

INTRODUCTION TO FOOD SCIENCE AND PROPERTIES OF FOOD

Abstract

Biological along with physical sciences and engineering are the disciplines in which the nature of food is studied and their deterioration caused by the food processing underlying principles is known as food science. It dealt with the changes or reactions that occur in food products due to induced or natural processes by the procedures of handling and made it clear with new knowledge. Food technology is the application of food science in which the major factors are the selection, processing, preserving, packing, and distribution of safe, healthy, wholesome, and nutritious food. It is based on the applications of the principles along with scientific facts, mathematics, and engineering for the preservation, processing, utilization, and storage safety of food. Food science and food technology are the disciplines in which different types of knowledge are linked and organized systematically which is required to inform for the purpose of effectively handling the food along with proper processing, distribution of food, and food marketing. In food technology, engineering concepts and principles are applied to the problems of handling food, processing food, and making changes in methods of handling and manufacturing along with the studies' interrelationship with the material properties. All the sense organs were involved during the selection of food including smell, sight, taste, touch, and hearing. The quality of various products is assessed with the help of the sensory organs of humans and this evaluation is known as the sensory or organoleptic or subjective. The sensory quality depends on various senses which are perceived by sense organs that play a role in the process of choosing food and

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eating. Whenever we eat food, we make a judgment. Various vocabulary words are used to describe the food product's sensory characteristics including taste, odor, texture, and appearance. This chapter will describe the enlarged knowledge of food technology, food science, and the mechanisms involved in it such as sensory evaluation.

Keywords: food science, Properties of food, Food Technology, Food Science, Sensory evaluation

I. INTRODUCTION

Biological along with physical sciences and engineering are the disciplines in which the nature of food is studied and their deterioration caused by the food processing underlying principles is known as food science. It dealt with the changes or reactions that occur in food products due to induced or natural processes by the procedures of handling and made it clear with new knowledge (Potter & Hotchkiss, 2012).

Food technology is the application of food science in which the major factors are the selection, processing, preserving, packing, and distribution of safe, healthy, wholesome, and nutritious food. It is based on the applications of the principles along with scientific facts, mathematics, and engineering for the preservation, processing, utilization, and storage safety of food (Clark et al., 2014).

Food science and food technology are the disciplines in which different types of knowledge are linked and organized systematically which is required to inform for the purpose of effectively handling the food along with proper processing, distribution of food, and food marketing. It also contains science and technology applications for preserving, processing, food packaging, and distribution along with food and food product utilization (Potter & Hotchkiss, 2012). The main aim and objective of this is to make a clear scientific understanding regarding food or food products as resolved via biochemistry, microbiology, physics, chemistry, and different sciences. Various kinds of processed and properly preserved foods are converted from raw agricultural substances or materials with the help of food science and food technology which helps in enhancing overall health, economy, living standard, and humanity's progress (Potter & Hotchkiss, 2012; Clark et al., 2014).

Food science involves a wide range of science such as biology including microbiology, botany, etc., chemistry including physical analytical, biochemistry, organic, etc., physics including thermodynamics, rheology, etc., nutrition, medicine including health and disease, psychology, and economics (Pomeranz, 2013; Boland et al., 2014).

In food technology, engineering concepts and principles are applied to the problems of handling food, processing food, and making changes in methods of handling and manufacturing along with the studies' interrelationship with the material properties (Fellows, 2022).

India is a country in which seasonal fruits and vegetables are grown in the season and also available in wide varieties. During the selection of fruits and vegetables, the factors we look for are color, gloss, degree of ripeness, wholesomeness, taste, smell, and texture. Selection through these attributes ensures quality. According to the definition, quality is the excellence degree that involves appearance, taste, and nutritional content. It plays a very crucial role in the acceptance of food products and is considered a significant quality or characteristic of food products (Hutchings, 2011).

All the sense organs were involved during the selection of food including smell, sight, taste, touch, and hearing. The quality of various products is assessed with the help of the sensory organs of humans and this evaluation is known as the sensory or organoleptic or

subjective. The sensory quality depends on various senses which are perceived by sense organs that play a role in the process of choosing food and eating (Sharif et al., 2017).

II. VARIOUS APPLICATIONS IN FOOD TECHNOLOGY

1. Food analysis along with the chemistry investigation of basic compositions and the biochemical, physical, and organic properties at the molecular level of various food constituents and the change the constituents go through during the methods of processing and storage (Awad et al., 2012). Changes are involved in these areas such as flavor, texture, color, and analysis of the effects that occur during processing on the food's nutritive value. Food analysts used various techniques for the lipids, proteins, carbohydrates, fats and oils, enzymes, colloids, emulsifiers, vitamins, oxidants, acids, antioxidants, flavors and pigments, and secondary metabolites of the plants in the food (Sikorski, 2006).
2. The measurements of food quality and their factor are appearance, nutritional, flavor, sanitary, textural, and the keeping factors, standard of quality, techniques of organoleptic evaluation and objective and the program, taste panels, consumer acceptance, physical along with chemical structure complex changes in the food that are influenced by various factors such as intrinsic and extrinsic (Barrett et al., 2010).
3. Food constituent's nutritive aspects along with the handling and processing such as nutrient stability, nutrients effects on the practices of agriculture, the process of processing, its handling and the storage of raw foods along with processed foods including the cultivation effects, cleaning, harvesting, preservation by freezing, treatment with heat, extrusion, baking, removing moisture, food additives, fermentation, home preparation effects along with the commercial practices of food service, ionizing radiation, complementation protein and enrichment of the foods, with the help of plant breeding improving the nutritional quality and the government's role in the regulation of nutritional value for the supply of food (Keding et al., 2013).
4. Mycology, toxicology, and food microbiology – use of molds, yeasts, and bacteria for food production and the ingredients of food – microorganism spoilage, foodborne pathogens indicators, presence of microbes in the fermentation, preservation and processing, detection, importance of food microorganisms physiology and their identification, culture of microbiomes, monitoring, methods of sampling and testing – developing methods for spoilage prevention for the processed foods, molecular biology tools for detecting the microbes, thermophiles, psychotropic, and microorganisms which are radiation-resistant, isolation and culture, biology, identifying the important fungi – fungal toxins quantification, toxicity, and the food toxins (Jay et al., 2008).
5. Safety and regulation of food – sanitation of food for the health of the public and the processing of food plants, USDA and FDA rules and regulations, labeling of food ingredients, the label of nutritive value, food additives, foodborne diseases, food laws, identification, detection, agencies that are governmental and nongovernmental concerned with the safety of food, recent issues such as the presence of salmonella in the eggs (Djukic et al., 2006; Shukla et al., 2014).

III.FOOD PRODUCT'S SENSORY CHARACTERISTICS

Whenever we eat food, we make a judgment. Various vocabulary words are used to describe the food product's sensory characteristics including taste, odor, texture, and appearance. In Table 1 sensory characteristics have been shown for the food products along with their vocabulary which is used to describe the characteristics of food (IGNOU, 2017b).

Table 1: Food Product's Sensory Characteristics

Odour	Taste	Appearance	Texture
Floral	Sweet	Heavy	Brittle
Perfumed	Bitter	Crystalline	Rubbery
Musty	Sour	Wet	Soft
Pungent	Cool	Cuboid	Sandy
Rotten	Warm	Fragile	Waxy
Acrid	Hot	Fizzy	Stodgy
Scented	Salty	Flat	Tender

The Table has been Adapted from IGNOU (2017b)

Food quality can have 3 different main categories such as appearance factor, flavor factor, and textural factor. These categories include: -

- 1. Appearance:** It is seen and judged by the eye. It includes various factors such as color, uniformity, size, shape, wholesomeness, absence of any defect, various forms of damage, transparency, gloss, along consistency. Let us understand this with some examples such as if the surface of a scrambled egg is dry then it will not be acceptable instead glossy surface of a fudge is highly acceptable. However, fish is selected by the quality of the eye of the fish by its brightness. Along with this other attributes of food also play a role such as the color and ripeness of various fruits that include mango, papaya, banana, tomato, etc. can be assessed. Chapati or toast if burnt then it will get rejected for its bitter scorched taste in anticipation. Therefore, the index of maturity of various foods is assessed by color and it is linked with other attributes such as texture and flavour in food along with its nutritive value Examples are pro-vitamin A or carotene. The attribute appearance not only covers color, it also covers size, greasiness, brightness, shape, transparency, etc., which should fulfill the expectations of consumers for the food products. So, it is crucial to pass the sight test for further sensory organ screening. Consistency is also considered a textural attribute of quality such as chocolate syrup that is thin-boiled and tomato sauce that is thin or thick. Similarly, as a sign of maturity size can be used to assess it such as the small size of a pea has shown less maturity and tenderness than the bigger ones. It also helps in making uniform product sizes and prevents the wastage of food giving high production and good quality products (IGNOU, 2017b).
- 2. Texture:** It is basically the mouthfeel or the touch. Food is taken to the mouth and the tongue surface along with other sensitive skin starts to react with the surface of food to feel the texture. Therefore, texture can be felt with the help of mouthfeel or hand feel which includes juiciness, firmness, grittiness, chewiness, and softness. With the help of

texture, one knows how much they like the food and it acts like a major determinant. The texture range is very great as it also shows the optimum or the typical deviation texture that is the quality defect. Potato chips and crackers should be crispy and easily compressible in between the teeth and chewing gum should be chewy is required. To select the bread, we first squeeze it to check whether the bread is fresh or not. To measure the texture refractometer is used (IGNOU, 2017b).

- 3. Flavour:** It is the factor that uses both sensations such as the sensation that is perceived by the tongue including salty, sour, and sweet along with bitter taste, and the aroma of food that is perceived with the help of the nose and tongue. Aroma or odor is the smell and taste is the combinations of flavor sensed through the nose and tongue respectively that are subjected largely and are difficult to measure. Rancid, citrus, strong, bland, mild, tart, spicy, weak, savoury, and tainted are the words that are commonly used to describe the taste of various food products that are illustrated in Table 1 (IGNOU, 2017b).

The factors that influenced the flavour were texture and colour. Certain colours are associated with certain flavours so let us understand this with an example strawberry, cherry, and raspberry, although these are compounds without colour, we generally associate them with colours as they occur in nature with specific colours. However, the evaluation of flavour can also be misleading through the texture. To understand this better let's take an example Suppose two similar samples of soups or gravies need to be judged then it is obvious that the thicker gravy has a higher chance of acceptance due to its rich flavours instead of the reason that it is thickened by using gum or tasteless starch that does not play any role in the flavour of the product and it can be totally psychological. It is not easy to differentiate the line between physiological and psychological reactions. The taste buds of humans react in a complex manner which is not clear fully yet.

To assess or measure the flavour sophisticated instruments are used including gas chromatography to measure the specific compounds that are volatile and responsible for a particular flavour and also can be assessed through sensory methods. To measure the acidity titrating by using alkali or through a pH meter is used. However, when consumer quality acceptance comes then nothing can substitute the measure that is made by people who tasted the products.

- 4. The Sense of Taste – Gustation:** Taste not only means the sensory response to the materials that dissolve in the mouth but also it is the aesthetic appreciation. Many times it is noticed that among the various senses of human taste has very poor relation. However, the contribution of taste has very less qualities that are important, to sum up, the human experience in comparison with vision. So, from a food scientist and food processor viewpoint, the sense of taste seeks interest in the role of recognition of food, its selection, and its acceptance along with its function of giving pleasure (IGNOU, 2017b).

It is already clear that taste is perceived by the receptors or taste buds that are present on the tongue. Taste is categorized by taste buds as salt, sweet, bitter, and sour. Salt and sweet taste is sensed by the tip of the tongue more intensely and bitter and sour on the hard palate more intensely. So there are four basic tastes explained further with factors affecting them.

IV. THE CHEMICAL CONSTITUENTS RESPONSIBLE FOR STIMULATING THE FOUR BASIC TASTES ON THE TONGUE ARE SWEETS, SALTS, SOUR AND BITTER

The chemical components responsible for the initiation of sweetness, salts, bitter and sour tastes are mentioned herewith (IGNOU, 2017b)

1. Sweet Taste

- **Sweet Taste:** Sweetness is the most potent taste sensation not only for humans but also for other animal species as well.
- The chemical components that provoke the 'sweet' sensation are basically organic compounds like simple sugar including mono and disaccharides such as glucose-fructose, sucrose and many other alcohols (such as sorbitol, glycerol, ethanol etc.). Some sweeteners are non-caloric or non-nutritive, which means they don't provide any calories but provoke a sweet taste such as cyclamate, saccharine, and aspartame.
- Additionally, sugar is the main foundation of sweetness in food, but not all sugar gives the same sweetness in the same amount. Fructose provides intensively most sweet sensation followed by sucrose, glucose, maltose, galactose and lactose respectively. Along with the sweet properties, the sugar (sucrose) performs additional functional properties such as texture modifier, mouthfeel modifier, bulking agent, preservative, and also the energy source for many foods fermentation.

The threshold value is the concentration required for the identification of the particular substance, which that means at that requisite threshold the particular particle can be identified and below which it cannot. So, for glucose, the threshold value is noted as 1.422%, for sucrose is noted as 0.342%, and for saccharine is 0.00047%.

2. **Salty Taste:** For the salt taste sensation, both the anionic and cationic ions are responsible. These ions include the K^+ (potassium), Na^+ (sodium), Br^{+2} (Bromine), Cl^{+2} (Chlorine), F (fluorine), I (iodine), Li^{+2} (lithium), NO_3 (nitrate), SO_4 (sulphate). The molecular weight consequently increases when we move from Li to NO_3 and the saltiness decreases. The salty taste is just due to the ions present in these salts; the Classic salt taste is epitomized by Sodium Chloride (NaCl) (IGNOU, 2017b). The threshold value for some salts is given herewith in Table 2.

Table 2: Salts and Their Threshold Values

Salts	Threshold values (%)
NaCl (sodium chloride)	0.175
LiCl (lithium chloride)	0.016
NaBr (sodium bromide)	0.247
NaI (sodium iodide)	0.42

The Table has been Adapted from IGNOU (2017b)

3. **Bitter Taste:** It is an inherent property of any substance. This is due to the presence of alkaloids, present in food or food substances. For example, tannin is the desirable alkaloid present in many foods such as tea, and coffee. When an apple juice is left outside for a while it gives a bitter taste is also due to the presence of tannin in it. Not only the alkaloids give a bitter taste but also some electrolytes give a bitter taste such as Ammonia (NH_3), magnesium (Mg) and some other nitro compounds. The greater the number of nitrogen compounds, the greater the bitterness in the food. Some of the amides (such as glycosides, and benzamides) are also known for their bitterness. Quinine found in citrus fruits and in grapes, lemonin in citrus fruits, caffeine, bromide and thromine in coffee, naringin in grapefruits, calcium, picric acid, ammonia, magnesium and many nitrous groups compounds are responsible for the bitter taste. Certain phenyl groups and urea also give the bitterness. The debittering can be done by using the supercritical fluid extraction method. In this technique, CO_2 , at the extreme critical pressure and temperature causes the extraction of bittering agents present in these foods (IGNOU, 2017b).
4. **Sour Taste:** This taste is usually due to the presence of acid (H^+ -ions) in the food or in foodstuff. The acids such as acetic acid, citric acid, benzoic acid and others. When these acids dissociate in water provide free H^+ -ions, which impart acidity. The greater the H^+ -ions concentration, the greater will be the acidity, which will impart more intensity of the sourness. The acids present in the fruits and the vegetable are tartaric acid (grapes and tamarind), and citric acid in lemon. Whether the acid is strong or weak only depends on the dissociation-ability in the water. The strong acid dissociates more shows more acidity, and imparts sourness to the particular substances. We know, that HCl is the strong acid apart from acetic acid is the more sour in nature, which indicates that the sourness also depends upon some other parameters. Among these is reaction time. A reaction time is a time interval between the substance tasting and the identification of the taste by the brain. As we know, everything is connected to our brain. So, the substances we taste are the impulse and are transmitted to the brain, then identification takes place, so the reaction time is nothing but a time interval between the initiation of the stimulus of the receptor and the final response (IGNOU, 2017b).

The acidic taste perceived to reaction time is inversely proportional to the concentration of the acid present in the food. The greater the acidic concentration, the lesser the time required. The individual has a different perception of the sour taste due to the difference in the pH of the saliva. Low-pH saliva will give a better perception of the sour taste.

V. FACTORS RESPONSIBLE FOR AFFECTING THE TASTE QUALITY

1. **Concentration:** Tasteful substances can be used at the desirable and at the specific range. The concentration is needed to identify the threshold of the particular substances. Within this range, the taste perception increases with an increase in concentration, and below or above this range the taste cannot adequately be perceived (IGNOU, 2017b).

The term threshold can be defined in two terms, absolute threshold and recognition threshold or terminal threshold. Absolute threshold is only detectable at minimum concentration and does not accurately define the concentration and it is a stimulus magnitude at which substance can be detected at the different tastes. The

terminal or recognition threshold is a threshold that can detect the specific taste at a particular concentration. The value of the terminal threshold is always higher than the absolute threshold. So, we can say that the terminal threshold is the maximum concentration of the substance beyond which tastes or changes in the sensation cannot be perceived, however, the substance is at its higher concentration.

The range starts from the absolute threshold to the terminal threshold. For the sweet substances, the range may vary widely, for the salty or sour substance its range is narrow, and the range for the bitter taste is very narrow. The range for the different tastes varies and is described herewith.

For sweet its range is 7-9% for all beverages and desserts, the higher concentration are used in jam and jellies preparation and just used for preservative purposes. For sour its range is 0.28% and for NaCl in cheese and butter 2%, and for the bitter its range is 0.0002% (IGNOU, 2017b).

- 2. Taste Interaction:** It is the other most important factor responsible for affecting the taste quality. As we know food contains a mixture of substances which produce all four sensations. The modification in one sensation takes place in the presence of other substances. For example, the addition of sugar or lemon juices to tea reduces the bitterness of the tea, which is suppressed after adding sugar or lemon juice to tea. Adding sugar or lemon to tea may cause to very bitter concentration, and modify the bitter taste (IGNOU, 2017b).

So, out of two sensations, the stronger sensation may suppress the effect of the other. For example, the tartness of the acid is minimized by adding a salt at its sub-threshold concentration. And adding a pinch of salt to sweet fruits to intensify the sweet taste or to make it in its more acceptable form.

- 3. Adaptation:** Now we will talk about the next important factor that affects the taste quality of the food. In this, if anyone taking or has a food with having high concentration, and immediately after that if takes the food having a low concentration, then the person will not be identify or perceive the sensation of the food having a lower concentration, This is due to the adaptation of tongue for the higher concentration of the food. For example, if the individual is taking soft/normal water for a longer time and if he suddenly drinks the hard water then he will perceive it as salty, this is because the mineral/groundwater contains various minerals and ion which gives the salty taste, as the distilled or purified water contains no ions and tastes as slightly sweet. After having sugary food, if anyone takes tea then he/she will not perceive the bitter taste of the tea just because of the adaptation of the tongue towards the sugary concentration (IGNOU, 2017b).
- 4. Reaction Time:** This is the last but not the least factor that affects sensation or the taste quality of the foods. Our tongue can sense salt in a very fraction of the time/seconds, whereas the bitter substances take a longer time to sense, say one full second. The Table 3 described below indicates the reaction times (in seconds) for the different tastes (IGNOU, 2017b).

Table: 3. Reaction Time as Per the Tastes

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

The Table has been Adapted from IGNOU (2017b)

VI. TEXTURE IN FOODS

Martz (1962) describes the texture as the mingled experience consequent from the sensation of the skin/muscle in the mouth after the ingestion of food or beverages. The texture is nothing but a physical characteristic of the food material. We generally concern ourselves with hardness of the tough meat, softness of the tender jellies, thickness of the sauce, bread elasticity, roughness of the salt crystal, stickiness of the caramel and chewiness of steak that realises the characteristic stimuli to the mouth present in the food (IGNOU, 2017b).

In other sense, texture of the food is nothing but a complex property that contains many physical properties, and the various constituents and the structural component of the food arranged in macro or micro structure and the external manifestation of the structure in the term of flow. The formation of the texture mainly influences:

- Consumers acceptability
- Packaging type
- Processing method of the food

The texture can be observed in the form of the tactile sensation i.e., mouthfeel and finger feel. The finger feel sensation is the sensation felt before the ingestion of the food, i.e., finding the freshness or the saltiness of the bread by hand feel, whereas the mouthfeel sensation is only felt when someone ingests the food, the mixed feeling derived from activation of palate and teeth.

The texture of the food can be felt when we chew the food by applying various kinds of pressure or force to the food. The forces such as tensile, cutting, compression and shearing, and during the objective evaluation of the textural properties these forces are limited. The mouthfeel sensation is derived from the sensation arising of the skin and the mouth during and after ingestion.

Szczezniac (1963) has classified the food based on the physical properties as mechanical characteristics (hardness, cohesiveness, viscosity, elasticity, and adhesiveness), Geometrical characterization (particle shape, size, and orientation) and other characteristics (moisture, fat content), as highlighted in below Table 4 (IGNOU, 2017b).

Table 4: Szczezmiac (1963) Has Classified the Food Based on Its Physical Properties

Sl. No.	Primary Parameters	Secondary	Popular nomenclature
1. Mechanical			
a.	Hardness		Softness firm to hardness
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-Goosey
2. Geometrical Characteristics			
a.	Particle shape and size		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

The Table has been Adapted from IGNOU (2017b)

1. **Hardness:** It may be defined as the forces necessary to destroy the structure of the given food. For the human senses, it is the force required to penetrate a food with molar teeth. Some solid and semisolid food have these properties. For example, cream cheese has low hardness and raw sugar candy is very hard (IGNOU, 2017b).
2. **Cohesiveness:** It is nothing but a strength derived from the internal bonding of the substances of the food. It includes brittleness, chewiness and gumminess. Brittleness is nothing but the cracking of the food then shattered or crumbling. Chewiness is the resistance of the product to compress and shearing action of the teeth/tongue (IGNOU, 2017b).
3. **Viscosity:** It measures the rate of the flow per unit force. The resistance of a liquid to the following. For example, in the mouth, it is sensed as thickness by a small variation of resistance against sensitive touch receptors of the lips, palates, cheeks and tongue (IGNOU, 2017b).

4. **Elasticity:** It defines the rate of the deformed material back to its original shape.
5. **Adhesiveness:** It measures the work necessary to overcome the attractive forces between the surface material and to which it contacts. While eating, this property is sensed between food and the teeth/tongue. Oil allows less adhesion while peanut butter most (IGNOU, 2017b).
6. **Colour:** It is an important attribute that indicates the quality of the food, and they do not influence the nutritional, flavour or functional quality of the food. Consumers strongly prefer the more coloured food. The colour is one of the most potent characteristics of the light that measures the intensity and wavelength of the food (IGNOU, 2017b).

The Function of the Colour in the Food

- It measures the maturity of fruits and vegetables, closely associated with colour development and change in colour.
- It indicates the freshness of the foods.
- The colour changes upon storage, so it indicates the shelf life of the food.
- It indicates the composition of the food, e.g., Egg yolk, and red tomato.
- It also helps to grade the food on the basis of its colour e.g., green tomato when ripped to tomato grades.
- It also helps to determine the end point of the storage and food processing.
- It indicates the flavour also, pink colour strawberry and orange colour oranges.

VII. CONCLUSION

It is already clear that taste is perceived by the receptors or taste buds that are present on the tongue. Taste is categorized by taste buds as salt, sweet, bitter, and sour. Salt and sweet taste is sensed by the tip of the tongue more intensely and bitter and sour on the hard palate more intensely. Szczezmiac (1963) has classified the food based on the physical properties as mechanical characteristics (hardness, cohesiveness, viscosity, elasticity, and adhesiveness), Geometrical characterization (particle shape, size, and orientation) and other characteristics (moisture, fat content). This chapter has concluded the broad aspect and application of food technology and food sciences, and how it impacts the sensory evaluation of individuals.

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