quality. So *colour serves as a standard of good quality*. Also, the flavour identification becomes difficult if the products are coloured deceptively. For example, green colour for an orange juice. Also people describe white wine as less sweet in taste in comparison to the red wine even though the sugar concentration has

been kept constant. Example, orange juice which had a yellow colour has been found to be less acceptable in comparison to bright orange colour juice.

Well then, colour, as is evident from the discussion above plays a crucial role in food acceptability. It contributes immeasurably to ones aesthetic appreciation for food in addition to being associated with other attributes. A number of instruments are used for colour measurements. The next sub-section presents a review on these instruments.

8.5.2 Measurement of Colour in Foods

A number of instruments are used for colour measurements in food. In this section we shall acquaint you to some of the simple methods/instruments used to measure colour in foods. These are highlighted herewith:

a) A simple method is to match the colour of a food with coloured chips or glass and give them name accordingly.

b) Disc Colourimetry, in which different coloured discs are spun on a stage, so that the colours merge into one colour. The test sample is placed adjacent to the spinning disc and the colours are matched.

c) Tintometers are simple instruments used to determine the colour and its depth in foods for a more reliable measurement of colour.

d) Spectrophotometers are also used to measure colour. In the case of clear and transparent solutions, spectrophotometric measurements give quantitative results. For the foods that are opaque in nature, "reflectance spectrophotometry" is used. In the Reflectance Spectrophotometery, colour is measured in terms of amount of light reflected from the surface of the object at each wavelength in the range of 380-700 nm.

e) Tri – Stimulus Colourimetry, in which the colour is specified by three attributes - dominant wavelength, brightness and purity- hence referred to as tristimulus system. These three refer to the actual colour, luminosity and strength of the colour respectively.

Other than the measurement of colour, analysis of colour in food is also important. You may recall reading about the three different classes of colours – natural, synthetic and natural identical, earlier. How can we analyse or check whether the colour present in food, particularly the synthetic one, is permitted or not? There are different ways of colour analysis. The next sub-section throws light on this analysis.

8.5.3 Qualitative and Quantitative Analysis of Colour

Primarily, two types of analysis are carried out for food colours - qualitative and quantitative.

The qualitative analysis is carried out to check whether the dye present in food as a colourant is permitted or not. This is done with the help of various separation techniques Gas Liquid Chromatography (GLC), Thin Layer Chromatography (TLC), paper chromatography and spectrophotometry.

The colour from the food product is extracted and subjected to one of these techniques for identification of colour. In case of paper chromatography and TLC, reference values of the extracted colours is compared with that of standard and in case of GLC, retention time values are compared. Retention time is *the time taken by the component to elute from the column.*

Quantitative analysis, on the other hand, is done to check whether the amount present is within the prescribed limits or not. In case of GLC area of the peak obtained is directly proportional to the amount of the component present. In case of TLC the spotted portion is scrapped from the plate and dissolved in a suitable solvent filtered and the colour intensity is measured using spectrophotometer. If the artificial colours used are preset beyond the prescribed limit they might prove to be toxic to the human health. All these determinations are done for synthetic colours only.

With qualitative and quantitative analysis of colours in foods, we come to an end of our study on the properties of foods.

Check Your Progress Exercise 4

1. Give the functions of colours in foods.

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2. Define the following terms:

(i) Colour

(ii) Retention time

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3. List a few methods to measure colour in foods.

8.6 LET US SUM UP

In this unit, you studied about various properties of foods, under which the quality attributes of foods were introduced to you in terms of food quality and its categories as appearance, texture and flavour factors. The sensory or subjective evaluation of foods was also described.

A detailed discussion on the sensory characteristics of foods was done, that included gustation, texture and colour. In this, you learnt about the techniques of measurement, analysis and evaluation of these characteristics.

8.7 GLOSSARY

Absolute threshold **:** The minimum detectable concentration; stimulus magnitude at which the subject an identify different tastes.

Adhesiveness : The work necessary to overcome the attractive forces between surfaces of material and surfaces that contact it.

Bitterness : A sensation of a peculiar, acid, biting taste.

Brittleness : The ease with which a food can be cracked.

Chewiness : The resistance of a product to compression and shearing action of teeth.

Cohesiveness : The strength of internal bonds holding the body of the substance together.

Colour : The characteristic of light that is measured in terms of intensity and wavelength.

Compression : The squeezing of the test material so that it still remains as an undivided unit but may occupy less volume.

Disc Colourimetry : A technique by which an unknown colour is evaluated in terms of standard colours; used in chemistry and physics; may be visual, photoelectric, or indirect by means of spectrophotometry.

Dissociation : The process that may occur when a chemical compound breaks up into simpler constituents as a result of an action of a solvent or a change in physical condition, as in pressure or temperature, causes a molecule to split into simpler groups of atoms, single atoms, or ions.

Elasticity : The rate at which a deformed material goes back to its original shape.

Emulsifying agents : An agent used to bind oil soluble and water soluble ingredients.

Flavour : A combination of taste and odour or smell or aroma.

Gas chromatography : The separation of a mixture of compounds into separate components, which then can be analyzed by a mass spectrometer to yield detailed empirical molecular information regarding chemistry of sample.

Gas Liquid Chromatography : The substance is held stationary by an inert solid coated with an inert liquid which is not likely to evaporate, while a gas flows past it bringing out the components one at a time.

Grades : A set of things all falling in the same specified limits; a class.

Gumminess : The energy required to disintegrate a semi-solid food prior to swallowing.

Gustation : An act of tasting.

Luminosity : The quality of being luminous; emitting or reflecting light.

Mouthfeel : The mingled experience desiring from the sensation of the skin and the mouth during and after ingestion.

Objective Evaluation : Evaluation by mechanical test or instrumental methods.

Odour : The sensation that results when olfactory receptors in the nose are stimulated by particular chemicals in a gaseous form.

pH meter : A device used to measure hydrogen ion concentration or pH.

Quality : A degree of excellence and includes such things as taste, appearance and nutritional content. It is the composite of characteristics that have significance and which help in making the product acceptable.

Reaction time : The time interval between tasting of a substance and identification of the taste by the brain.

Recognition/Detection

Rheology : Study of stress and strain; the study of flow and deformation of materials, both liquids and solids under stress and strain conditions.

Sensory evaluation : When the quality of a food product is assessed by means of human sensory organs.

Shearing : The application of force where the test material is separated to two or more parts with one part sliding beyond the other part.

Spectrophotometer : An instrument for measuring or comparing the intensities of the colours of the spectrum.

Tensile strength : The application of force away from the material rather than towards the material.

Terminal Threshold : The maximum concentration beyond which taste or a change in sensation is not perceived.

Texture : A composite properly involving many physical properties in a complex relationship.

Threshold : The concentration required for identification.

Threshold : The concentration at which the subject can identify a specific taste. It is always higher than absolute threshold.

Tintometer : A measuring instrument used in colorimetric analysis to determine the quantity of a substance from the colour it yields with specific reagents.

Viscosity : The rate of flow per unit force.

Wavelength : The distance between successive peaks or nodes of a wave.

8.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1.

(i) colour, wholesomeness, gloss, degree of ripeness, smell, taste and texture

(ii) quality

(iii) sensory; subjective; organoleptic

(iv) appearance; texture and flavour

(v) texture

2.

a) taste

b) texture

c) appearance

d) odour

e) texture

f) taste

g) odour

h) appearance

i) texture

j) texture

Check Your Progress Exercise 2

1.

i) few important qualities.

ii) Sweet, sour, salty and bitter

iii) Organic compounds

iv) 10 ppm

2. The areas where various taste sensations are perceived are:

- Sweet taste: more on the tongue than on hard palate
- Bitter taste: hard palate
- Salty taste: tip of the tongue
- Sour taste: hard palate

3.

a) Threshold is the concentration required for identification

b) Reaction time is the time interval between tasting of a substance and identification of the taste by the brain.

4.

Concentration, taste interactions, Adaptations and time.

Check Your Progress Exercise 3

1.

(i) Texture is a composite property involving many physical properties in a complex relationship

(ii) The mingled experience arising from the sensation of the skin and the mouth during and after ingestion is referred to as mouthfeel.

(iii) Hardness is the force necessary to affect a given deformation.

(iv) Cohesiveness is the strength of internal bonds holding the body of the substance together.

(v) The rate at which a deformed material goes back to its original shape is referred to as elasticity.

(vi) Adhesiveness is the work necessary to overcome the attractive forces between surfaces of material and surfaces that contact it.

(vii) Chewiness is the resistance of a product to compression and shearing action of teeth, or the energy needed to masticate a solid food.

(viii) Rheology is the study of flow and deformation of materials, both liquids and solids, under stress and strain conditions.

2.

(i) Stimulating and measuring the sensations

(ii) Compression, cutting, shearing, tensile strength

(iii) Instron – texture measuring system

(iv) Dash pot model, spring model, spring clip model and shear pin model

(v) Gels of pectin, gelatin and starch baked custard

3.

(i) Meat - penetrometer; Warner Braztler Shear

(ii) Fruits and vegetables - punctured testing; shear press

(iii) Doughs and batters - line-spread apparatus; Farinograph; mixograph

(iv) Baked products - Shortometer; Compressimeter; Instron – texture measuring system

Check Your Progress Exercise 4

1. The functions of colour in foods are: as a ripening index, indicator of composition of food, allocation of different grades, determining the end point during processing, association with different flavours and indicator of standard of good quality.

2.

(i) Colour is the characteristic of light that is measured in terms of intensity and wavelength

(ii) Retention time is the time taken by the component to elute from the column.

3. Matching the colour of a food with coloured chips / glass, Disc colourimetry, Tintometers, Spectrophotometers and Tri-stimulus colourimetry.