Fundamentals of Food Science and Beyond

Contributed by
Department of Food and Nutrition

ISBN: 978-93-6039-536-0

Swami Vivekananda University

Fundamentals of Food Science and Beyond

Swami Vivekananda University, Barrackpore (Institutional publisher)

Published by the Swami Vivekananda University (Institutional Publisher), Kolkata-700121,

West Bengal, India

ISBN: 978-93-6039-536-0

First Edition: November, 2023

Publisher: Swami Vivekananda University (Institutional Publisher), Barrackpore, W.B., 700121, India

Contact us: hod.nutrition@svu.ac.in

Preface

As we stand at the intersection of culinary artistry and scientific inquiry, this book seeks to unravel the mysteries that lie beneath the surface of the foods we consume daily. In the following pages, we embark on a journey through the fundamental principles that govern the creation, transformation, and enjoyment of food. The inspiration for this book stems from a profound fascination with the intricate dance of molecules, flavors, and textures that transpires within our kitchens. Food is more than mere sustenance; it is a mosaic of biochemical processes, sensory experiences, and cultural narratives. Through the lens of food science, we explore the alchemy behind the recipes, transforming the mundane into the extraordinary. In these chapters, we delve into the core concepts that define the field of food science, demystifying the complexities of ingredients, cooking techniques, and the physiological responses that make dining a multisensory delight. From the chemistry of caramelization to the physics of baking, every culinary phenomenon is dissected and explained with clarity and enthusiasm. This book is not just for the aspiring chef or the budding food scientist; it is for anyone who has ever marvelled at the wonders of a perfectly risen loaf of bread, a flawlessly emulsified sauce, or the symphony of flavors in a thoughtfully crafted dish. Whether you are a seasoned professional or a curious home cook, these pages are designed to deepen your appreciation for the science that underpins the culinary world. As we journey through the realms of taste, aroma, and nutrition, my hope is that this book serves as a bridge between the kitchen and the laboratory, fostering a greater understanding of the science behind the art of cooking. So, grab your apron and scientific curiosity, and let's explore the fundamental principles that make food not just a necessity but a celebration of life.

(Dr. Manisha Maity) 30/11/2023

Assistant Professor and HOD, Swami Vivekananda University
Barrackpore, W.B., India.

Author Details:

Mrs. Paromita Mukherjee
Assistant Professor and Co-ordinator,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Manisha Maity
Assistant Professor and Head,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Saheli Ghosal
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Souvik Tewari
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Moumita Dev
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Nabanita Ghosh
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Rupali Dhara Mitra
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Dr. Jagannath Ghosh
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

Ms. Shreyasi Das
Assistant Professor,
Department of Food and Nutrition, School of Allied Health Sciences
Swami Vivekananda University, Barrackpore, W.B., India.

CONTENTS

Chapter-1
Health & Healthy Wellbeing

Paromita Mukherjee

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: paromitam@svu.ac.in

1.1 Introduction to Health:

The ultimate achievement of one's life can be optimum sound health. World Health Organization (WHO) stated that, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Human health is a subject to be nourished by consumption of food we consume for maintenance & overall growth & development. Once when men used to be cave dwellers, this food was not easily available. Foods were being chosen by multiple trails and errors to find out the best suited source of edible things, that could be plant sources or animals.

A variety of cereals, fruits and vegetables, oilseeds, nuts have been started cultivating over the decades by human race; also rearing of birds and animals for use as livestock over the centuries, during the period of evolutions. Selection was very important in respect of obtaining health benefits. Since ancient era milks from different mammals also have been used as infant foods and also as beneficial edible substances for adults (Roberts et al., 2021). This chapter is going to give a clear picture of Food, relationship between food and health, classification and proximate components of food, concept of nutrients and discussion about five different food groups and many more.

1.2 Healthy Wellbeing:

As discussed in the earlier paragraph, food is to a human as soil is to trees. In accordance to the above, this will encompass some worthwhile issues such as; "What we consider as food"; "The impact that a person's dietary habit has on his/ her living habits" and "The necessity of a Healthy and Balanced Diet" (Buecker et al., 2021).

The following chapter will reveal the various aspects associated with the regular foods we consume along with the different elements of balanced diet and its impact on healthy wellbeing of individuals. Apart from balanced diet and its contribution to wellbeing this chapter will also discuss about the importance of exercises and sports activities for sound health and wellbeing.

1.3 What is Food?

The edible substances that provide the nourishing elements for body and energy for keeping us alive and working, in any state; that may be solid or liquid or in semi solid/semi liquid form, is known as food (Clapp, 2020).

After consumption of any edibles, that ingests inside the gastrointestinal system. The salivary enzymes start playing their actions over the food for primary digestion inside buccal cavity and turns the food particle into bolus. This bolus starts travelling in the downward direction, reaches into the stomach where it gets fully digested sparing the carbohydrate. Here the bolus gets converted into chyme, and goes inside the small intestine. This SI is the organ from where nutrients get absorbed into the blood stream via intestinal epithelial linings and gets transported to all those areas where ever there is a need (McQuilken, 2021).

1.4 Relationship between Food and Healthy Wellbeing:

From earlier discussion, it is now quite clear that food is that organic or inorganic edible substance which helps in overall growth development and nourishment of human body. Here, nutrition is physiological approach of human body where the consumed food is being ingested, digested, absorbed, assimilated and metabolized in every cell and produce the end products of metabolism in form of energy (Hsu et al., 2022). Human biochemistry is the subject which encompasses food, physiological pathways of their absorption and metabolism for their assimilation. Food that leads to nutritional way for assimilation of the proximate components of foods in our body, are mostly responsible for wellbeing of our life. This is the reason food is prime element of our healthy wellbeing (Edinburgh et al.,2020). Several scientific researches reveal that, good nutrition is important for-

- Enhancement of physical development
- Enhancement of Cognitive ability during formative years of life
- Improvement of breast milk production
- Strengthening the immune system of body
- Building up the protection against interaction of microbe in human systems.

The high-end affluent part of our society may have privilege to be free from malnourishment caused by lack of food but in the lower strata of society in our country, malnutrition is the very common burning crisis (Siddiqui et al., 2020). Lack of education, awareness, lack of availability of food in the period of pregnancy, lactation and in infancy period is the major causative threat

for public health (Landi et al., 2019). Whereas in affluent part of our country, illness like diabetes mellitus type 2, obesity, hyperlipidaemia, atherosclerosis are very common because of the excess consumption of processed foods, zero calorie foods like burger, pizza, frozen meat etc (Volaco et al., 2018). The foods we consume, should be metabolised inside human body in the process of nutrition, in case there is any disorder of normal metabolic pathways a varied number of diseases may take place (Upadhyay et al., 2018).

1.5 Functions of Food

Food can be grouped into three kinds of functions, those are; Physiological Functions, Social Functions and Psychological Functions respectively.

Physiological Functions:

1. Food provides energy for keeping us active and for maintaining thermogenesis of body
2. Food provides with physiological and cognitive development in human
3. Food regulates our immunological system in an ever progressive manner
4. Cell division and reproduction needs thermal effects and energy which comes from food
5. Food regulated overall physiological processes for making us alive.

Social Functions:

Food carries immense value in social gathering and rituals. We all know every culture, religion and caste holds their special food preparations along with different cooking recipes & ingredients. For example, in the festival of Eid; Simai, Halim etc takes major role for satisfying the rituals whereas, Payasam, Khichdi Bhog have their own cultural & ritualistic values associated with Durga Puja. Diwali reminds us the tastes of Kaju katli, Soan papdi etc. However, in different social functions, variety of foods hold their importance too. Marriage ceremonies, Upanayan, Sradhh are the social functions which come with different essence and preparations of foods; selections of menus are also important in these different social, ritualistic functions. Also, for showing love and respect to dear one's special food preparation have a dignified social value (Barthes, 2018).

Psychological Functions:

Food holds a psychological aspect along with social impacts. In addition with imparting nutritional aspects, food provides us with its taste, appearance, essence , flavour and odour , also the texture of it enhances the psychological state ie. mood upliftment. One can easily gets driven with his best choice of food. Even in depression or condition of poor mental health, one's favourite food can make him/her to feel good. Endorphin is the hormone, related with mood upliftment, secrets with the odor , essence and also with the presence of the favourite foods. For example, dark

chocolate plays the role for this mood upliftment in a great way. Also, the mental states like frustration, anxiety can gets removed simply by the selection of good food and their ingestion (Okumus et al., 2018).

1.6 Classification of foods according to their functions:

As the functions of food already being discussed, now it will be easily understandable how foods are categorized according to their different functions.

Energy yielding/producing foods:

Carbohydrates enriched foods along with fatty foods, produces calorie/energy in form of ATP in metabolism (Petrus et al.,2021). Hence, they are known as energy producing or energy yielding foods. The energy we obtain from these foods helps to carry out all the voluntary and involuntary physiological processes. Oxidation is one of the chemical reactions, which produces the energy by oxidising the food substances in metabolic pathways (Martino et al., 2023). Some of the examples are cereal and cereal products, tuber & root vegetables, Butter, ghee, oils etc.

Body building foods:

Body mass development is one of the important roles of food we consume, from the infancy, throughout adulthood and even in geriatric period of life (Dey et al., 2022). Not every food gets assimilated in body and contributes to muscles development, expect for the foods enriched with protein. These protein rich foods also help in promoting healthy lean muscle mass and decrease the extra adipose tissues (Montuori et al., 2021). Some of the items from foods aids in body mass development, are- Milk, Meat, Eggs, Fishes, Nuts, Pulses etc.

Protective foods:

Another important function of foods is to protect human body from external foreign particles and protection from infectious agents which cause diseases and infections. Also, if any infection takes place, food should enhance the mending procedures to reduce inflammation and other complications associated with it. Foods which are specially known for carrying out these healing, mending, and protecting roles against diseases are known as protective foods. Protein rich foods along with minerals & vitamins rich foods take parts in these actions (Jayathilake et al., 2021). Hence, protective foods are being categorized into two forms-

- Foods enriched with proteins - Milk, eggs and liver.
- Foods enriched with minerals and vitamins only- GLVs and fruits

This following table contains classification of food with the respective food sources.

CLASSIFICATION OF FOODS	FOOD SOURCES
Energy yielding foods	Millets, Sorghum, Whole wheat Flour, Whole Grain, Cornflakes, White Rice, Brown Rice, butter, beef fat, chicken fat, pork fat (lard), Potatoes, Yum, Pumpkin, Sunflower Oil, soybean Oil, corn/maize Oil, Milk fat (ghee), groundnut, sesame oil, olive, sunflower, cottonseed Oil, palm oil
Body Building Food	**Animal Sources**: Beef, Poultry foods, lamb, pork, veal and game meat, Chicken, Eggs, Turkey, Silverfish, tilapia, catfish, mudfish, Milk, cheese, yoghurt, Liver, giblets, offal, kidney **Plant Sources**: chickpeas, , common beans, iron-rich beans, lentils, pegion beans, soybeans, peas, soy milk, soy flour, roasted soy snacks, groundnuts, cashew nuts, sesame seeds.
Protective Food	Spinach, amarantha, cow pea leaves, sweet potato leaves, broccoli, lettuce, hibiscus leaves, Carrots, pumpkin, red peppers, sweet potatoes, tomatoes, red amaranths, red hibiscus, Beet roots, cabbage, cucumbers, cauliflower, green beans, mushrooms, onions, Bananas, pineapples, papaya (Paw paw), mangoes, beans sprouts, guavas, oranges, jack fruit, apples, avocado, orange, apple, grapefruit, melon.

1.7 Proximate Components of Foods:

Food which can be obtained from animal and plant origin/sources, as discussed in the table given, produces energy for our activities of daily life. The substances present in foods and provides nourishment to our body in form of energy or heat generation, body mass developments, protection from infectious agents are the proximate components of foods, which are being known as nutrients.

Maintenance of physiological and metabolic functions is one of the prime need of human health which is being carried out with the help of nutrients. Energy productions, thermogenesis, enhancing immunity are some of the examples of this. In addition of water the nutrients obtained for dietary sources helps in all these physiological actions (UNICEF, 2021).

Carbohydrates:

The major source of calorie and energy production in human body is carbohydrate. They are of different chemical structures: Monosaccharides, Disaccharides, Oligosaccharides, Polysaccharides. 50% to 60% of energy for our daily living and activities come from carbohydrate consumption. Easily available and cheaper source of energy is this nutrient, easily obtained from rice, wheat, barley, maize, millets etc. (Holesh et al., 2023)

Every different individual have different and varied ranges of carbohydrate requirements, depending on gender, age, gender and individual's level of physical activities. 45% to 65% of total energy is required from 2000–3000 kilocalories. 1 gram of carbohydrates provides 4 kilocalories (Geosskopf & Simm, 2020).

Proteins:

Mass development and muscle growth improvement depends on the proximate energy, known as protein. In formative and developing years of children, protein is one of the major components which develops body mass, deficiency leads to kwashiorkor, which develops due to inadequate protein intake (Verzola et al., 2020).

Amino acids are the functional and structural blocks of protein. These even different in numbers and structure depending on the types of protein. Protein intake recommendation according to ICMR prescribed RDA, its 1 gram per kg of one;s body weight (Iddir et al.,2020). However, children, teenagers, and pregnant and lactating mothers require more protein as indicated below:

For Children it ranges: 30–50 g

For Teenagers it ranges: 60–75 g

For Adults it ranges : 60–70 g

Expecting women and nursing mothers: 90 grams

Fats:

The proximate components of food that generates thermogenesis for producing heat and energy in human body are, fats and oils. Deficiency of dietary fat consumption leads to several disorders like development of bile stone, skin disorder like phrynoderma.

1 g of fat produces over 9 kcals.

Limited consumption of saturated fat should be recommended, the higher limit of daily oils or fat intake should not exceed 25% of total kilocalories of the daily requirements (Dahl et al., 2020).

Minerals:

Dietary minerals, those are being ingested by regular food substances are considered as micro nutrients. Micro nutrients in form of vitamins are important for protective functions of human body. Dietary minerals, those are important for human are calcium, phosphorous, potassium, sodium, chloride, magnesium, iron, copper, fluorine, iodine, zinc (Godswill et al., 2020).

Iron is one of the essential minerals, which is important for development of red blood cells, in term of haemoglobin formation, important for the conduction of oxygen in body tissues. Red meat, poultry foods, different legumes, GLVs are some of the important sources of dietary iron. Iron absorption gets promoted with increasing consumption of vitamin C along with the sources of iron.

Calcium is that micronutrient, except which the developments of teeth and bones can not be possible. Most importantly dietary calcium can be obtained from milk and milk products. Apart from milk and milk products calcium can also be fetched from dark green veggies, fish bones etc. Deficiency of this nutrient may lead to ricket, osteoporosis etc.

Iodine is the nutrient which plays pivotal role in cognitive developments of children in formative years. Mental retardation is evident due to lack of iodine in children's diet. In adults, deficiency of thyroid leads to thyroid hormone malfunctioning, results in goitre, hyperthyroidism, hypothyroidism etc. Iodized salt is one of the important dietary sources of iodine.

Zinc contributes in building up and development of protection of human body through an impeoved immunity, promotes mending and healing functions of body. Zinc is important component of human nervous system and for the maintaining synaptic connections. Some of the resources of dietary zinc are- liver, beans, nuts, whole grains, seafood, etc.

Other minerals namely, chromium, copper, fluoride, magnesium, manganese, molybdenum, nickel, potassium, phosphorus, sodium and selenium carry out several immune boosting, healing, protecting and mending activities of body.

Vitamins:

A group of Micronutrients, with own vital activities, taking part in specific physiological activities, are known as vitamins. They are non-negotiable component containing certain chemical structures. Researchers found 17 vitamins so far. A varied number of diseases may take place in infancy and throughout all age groups as result of vitamin deficiency. Also, excessive consumption of vitamins results into vitamin toxicity (Weikert et al., 2020).

Vitamins are grouped into two types –

- Fat soluble vitamins for example Vit. A, D, E and K.
- Water soluble vitamins for exampleVit. B_1, Riboflavin, Vit. B_6, Vit. C etc. Niacin, Panthothenic acid, Folic acid.

1.8 Balanced Diet:

Healthy life and healthy wellbeing are the utmost focuses of human life, which should be achieved. The chapter is concentrating on the measures of accomplishing wellbeing of life. Balanced dietary practice is one of the prime gateways for obtaining good health and wellbeing (Banerjee, 2021).

The balanced diet is one of the diet protocols which can be defined as varied quantity of foods from different food groups in a patter so that it can accomplish all the required nutrients in form of energy, protein, minerals, oils, vitamins, and fluid, also in case of illness a relaxation of nutrient intake should be given in balanced diet (Jayawardena & Misra, 2020).

A balanced diet is a platter of all the nutrients in correct and proper quantities. Correct selection of foods from different group makes the menu plan balanced. According to the different age groups the quantity of different food groups vary (Reji et al., 2020).

Followings are the aspects of balanced diet:

A BALANCED DIET CONSISTS OF DIFFERENT ITEMS.

A balanced diet should assure a completeness with the different menus from all the food groups, will be discussed later in the chapter. All the nutrients in adequate amounts should be obtained from a ideal balanced diet.

SELECTING ITEMS FROM DIFFERENT FOOD GROUP

Including items from each five-food group established by ICMR, ensures that all the nutrients will be supplied.

A BALANCE DIET MEET THE NUTRIENTS NEEDS

All the proximate components, termed as nutrients must be available and be supplied from a balanced diet menu plan.

BALANCED DIET SHOULD FOLLOW FOOD PYRAMID OR MYPLATE

It should be kept in knowledge the proper portion and serving sizes of foods to be kept in the prescribed balanced diet according to food pyramid and My plate.

1.9 Components of Balanced Diet:

A proper balanced diet is based on some non-negotiable components, on which the balanced diet is based upon. Those are:

- ICMR recommended Five Food Groups
- ICMR recommended dietary guidelines
- Food Guide Pyramid
- My Plate

These are inseparable elements for prescribing a balanced diet because, balanced diet must be included with different foods from each food group with proper serving sizes by taking reference from Food Guide Pyramid and My Plate.

1.10 Five Food Groups:

ICMR has recommended the five groups of food, that has been discussed in this chapter.

Cereals, Grains and Products:

Grains or Cereals - Rice, Wheat, Barley, Oats, Rye.

Millets - Ragi, Maize, Jowar, Kodo millet Little millet, Prosno Millet, Bajra

Cereal Products - Flakes, Flour, Puffed products.

Pulses and Legumes:

Pulses - lentils, Black gram, Green gram, Bengal gram, Red gram, Horse gram, Cow pea.

Beans- Broad bean, Field bean, Haricot bean, Lima bean, Moth

Milk and Meat Products:

Milk - Curd, Skimmed Milk, Cheese, Khoa, Chicken, Liver, Fish, Egg, Beef, Mutton, Pork.

Fruits and Vegetables:

Fruits – Apple, Banana, Pomegranate, Guava, Tomato, Papaya, Orange, Melons, Berries, Watermelon.

Vegetables:

Green Leafy: Spinach, Drumstick leaves, Amarnath, Cabbage, Coriander leaves, Mustard leaves, fenugreek leaves, cabbage.

Roots and tubers: Radish, Carrot, Onion, Potato, Yam. Beetroot, Tapioca.

Other Vegetables: Brinjal, Ladies fingers, Capsicum, Beans, Drumstick, Cauliflower, bottle gourd, snake gourd.

Fats and Sugars:

Fats - Butter, Ghee, Hydrogenated fats, cooking oils like Groundnut, Mustard, Coconut.

Sugars: Sugar, Jaggery

The five-food group system can be used for the Planning wholesome balanced diet plan or menu plan to achieve nutritional adequacy (Deepthi et al., 2020).

1.10 Dietary guidelines of ICMR to ensure a balanced diet:

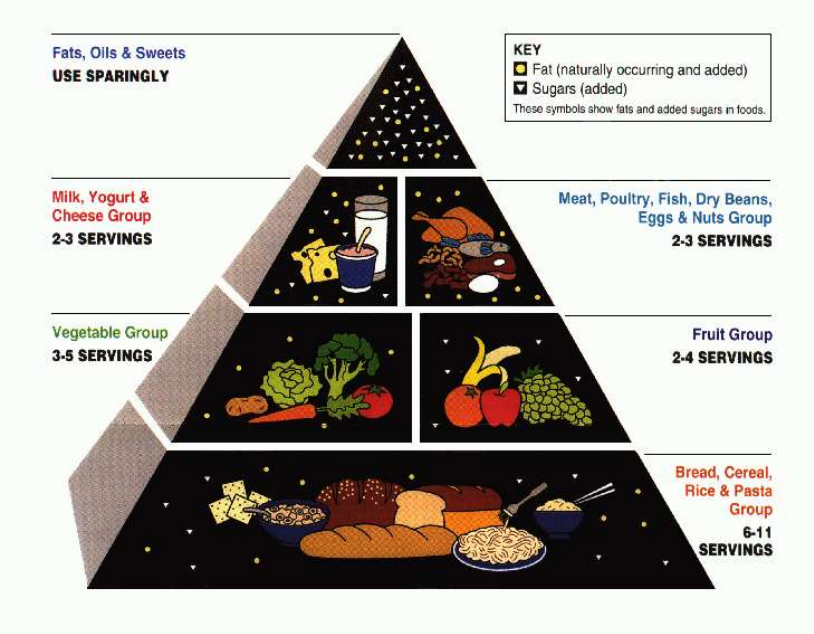
The ICMR has provided guidelines for Indians to ensure balanced diet. The guidelines are as follows:

- Five food groups will be utilised in one's menu planning, that will be looked acceptable, attractive food plate, with supply of all the required nutrients.
- Different combination of edibles will be important for the diet, edibles from different groups of food; which has already been discussed
- Whole grains, grains, pulses, millets and their products will be important as primary foods to be kept in menu planning.
- For infants, children, those who do not have lactose intolerance must be recommended with milk in their daily diet. At least one exchange of milk should be suggested.
- Oils is one of the important proximate components for thermogenesis but must not exceed given limit.
- Eggs, flesh food, meat are important dietary sources for mass development in human body.
- Vitamins, phytonutrients & essential vitamins are important for strengthening immune system, can be obtained from GVLs, dark leafy veggies, variety of fruits (Sharma & Dhawan, 2023).

1.11 Food Pyramid:

A pictorial diagram, triangle in shape which reveals maximum servings, that should be optimum in respect of serving from different groups of food. This triangular diagram is Food guide pyramid. The soul purpose of this food guide pyramid is to provide optimum nutrient (Aigner et al., 2021).

The United States Department of Agriculture (USDA) brought forward a guide on food and nutrition known as the "Food Guide Pyramid" in 1992. The main reason for introducing this guide was to provide a generic diet to consumers for them to decipher the intricacies of a dietary plan for each day. Per studies, it was noted that 50 to 60 % of a balanced diet should compromise of carbohydrates which are complex in form, eg-whole grains, multigrain, unpolished rice etc. This in essence forms the bible of the Food Pyramid (Waidi et al., 2021). It is recommended that a structured food plan would include a serving of cereals to the extent of 6-11 times per day along with a serving of vegetables to the tune of 3-5 servings in order to provide a balance of vitamins, minerals and dietary fibre. Additionally, it is recommended to include at least 2-3 instances whereby an individual consumes Pulses, Dairy and Dairy Products along with Proteins such as Meat (Lean and Normal), Fishes and Eggs. This constitutes 10-15% of protein intake recommended for an average adult. It may be noted that an ideal food guide pyramid includes healthy fats, sugars as well as oils within prescribed limits to ensure that there are no adverse effects of the diet (Vlassopoulos et al., 2022).



Source: Food Guide Pyramid USDA

Food guide pyramid helps us to decide the ideal portion of food in each serving size. Food guide pyramid tells that, Major resources like Cereals, pulses, millets, milk for most of the proximate compounds of foods, should be in taken **adequately**. Milk, green leafy veggies, different seasonal

fruits are the harbour of protective components, in term of vitamins/minerals/ phytonutrient, one should incorporate in daily diet, **liberally**.

A great source of protein and dietary iron can be opined as Meat and Meat products. Oils and lipids, also meat & various meat products should have a moderate limit, while consuming. **Lastly,** processed foods, sugary foods should be consumed **sparingly** (Fernandez et al., 2021).

1.12 My Plate:

Myplate is the new age concept for dietary guideline, introduces by USDA for the purpose of assisting and helping people world wide in their selection of foods with respect of nutritional aspects. In this view USDA introduced another guideline, as a replacement Food Guide Pyramid, which is termed as MyPlate. Myplate suggests a combination of healthy food choices. This helps consumers to achieve a gateway for making healthy food choices (Wansink & Wansink, 2021).

This guideline of healthy food choice, MyPlate, is basically a pictorial diagram of a multicoloured plate with four divided areas for Fruit, vegetables, grains and proteins in form of eggs/lean meat respectively along with dairy food group on the out skirt of the plate.

30% cereals, 40% vegetables, 10% fruits and 20% protein- the sections planned in myplate in the pictorial diagram , along with a glass full of dairy , in form of milk or curd (Westfall et al., 2020).

Source: USDA MyPlate

1.13 Impact of Physical Activities over Healthy Wellbeing:

Along with healthy balanced dietary practices physical activities have countless impact on several health benefits and wellbeing.

Over the decades, researchers have found that physical activities in form of different sports and in form of exercises reflect over one's livelihood (Battista et al., 2021). Studies reveal that people practicing any sports activity at least 5 days a week can live a healthier life. For improving blood circulation, endurance, neural connectivity, improvement of joints, bone health, even for improving bone density; physical activities are non-negotiable for achieving a healthy wellbeing. Cognitive and psychological status improvement can be expected from exercise practitioners. Physical activities can be in form of sports or exercises enhance overall health status and improve physiological & cognitive health of individuals (Ramos et al., 2022).

The health benefits obtained by optimum level of physical activities will be discussed in this chapter.

Let us know, what is exercise and how exercise is different than sports activities.

1.14 Understanding of Exercises and Sports:

Exercise can be described as movement of body in proper manner under supervision or without supervision for achieving overall health status for self. Whereas, Sports can be any casual or organized participation into a game in strong sense of loss or win.

In other words, exercises are a planned, structured bodily movement, which is focused towards improving or maintaining physiological state and fitness Whereas we can define sports as a competitive form of different exercises together to accomplish a single goal with other participants in one team or as a single participate (Koch at al., 2020).

1.15 Health benefits of Exercises and Sports:

Several health benefits has been documented as the beneficial effect of exercises. Exercise is repetitive body movement for a proper goal accomplishment, directed towards a varied number of health improvement and disease termination. Increase of good cholesterol, decrease of bad cholesterol, improvement in lung capacity, improved muscles mass, strength, endurance, controlling the risks of osteoporosis and osteoarthritis are the boon of exercises and to achieve a healthy life. (Thyfault & Bergouignan, 2020).

References:

Roberts, S. B., Silver, R. E., Das, S. K., Fielding, R. A., Gilhooly, C. H., Jacques, P. F., ... & Booth, S. (2021). Healthy aging—nutrition matters: start early and screen often. *Advances in Nutrition*, *12*(4), 1438-1448.

Buecker, S., Simacek, T., Ingwersen, B., Terwiel, S., & Simonsmeier, B. A. (2021). Physical activity and subjective well-being in healthy individuals: a meta-analytic review. *Health Psychology Review*, *15*(4), 574-592.

Clapp, J. (2020). *Food*. John Wiley & Sons.

McQuilken, S. A. (2021). Digestion and absorption. *Anaesthesia & Intensive Care Medicine*, *22*(5), 336-338.

Hsu, M., Safadi, A. O., & Lui, F. (2022). Physiology, Stomach. In *StatPearls [Internet]*. StatPearls Publishing.

Edinburgh, R. M., Bradley, H. E., Abdullah, N. F., Robinson, S. L., Chrzanowski-Smith, O. J., Walhin, J. P., ... Gonzalez, J. T. (2020). Lipid metabolism links nutrient-exercise timing to insulin sensitivity in men classified as overweight or obese. *The Journal of Clinical Endocrinology & Metabolism*, *105*(3), 660-676.

Siddiqui, F., Salam, R. A., Lassi, Z. S., & Das, J. K. (2020). The intertwined relationship between malnutrition and poverty. *Frontiers in Public Health*, *8*, 453.

Landi, F., Camprubi-Robles, M., Bear, D. E., Cederholm, T., Malafarina, V., Welch, A. A., & Cruz-Jentoft, A. J. (2019). Muscle loss: The new malnutrition challenge in clinical practice. *Clinical Nutrition*, *38*(5), 2113-2120.

Volaco, A., Cavalcanti, A. M., & Précoma, D. B. (2018). Socioeconomic status: the missing link between obesity and diabetes mellitus?. *Current diabetes reviews*, *14*(4), 321-326.

Upadhyay, J., Farr, O., Perakakis, N., Ghaly, W., & Mantzoros, C. (2018). Obesity as a disease. *Medical Clinics*, *102*(1), 13-33.

Barthes, R. (2018). Toward a psychosociology of contemporary food consumption. In *Food and culture* (pp. 13-20). Routledge.

Okumus, B., Ali, F., Bilgihan, A., & Ozturk, A. B. (2018). Psychological factors influencing customers' acceptance of smartphone diet apps when ordering food at restaurants. *International Journal of Hospitality Management*, *72*, 67-77.

Petrus, R. R., do Amaral Sobral, P. J., Tadini, C. C., & Gonçalves, C. B. (2021). The NOVA classification system: a critical perspective in food science. *Trends in Food Science & Technology*, *116*, 603-608.

Di Martino, M., Linke, P., & Pistikopoulos, E. N. (2023). A comprehensive classification of food-energy-water nexus optimization studies: State of the art. *Journal of Cleaner Production*, 138293.

Dey, N., Kumar, G., Vickram, A. S., Mohan, M., Singhania, R. R., Patel, A. K., ... & Ponnusamy, V. K. (2022). Nanotechnology-assisted production of value-added biopotent energy-yielding products from lignocellulosic biomass refinery–a review. *Bioresource technology*, *344*, 126171.

Montuori, P., Loperto, I., Paolo, C., Castrianni, D., Nubi, R., De Rosa, E., ... & Triassi, M. (2021). Bodybuilding, dietary supplements and hormones use: Behaviour and determinant analysis in young bodybuilders. *BMC Sports Science, Medicine and Rehabilitation*, *13*, 1-11.

Jayathilake, P. A. L., Jayasinghe, M. A., Walpita, J., & Dilani, K. P. R. I. (2021). Turmeric and ginger as health protective food sources-an integrative review.

UNICEF. (2021). The state of food security and nutrition in the world 2021.

Holesh, J. E., Aslam, S., & Martin, A. (2023). Physiology, carbohydrates. In *StatPearls [Internet]*. StatPearls Publishing.

Grosskopf, A., & Simm, A. (2020). Carbohydrates in nutrition: friend or foe?. *Zeitschrift für Gerontologie und Geriatrie*, *53*(4).

Verzola, D., Picciotto, D., Saio, M., Aimasso, F., Bruzzone, F., Sukkar, S. G., ... & Garibotto, G. (2020). Low protein diets and plant-based low protein diets: Do they meet protein requirements of patients with chronic kidney disease?. *Nutrients*, *13*(1), 83.

Iddir, M., Brito, A., Dingeo, G., Fernandez Del Campo, S. S., Samouda, H., La Frano, M. R., & Bohn, T. (2020). Strengthening the immune system and reducing inflammation and oxidative stress through diet and nutrition: considerations during the COVID-19 crisis. *Nutrients*, *12*(6), 1562.

Dahl, W. J., Mendoza, D. R., & Lambert, J. M. (2020). Diet, nutrients and the microbiome. *Progress in molecular biology and translational science*, *171*, 237-263.

Godswill, A. G., Somtochukwu, I. V., Ikechukwu, A. O., & Kate, E. C. (2020). Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: A systematic review. *International Journal of Food Sciences*, *3*(1), 1-32.

Weikert, C., Trefflich, I., Menzel, J., Obeid, R., Longree, A., Dierkes, J., ... & Abraham, K. (2020). Vitamin and mineral status in a vegan diet. *Deutsches Ärzteblatt International*, *117*(35-36), 575.

Deepthi, R., Anil, N. S., Narayanaswamy, D. M., & Sathiabalan, M. Recommended dietary allowances, ICMR 2020 guidelines: A practical guide for bedside and community dietary assessment–A review.

Banerjee, N. (2021). Physical exercise and balanced diet for healthy body and mind. *Basic and applied sciences into next frontiers: the aspects of bio and physical sciences*, 173-183.

Jayawardena, R., & Misra, A. (2020). Balanced diet is a major casualty in COVID-19. *Diabetes & metabolic syndrome*, *14*(5), 1085.

Reji, K., Jacob, L., Liby Kuriakose, L. K., Augustine, M., George, M., & PR, A. (2020). Balanced diet: knowledge and practice of adolescents. *Indian J Public Health Res Dev*, *11*, 114-118.

Sharma, S., & Dhawan, D. (2023). Diet: The Balancing Act. *Resonance*, *28*(6), 907-922.

Fernandez, M. L., Raheem, D., Ramos, F., Carrascosa, C., Saraiva, A., & Raposo, A. (2021). Highlights of current dietary guidelines in five continents. *International Journal of Environmental Research and Public Health*, *18*(6), 2814.

Aigner, C., Resch, E. M., El Agrod, A., Baranyi, R., & Grechenig, T. (2021, August). Food Pyramid Escape-A serious escape game for the support of nutritional education in Austria and beyond. In *2021 IEEE 9th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1-8). IEEE.

Waidi, S. A. A., Ibrahim, A. B., Ariffin, A. H., Yunus, M. S. F. M., Razak, N. A., & Rasli, R. M. (2021). Development of food pyramid application using Augmented Reality (AR) technology. *Journal of Information and Communication Technology in Education*, *8*(4), 22-31.

Vlassopoulos, A., Katidi, A., Savvidou, T., & Kapsokefalou, M. (2022). Alignment of Nutri-Score with Mediterranean Diet Pyramid: A Food Level Analysis. *Nutrients*, *14*(23), 5097.

Wansink, B., & Wansink, A. (2021). MyPlate, Half-Plate, and No Plate: How Visual Plate-related Dietary Benchmarks Influence Meal Composition. *medRxiv*, 2021-08.

Westfall, M., Roth, S. E., Gill, M., Chan-Golston, A. M., Rice, L. N., Crespi, C. M., & Prelip, M. L. (2020). Exploring the relationship between MyPlate knowledge, perceived diet quality, and healthy eating behaviors among adolescents. *American Journal of Health Promotion*, *34*(7), 713-721.

Ramos, C., Gibson, G. R., Walton, G. E., Magistro, D., Kinnear, W., & Hunter, K. (2022). Systematic review of the effects of exercise and physical activity on the gut microbiome of older adults. *Nutrients*, *14*(3), 674.

Battista, F., Ermolao, A., van Baak, M. A., Beaulieu, K., Blundell, J. E., Busetto, L., ... & Oppert, J. M. (2021). Effect of exercise on cardiometabolic health of adults with overweight or obesity: Focus on blood pressure, insulin resistance, and intrahepatic fat—A systematic review and meta-analysis. *Obesity Reviews*, *22*, e13269.

Koch, E. D., Tost, H., Braun, U., Gan, G., Giurgiu, M., Reinhard, I., ... & Reichert, M. (2020). Relationships between incidental physical activity, exercise, and sports with subsequent mood in adolescents. *Scandinavian Journal of Medicine & Science in Sports*, *30*(11), 2234-2250.

Zarotis, G., & Tokarski, W. (2020). The effect of recreational sports on human health. *Journal of Sports and Physical Education*, *7*(3), 25-33.

Thyfault, J. P., & Bergouignan, A. (2020). Exercise and metabolic health: beyond skeletal muscle. *Diabetologia*, *63*, 1464-1474.

Chapter-2
Functional Foods

Manisha Maity

Assistant Professor and Head, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: manisham@svu.ac.in

2.1. Introduction

Several foods are reported as "functional foods". Functional foods are basically defined as "foods that have a potentially positive effect on health beyond basic nutrition" (Temple et al., 2022). The establishment of the definition of functional food was done by Japan in 1991. Then it was given the definition "foods for special health use" (FOSHU). After that, FOSHU was allowed for labelling. FOSHU cannot be taken as a supplement, but it should exhibit positive health effects.

The second definition of functional foods was established by "Functional Food Science in Europe" (FUFOSE). According to them, functional foods cannot be taken as a capsule, pill, or supplement but may be taken as part of our regular diet.

A new definition has been given by the Functional Food Centre (FFC) as "natural or processed foods that contain known or unknown biologically active compounds that, in defined, effective nontoxic amounts, provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease" (Martirosyan and Sing, 2015).

Nutraceuticals are essential constituents of food. Nutraceuticals have medicinal effects as well as nutritional benefits (AlAli et al., 2021). The term "Nutraceutical" was given by Dr. Stephen De Felice in 1989. The word "Nutraceutical" is a portmanteau of the two words "nutrition" and "pharmaceutical" (Puri et al., 2022). Nutraceuticals are basically isolated from herbal products. Most of the novel nutraceuticals are vitamin D, polyunsaturated fatty acids, folic acid, omega-3 fatty acids, calcium, inositol, zinc, and different supplements containing probiotics. Current study reported that the trends in increasing of the nutraceutical market have been seen rapidly, and tentatively, the market will reach $340 billion by 2024.

2.2. Types of functional food:

Functional foods can be conventional or modified foods. Almost every category of food contains functional foods to some extent. Mainly in bakery, baby foods, soft drinks, confectionary, dairy, and various other markets related to foods. Generally, the acceptance of

these bioactive functional foods has been developed because of their vast range of health-beneficial effects. **Figure 1.** depicts the categories of functional foods.

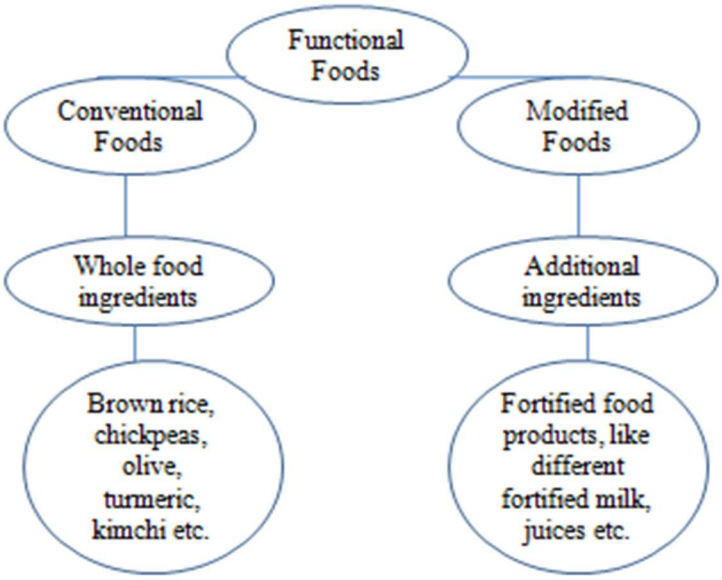


Figure.1. Types of Functional Foods

2.3. Functional components:

Four basic components of functional food are

- Fibers
- Vitamins
- Minerals
- Antioxidants

2.3.1. Fibers:

Fibers are very essential components of food, though they are not recognized as nutrients. They are very essential for our sound gut health and the proliferation of health-beneficial gut microbiota (Yang et al., 2017). They are composed of various soluble and insoluble polysaccharides. Depending on their solubility, dietary fibers are graded into these two categories. Hemicelluloses, cellulose, and lignin are insoluble dietary fibers, whereas soluble fibers are pectin, beta-glucan, and mucilage. The common sources of soluble fibers are beans, nuts, oats, barley, pees, etc. (Ahmad & Al-Shabib, 2020). They help increase the volume of food in the stomach and reduce satiety. These non-digestible polysaccharides pass to the large intestine from the small intestine without digestion, and enzymes can’t digest them.

Various research studies have reported that fibers are healthful as they can prevent several non-communicable diseases. They can absorb glucose and fat from the small intestine and transfer them to the large intestine. These extra glucose and fat pass through the stools. Because of this underlying cause, fiber can prevent some diseases, such as cardiovascular disorders and diabetes. Generally, they help in decreasing the abrupt increase of glucose and fat in our bloodstream.

Dietary fibers are also well-known food additives. Fiber can also fortify dairy products and increase their structural properties, shelf life, and sensory qualities (Yegin et al., 2020).

2.3.2. Vitamins:

Vitamins are very essential micronutrients and very effective in reducing enormous health disorders. They help us build up anti-carcinogenic, anti-inflammatory, anti-proliferative, and anti-oxidative effects in our body.

Food gets oxidized during processing and storage. Some vitamins, like vitamin C, A, and E, play a vital role in scavenging the oxidation process and increasing shelf life (Traber and Stevens, 2011). Vitamin C acts as a cofactor for α-ketoglutarate-dependent dioxygenases. That is one of the most important biological activities of vitamin C. Hydroperoxyl radicals can be scavenged by vitamin E, also known as α-tocopherol. Hydroperoxyl radicals are present in the lipid milieu.

Food fortification with these fat- and water-soluble vitamins can be a very good alternative for communities. The daily intake of different vitamins can be easily met by consuming supplemented or fortified foods. The current trends in the food processing industries have changed, and they are using these fortified foods for better currency exchange and to increase food value and stability.

2.3.3. Minerals:

Minerals are inorganic in nature and are believed to treat several diseases. They are required in very small quantities for maintaining various physiological functions. The main two functions of minerals are regulating processes and body building tissues. Generally, they are associated with tissue and bone formation, osmotic pressure maintenance, contraction of muscle, and transportation of oxygen to the tissues and organs. The recommended daily allowance for micro (potassium, sodium, phosphorus, chloride, calcium, and magnesium) and macro (nickel, iron, zinc, selenium, manganese, fluorine, chromium, boron, and cobalt) elements has been set by the ICMR for Indian peoples. Some microelements, such as nickel,

iron, and chromium, act in organisms as cations (Dixit et al., 2023).These cations function by merging with ligands (flavones, proteins, pterins, and porphyrins) and chelators. Minerals are also associated with the absorption of micronutrients (carbohydrate, protein, and fat) and their bioavailability. Most minerals act as catalysts and cofactors of various enzymes. Without some minerals, most of the enzymes can't work properly.

Table 1: Several important minerals and their important roles

Sources	Compounds	Role	Reference
Milk, green leafy vegetables, fish, and legumes	Calcium	Formation of bones and teeth, muscle contraction, enzyme activation, stimulation of nerves, blood clotting	Vannucci et al., 2018
Salt, milk and milk products, sea food, salted food	Sodium	Muscle contraction, osmotic pressure regulation, water balance, and nerve stimulation	Strazzulloo and Leclercq, 2014
Eggs, milk, cheese, whole grains, and meat	Phosphorous	Bone and tooth formation, components of DNA and RNA, enzyme activation, etc.	Valvo et al. 2019
Whole grains, nuts, meat, fish, and oysters	Zinc	Wound healing, transportation of vitamin CO_2, utilization of vitaminA	Roohani et al., 2013
Liver, legumes, meat, and dry fruits	Iron	Formation of hemoglobin and myoglobin, vital components of enzymes	Abbaspour et al., 2014
Nuts, oysters, liver, kidney, dry fruit,	Copper	Development of bones, iron utilization, andhemoglobin formation	Wen et al., 2022
Liver, egg, fish, dairy foods, cabbage, lettuce	Cobalt	Strengthening the immune system, acts as a co-factor	Czarnek et al., 2015

2.3.4. Antioxidant

In the biological system, some compounds are produced due to metabolic processes that are highly reactive. These free radicals can be produced by a chain of chemical reactions known as the oxidation procedure. Antioxidants are substances that can counter act these highly reactive substances produced in our cells. An antioxidant can retard this procedure and protect the cell from damage. These antioxidants are used in several food products to enhance their storage stability and maintain their quality. Macronutrients can produce free radicals (Dixit et al., 2023). We can get antioxidants through our diet: polyphenols, vitamins (vitamins A, C, and E), minerals, and carotenoids (lutein, lycopene, and β-carotene). These antioxidants can prevent a vast range of chronic diseases as functional ingredients. Nowadays, antioxidants steal the limelight for their anti-carcinogenic properties.

Table 2: Sources, compounds, and physiological roles of various Functional foods

Sources	Compounds	Role	Reference
Green leafy vegetables	Lutein	Reduces the visual trouble	Abdel-Aal et al., 2013
Citrus fruit	Flavanones	Can prevent Alzheimer's disease	Li et al., 2022
Tea	Catechins	Can reduce CVD, obesity and Type II diabetes	Nagao et al., 2007
Tomato	Lycopene	Reduces the risk of prostate cancer	Moran et al., 2022
Fruit and vegetables	α and β-carotene	Can prevent cell damage by neutralizing the free radicals in cells	Prior, 2003
Nuts, legumes, fruits, cereals, and vegetables	Tannin	Reduces urinary tract disorders and retards the occurrence of CVD	Ojo et al., 2022; Sosnowska et al., 2017
Rye, flax seeds	Lignans	Anti-carcinogenic effect and increase the health of the kidney	Imran et al., 2015
Different vegetables and fruits	Flavones	Can neutralize the free radicals present in cells and lower the risk of cancer	Prior, 2003

Kale and Kiwi	Carotenoids	Reduces the risk of various chronic disorders	Richardson et al., 2018
Pomegranate and blueberries	Total phenolic content	Increases the health of neuron cells and reduces the risk of CVD	Aviram and Rosenblat, 2012

2.4. Classification of nutraceuticals:

Nutraceuticals can be classified depending on their chemical constituents, pharmacological conditions, and natural sources present in the product. Generally, they are classified as **functional foods**, **medicinal foods**, **pharmaceuticals,** and **dietary supplements**.

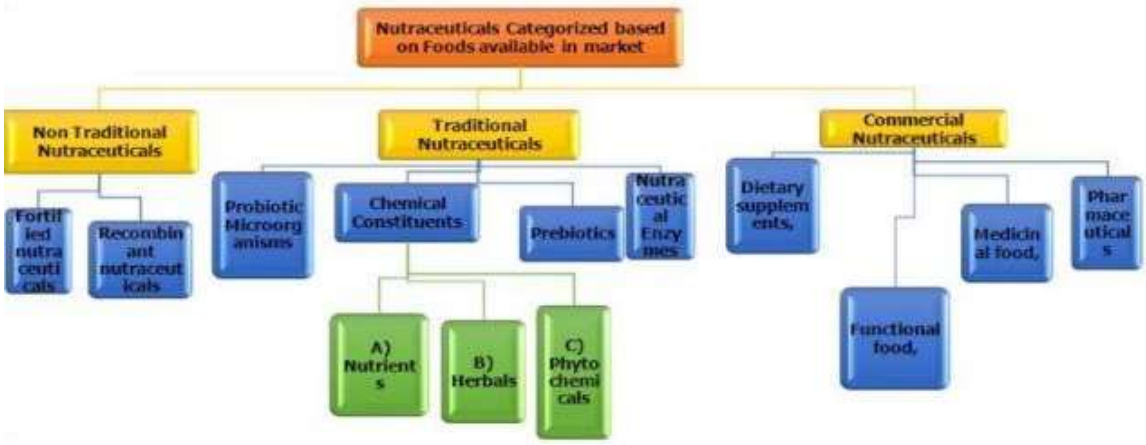


Figure: 2 Categories based on foods available in the market (Source: Ruby et al., 2021).

2.5. The marketing of Functional food:

Food manufacturers may make exaggerated claims that a product is functional in order to increase sales, which is one possible risk associated with functional foods. There are several notable instances of food corporations selling their products with false or deceptive health claims. This is a typical marketing strategy for dietary supplements (Temple, 2022). Another instance is vitamin water. Available in many formulations, this beverage made its debut in 2000. It has nearly half the sugar content of Coca-Cola, with 5.5 g per 100 ml. Vitamins and other different compounds are also present. The product's name and contents suggest that it is healthy, yet consumers still get the flavor of a sweet beverage—the creators have successfully combined the best of both worlds. This product exemplifies the dishonest marketing that functional foods may undergo.

2.6. Functional Food Development:

The manufacturing of functional food involves several separate stages, ranging from definition to successful consumer implementation. Customers fervently endorse food items bearing health claims that demonstrate their feasible ability to enhance well-being beyond essential nutrient provision. This is expected to lead to a decrease in mortality and morbidity as well as an improvement in the general population's overall quality of life (Jones and Jew, 2007).

The FDA's acceptance of qualifying health claims for a number of ingredients when used in certain amounts has contributed to the expansion of the functional food sector and increased consumer knowledge of plant sterols, soy protein, dietary fiber, and omega-3 fatty acids, among other nutraceutical components. Over the past 10 years, there has been a surge in the introduction of functional food products that target certain health areas. Functional health statements have included immune system function, bone health, gut health, heart health, and weight control (Weaver et al., 2015).

A comprehensive grasp of the materials as well as the processes accessible, together with an understanding of the fundamental science of the heart, are necessary for a successful product development process. It is necessary to specify the shape of the final product (dry or liquid) and demand (value and size) early on in order to produce a customized, cost-effective product that is appropriate for its intended purpose (a final food product).These factors might significantly affect the available items, formulations, and techniques. At this point in the formulation and operation process, it is important to validate potential interactions with other constituents, core stability and physical performance and features (Sanguansri and Ann Augustin, 2010).

Almost every food group, functional foods have been created. Functional quality can be used in a multitude of ways from the perspective of a commodity. Differently classified, some functional items “bring good to your life,” like enhancing regular functions of the colon (prebiotics and probiotics) and stomach or they “improve children's lives,” like enhancing their cognitive ability and creating a favorable learning environment. However, it is difficult to identify reliable biomarkers for psychological, behavioral, and cognitive processes. Another type of functional food is intended to help individuals manage a health condition that they already have, such as high blood pressure or cholesterol. Products that “make your life easier” are included in the third type (such as gluten- and lactose-free items).

The scientific understanding of how specific food ingredients impact bodily processes that affect overall health and well-being makes it possible to create indicators that might verify the impacts of contemporary food ingredients and be utilized during their protection review. By utilizing state-of-the-art food science and biochemical techniques to produce functional ingredients, consumers will gain improved health and a reduced chance of illness. In order to provide evidence-based guidance for the acceptance of health claims and the successful modification of currently available functional foods, these trials must be meticulously designed and executed. The functional foods development and the health advantages they are linked to will be enhanced by developments in food security, which will guarantee the veracity of the claims and the safety of the food. Technology, in and of itself, cannot be regulated, and the systematic fundamentals of practical food science merely provide the framework for this legislation.

A food that is beneficial can be any of the following: it can be a regular food; it can contain a diet element added or removed for specific health reasons; it can contain a material altered through biochemical or technical processes to have a specific health benefit; it can alter a product's bioactivity; or it can contain a combination of all of these.

Although the terms "functional food" and "nutraceutical" are frequently used worldwide, there is no universal consensus over their exact meanings. The Food Directorate of the Bureau of Nutritional Sciences of Health Canada has proposed the following ideas: Beyond their specialized nutritional purposes, functional foods are those that resemble or are connected to traditional foods, are consumed as part of a daily diet, and have been shown to provide metabolic advantages and/or lessen the risk of acquiring chronic diseases. Nutraceuticals are foods that are sold as powders, pills, and other pharmaceutical preparations that aren't usually connected with fruit. It has been shown that these foods have biochemical benefits that protect against chronic illnesses. It goes without saying that a functional meal is not the same as a pharmaceutical, nutritional supplement, or nutraceutical. It's a kind of substance, not a drug, and its health benefits are usually preventive rather than curative.

2.7. Probiotics as functional foods

Sedentary lifestyles, obesity, and diets containing poor-quality nutrients are the leading causes of disorders dealing with the natural microbiota. The most affected area is the intestine of our body. Organ dysfunction is very common due to the underlying cause. More than 500

bacterial species are present in our gut and are beneficial to inhibit the diseases caused by infection (Ballini et al., 2023).

Probiotics are beneficial living organisms that can play a vital role in maintaining our gut health. In accordance with Fuller (1991), probiotics can be single or mixed cultures of living organisms that can confer a plethora of health-promoting effects when given to animals or humans. These can also help improve the acquired microbial load of our body (Gomma et al., 2020). The most common sources of probiotics are fermented foods, yogurt, cereal juices, candy bars, etc. We can get the beneficial effects of probiotics by consuming a minute amount of them. Nowadays, we can get them in the form of capsules or pills. They have been proven to be beneficial for enhancing the immunity of the host cell (Maldonado Galdeano et al., 2019).The most common probiotics are Lactobacillus bacteria (LAB) and Bifidobacterium (Kerry et al., 2018). **Fig. 3** depicts the schematic diagram of the mechanism of probiotic action in our gut.

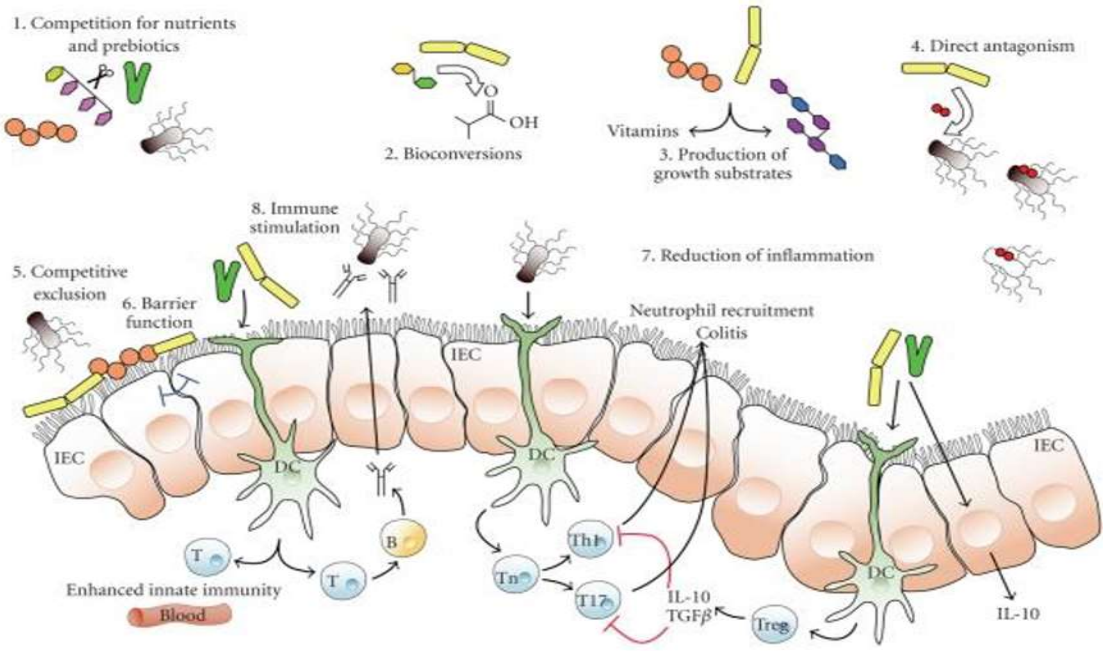


Figure: 3 Schematic diagram of the mechanism of probiotic action in our gut (Source: Khalighi et al., 2016)

Some probiotic foods are associated with a few bioactive compounds, like plant sterols and stanols. These constituents help to reduce the cholesterol levels of the host cells (Ballini et al., 2023). Several autoimmune disorders, such as allergic reactions, different infections, rheumatoid arthritis, Cronh's disease, and ulcerative colitis, can be prevented by consuming a

sufficient amount of probiotics (Iwe, 2006). Table 3 represents the names of some of the most commonly used probiotics.

Table 3: Most commonly used probiotics

Lactobacillus sp.	***Bifidobacterium sp.***	***others***
Lactiplantibacillus plantarum subsp. plantarum	*Bifidobacterium bifidum*	*Escherichia coli*
Lactobacillus acidophillus	*Bifidobacterium lactis*	*Clostridium butyricum*
Lacticaseibacillus casei	*Bifidobacterium longum*	*Aspergillus oryzae*
Lacticaseibacillusrahmnosus	*Bifidobacterium breve*	*Aspergillus niger*
Limnosalactobacillussalivarius	*Bifidobacterium infantalist*	*Saccharomyces cerevisiae*
Lactobacillus gasseri	*Bifidobacterium animalis*	
Lactobacillus helveticus		
Lactobacillus crispatus		
Lactobacillus reuteri		

(Source: Ballini et al., 2023)

2.8. Prebiotics as functional foods

According to Gibson et al. (2017), prebiotics, such as non-digestible oligosaccharides (NDO's), are substrates that can be used by the selective microbiota of the host and serve enormous health benefits. These are non-digestible components. Various types of prebiotics differ from each other depending on their chemical characteristics and origins. They are mainly served as bioactive ingredients in food (Fernàndez et al., 2018). The most known prebiotics are fructo-oligosaccharides (FOSs), galacto-oligosaccharides (GOS), cello dextrin, human milk oligosaccharides (HMO), and inulin (Maity et al., 2023). Very common sources of plant prebiotics are raw wheat, soybeans, oats, barley, onions, and garlic.

Enzymes are unable to hydrolyze the polymer bonds of prebiotics. These remain unused and are transferred to the large intestine, where probiotics utilize them as substrates, maintain their health, and confer essential benefits to the host cells. Intestinal flora utilizes prebiotics and generates some secondary metabolites. These secondary metabolites are absorbed through the intestinal lumen, and portal veins help carry these metabolites to the liver (You et al., 2022). Mainly short-chain fatty acids (SCFA) such as propionate, acetate, and butyrate are produced, which helps to maintain gut homeostasis (Maity et al., 2023). **Figure: 4** illustrates the role that prebiotics play in our body with the help of probiotics.

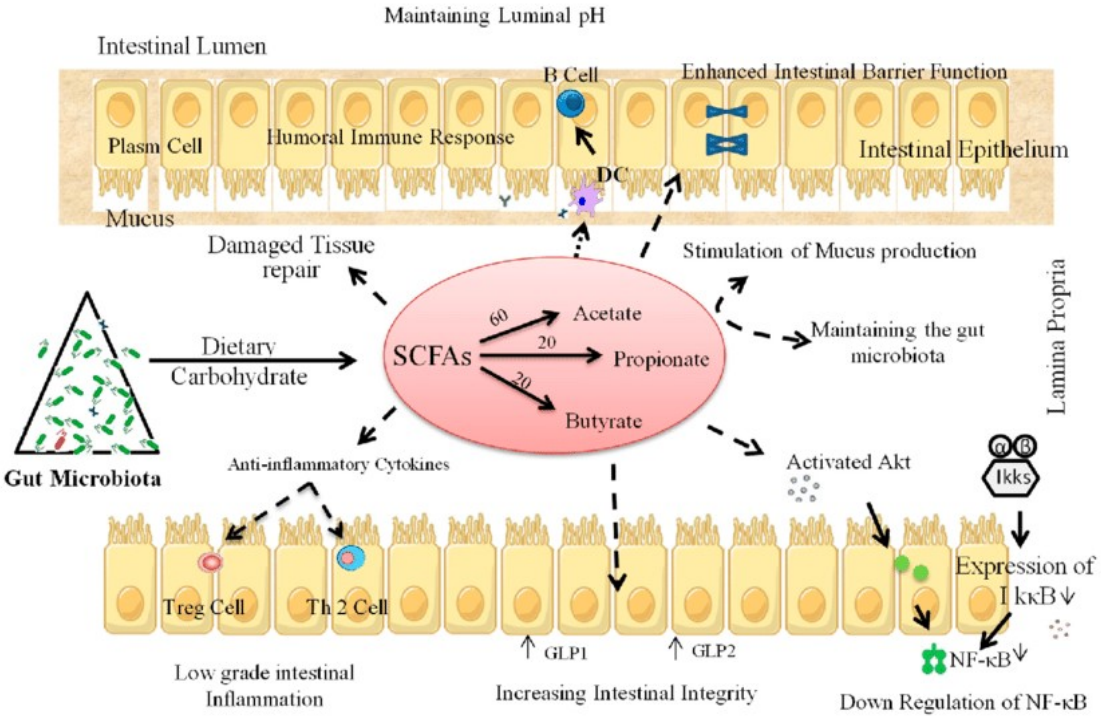


Figure: 4 Mechanism that prebiotics play in our body with the help of probiotics (Source: Mishra et al., 2019)

References:

Abbaspour, N., Hurrell, R., &Kelishadi, R. (2014). Review on iron and its importance for human health. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, *19*(2), 164.

Abdel-Aal, E. S. M., Akhtar, H., Zaheer, K., & Ali, R. (2013). Dietary sources of lutein and zeaxanthin carotenoids and their role in eye health. *Nutrients*, *5*(4), 1169-1185.

Ahmad, S., & Al-Shabib, N. A. (Eds.). (2020). *Functional Food Products and Sustainable Health* (pp. 199-218). Berlin, Germany:: Springer.

AlAli, M., Alqubaisy, M., Aljaafari, M. N., AlAli, A. O., Baqais, L., Molouki, A., ... & Lim, S. H. E. (2021). Nutraceuticals: Transformation of conventional foods into health promoters/disease preventers and safety considerations. *Molecules*, *26*(9), 2540.

Aviram, M., & Rosenblat, M. (2012). Pomegranate protection against cardiovascular diseases. *Evidence-Based Complementary and Alternative Medicine*, *2012*.

Ballini, A., Charitos, I. A., Cantore, S., Topi, S., Bottalico, L., & Santacroce, L. (2023). About Functional Foods: The Probiotics and Prebiotics State of Art. *Antibiotics*, *12*(4), 635.

Czarnek, K., Terpiłowska, S., & Siwicki, A. K. (2015). Selected aspects of the action of cobalt ions in the human body. *Central European Journal of Immunology*, *40*(2), 236-242.

Dixit, V., Joseph Kamal, S. W., Bajrang Chole, P., Dayal, D., Chaubey, K. K., Pal, A. K., ... &Bachheti, R. K. (2023). Functional Foods: Exploring the Health Benefits of Bioactive Compounds from Plant and Animal Sources. *Journal of Food Quality*, *2023*.

Fernández, J., Moreno, F. J., Olano, A., Clemente, A., Villar, C. J., &Lombó, F. (2018). A Galacto-oligosaccharides preparation derived from lactulose protects against colorectal cancer development in an animal model. *Frontiers in microbiology*, *9*, 2004. https://doi.org/10.3389/fmicb.2018.02004

Gibson, G. R., Hutkins, R., Sanders, M. E., Prescott, S. L., Reimer, R. A., Salminen, S. J., Scott, K., Stanton, C., Swanson, K. S., Cani, P. D., Verbeke, K., & Reid, G. (2017). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature reviews Gastroenterology & hepatology*, *14*(8), 491. https://doi.org/10.1038/nrgastro.2017.75

Gomaa, E. Z. (2020). Human gut microbiota/microbiome in health and diseases: a review. *Antonie Van Leeuwenhoek*, *113*(12), 2019-2040.

Imran, M., Ahmad, N., Anjum, F. M., Khan, M. K., Mushtaq, Z., Nadeem, M., & Hussain, S. (2015). Potential protective properties of flax lignan secoisolariciresinoldiglucoside. *Nutrition journal*, *14*(1), 1-7.

Iwe, M. O. (2006, March). Current trends in processed foods consumption–Emphasis on prebiotics and probiotics. In *A technical paper presented at the quarterly meeting of the south-east chapter of NIFST at MOUA, Umudike, Abia state, Nigeria on* (Vol. 11).

Jones, P. J., & Jew, S. (2007). Functional food development: concept to reality. *Trends in Food Science & Technology*, *18*(7), 387-390.

Kerry, R. G., Patra, J. K., Gouda, S., Park, Y., Shin, H. S., & Das, G. (2018). Benefaction of probiotics for human health: A review. *Journal of food and drug analysis*, *26*(3), 927-939.

Khalighi, A., Behdani, R., &Kouhestani, S. (2016). Probiotics: a comprehensive review of their classification, mode of action and role in human nutrition. *Probiotics and prebiotics in human nutrition and health*, *10*, 63646.

Li, J., Sun, M., Cui, X., & Li, C. (2022). Protective Effects of Flavonoids against Alzheimer's Disease: Pathological Hypothesis, Potential Targets, and Structure–Activity Relationship. *International Journal of Molecular Sciences*, *23*(17), 10020.

Maity, M., Majumdar, S., Bhattacharyya, D. K., Bhowal, J., Das, A., & Barui, A. (2023). Evaluation of Prebiotic Properties of Galactooligosaccharides Produced by Transgalactosylation Using Partially Purified β-Galactosidase from Enterobacter aerogenes KCTC2190. *Applied Biochemistry and Biotechnology*, *195*(4), 2294-2316.

Maldonado Galdeano, C., Cazorla, S. I., Lemme Dumit, J. M., Vélez, E., &Perdigón, G. (2019). Beneficial effects of probiotic consumption on the immune system. *Annals of Nutrition and Metabolism*, *74*(2), 115-124.

Martirosyan, D. M., & Singh, J. (2015). A new definition of functional food by FFC: what makes a new definition unique?. *Functional foods in health and disease*, *5*(6), 209-223.

Mishra, S., Wang, S., Nagpal, R., Miller, B., Singh, R., Taraphder, S., & Yadav, H. (2019). Probiotics and prebiotics for the amelioration of type 1 diabetes: present and future perspectives. *Microorganisms*, *7*(3), 67.

Moran, N. E., Thomas-Ahner, J. M., Wan, L., Zuniga, K. E., Erdman Jr, J. W., & Clinton, S. K. (2022). Tomatoes, lycopene, and prostate cancer: what have we learned from experimental models?. *The Journal of nutrition*, *152*(6), 1381-1403.

Ojo, M. A. (2022). Tannins in foods: Nutritional implications and processing effects of hydrothermal techniques on underutilized hard-to-cook legume seeds–A review. *Preventive Nutrition and Food Science*, *27*(1), 14.

Prior, R. L. (2003). Fruits and vegetables in the prevention of cellular oxidative damage. *The American journal of clinical nutrition*, *78*(3), 570S-578S.

Puri, V., Nagpal, M., Singh, I., Singh, M., Dhingra, G. A., Huanbutta, K., Dheer, D., Sharma, A., & Sangnim, T. (2022). A comprehensive review on nutraceuticals: therapy support and formulation challenges. *Nutrients*, *14*(21), 4637.

Richardson, D. P., Ansell, J., & Drummond, L. N. (2018). The nutritional and health attributes of kiwifruit: A review. *European journal of nutrition*, *57*, 2659-2676.

Roohani, N., Hurrell, R., Kelishadi, R., & Schulin, R. (2013). Zinc and its importance for human health: An integrative review. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, *18*(2), 144.

Sanguansri, L., & Ann Augustin, M. (2010). Microencapsulation in functional food product development. *Functional food product development*, 1-23.

Sosnowska, B., Penson, P., & Banach, M. (2017). The role of nutraceuticals in the prevention of cardiovascular disease. *Cardiovascular diagnosis and therapy*, *7*(Suppl 1), S21.

Temple, N. J. (2022). A rational definition for functional foods: A perspective. *Frontiers in Nutrition*, *9*, 957516.

Temple, N.J. (2022) Supplements to our diets: navigating a minefield. In: T Wilson, NJ Temple, GA Bray. editors. *Nutrition Guide for Physicians and Related Healthcare Professions, 3rd Edn*. (Cham, Switzerland: Humana Press). p. 435–45.

The European Parliament and the council of European Union. Regulation no 1924/2006 of the European parliament and of the council on nutrition and health claims made on foods. Official Journal of the European Union. 2006; 404:9-25.

Traber, M. G., & Stevens, J. F. (2011). Vitamins C and E: beneficial effects from a mechanistic perspective. *Free radical biology and medicine*, *51*(5), 1000-1013.

Vannucci, L., Fossi, C., Quattrini, S., Guasti, L., Pampaloni, B., Gronchi, G., ... & Brandi, M. L. (2018). Calcium intake in bone health: a focus on calcium-rich mineral waters. *Nutrients*, *10*(12), 1930.

Wen, Y., Li, R., Piao, X., Lin, G., & He, P. (2022). Different copper sources and levels affect growth performance, copper content, carcass characteristics, intestinal microorganism and metabolism of finishing pigs. *Animal Nutrition*, *8*, 321-330.

Yang, Y. Y., Ma, S., Wang, X. X., & Zheng, X. L. (2017). Modification and application of dietary fiber in foods. *Journal of Chemistry*, *2017*.

Yegin, S., Kopec, A., Kitts, D. D., & Zawistowski, J. (2020). Dietary fiber: A functional food ingredient with physiological benefits. In *Dietary sugar, salt and fat in human health* (pp. 531-555). Academic Press.

You, S., Ma, Y., Yan, B., Pei, W., Wu, Q., Ding, C., & Huang, C. (2022). The promotion mechanism of prebiotics for probiotics: A review. *Frontiers in Nutrition*, *9*, 1000517.

Chapter-3
Food Chemistry

Saheli Ghosal

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: sahelighosal@svu.ac.in

3.1. Introduction

The field of food chemistry is primarily concerned with the chemical structure of foods, the basic biomolecules, the properties and chemical structure of food components, the chemical changes of food undergo by processing and storage, and strategies for identifying and managing food spoilage. The study of food chemistry is related to chemistry as well as biological sciences such as biochemistry, molecular biology, botany, and zoology. In recent years, new methods have enabled us to identify and classify not only the major nutrients but also essential minor components, as well as thousands of minor and micro-components that are naturally present in food (such as natural colorings, flavor compounds, and natural antioxidants). The current activity of food chemistry primarily focuses on providing healthy foods to the population (Sethi et al., 2022).

3.2. History of Food Chemistry

Food chemistry is rooted in the oldest civilization on earth and is shrouded in mystery. Food chemistry was founded on revolutionary discoveries made between 1780 and 1850 by many famous scientists. In the field of food chemistry, Carl Wilhelm Scheele (1742-1786) is considered one of the greatest chemists of all time. Antoine Laurent Lavoisier (1743-1794) studied organic acid content in a number of fruits as well. Theodore de Saussure (1767-1845) studied the exchange of CO2 and O2 during plant respiration. A method for measuring the amount of carbon, hydrogen, and nitrogen in vegetables was devised in 1778 by Joseph Louis Gay-Lussac and Louis-Jacques Thenard. During the discovery of the law of definite proportions, Jons Jacob Berzelius (1779-1848) determined the elemental composition of approximately 2000 compounds. Justus von Liebig (1803-1873) classified foods as nitrogenous or non-nitrogenous based on their fibrin content, albumin content, casein content or flesh content (Mehta and Cheuk, 2015).

3.3. Food Pigment

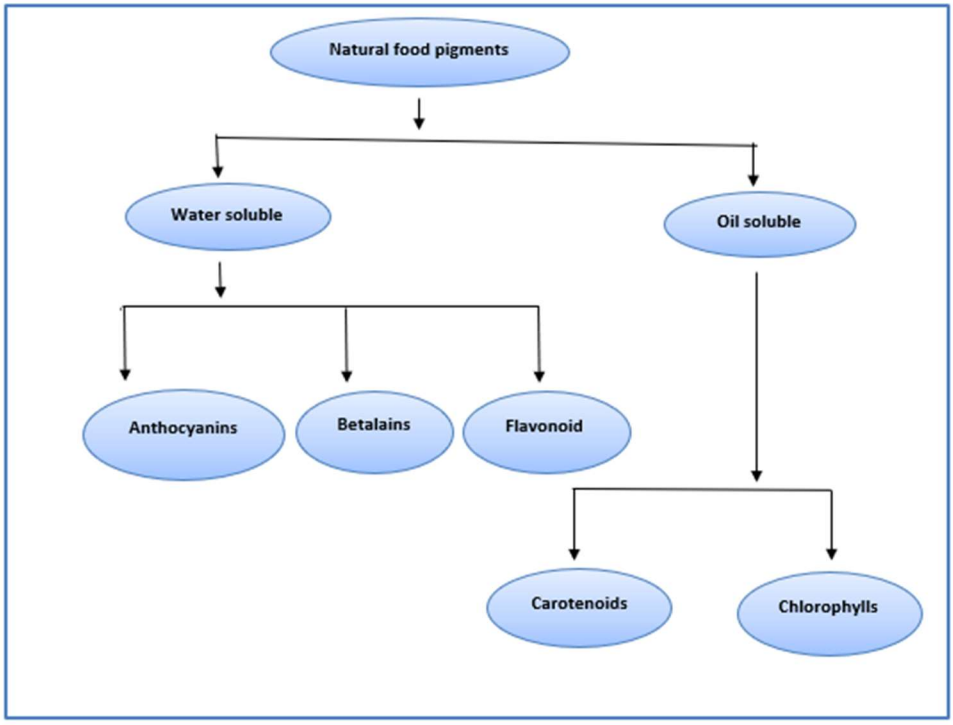
Pigments absorb light in the visible region due to a chromophore (a molecule-specific structure) that captures the energy of a radiant source. By capturing this non-absorbed energy, the eye creates nerve impulses that are communicated to the brain and interpreted as colors. The color

of food has been an integral part of the choice of food and the desire to consume it for thousands of years (Policegoudra et al., 2022).

The color of food plays a key role in defining its quality. The color of a food is the first thing that catches our attention, and it determines both the quality and the taste of the food. Color constitutes the first sensory quality by which foods are evaluated; it is closely associated with food quality and flavor. Color plays an important role in the acceptance of food, along with flavor and texture (Policegoudra et al., 2022).

Food compounds, known as natural pigments, are responsible for the color of the products. Consumers today are increasingly demanding products that are colored with natural pigments. Since artificial pigments are viewed as harmful and undesirable, food manufacturers focus their efforts on the use of natural colorants.

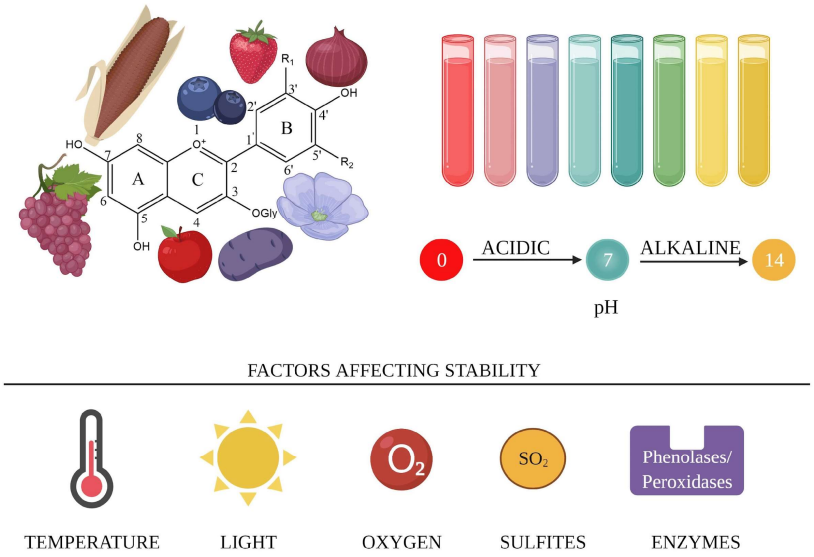
3.3.1. Classification of Natural food pigments



3.3.1.1. Anthocyanins:

The anthocyanins are glucosides of the flavonoid and anthocyanidins derivatives derived from phenylpropanoid molecules. In plants, they are found in all plant tissues, including leaves, stems, fruits, roots, and flowers. Cyanidin, delphinidin, pelargonidin,

peonidin, petunidin, and malvidin are the six predominant anthocyanidins found in food (Meacham, 2023). The utilization of anthocyanin pigments as natural food coloring has been widely accepted. However, the stability and the color of these pigments are influenced by factors such as temperature, light, pH, and structure. Anthocyanins are red pigments at acidic pH levels, but they become blue when pH levels are basic (Meacham, 2023).



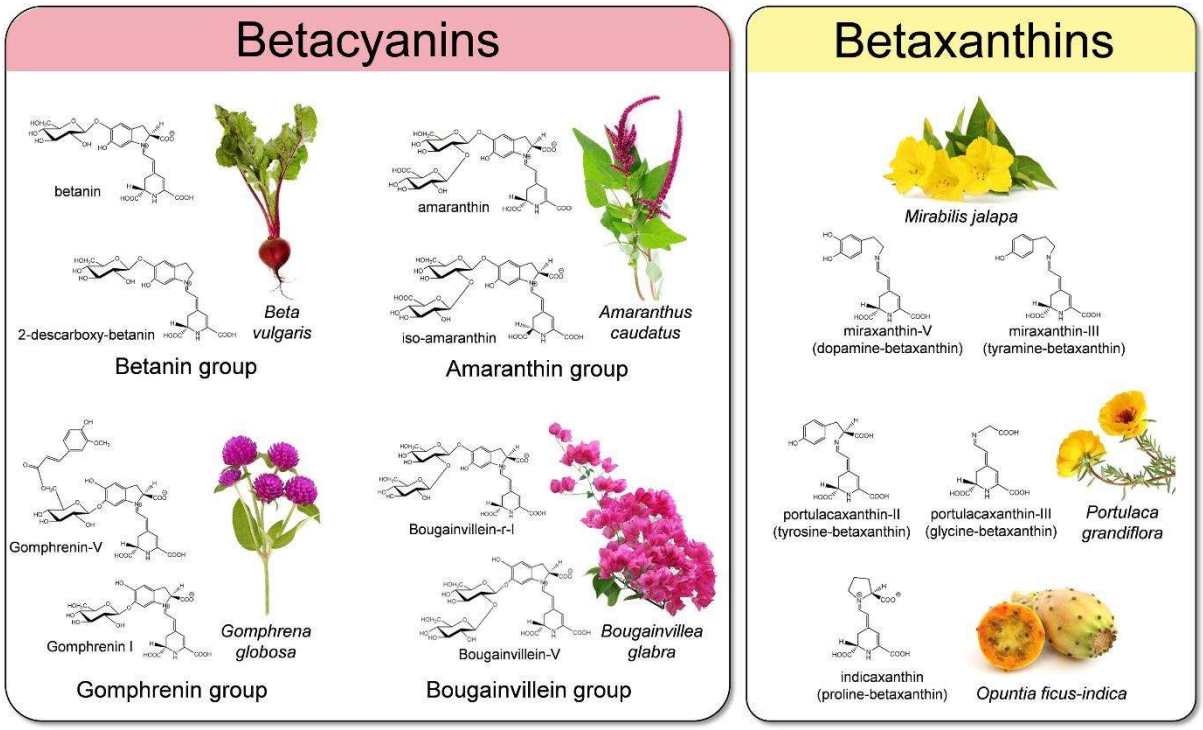
(Source: Enaru et al., 2021)

On the other hand, anthocyanins are unstable at basic pH and are prone to degrading into an oxidized compound (dark brown in color). A stable anthocyanin is also dependent on the B-ring present in its structure and on the existence of methoxyl or hydroxyl groups. Additionally, these compounds can be used as nutraceuticals since they give a number of health benefits (Mattioli et al., 2020).

3.3.1.2. Betalains

The betalains are pigments occurring in about 17 families of plants in the Caryophyllales order. There are two subclasses of betalains: betacyanins (red-violet) and betaxanthins (yellow-orange). These pigments are hydrophilic and accumulate in the vacuoles of cells, pacifically in the epidermis and subepidermis of plants (Rahimi et al., 2019). A variety of edible sources of betalains have been identified within the Caryophyllales, including leafy amaranth, red beetroots, cacti fruits, and fruits of *Eulychnia* species. Among them is the dragon fruit of *Hylocereus polyrhizus*, containing red betanin and yellow vulga xanthin I pigments, has been recognized for some time as the sole source of betalains (Bartosz and Bartosz, 2021).

In the order of Caryophyllales, plants produce betalains, which contain anti-inflammatory, cancer-fighting, and anti-hepatitis properties (Madadi et al., 2020).

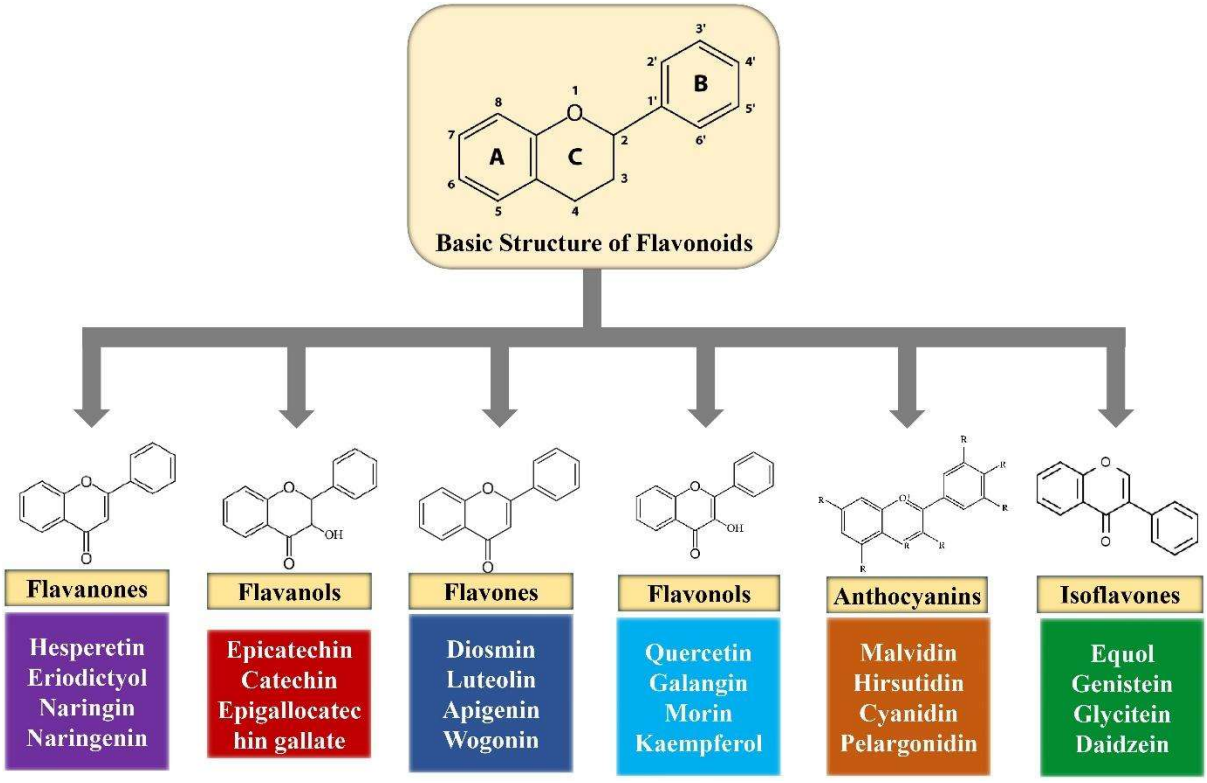


(Source: Plolturak and Aharoni, 2017)

3.3.1.3. Flavonoids:

A flavonoid is a secondary metabolite that is very abundant in plants and contributes significantly to their color, fragrance, and flavor. Flavonoid belongs to the family of polyphenols and is composed of more than six thousand different compounds (Šamec et al., 2021). There are two biosynthetic pathways in plants that produce flavonoids, the phenylpropanoid pathway (C6-C3) and the polyketide pathway (C2 polymerization blocks).

There are two oxygen-containing heterocycles pyrene rings (C) attached to the benzene rings (A and B) of most flavonoids. Flavonoids have two major categories according to the degree of saturation of the central heterocyclic ring. As an example, Flavanones, dihydroflavonols, and flavan-3-ols are saturated, whereas anthocyanidins, flavones, flavonols, and isoflavones are unsaturated (Nabavi et al., 2020).



(Source: Uddin et al., 2020)

Plants, fruits, vegetables, stems, flowers, tea, grains, bark, roots, and wine contain flavonoids as phytonutrients. Flavonoids are known for their medicinal value, including their characteristics that reduce oxidation, inhibit inflammation, inhibit the development of cancer, and gene mutation prevention. Also, they regulate the function of enzymes in cells (proteins that stimulate chemical reactions) (Schiller, 2021).

3.3.1.4. Carotenoid:

The carotenoid pigments are produced by plants to help them absorb the energy of light and convert it into the energy of chemicals. Carotenoids differ only in the amount of oxygen they contain, namely xanthophylls and carotenes. There are eight isoprene molecules in the base structure of carotenoids. It is composed of five carbon molecules with a total of 40 carbons when eight are combined together (Yasmeen et al., 2022). A diet high in carotenoids has been found to lower the risk of breast, cervical, vaginal, colorectal, cardiovascular, and eye diseases (Ngamwonglumlert and Devahastin, 2019).

3.3.1.5. Chlorophyll:

Phytochemically, chlorophyll is the pigment that gives green plants their color. In the process of photosynthesis, it assists plants in absorbing energy from the sun. Plant-based foods, such as green vegetables and algae, contain this nutrient. Chlorophyll content increases with

the greenness of the vegetable. Chlorophyll a and chlorophyll b are two types of chlorophyll found in plants. There is at least one of these two varieties present in all plants. Both compounds possess antioxidant properties and are fat-soluble (Juber, 2022).

3.4. Food Processing Treatments

Food processing refers to the process of converting raw materials obtained from plants or animals into different types of food or ingredients for food. A food product is a very good culture medium for many microbes that cause spoilage of food and it is important to prevent food spoilage, regardless of whether the cause is microbes or enzymes (Albuquerque et al., 2022). The processing of food is essential to ensuring the security of food and nutrition globally and is a necessary prerequisite for a society that is healthy and safe. A food processing facility is the only method of achieving food demand, whether in terms of energy and/or macronutrients and micronutrients for good health (Augustin et al., 2016). The processing of food increases its shelf life, improves its bioavailability, and reduces postharvest losses and waste. The traditional method of food processing involved long-term storage and transportation of foods, using techniques such as curing and smoking. Although pasteurization and other heat treatment technologies have effectively reduced spoilage and pathogenic microorganisms, processed foods have also become safer as a result (Kushwaha et al., 2021).

3.4.1. Different food processing treatment

Depending on the process employed, food processing can have both adverse and beneficial effects on the quality of the food (Weaver et al., 2014). Heating, canning, smoking, and drying are some of the common processes used in food processing.

3.4.1.1. Drying:

In the food processing industry, drying is the most common method to preserve foods. Vegetables and fruits can be preserved by drying for centuries. Resulting from the removal of the water (75-90%) present in fresh commodities will result in a reduction in water activity as well as resistance to most deterioration agents. Generally, drying methods are two types, natural drying and artificial drying. Food products are naturally dried by using solar energy. Due to the variability of weather conditions, this method is highly unreliable (Adeyeye et al., 2022). However, artificial drying is preferred over natural drying due to its faster drying rate and ability to remove large amounts of moisture from produce, resulting in a higher-quality dried product. Heat and moisture removal can cause poor textural attributes, loss of nutritional value (vitamins), discoloration, and loss of flavor (Adeyeye et al., 2022). There are a number

of types of food products that can be enhanced by the drying process. It is possible to preserve and transform low-value products, such as cereals, legumes, and root crops, into high-value products. It is possible to the shelf life extension of intermediate-value products like vegetables, fruits, meat, and fish by drying them. For enhanced preservation and concentrated flavors, high-value products such as spices, herbs, medicinal plants, nuts, and bioactive materials can be dried (Radojcin et al., 2021).

The process of drying is an effective, versatile preservation method that can be adapted to a wide range of food products. It offers a long shelf life, reduced weight, and bulk, as well as a significant value addition.

3.4.1.2. Dehydration:

The dehydration of food is the oldest method in the food processing unit. Dehydration involves adding one or more forms of energy to foods in order to reduce their moisture levels for better shelf life (Jayas, 2016). Food spoilage is prevented by dehydrating it by reducing its moisture content, which inhibits bacterial growth and changes in chemicals. Besides preserving food microbiologically, this method also preserves its flavor and nutritional value (Riaz et al., 2022).

3.4.1.3. Irradiation:

Food irradiation is exposing food to electrons, gamma, and X-rays in a radiation-shielded chamber to process and preserve it. To the shelf-life extension of fresh produce, it controls and interrupts biological processes, and it can be useful in sterilizing packaging materials as well. The use of irradiation has various beneficial biological effects, including inhibiting sprouting, delaying ripening, and sometimes also disinfesting insects (Kushwaha et al., 2021). There is a wide range of radiation resistance among bacteria, yeasts, and molds. Viral spores are more radiation resistant than vegetative cells due to their lower moisture content. In order to achieve the desired effect, the radiation dose used is determined by the type of food being processed and the desired outcome. It is important to find a balance between the radiation dose that is needed and the radiation dose that can be tolerated when processing a product (Singh and Singh, 2020).

3.4.1.4. Freezing:

Freezing food is an old and well-known method of food preservation. It is the most effective method of preserving the food's taste, texture, or nutritional value (Kang et al., 2020). Freezing is a combination of low temperatures that prevent microorganisms from growing,

reduce chemical reactions, and delay cellular metabolic processes. Many foods can be successfully preserved through freezing, extending their shelf life significantly. A temperature of -18°C or below is generally used in the process of cooling the product. Food material changes its physical state when it is cooled below freezing temperatures because energy is removed. Food quality or spoilage can be slowed by extreme cold by retarding microorganism growth (Bishnoi et al., 2020).

3.4.1.5. Canning

The canning process preserves food by sterilizing the food product as well as its container, giving the contents shelf stability for some time. Conventional canning and aseptic canning are two types of canning (McHugh and Thai, 2020). Canning involves placing food in containers, heating them, and sealing them, usually under a vacuum. In the food industry, it is used for products such as fruit juices, syrups, and sauces. Food items can be preserved with the canning process in order to maintain vitamins, flavors, and colors. The majority of food nutrients are preserved by canning. There is no adverse effect on proteins, carbohydrates, or fats, as well as on vitamins (Britannica, 2021).

3.4.2. Browning reaction in food

Browning is the change of color that occurs in food during processing and storage. Food items and the degree of the reaction determine the color produced, which can range from pale yellow to dark brown. Based on the circumstances, browning may be desirable or undesirable (Rajak, 2023).

Generally, browning reactions are of two types: enzymatic and non-enzymatic. Browning reactions that do not involve enzymes are known as non-enzymatic browning of foods.

3.4.2.1. Enzymatic Browning

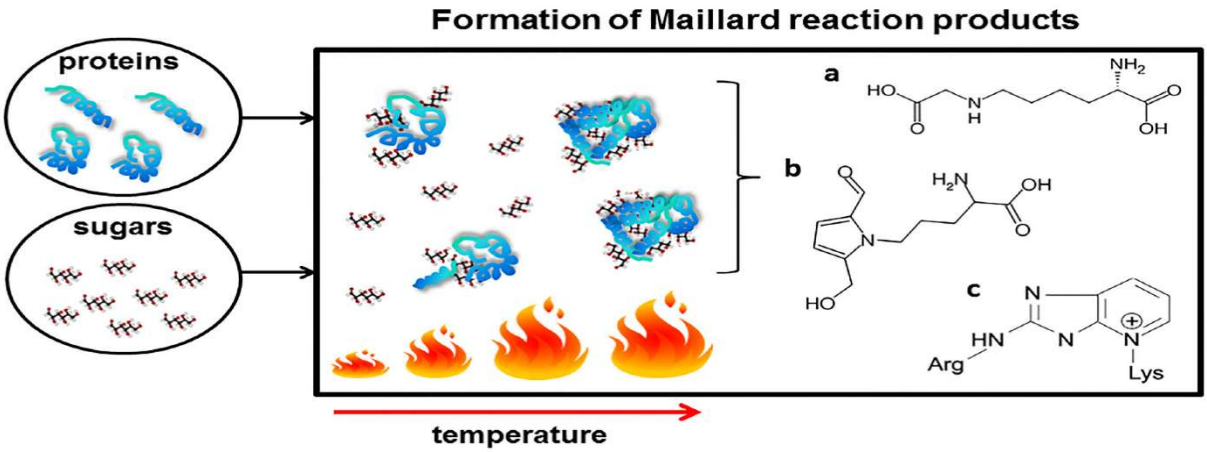
Enzymic browning reaction occurs when certain foods, mainly fruits and vegetables, are subjected to an oxidation reaction. During enzymic browning (an oxidation reaction), oxygen in the air can cause sliced fruit to brown. During the cutting of the apple, oxygen in the air causes a reaction between phenols and the enzyme phenolase in the apple's cells. Phenolase transforms the phenols into brown melanin. It is required to denature the phenolase enzymes in order to stop the oxidative reaction. Using heat and acids would be a suitable method to stop the oxidative reaction. Food is composed of many different molecules, including enzymes. An enzyme is responsible for accelerating chemical reactions and acting as a biological catalyst, causing ripening and overripening in fruit (Jiang et al., 2016).

3.4.2.2. Non-enzymatic browning

The non-enzymatic browning of food, including the Maillard reaction, is a diffusion-limited reaction model. Non-enzymatic browning occurs when amino acids react with reducing sugars generating melanoidins. Further, although non-enzymatic browning improves the flavor and color of foods, it is important to be aware that it can also be unfavorable (Wu et al., 2022).

3.4.2.2.1. Maillard Reaction:

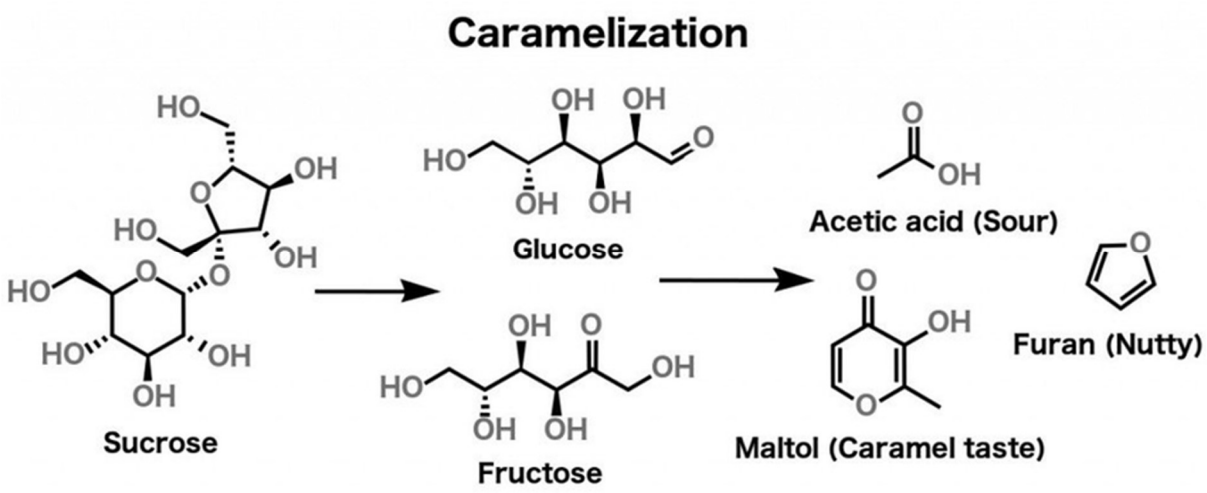
Maillard reactions occur when an amino acid reacts with a reducing sugar, usually with heat as a catalyst. There is a reaction that occurs between the nucleophilic amino group of the amino acid and the reactive carbonyl group of the sugar and produces a flavor (Gaur, 2023). During this process, the amino groups are not neutralized by an alkaline environment. The flavor of this reaction is determined by the type of amino acid, which is the basis for the flavor industry (Schulze, 2023).



(Source: Teodorowicz, 2017)

3.4.2.2.2. Caramelization Reaction:

The caramelization process involves heating sugar slowly to around 170°C, which is a non-amino browning reaction. Heat breaks down the carbohydrates into compounds with a characteristic brown color and taste. This is a chemical reaction that occurs spontaneously at high temperatures that results in the decomposition of non-protein substances. There are hundreds of chemical products that can be produced by caramelization, but its process is complex. A small amount of caramelization occurs during baking and thus has limited significance in milk and milk products (Alfaro, 2019).



(Source: Cao et al., 2022)

3.4.2.2.3. Ascorbic acid oxidation

Ascorbic acid in fruits undergoes oxidation, resulting in a brown pigment and discoloration. The easily oxidized and decomposed nature of ascorbic acid contributes to food browning, regardless of its antioxidant properties. In the citrus industry, ascorbic acid is particularly important since it causes fruit juice and concentrates to brown. Various factors influence ascorbic acid degradation, including oxygen, p^H, concentration of ascorbic acid, metals, temperature, light, and citric acid (Das et al., 2022).

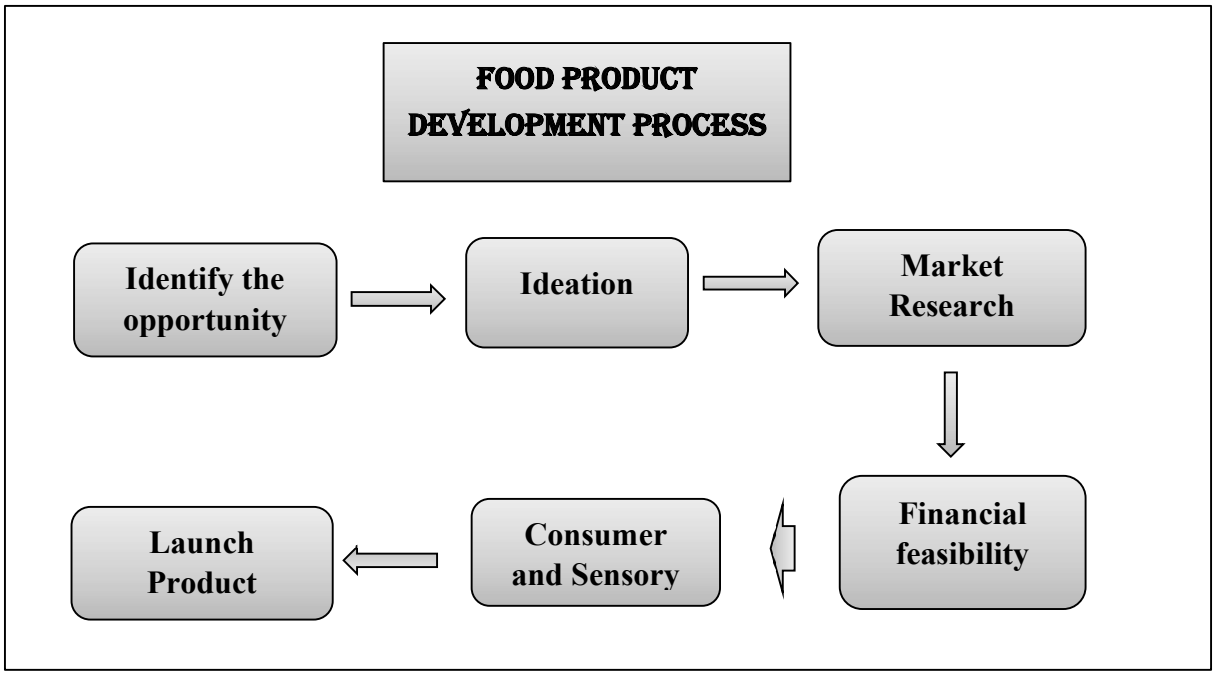
3.5. Food Product Development

Food product development is a multi-step process that includes many crucial steps including ideation, packaging design, regulatory compliance, marketing strategy, and distribution. Bringing a successful product to market requires balancing product quality, cost-effectiveness, sustainability, and consumer appeal iteratively (Aquino, 2023).

3.5.1. Importance of food product development

Food product development plays a vital role in determining the success of a product on the market. An elaborate process is used in the development of a new food product to capture the interest of target consumers, address gaps in their current preferences and needs, meet quality and food safety specifications, generate profit, and sustain a business. People with specific health problems or who live in different cultures and religions will also find specific food products developed by the food processing unit. The production of superior food products has led to an increase in global food consumption as a result of advances in food product development (Sharif et al., 2018).

3.5.2. Steps of product development



- **Identify opportunity:** The source of an idea can be anywhere. A great suggestion might come from a consumer or employee, or you might pick something up on the market. The idea must be more specific and ideally tested against other similar ones.
- **Ideation:** A business opportunity must be determined whether it meets a business need regardless of how nebulous it is. It is common for R&D to work with marketing to develop an idea, or for sales to have a customer request.
- **Market research:** The market research process is ongoing from the moment of ideation to the moment of sale. Making decisions based on assumptions can have bad consequences and cost you a lot of time and money. A new food product can be made even better with the help of different types of market research.
- **Financial feasibility:** To develop a rough manufacturing process and formulation, the product developer usually makes up samples on a benchtop or test kitchen scale. Financial analysis is also being conducted to determine if the production costs of the product make fiscal sense and what potential profits might be generated. Food companies are likely to consult their regulatory/legal departments to determine potential constraints regarding naming and labeling.
- **Consumer and Sensory insights:** Prototyping is an iterative process, and prototypes are often tested and showcased in order to ensure they meet all of the company's requirements.

Sensory testing might be conducted, or the sales team might sample the products at retailers to ensure that they meet all requirements.

- **Launch Product:** Launching a new product successfully plays a significant role in achieving optimal performance, and it is often the most expensive phase. A project comes to a conclusion at this point after a great deal of planning, research, and development. Launching a product involves three elements: strategy, activities, and demand outcomes, such as setting a launch date and label, as well as developing marketing strategies to create awareness and interest.

There is a wide range of product development processes available to manufacturers based on their products, services, markets, and areas of expertise.

References:

Adeyeye, S. A. O., Ashaolu, T. J., & Babu, A. S., Dr. (2022). Food drying: A review. Agricultural Reviews, (Of). https://doi.org/10.18805/ag.R-2537

An introduction to the Maillard reaction: The science of Browning, aroma, and flavor, Eric Schulze. (2023). https://www.seriouseats.com/what-is-maillard-reaction-cooking-science

Bishnoi, S., Singhania, N., & Rani, S. (2020). Freezing and frozen storage.

Cao, Xiaotong & Wu, Hanjing & Gonzalez Viejo, Claudia & Suleria, Hafiz. (2022). Effects of Postharvest Processing on Aroma Formation in Roasted Coffee - A Review. International Journal of Food Science & Technology. 58. 10.1111/ijfs.16261

Caramelization: It's what makes food turn brown when you cook it, Danilo Alfaro. (2019). https://www.thespruceeats.com/what-is-caramelization-995761

Das, D., Bhattacharya, A., Ikbal, A., Chowdhury, S., Murmu, P., Nath, S., Ahmed, R., International Research Journal of Innovations in Engineering and Technology (IRJIET) ISSN (online): 2581-3048. (August 2022). A mini-review: Enzymatic and non-enzymatic Browning 1Debjani, 6(8), 118–123. https://doi.org/10.47001/IRJIET/2022.608014

Devinder. (2021). Kushwaha, Radha and Singh, Vinti and Singh. Monika and Puranik. Effect of Food Processing on Nutritional and Anti-nutritional Components.

Enaru, B., Drețcanu, G., Pop, T. D., Stănilă, A., & Diaconeasa, Z. (2021). Anthocyanins: Factors affecting their stability and degradation. Antioxidants, 10(12), 1967.

Gaur, A. (2023). Maillard reaction temperature, mechanism, examples. https://www.adda247.com/school/maillard-reaction/

Jayas, D. S. (2016). Food dehydration. In Reference module in food science.

Jiang, Y., Duan, X., Qu, H., & Zheng, S. (2016). Browning: Enzymatic Browning. In B. Caballero, P. M. Finglas & F. Toldrá (Eds.), Encyclopedia of food and health (pp. 508–514), ISBN 9780123849533. https://doi.org/10.1016/B978-0-12-384947-2.00090-8

Kang, T., You, Y., & Jun, S. (2020). Supercooling preservation technology in food and biological samples: A review focused on electric and magnetic field applications. Food Science and Biotechnology, 29(3), 303–321. https://doi.org/10.1007/s10068-020-00750-6

Mahammad Juber, M. D. (2022). Written by WebMD editorial contributors. https://www.webmd.com/diet/health-benefits-chlorophyll

McHugh, T., & Thai, S. (2020). Canning clarified, FOOD TECHNOLOGY MAGAZINE britannica, the editors of encyclopaedia. "canning". Encyclopaedia Britannica, Retrieved November 15, 2021. https://www.britannica.com/topic/canning-food-processing.

Mattioli, R., Francioso, A., Mosca, L., & Silva, P. (2020, August 21). Anthocyanins: A comprehensive review of their chemical properties and health effects on cardiovascular and neurodegenerative diseases. Molecules, 25(17), 3809. https://doi.org/10.3390/molecules25173809

Meacham, J. (2023). https://www.healthline.com/nutrition/anthocyanin#benefits

Mehta, B. M., & Cheung, P.CK. (2014). Overview of food chemistry. In P. Cheung (Ed.), Handbook of food chemistry. Springer. https://doi.org/10.1007/978-3-642-41609-5_34-1

Madadi, E., Mazloum-Ravasan, S., Yu, J. S., Ha, J. W., Hamishehkar, H., & Kim, K. H. (2020). Therapeutic application of betalains: A review. Plants, 9(9), 1219. https://doi.org/10.3390/plants9091219

Nabavi, S. M., Šamec, D., Tomczyk, M., Milella, L., Russo, D., Habtemariam, S., Suntar, I., Rastrelli, L., Daglia, M., Xiao, J., Giampieri, F., Battino, M., Sobarzo-Sanchez, E., Nabavi, S. F., Yousefi, B., Jeandet, P., Xu, S., & Shirooie, S. (2020). Flavonoid biosynthetic pathways in plants: Versatile targets for metabolic engineering. Biotechnology Advances, 38, 107316. https://doi.org/10.1016/j.biotechadv.2018.11.005

Ngamwonglumlert, L., & Devahastin, S. (2019). In Encyclopedia of food chemistry.

Radojčin, M., Pavkov, I., Bursać Kovačević, D., Putnik, P., Wiktor, A., Stamenković, Z., Kešelj, K., & Gere, A. (2021). Effect of selected drying methods and emerging drying intensification technologies on the quality of dried fruit: A review. Processes, 9(1), 132. https://doi.org/10.3390/pr9010132

Policegoudra, R., M., S., Chauhan, O. P., & Semwal, A. D. (2022). Pigments and colors. In O. P. Chauhan (Ed.), Advances in food chemistry. Springer. https://doi.org/10.1007/978-981-19-4796-4_8

Polturak & Aharoni, (2017). ‘‘La Vie en Rose’’: Biosynthesis, Sources, and Applications of Betalain Pigments, Molecular Plant, https://doi.org/10.1016/j.molp.2017.10.008

Rahimi, P., Abedimanesh, S., Mesbah-Namin, S. A., & Ostadrahimi, A. (2019). Betalains, the nature-inspired pigments, in health and diseases. Critical Reviews in Food Science and Nutrition, 59(18), 2949–2978. https://doi.org/10.1080/10408398.2018.1479830

Rajjak, H., (2023). Types of Browning (enzymatic and non-enzymatic), https://hmhub.in/types-browning-enzymatic-non-enzymatic/

Riaz, S., Kabir, A., Haroon, A., Ali, A., & Manzoor, M. F. (2022). Food dehydration recent advances and approaches, A comprehensive review of the versatile dehydration processes. https://doi.org/10.5772/intechopen.108649

Sadowska-Bartosz, I., & Bartosz, G. (2021, April 26). Biological properties and applications of betalains. Molecules, 26(9), 2520. https://doi.org/10.3390/molecules26092520

Šamec, D., Karalija, E., Šola, I., Bok, V. V., & Salopek-Sondi, B. (2021). The role of polyphenols in abiotic stress response: The influence of molecular structure. Plants, 10(1), 118. https://doi.org/10.3390/plants10010118.

Schillers, R. (2021). What Are Flavonoids? http://bvttav.ttu.cc

Sethi, S., Joshi, A., Arora, B., & Chauhan, O. P. (2022). Chemical composition of foods. In O. P. Chauhan (Ed.), Advances in food chemistry. Springer. https://doi.org/10.1007/978-981-19-4796-4_1

Singh, R., & Singh, A. Applications of food irradiation technology. (2020). Defence Life Science Journal, 5(1, January), 54–62. https://doi.org/10.14429/dlsj.5.14398

Teodorowicz M, Van Neerven J, Savelkoul H. Food Processing: The Influence of the Maillard Reaction on Immunogenicity and Allergenicity of Food Proteins. *Nutrients*. 2017; 9(8):835. https://doi.org/10.3390/nu9080835

Uddin MS, Mamun AA, Rahman MA, Kabir MT, Alkahtani S, Alanazi IS, Perveen A, Ashraf GM, Bin-Jumah MN and Abdel-Daim MM (2020) Exploring the Promise of Flavonoids to Combat Neuropathic Pain: From Molecular Mechanisms to Therapeutic Implications. Front. Neurosci. 14:478. doi: 10.3389/fnins.2020.00478

Yasmeen, N., Sameer, A. S., & Nissar, S. (2022), Chapter 6. Lycopene. In J. Kour & G. A. Nayik (Eds.), Nutraceuticals and health care (pp. 115–134), ISBN 9780323897792. https://doi.org/10.1016/B978-0-323-89779-2.00009-0

Wu, Y., Ye, H., & Fan, F. (2022). Nonenzymatic Browning of amorphous maltose/whey protein isolates matrix: Effects of water sorption and molecular mobility. Foods, 11(14), 2128. https://doi.org/10.3390/foods11142128

Chapter-4
Bakery and Confectionary

Souvik Tewari

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: souvikt@svu.ac.in

4.1 Introduction:

A bakery is a business or store that makes and markets baked goods made with flour. Food products like bread, bagels, buns, cakes, pastries, pies, cookies, muffins, brownies, pizza, and so on are sold in bakeries. Bakeries manufacture and market both savoury and sweet foods, as the list above illustrates. Unlike candies, a bakery produces a wide range of foods (Jagarlamudi, 2022).

Confectionery can refer to the candies or sweets made in a confectionery (Hansen, 1986). The primary distinction between confectionery and bakery is that the latter solely offers candies for sale. A bakery manufactures and markets both sweet baked goods and unsweetened food items (Mathuravalli, 2021).

Bakers' confections and sugar confections are the two broad categories into which the term confectionery is divided. Sweet foods with a sugar base that are typically consumed as snacks are known as sugar confections. Chocolates, chewing gum, and candies are examples of sweet confections. Sweet baked goods are among a baker's confections, especially those consumed as desserts. Pastries, cakes, doughnuts, and so forth are examples of this category.

4.2 History, Prospects and Trends in Bakery industry

There have been baked goods for thousands of years. Early on in the Roman Empire, baking became an art. It was a very well-known craft because Romans adored baked goods and regularly requested them for special events like feasts and weddings (Benton, 2020). Because baking became so popular and in demand, baking was recognised as a legitimate occupation for Romans around 300 BC. The bread was first baked by the bakers in their homes using mills to grind grain into flour. The initial bakers' guild was founded in Rome in 168 BC as a result of the persistent demand for baked goods. This dramatic increase in demand for baked goods encouraged baking throughout Europe and even spread to eastern Asia. Breads and other goods were first baked by bakers at home and then sold on the streets.

Once this pattern spread, baked goods were soon being sold on the streets of Rome, Germany, London, and many other places. Due to the sharp rise in demand for baked goods and breads, a system of delivering the goods to households was created. This incited the bakers to open a shop where customers could buy baked goods for themselves. As a result, the first outdoor bakery in Paris was established, and ever since, bakeries have become a popular location to purchase delicious goods and get together around the world.

One of the largest industries in India's food processing sector, baking offers a wealth of opportunities for growth, innovation, and job development. In 2018, the market value of the bread, biscuits, cakes, and pastries segment of the bakery business was USD 7.22 billion. India is a major player in the global biscuit market, ranking second only to the United States in terms of production. The nation's spirit of entrepreneurship makes it an extremely promising area for the baking sector.

The changing tastes and lifestyles of consumers are shaping the bakery sector in India. As part of a global trend, there is an increasing demand for healthier options and products, especially in the case of bakery goods, which are now more frequently consumed on a daily basis rather than as a treat. Due to high consumption rates, consumers want "guilt-free" baked goods and are increasingly looking for gluten-free or products made with substitute ingredients like whole-wheat and multigrain cereal. Flavour innovation is important because millennials, in particular, are constantly looking for new flavours and experiences in addition to healthier options.

4.2.1 Markets of India Bakery Products:

The market for bakery products in India was valued at USD 7.5 billion in 2020 and is expected to increase at a compound annual growth rate (CAGR) of 8.3% to reach USD 13.0 billion by 2027. Baking items have gained popularity among consumers all across India due to their affordable pricing and great nutritional value. The Indian bakery products market is experiencing considerable growth and product line improvements due to the growing working population and the health benefits of products manufactured from different grains like as maize, wheat, oats, and so on. Furthermore, a major factor in the market's expansion is India's increasing proportion of working women (Kumar & Singh, 2022).

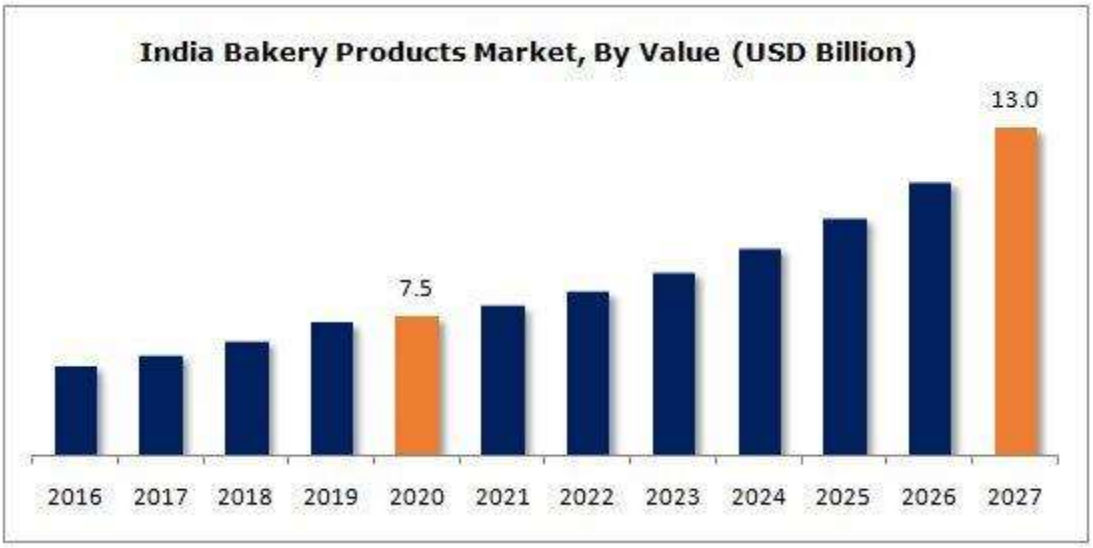


Figure: 4.1 India Bakery Products Market (Source: Kumar & Singh, 2022).

4.2.2 Nutritional quality and safety of bakery products:

Important processed foods that are ready to consume include those from bakeries. Due to the poor nutritional makeup of wheat grains in general, these goods have low nutritional quality. The fact that they prepare with refined flours serves to emphasise this even more (Chavan *et al*., 1993).

4.2.3 Product quality and characteristics of bakery products

According to extensive review of literature, crispy baked products are required by consumers as it is inter-related along with texture, flavour, and other organoleptic attributes. Lesions the crispiness of biscuits delay the storage period of bakeries. Mechanical attributes of bakery foods are depended upon mixing and processing of food ingredients (Silva & Costa, 2017). The principal attributes of bread are associated along with protection of dough from deformation, the harmony among elasticity and viscosity and rate in dough development like raising, people approval of bread can be associated with moisture containing of developed product, moisture may hamper crispiness of bakeries (García-Gómez et al*.,* 2022). In food industry, textural attributes of bakery confectionaries are very essential for instance quality control (Kpossa & Lick, 2020; Hasgucmen & Sengun, 2020). Instrumental texture analysis especially Texture Profile Analysis (TPA) is the objective procedure which may be correlated along with sensory textural characteristics (Rahman et al*.,* 2021). TPA is defined as imitation of compression of a bite on a piece of food, possessing twice the movements of the jaws in chewing. This test is present based on sample's responsibility to the applied force. Strains quantity is 20 to 50% are generally utilised to semi solid compounds, under these all situation,

samples may not break down and develop it possible to make adequate textural attributes. Sensory evaluation is most preferrable for evaluating quality and preference of purchaser. Furthermore, organoleptic properties of baked product like flavour, texture and taste must have supreme efficacy to people (García-Gómez et al., 2022; Kpossa & Lick, 2020; Kock & Magano, 2020). Discriminating sensory evaluation is classified into two types for instance difference test like triangular test and simple paired difference test (Carmo, 2018). Furthermore, attribute differentiation in which bakery products have gotten rating according to it's intensity. Descriptive sensory methodology is regarded as identification, description and quantifying the sensory properties of food constituent. The food industry applies this methodology for generating newly developed products and quality control moderating the food constituents and analyse the developed products during storage (de Alcantara et al., 2018; Caballero et al., 2016). In accordance with Almendras & Kirigin, 2011; instrumental and sensorial two types of methods these evaluate the textural attributes and other organoleptic features of bakery compounds.

4.2.4 Fault and corrective measures of bakery products

Faults in bakery products can arise from various factors. Here are common issues and corrective measures:

4.2.4.1 Crumbly Texture:

Fault: Too much fat or sugar.
Correction: Adjust fat and sugar ratios, or increase liquid content.

4.2.4.2 Tough Texture:

Fault: Overmixing the dough.
Correction: Mix ingredients just until combined, avoiding excessive mixing.

4.2.4.3 Flat or Sunken:

Fault: Insufficient leavening (yeast or baking powder).
Correction: Ensure proper measurement of leavening agents, and check their freshness.

4.2.4.4 Uneven Browning:

Fault: Uneven oven temperature or incorrect placement.
Correction: Calibrate your oven, rotate pans during baking, and place them in the center.

4.2.4.5 Soggy Bottom:

Fault: Underbaking or improper cooling.
Correction: Bake thoroughly and allow proper cooling on a wire rack.

4.2.4.6 Bitter Taste:

Fault: Excessive baking soda or baking powder.
Correction: Double-check measurements and balance the recipe.

4.2.4.7 Dense Texture:

Fault: Using too much flour or not enough leavening.
Correction: Measure flour accurately, and ensure proper leavening agent quantities.

4.2.4.8 Cracked Top:

Fault: Rapid temperature changes during baking.
Correction: Preheat the oven, avoid opening it excessively, and cool

4.3 Biscuits, cookies & crackers: ingredients and process, product quality, characteristics, faults and corrective measures

Biscuits are very much convenient foods for people of different age groups in worldwide (Adebowale et al., 2013). In emerging baking industry, wheat is the proficient cereal component & widely used for formulation of biscuits as it provides some physicochemical properties that share positive impact in baking industry (Svec & Hruskova, 2010). These types of foods are governed by wheat & various cereal products that's why fount of weak protein shares bad nutritional efficacy. Researchers have found that, cereal enriched food compounds along with another protein like oil seeds & legumes has gained much positive outcome. Essential amino acid consist lots amount at oil seed & legumes whereas cereals carry limited amount of protein, amino acid. The utilization of combined flour based on wheat & another cereal constituents in bakery industry are very much gained attention as of the commercial & nutritional benefits of compounded flour. Researchers have pointed out that, cereals & legumes has effective activity in human microbiome. Dietary formulation of unprivileged section of people generates from cereals & legumes in some developing countries therefore it is the superficial for amalgamation to transport the nutrients (CSA, 2015). Biscuits are probably evolved from cereal products like maize, barley, wheat, sorghum, millet & much more. Cereals are best transporter of macronutrients & also micronutrients (Dicko et al., 2006).

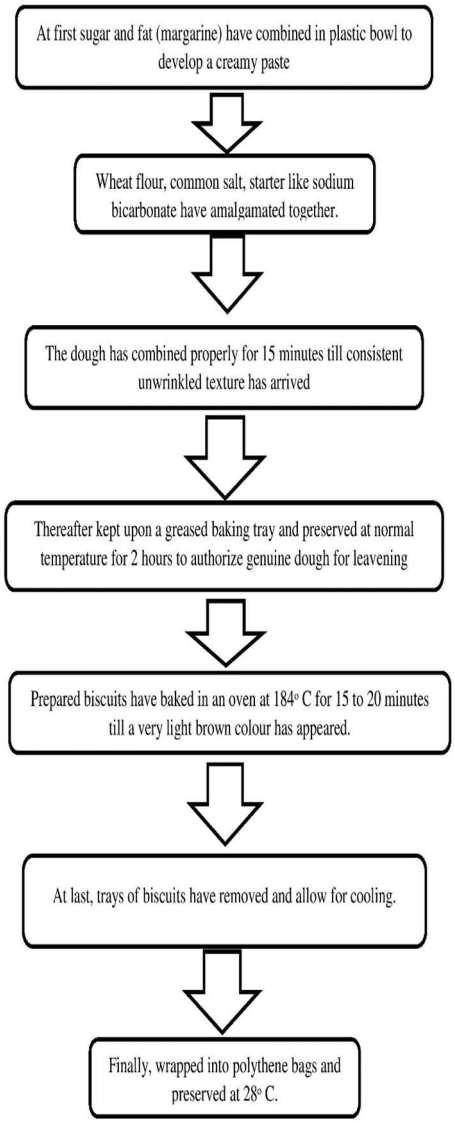
Researchers have also shared that, in modern community biscuits are very much prepared from legumes as people prefer snack foods like biscuit which consists of low fat, high protein, dietary fibre & along with phytochemicals & nutraceuticals. Noteworthy, cereals are deficient in essential amino acids like lysine but that is present in highest quantity in pulses. On the other side essential amino acid like methionine is present in cereal adequately but legumes contain

this amino acid in less quantity. Furthermore, legumes are essential plant origin that is known to be complementary product of cereal in baking industry like biscuits (Ayo et al., 2014).

4.3.1 Ingredients & Process of Biscuits preparation:

Biscuits are prepared by using primary constituents including wheat flour, fat/oil, common salt, sugar, water besides secondary ingredients for developing this are salt, egg, emulsifier, starter like sodium bicarbonate/ ammonium bicarbonate, milk powder and seasoning spices (Mancebo et al*.,* 2015).

4.3.1.1 Flow diagram of Biscuit production (Source: Ukpong et al*.,* 2021)



4.3.1.2 *Structure formation in biscuits at different baking times:*

Researchers reviewed the theories regarding the development of structure and texture of biscuits during production, which are readily summarised in a qualitative manner using the Complex Dispersed Systems technique. Following that, they depict the changes in the state of the biscuit during manufacturing in the supplementary state diagram, which shows the significant phase transitions that occur during mixing and baking. The author hypothesised that similar forms and textures can be generated by reformulated biscuits following similar paths in the state diagram. Physical theories exist to predict these phase transitions in present sucrose-rich biscuits as well as reformed biscuits incorporating a variety of sweeteners as sugar substitutes. When structure and texture predictions are integrated with computational models that include heat and moisture flow, more accurate forecasts of structure and texture can be obtained (Van der Sman and Renzetti, 2019).

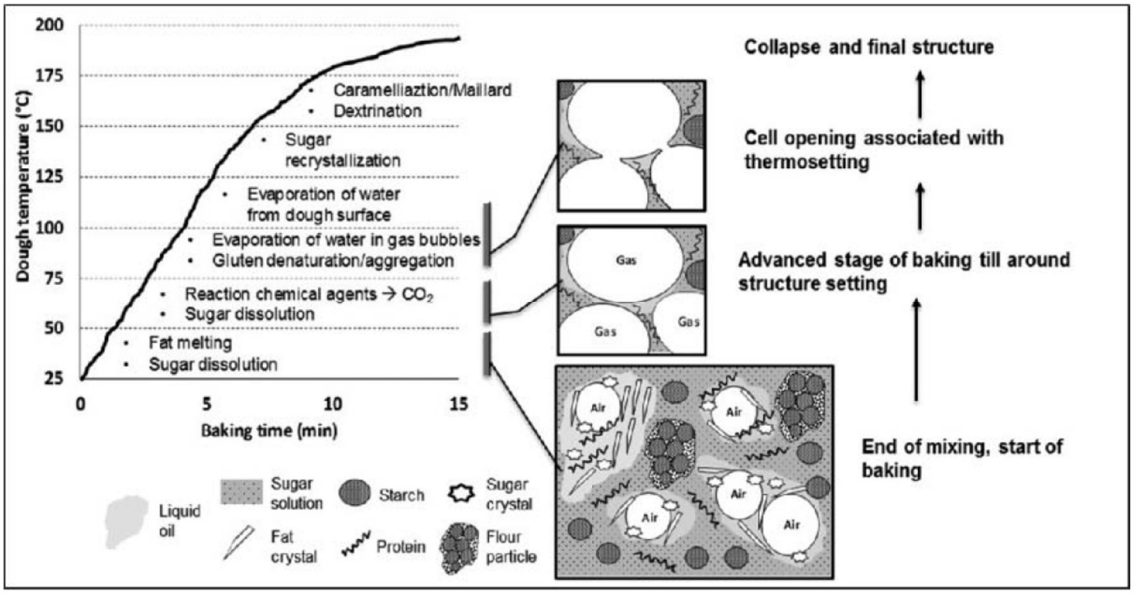


Figure: 4.2 Structure evolution in biscuits throughout various phases of baking, linked to physical chemical transitions. Based on dough making insights, the dough structure at the end of mixing is elaborated (Source: Van der Sman and Renzetti, 2019).

4.3.2 Ingredients & Process of cookies making:

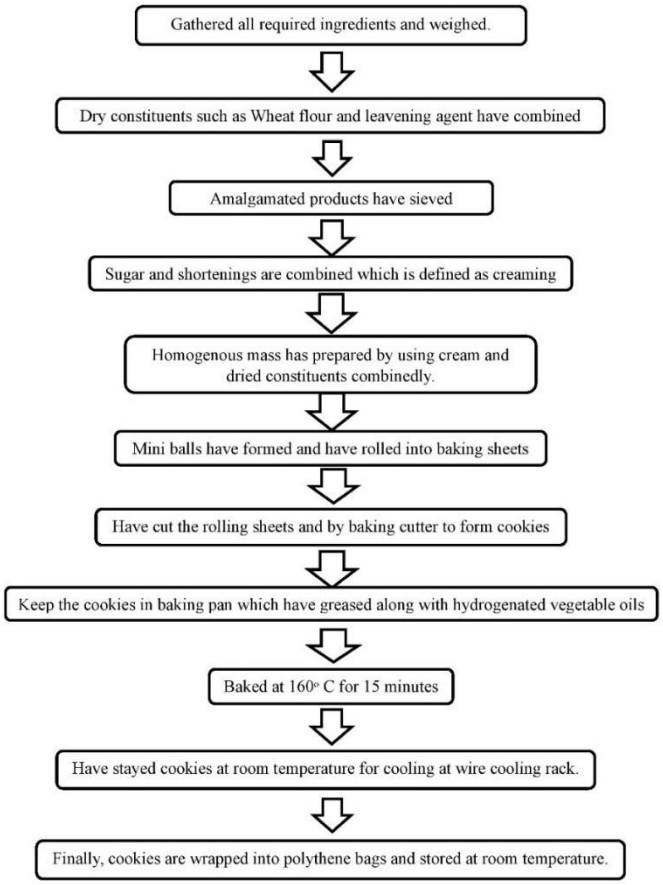
Cookies are defined as baked confectionaries composed by major constituents like flour, sugar, and fat these are amalgamated along with other compounds for producing dough. According to literature review, for developing biscuit wheat flour is the principal ingredient. Wheat flour has ability to develop adequate texture of glutenous product, that involves into

expanding the airy cells and promote rigidity and baking. Apart from good site, wheat flour has negligible quantity of essential amino acids compared along with oilseeds and pulses (Kulkarni & Joshi, 2015; Murugkar, 2014). Cookies are accepted by all aged people as it is convenient to carry, promote good psychological health, also have extensive storage capacity, furthermore protein fortified cookies are involved to mitigate malnourishment. Cookies are developed by utilising refined wheat flour. This flour is amalgamated with oilseeds and pulses like soyabean, chickpeas that uplifted nutritional quality of cookies. Most importantly, Soybean created essential oil. Soybeans contain 30 to 45% protein with better origin of all indispensable amino acids. Noteworthy, Defatted soy flour (DSF) is a cheaper, convenient, conventional, and best source of protein. Soy proteins are novel protein among Phyto-proteins and it carries superb biological value and essential amino acid lysine, is the limiting amino acid in cereals (Kulthe et al*.,* 2011; Sreerama et al*.,* 2010).

Ingredients: Refined wheat flour, Soybean, Moth bean, Chickpea, Sugar, Shortening, Leavening agent and Flavouring agent (Custard powder), hydrogenated vegetable oil.

Equipment's- Baking sheets, baking cutter, wire cooling rack.

4.3.2.1 Flow diagram of developing cookies (Source: Soni et al*.,* 2018)



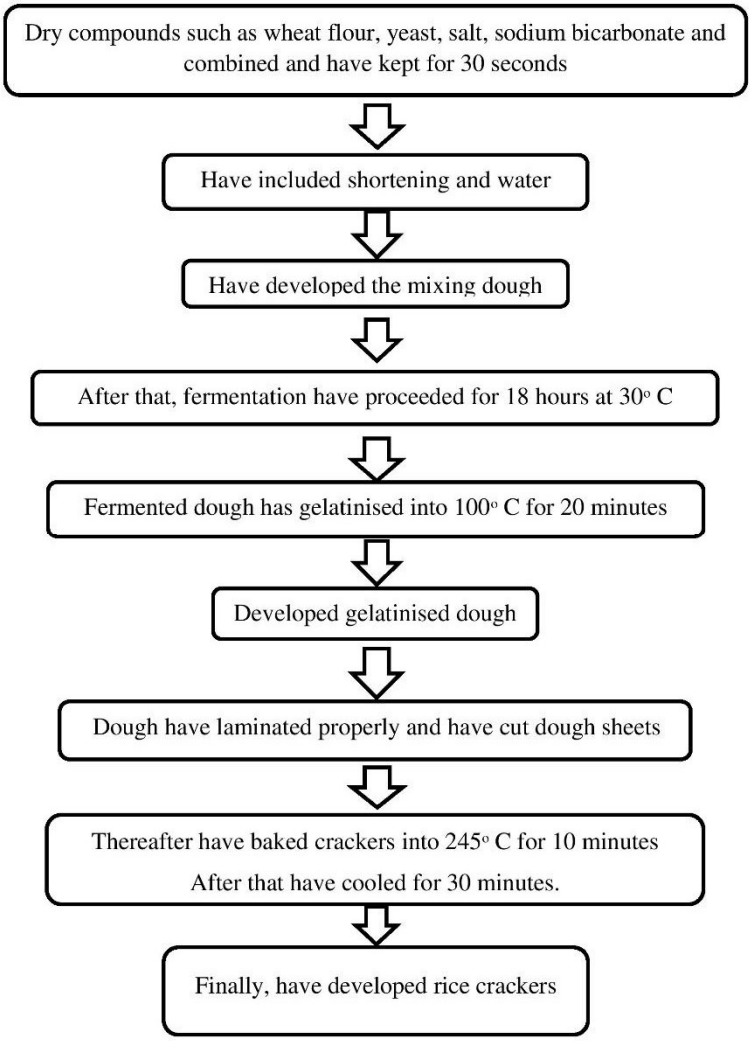
4.3.3 Ingredients & Process of Crackers preparation:

According to literature review, rice crackers are defined as "Arare" developed from glutenous rice and "Senbei generated from non-glutenous rice" (Keeratipibul et al*.,* 2008). The development procedures and its organoleptic characteristics of these products are comparatively distinct from western crackers. Rice flour is steamed, kneaded, cooled, dried, and baked (Noomhorm et al., 1997).

Authors have revealed that, western typed crackers are classified into 3 types these are soda cracker regarded as saltine cracker, chemically leavened crackers, and enzyme crackers. Conventional saltine crackers carry no harmony methodology for developing crackers along with another cereals and wheat flour (Li et al*.,* 2014). According to Han et al*.,* 2010, for developing gluten free crackers there have utilised pulse flour which consists of <1% xanthan gum, results have shown that, restricted gluten and highly absorption capacity of water in whole wheat flour stop the development of gluten network. Furthermore, Rice has approximately 20–25% (w/w) amylose content which is good for developing the yeast leavened rice bread having a softer texture and extended volume in comparison to rice with lower or higher amylose (Han et al*.,* 2012).

The protein Gluten is the super structural-forming protein that is present in yeast-leavened wheat bread and is best for its viscoelastic characteristics. However, rice protein may not develop a network which can hold fermentation gases. Thus, the amylose of rice monitors the expanded volume at the time of the popping of heated raw rice and the texture of yeast-leavened rice bread (Han et al*.,* 2012).

4.3.3.1 Flow diagram of developing crackers (Source: Kim & Soo, 2019)



4.3.4 Ingredients & Process of Breakfast cereals

The advantages of breakfast are the prime meal of the day, it is most of the superior meal of healthy and adequate harmonised lifestyle. The breakfast cereals are prominently associated along with multiple health factors like body weight of children to adolescents' period (De la Hunty et al*.,* 2013). Breakfast cereals are defined as processed cereals like porridge type breakfast and ready to eat cereals (RTECs) or cold breakfast cereals like cornflakes and muesli (Priebe & McMonagle, 2016). Adequate breakfast cereals intake is associated with psychological wellbeing besides improve the complications of metabolic distress like obesity, hypertension, diabetes (Malik et al*.,* 2010), cardiovascular complications (Huang et al*.,* 2014), dental cavity (Moynihan, 2016) and so on (Williams, 2014). RTECs are mainly involved along with increased consumption of vitamins and minerals from children to adult age group either by intake in direct or consume along with milk (Fulgoni & Buckley,

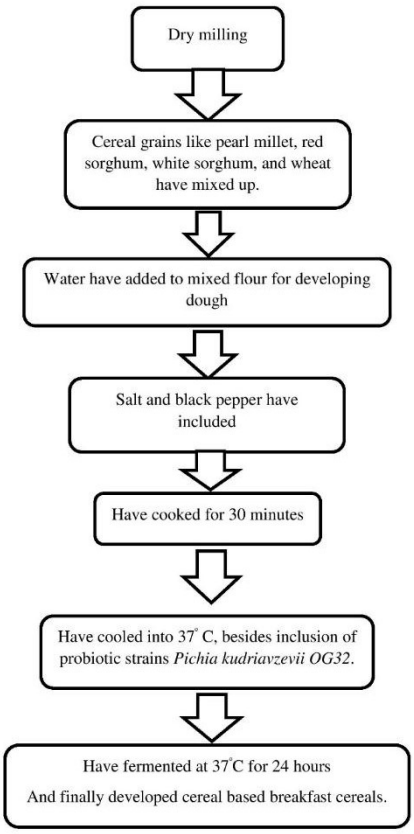
2015). RTECs carry extensive amount of macro and micro nutrients, that authorize the recommended nutritional requirements of some nutrients to be met, these efficacies have observed because of fortifying the breakfast cereals (Williams, 2014). As it contains excessive level of salt and sugar therefore develop multiple health disorders if excess quantity has imbibed (Chepulis et al*.,* 2020). Harmonically construction must develop to the consumption of positive nutrients like dietary fibre.

4.3.4.1 *Ingredients of breakfast cereals:*

Breakfast cereals can be made with a variety of ingredients, and the specific components can vary depending on the type of cereal. However, here are some common ingredients found in many breakfast cereals (Ferriola and Stone, 2006):

- **Grains:** Cereals often contain a base of grains. Common grains include oats, wheat, rice, corn, barley, and rye.
- **Sweeteners:** To add sweetness, various sweeteners may be used. This can include sugar, honey, maple syrup, or other natural sweeteners.
- **Flavorings:** Ingredients like vanilla, cinnamon, or other flavorings may be added to enhance the taste.
- **Nuts and Seeds:** Some cereals include nuts (such as almonds, walnuts, or pecans) or seeds (like sunflower seeds, flaxseeds, or chia seeds) for added texture and nutritional value.
- **Dried Fruits:** Raisins, cranberries, apricots, or other dried fruits are often added to cereals for sweetness and chewiness.
- **Fortifications:** Many breakfast cereals are fortified with vitamins and minerals, such as iron, calcium, and various vitamins, to enhance their nutritional content.
- **Salt:** A small amount of salt may be added for flavor.
- **Preservatives:** Some cereals may contain preservatives to prolong shelf life.
- **Binding Agents:** Ingredients like oil, fat, or lecithin may be used as binding agents to help the cereal maintain its shape (Murphy-Gutekunst and Barnes, 2005).

4.3.4.2 ***Flow diagram for developing breakfast cereals*** (Source: Ogunremi et al*.,* 2015)



4.3.4.3 Quality of Breakfast cereals

In accordance with extensive review of literature, flavour of breakfast cereals relied upon the harmonisation of volatile constituents which is there at present in foods or developed during processing. Furthermore, volatile compounds are produced with the help of yeast during fermentation which promote adequate quality of breakfast cereals (Callejon et al*.,* 2010). Probiotic strain *Pichia kudriavzevii OG32* upgraded the flavour and quality of functional breakfast cereals. Noteworthy, fermented volatile components are developed primely at the time of fermentation (Annan et al*.,* 2003). This type of cereals should enrich along with good nutrients and energy (Van den Boom et al*.,* 2006).

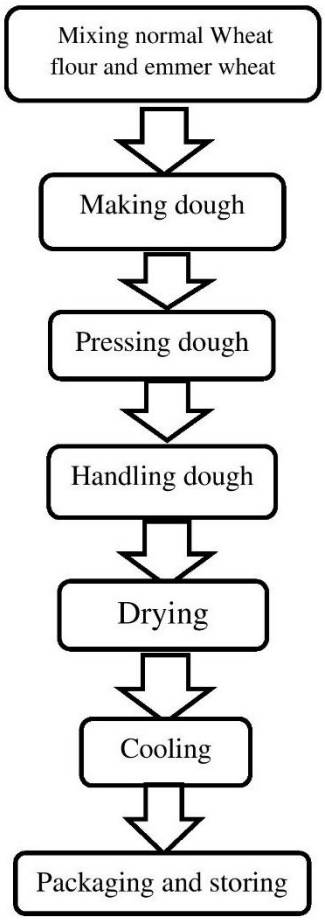
4.4 Macaroni products

4.4.1 Production and quality

Balanced diet provides an advantageous function in human health. Macaroni products are regarded as pasta. Pasta contains crucial nutrients which have extensive efficacy on human health. Pasta is accepted by people especially teenage to adult as it relishes mood and other

psychological satisfying. Food compounds are supplemented by dietary constituents which are manufactured by macaroni generating enterprises, which are instigated in the trade zone however it's quantity in rather tiny in proportion. According to literature review, macaroni compounds including pasta is non-conventional food compounds, however now a days, macaroni products including pasta is enriched by several nutrients (Avetisyan, 2015).

4.4.2 Flow diagram for developing macaroni (pasta) (Source: Aptrakhimov et al*.,* 2023)



4.4.3 Quality of macaroni products

Pasta is generally flour compound as it has higher digestibility of the essential constituents, have prolonged shelf life, lower quality, and accessibility. Authors have revealed that, multigrain flour in B grade macaroni compounds such as pasta has superb quality, 30 % of wheat flour in composition of pasta. Multigrain flour is comprised of barley, rye, and oat, this has extensive dietary fibre consistency. Macronutrients like lipid, micronutrients like magnesium, phosphorus are present in minute quantity as it hampers good quality as well as bearable cooking attributes (Betz et al*.,* 2020). To improve the technological stability, must use emmer wheat flour in developing macaroni products. Some attributes should be reviewed for

determining the quality of pasta such as gluten, carotenoid, the presence of dark inclusion, the roughness of grinding (Khmeleva et al*.,* 2021), among these attributes' carotenoid pigment and dark incorporation play a graceful function, this also discover the organoleptic characteristics of pasta. The colour of this wheat flour depends on raw material utilisation. Raw gluten and starch are utilised as structural constituent in developing pasta. Authors have also noted that, to develop superior qualified macaroni products like pasta 28% raw gluten powder should be utilised, the emmer wheat flour may be applied in amalgamation along with wheat flour. Noteworthy, emmer wheat flour and soft wheat flour have distinct composition, soft wheat flour have extensive quantity of gluten that is composed of gliadin and glutelin, gluten is accountable for unbreakable ability.

Emmer wheat flour is used alone impossible as it contains low gluten therefore, wheat flour must be applied for binding along with this type of wheat flour. Emmer wheat flour and wheat bran into macaroni products upgraded the elasticity of natural gluten. The principle rheological attributes pasta is the maximum shear stress through 1.65 to 2.35 times, enhances the temperature of viscosity of starch gel through 0.25 to 1.5° C these are the patrons for generating inflated quality of pasta. Furthermore, wheat bran requites the efficacy of emmer wheat flour, it has strengthened impact upon the attributes of raw gluten, has extensive water absorption impact that uplifted the viscosity of pasta and rightly develop structure forming application of pasta. Amalgamation of emmer heat flour and raw wheat flour improve the composition of dietary fibre which is more than 15% along with another essential nutrients (Khmeleva et al*.,* 2021).

4.5 Malt: Production and quality

An enzymatic process that starts grains germination and allows them to sprout produces malt. Because of its high enzyme content, barley is the most widely malted grain. You can also use other grains like triticale, rye, corn, sorghum, oats, wheat and rice.

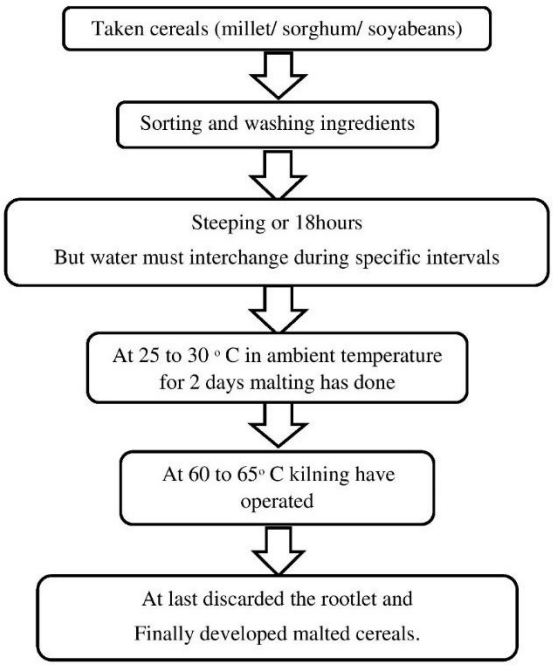
According to extensive review of literature, beer is regarded as most accepted alcoholic beverages that is comprised of malt, hops, water, and yeast. Except water, malt is the main ingredient and may be prepared from various constituents including cereals like barley, wheat, corn, rye, sorghum and so on. Barley has been utilising as principal malt cereal as it carries adequate quantity of macronutrients like carbohydrate, protein, and the inclusion of husk and after that able fort wort filtration at the time of lautering (Kunze & Mieth, 2014). Noteworthy, barley is the good cereal for developing the new product and germination that are simply

managed and able for providing an adequate number of enzymes which are needed for malt as well as beer development. Furthermore, malting is regarded as the transformation of barley kernels by enzymes and breakdown high molecular weight compounds like starch granules and insoluble proteins into small molecular weight constituents besides soluble as substrate for fermentation furtherly (Baxter & Hughes, 2001). Noteworthy, cereals are included into germination process., that is swinged at a convenient time through highest temperature. Precisely, flavour and colour are developed depends upon intensity and exposure time to such a temperature and humidity utilised and moderating the level of nutrients (Narziß et al*.,* 2017). Malt products are developed through such variables. Authors have documented that, pilsner pale malt are developed by three conventional malting procedure including steeping, germination and kilning. Barley malts are constructed after extension of modification level during germination and enhancing the final temperature are applicable along with humidity, offering the mass of substrate and energy for developing enzymatic browning including caramelisation, pyrolysis, Maillard reactions. Moreover, roasted barley malts are included many malting techniques, being the roasting drum the efficient element for thermal process (Kunze & Mieth, 2014).

In highest temperature, nutrient composition and enzymatic activity are totally decreased during thermal processing. So that, malts are utilised as tiny fraction in combining with the base pilsner malt for adding fine colour and flavour to wort filtration which permit the generation of vast pool of beer designs and another liquid refreshment. Furthermore, enhancing the appetite mouthfeel Ness are another characteristic of malt to beer as they contain melanoidin and non-fermentable saccharides like dextrin. Moreover, malt is the encouraging modifier as it has ability to develop adequate organoleptic attributes of ultimate compounds, it's colour is varied from light to dark. Sharp to sugary taste, beautiful to bad smoke fragrance. Malt development usually depends upon coloured kernels. Malting procedure are solely involved for generating flavour, colour by steeping, germination, kilning (Kunze & Mieth, 2014; Narziß et al*.,* 2017) The intension of the pilsner-malting procedure is very solely and innovative to develop enzymes along with breakdown of β-glucan, starch, and macronutrients like insoluble proteins. This process addresses the biotransformation of the nutrients of the endosperm toward the synthesis of specific proteins and amino acids. Besides, specialty malts differing from the traditional malting in terms of such aspects as colour, flavour also acidity (Narzib). Conventional non-alcoholic liquid refresher drink which is developed from millet have minimum viscosity and share sweet-sour taste, milky cream in aspect and is favoured by

people of northern Nigeria (Adeyemi & Umar, 1994). In certain tribes, kunu is used as a refreshment or as a thirst quencher for adults, but it is also occasionally used to wean infants. But because grains are used to make this beverage, it lacks sufficient protein and needs to be supplemented. The principal cereals utilised in the making of Kunu include rice, sorghum, guinea corn, millet, and maize. Ginger, black pepper, red pepper, alligator pepper, and kakandoru are the materials needed to develop Kunu. Each of these ingredients offers a wide range of benefits. The primary component of kunu is water, which serves as a medium for the dissolution of other ingredients and contains very little in the way of inorganic compounds. Kunu has a high nutritional value because to its protein, carbohydrate content, and many vitamins, particularly vitamin B (Adelekan et al*.,* 2013).

4.5.1 ***Flow diagram for developing malt*** (Source: Adelekan *et al.,* 2013)



4.6 Sweet Products - classification - Ingredients used in the preparation

4.6.1 Caramel: classification - Ingredients used in the preparation

Caramel is regarded as colouring matter, it is very much potent antioxidant, which is utilised in developing various food constituents. It is classified into 4 classes to promote the needed lots of food and beverage. Furthermore, caramel is an amalgamation of fat globules consist of different sizes, which is adjacent by excess concentrated sugar solution in this milk solids not fat is disintegrated. Naturally, it is developed by heated mixture of glucose syrup, milk, and vegetable fat in temperature of 118°C to 130°C. Heating escalates browning

mechanism and monitors the moisture content of final compounds. Some attributes influence the texture of caramel product and chew is the amount of moisture left in the caramel. Colour and flavour are prime attributes of food caramels. Apart from that, caramel stop the prevalence of non-enzymatic browning reaction. A strong type of caramelisation with yet another flavour is obtained by alkaline treatment for instance- chemical reaction among sodium bicarbonate along with syrup in boiling condition at 148.8° C. The mechanism of ammonia upon reducing sugars therefore develop caramel colour. The polymeric compounds from normal caramel are developed from liquification of aldehyde and ketone produced through heating the sugar along with bases or acids. Ammonia caramel is developed in Maillard mechanism in which carbonyl group chemically reacts along with amino groups or ammonia. Sulphite caramel is also Maillard types polymer. According to extensive review of literature, caramel is classified extensively into 4 types, these are caramel colour-1 also defined as plain or spirit caramel, caramel colour-II which is caustic sulphite caramel, caramel colour- III this is the ammonia beer caramel and also defined as baker's and confectionaries' caramel, caramel colour- IV that is defined as sulphite- ammonia, soft drink caramel or acid proof caramel (Sengar & Sharm, 2014). Authors have revealed that, high pressure liquid chromatography is capable to distinct each class of caramel, monosaccharides like D-glucose, D-fructose, anhydro sugars, disaccharides like glucobioses and Pseudodisaccharides like di-D- fructose dianhydrides consist D-fructose, D-glucose, and sucrose caramels are distinct through gas-liquid chromatography-mass spectrometry (GLC-MS).

4.6.2 Classification of caramel:

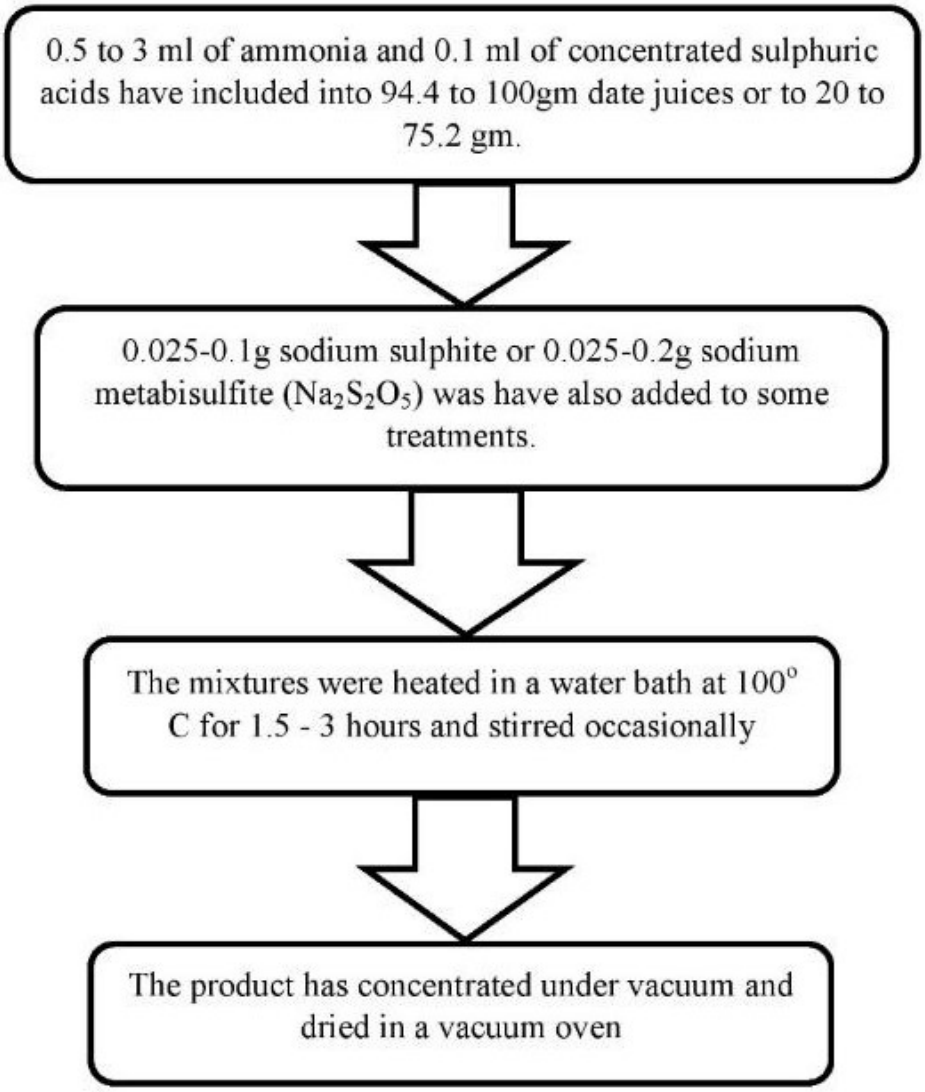
Caramel is a type of confectionery product that is made by heating sugar. It can come in various forms, including liquid, solid, and as a sauce. The classification of caramel can be based on its stage of preparation, color, flavor, and usage. Here is a general classification with a brief explanation of each type (Sengar and Sharma, 2014; Kamuf et al., 2003):

- **Stage of Preparation:**
    - **Soft or Light Caramel:** This is achieved by heating sugar until it reaches a temperature of around 320°F (160°C). It has a pale golden color and a mild caramel flavor.
    - **Firm or Medium Caramel:** Cooked to a higher temperature (around 338°F or 170°C), resulting in a deeper color and a more intense flavor.

- **Hard or Dark Caramel:** Cooked to an even higher temperature (about 350°F or 177°C), producing a dark color and a robust, bitter-sweet flavor.

- **Based on color:**
  - **Golden Caramel:** Light in color, often used in candies, sauces, and some desserts.
  - **Amber Caramel:** A deeper, amber color, commonly used in baking and confectionery.
  - **Dark Caramel:** A dark brown color, often used for flavoring in beverages and rich desserts.
- **Based on flavor:**
  - **Butterscotch:** Caramel made with the addition of butter, giving it a rich and buttery flavor.
  - **Salted Caramel:** Caramel with the addition of salt, providing a sweet and salty flavor profile.
- **Based on usage:**
  - **Caramel Sauce:** A liquid form of caramel used as a topping for desserts or as an ingredient in various recipes.
  - **Caramel Candy:** Solid caramel often made into bite-sized candies or used as a filling in chocolates.
  - **Caramelized Sugar:** Used as a decorative element in desserts or as a topping for various dishes.

4.6.3 Flow diagram for developing caramel colour from dates (Source: Kumar et al., 2022)



4.7 Fruit Toffee: classification - Ingredients used in the preparation

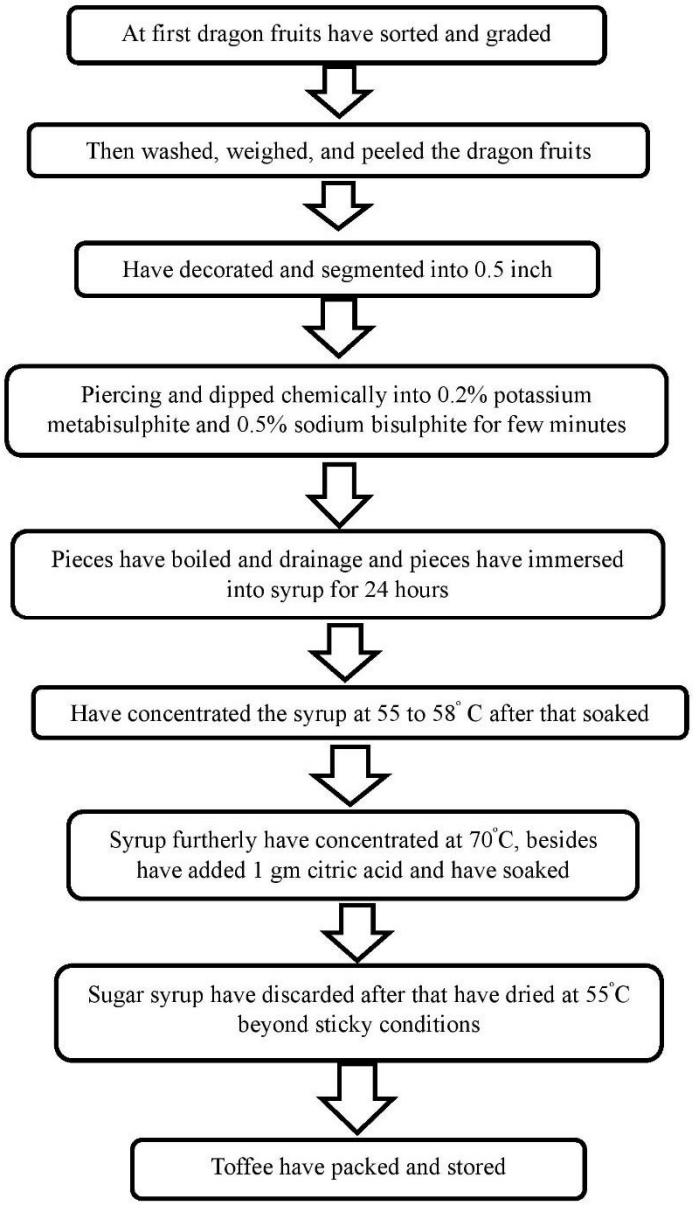
Candy or toffee are imbibed by all aged people worldwide, it is favoured especially to infants to young children. Advantages of candies are easily carried and has extensive storage magnitude without preservation in refrigerator (Kumar et al., 2022). Candies or toffies are also employed as ready to eat snacks.

4.8.1 Classification of toffee:

Toffees can be classified based on various factors such as ingredients, texture, flavor, and manufacturing processes. Here's a general classification of toffees (Lata et al., 2022):

- **Based on ingredients:**
    - **Traditional Toffee:** Made with sugar and butter, often with the addition of milk or cream.
    - **Nut Toffee:** Contains various nuts such as almonds, walnuts, or peanuts.
    - **Chocolate Toffee:** Toffees with chocolate coatings or containing chocolate chips.
- **Based on texture:**
    - **Hard Toffee:** Toffees that are firm and crunchy.
    - **Soft Toffee:** Toffees that are chewy and have a softer texture.
- **Based on flavor:**
    - **Classic Toffee:** Featuring the traditional buttery and caramelized sugar flavor.
    - **Fruit-flavored Toffee:** Toffees with added fruit extracts or flavors.
- **Based on specialty Toffees:**
    - **Coffee Toffee:** Toffees with a coffee flavor.
    - **Spiced Toffee:** Toffees with added spices like cinnamon or nutmeg.
    - **Salted Toffee:** Toffees that combine sweet and salty flavors.
- **Based on sugar base:**
    - **Brown Sugar Toffee:** Made with brown sugar, giving it a richer flavor.
    - **White Sugar Toffee:** Traditional toffees made with white sugar.
- **Based on production process:**
    - **Handmade Toffee:** Artisanal toffees made in small batches by hand.
    - **Commercial Toffee:** Mass-produced toffees often made using automated processes.
- **Based on packaging and presentation:**
    - **Individually Wrapped Toffees:** Toffees that are individually wrapped for convenience.
    - **Assorted Toffee Packs:** Variety packs containing different flavors or types of toffees.
- **Based on dietary considerations:**
    - **Sugar-Free Toffee:** Toffees made with sugar substitutes for those on sugar-restricted diets.
    - **Dairy-Free Toffee:** Toffees made without dairy products for individuals with lactose intolerance or vegan preferences.

4.7.2 Flow diagram for developing dragon fruits toffee (Source: Lata et al., 2022)



4.8 Fudge: classification - Ingredients used in the preparation

Confectionary dairy products are very much accepted by all aged people, among these items fudge is another beneficial confectionary which are very much associated in prevention of various disorders. They are defined as a constituent of balanced diet. It is comprised of macronutrients like protein, fat besides micronutrients vitamins and minerals like calcium, phosphorus. According to review of literature, fortified dairy products along with cocoa increases nutritional composition of fudge. Varieties of cheese fudge have developed along with two flavours like vanilla and chocolate. Cheese fudge have developed with ingredients in like milk and sweet cheese curd proportion into1:1, additionally sugar and hazelnut have applied to form besides two flavourings have applied like cocoa and vanilla. Cocoa constitutes by extensive quantity of Flavonol and polyphenolic components which carries extensive antioxidant status. Furthermore, Flavonol decreases LDL cholesterol oxidation, lesions platelet assemblage, escalated arterial blood flow concentration as well as fallen excess blood pressure (Engler & Engler, 2006). Noteworthy, vanilla conveys most prompt antioxidant. Vanilla is of an influenced flavouring compound in frozen confectionaries (Cadena et al*.,* 2012). Vanilla provides safeguard against oxidation of protein and peroxidation of lipid. Cheese Fudge along with two flavours like Vanilla and Cocoa gain superior scores for taste and texture as delicious rich and creamy with acceptable quality.

4.8.1 General classification of fudge:

- **Based on ingredients:**
    - **Classic Chocolate Fudge:** Made with chocolate, sugar, butter, and often condensed milk.
    - **Nut Fudge:** Includes nuts such as walnuts, pecans, or almonds.
- **Based on flavorings:**
    - **Vanilla Fudge:** Features a vanilla flavor profile.
    - **Fruit-flavored Fudge:** Infused with fruit extracts or purees for added flavor.
- **Based on texture:**
    - **Creamy Fudge:** Smooth and velvety in texture.
    - **Crumbly Fudge:** Has a crumbly or grainy texture.
- **Based on variations:**
    - **Peanut Butter Fudge:** Includes peanut butter in the mixture.

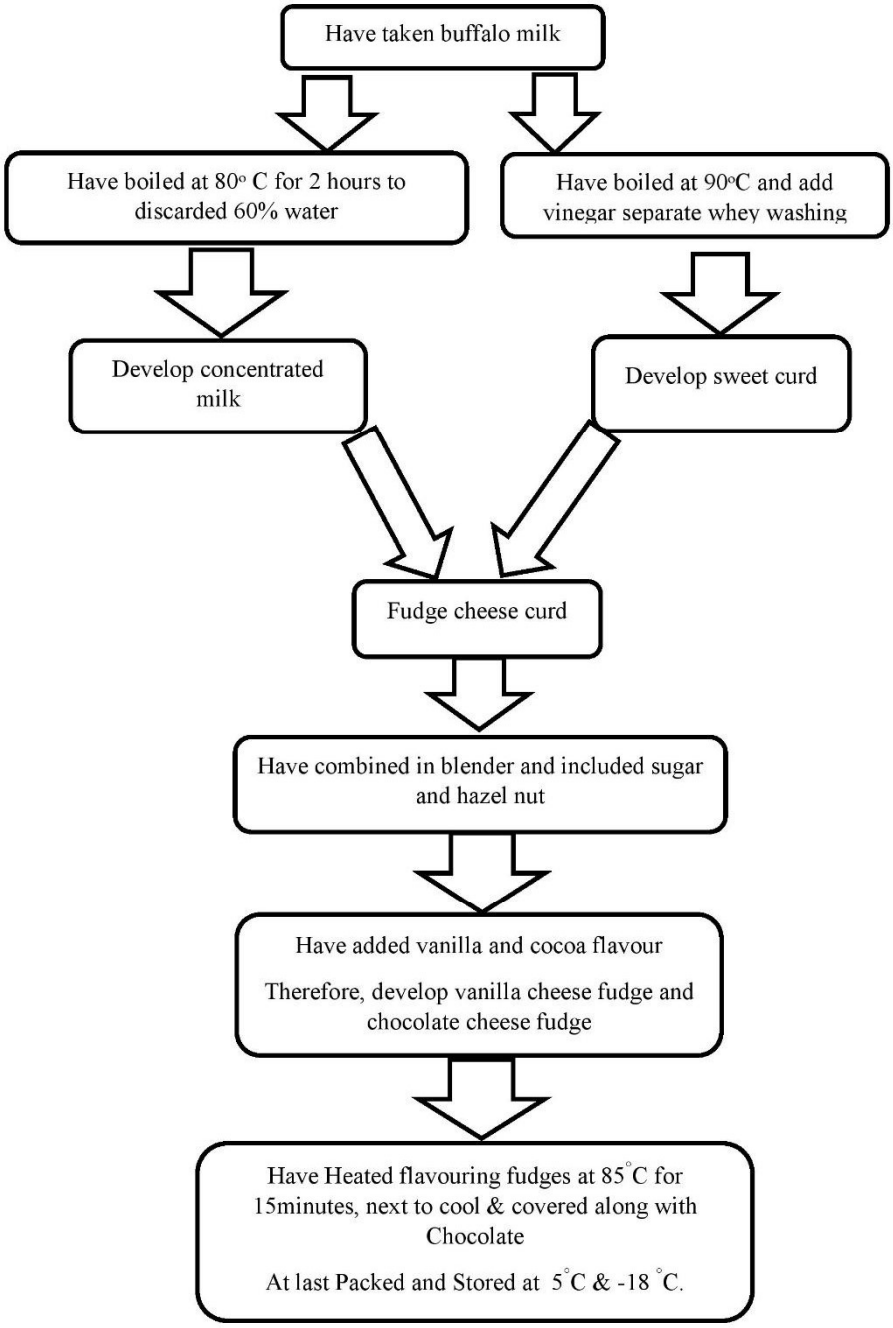
    - **Maple Fudge:** Sweetened with maple syrup for a distinct flavor.
- **Based on dietary considerations:**
    - **Vegan Fudge:** Made without animal products, often using plant-based alternatives like coconut oil.
    - **Sugar-Free Fudge:** Sweetened with sugar substitutes for those on sugar-restricted diets.
- **Based on additional inclusions:**
    - **Marbled Fudge:** Combines different flavors or colors in a marbled pattern.
    - **Layered Fudge:** Features distinct layers of different flavors or textures.

4.8.2 Ingredients for the preparation of fudge:

Traditional chocolate fudge typically requires a few basic ingredients. Here's a simple recipe for making classic chocolate fudge (LaBau, 2012):

- **Chocolate:** Use high-quality chocolate, either in the form of chocolate bars or chocolate chips. You can use semisweet or bittersweet chocolate depending on your preference.
- **Sweetened Condensed Milk:** This adds sweetness and creaminess to the fudge. It's a key ingredient in many fudge recipes.
- **Butter:** Unsalted butter is commonly used in fudge recipes. It contributes to the smooth and rich texture of the fudge.
- **Vanilla Extract:** Adds flavor to enhance the overall taste of the fudge.
- **Salt:** A pinch of salt can help balance the sweetness and enhance the chocolate flavor.

4.8.3 Flow diagram for developing fudge (Source: Attalla et al., 2016)



References:

Adebayo, SF., Okoli, EC. (2017) Production and Evaluation of Biscuits from Lima Bean (Phaseolus Lunatus), Sorghum and Wheat Flour Blends. *J EnvironScience Toxicol Food Technol,* 11. 44-48.

Adelekan, O Aminat., Alamu, E Adediran., et al., (2013). Nutritional, Microbiological and Sensory Characteristics of Malted Soy-Kunu Zaki: An Improved Traditional Beverage. *Advances in Microbiology*, 3, 389-397.

Adeyemi, A. I., Umar, S. (1994). "Effect of Method of Manufacture on Quality Characteristics of Kunu Zaki, a Milletbased Beverage," *Nigerian Food Journal*, 12. pp. 34-41.

Almendras, J.C.S., Kirigin, J.A.A. (2011). Estudio estadístico de pruebas sensoriales de harinas compuestas para panificación. Rev. *Boliv. Quím*, 28, 79–82.

Annan , N. T. , L. Poll , S. Sefa Dedeh , W. A. Plahar , and M. Jakobsen. (2003) . Infl uence of starter culture combinations of Lactobacillus fermentum, Saccharomyces cerevisiae and Candida krusei on aroma in Ghanaian maize dough fermentation. *Eur. J. Food Res. Technol,* 216, 377 – 384.

Aptrakhimov, Denis., Rebezov, Maksim., Khayrullin, Mars., Fedorov, Boris., Goncharov, Andrey., Makarova, Svetlana. (2023). Study of nutritional value of macaroni pasta from composite flour. ALKHAS, 5(2), 1-5.

Attalla, N. R., Mohamed, E. F., & Bassuony, N. I. (2016). Preparation and Properties of Cheese Fudge. *Journal of Food and Dairy Sciences*, *7*(4), 219-227.

Avetisyan, M.H. (2015). Improvement of Short Pasta (Pasta Corta) Production Technology, Development of New Recipes and Drying Regimes. Thesis Work. Yerevan.

Ayo, JA., Ayo, VA., Popoola, C., Omosebi, M., Joseph L (2014) Production and evaluation of malted soybean-acha composite fl our bread biscuit. *African J Food Sci Technology*.5, 21-28.

Baxter, E. D., Hughes, P. S. (2001). An overview of the malting and brew.

Benton, J. T. (2020). Baking as cultural heritage: regional variation in the Roman production of bread. The Bread Makers: The Social and Professional Lives of Bakers in the Western Roman Empire, 37-89.

Betz, Ju., Naumova, N.L., Burmistrova, O. (2020). *Bulgarian Journal of Agricultural Science,* 26(6).

Caballero, B., Finglas, P.-M., Toldrá, F. (2016). Encyclopedia of Food and Health; Academic Press: Cambridge, MA, USA.

Cadena, R. S., Cruz, A. G., Faria, J. A. F., & Bolini, H. M. A. (2012). Reduced fat and sugar vanilla ice creams: Sensory profiling and external preference mapping. *Journal of dairy science*, *95*(9), 4842-4850.

Callejon, R. M., A. Clavijo , P. Ortigueira , A. M. Troncoso , P. Paneque , and M. L. Morales . (2010). Volatile and sensory profi le of organic red wines produced by different selected autochthonous and commercial Saccharomyces cerevisiae strains. *Anal. Chimi. Acta,* 660 , 68 – 75 .

Carmo, J.L. (2018). Manual de Boas Práticas em Análise Sensorial. Master's Thesis, Food Quality and Technology, Instituto Politécnico de Viseu, Viseu, Portugal.

Chavan, J. K., Kadam, S. S., & Reddy, N. R. (1993). Nutritional enrichment of bakery products by supplementation with nonwheat flours. Critical Reviews in Food Science & Nutrition, 33(3), 189-226.

Chepulis, L., Everson, N., Ndanuko, R., Mearns, G. (2020). The nutritional content of children's breakfast cereals: A cross-sectional analysis of New Zealand, Australia, the UK, Canada and the USA. *Public Health Nutr*., 23, 1589–1598.

CSA (Central Statistics Agency for Ethiopia) (2015) Ethiopian crop and livestock Survey reports. Addis Ababa, Ethiopia.

de Alcantara, M., De, Grandi Castro Freitas-Sá D. (2018). Rapid and versatile sensory descriptive methods—An updating of sensory science. *Braz. J. Food Technol*, 21, e2016179.

De la Hunty, A., Gibson, S., Ashwell, M. (2013). Does Regular Breakfast Cereal Consumption Help Children and Adolescents Stay Slimmer? A Systematic Review and Meta-Analysis. *Obes. Facts*, 6, 70–85.

Dicko, MH., Gruppen, H., Traoré, AS., Voragen, AG., van, Berkel WJ. (2006) Sorghum grain as human food in Africa. relevance of the content of starch and amylase activities. *Afr J Biotech* 5, 384-395.

Engler, M. B., & Engler, M. M. (2006). The emerging role of flavonoid-rich cocoa and chocolate in cardiovascular health and disease. *Nutrition reviews*, *64*(3), 109-118.

Ferriola, D., & Stone, M. (2006). Sweetener Effects on Flaked Millet Breakfast Cereals. *Journal of Food Science*, *63*(4), 726–729. https://doi.org/10.1111/j.1365-2621.1998.tb15823.x

Fulgoni, V.L., Buckley, R.B. (2015). The contribution of fortified ready-to-eat cereal to vitamin and mineral intake in the U.S. population, NHANES 2007–2010. *Nutrients*, 7, 3949–3958.

García-Gómez, B., Fernández-Canto, N., Vázquez-Odériz, M.L., Quiroga-García, M., Muñoz-Ferreiro, N., Romero-Rodríguez, M.Á. (2022). Sensory Descriptive Analysis and Hedonic Consumer Test for Galician Type Breads. *Food Control*, 134, 108765.

Han, H. M., Cho, J. H., Kang, H. W., Koh, B. K. (2012). Rice Varieties in Relation to Rice Bread Quality. *J. Sci. Food Agri,* 92, 1462–1467.

Han, J. J., Janz, J. A., Gerlat, M. (2010). Development of Gluten-free Cracker Snacks Using Pulse Flours and Fractions. *Food Res. Int*, 43, 627–633.

Hansen, T. J. (1986). Candy and sugar confectionery. *Handbook of Food and Beverage Stability.*, 423-465.

Hasgucmen, C.K, Sengun, I.Y. (2020). Viability of Probiotic Strain Lactobacillus Rhamnosus and Its Impact on Sensory Properties of Cheesecake during Storage at −20 ◦C and 4 ◦C. *LWT*, 134, 109967.

Huang, C., Huang, J., Tian, Y., Yang, X., Gu, D. (2014). Sugar sweetened beverages consumption and risk of coronary heart disease: A meta-analysis of prospective studies. *Atherosclerosis*, 234, 11–16.

Jagarlamudi, L. (2022). *Bakery and confectionery products: Processing, quality assessment, packaging and storage techniques*. CRC Press.

Kamuf, W., Nixon, A., Parker, O., & Barnum Jr, G. C. (2003). Overview of caramel colors. *Cereal foods world*, *48*(2), 64.

Keeratipibul, S., Luangsakul, N., Lertsatchayarn, T. (2008). The Effect of Thai Glutinous Rice Cultivars, Grain Length and Cultivating Locations on the Quality of Rice Cracker (Arare). *LWT-Food Sci. Technol*, 41, 1934–1943.

Khmeleva, E., Osipova, G., Seregina, T., Rogachev, Yu. (2021). Innovative technology for the production of macaroni products made of emmer wheat flour. *BIO Web of Conferences*, 37, 00082.

Kim, Soo Jin., Koh, Kyung Bong. (2019). Rice varieties in relation to saltine rice cracker quality. *International Journal of Food Properties*, 22(1). 1899-1909.

Kock, H.L., Magano, N.N. (2020). Sensory Tools for the Development of Gluten-Free Bakery Foods. *J. Cereal Sci.*, 94, 102990.

Kpossa, M.R., Lick, E. (2020). Visual Merchandising of Pastries in Foodscapes: The Influence of Plate Colours on Consumers' Flavour Expectations and Perceptions. *J. Retail. Consum. Serv*, 52, 101684.

Kulkarni, AS., Joshi, DC. (2013), Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *International Food Research Journal*, 20(2), 587.

Kulthe, AA., Pawar, VD., Kotecha, PM., Chavan, UD., Bansode, VV. (2011). Development of high protein and low calorie cookies. *J food Sci. Tech*, 51(1), 153-157.

Kumar, S., & Singh, C. (2022). Productivity growth in India's bakery manufacturing industry. *Journal of Agribusiness in Developing and Emerging Economies*, *12*(1), 94-103.

Kunze, W., Mieth, H. (2014). Technology brewing and malting (T. Wainwright, Trans., 5th English Edition). Berlin: VLB.

LaBau, E. (2012). *The Sweet Book of Candy Making: From the Simple to the Spectacular-how to Make Caramels, Fudge, Hard Candy, Fondant, Toffee, and More!*. Quarry Books.

Lata, P., Kumari, R., Sharma, K. B., Rangra, S., & Savitri. (2022). In vitro evaluation of probiotic potential and enzymatic profiling of Pichia kudriavzevii Y33 isolated from traditional home-made mango pickle. Journal of Genetic Engineering and Biotechnology, 20(1), 132.

Li, J., Hou, G. G., Chen, Z., Chung, A. L., Gehring, K. (2014). Studying the Effects of Whole-wheat Flour on the Rheological Properties and the Quality Attributes of Whole-wheat Saltine Cracker Using SRC, Alveograph, Rheometer, and NMR Technique. *LWT-Food Sci. Technol,* 55, 43–50.

Malik, V.S., Popkin, B.M., Bray, G.A., Despres, J.-P., Willett, W.C., Hu, F.B. (2010). Sugar-Sweetened Beverages and Risk of Metabolic Syndrome and Type 2 Diabetes: A meta-analysis. *Diabetes Care*, 33, 2477–2483.

Mancebo, C. M., Picon, J., and omez, M. G., (2015). "Effect of flour ´ properties on the quality characteristics of gluten free sugarsnap cookies," *LWT-Food Science and Technology*, 64 (1), 264–269.

Mathuravalli, S. M. D. (2021). *Handbook of Bakery and Confectionery*. CRC Press. ISBN: 978-1-032-15126-7, DOI: 10.1201/9781003242635.

Moynihan, P. 9 (2016). Sugars and Dental Caries: Evidence for Setting a Recommended Threshold for Intake 1–3. *Adv. Nutr.*, 7, 149–156.

Murphy-Gutekunst, L., & Barnes, K. A. (2005). Hidden Phosphorus at Breakfast: Part 2. *Journal of Renal Nutrition*, *15*(3), E1–E6. https://doi.org/10.1016/j.jrn.2005.04.007

Murugkar, DA. (2014). Effect of sprouting of soybean on the chemical composition and quality of soymilk and tofu. *Journal of food science and technology*, 51(5), 915- 21.

Narziß, L., Back, W., Gastl, M., & Zarnkow, M. (2017). Die Technologie der Malzbereitung Abriss der Bierbrauerei. Weinheim: Wiley-VCH, 8, 1–100.

Noomhorm, A., Kongseree, N., Apintanapong, M. (1997). Effect of Aging on the Quality of Glutinous Rice Crackers. *Cereal Chem*, 74, 12–15.

Ogunremi, R Omotade., Agrawal, Renu., Sanni, I Abiodun. (2015). Development of cereal- based functional food using cereal- mix substrate fermented with probiotic strain – Pichia kudriavzevii OG 32, Food Science and Nutrition.

Priebe, M.G., McMonagle, J.R. (2016). Effects of Ready-to-Eat-Cereals on Key Nutritional and Health Outcomes: A Systematic Review. *PLoS ON*, 11, e0164931.

Rahman, M.S., Al-Attabi, Z.H., Al-Habsi, N., Al-Khusaibi, M. (2021). Measurement of Instrumental Texture Profile Analysis (TPA) of Foods. In Techniques to Measure Food Safety and Quality: Microbial, Chemical, and Sensory; Khan, M.S., Shafiur Rahman, M., Eds.; Springer International Publishing: Cham, Switzerland, pp. 427–465.

Sengar, G., & Sharma, H. K. (2014). Food caramels: a review. *Journal of food science and technology*, *51*, 1686-1696.

Silva, V.B., Costa, M.P. (2017). Rheology Applied to Dairy Products. *Rheol. Open Access*, 1, e104.

Soni, Nihir., Kulkarni S Anant., Patel, Luv. (2018). Studies on development of high protein cookies. *International Journal of Chemical Studies*, 6(6), 439-444.

Sreerama, YN., Sashikala, VB., Pratape, VM. (2010). Variability in the distribution of phenolic compounds in milled fractions of chickpea and horse gram: evaluation of their antioxidant properties. *Journal of agricultural and food chemistry*, 58(14), 8322-30.

Svec, I., Hruskova M (2010) Evaluation of wheat bread features. *Journal of Food Engineering* 99, 505-510.

Ukpong, Ekere Susana., Njoku, Obiyo Henry., and Ire Sopuruchukwu Francis. (2021). Quality evaluation of flour and biscuits produced from wheat and African Yam Bean Tempeh Flours. *GSC Biological and Pharmaceutical Sciences*, 17(01), 124-132.

Van den Boom, A., Serra-Majem, L., Ribas, L., Ngo, J., Pérez-Rodrigo, C., Aranceta, J., Fletcher, R. (2006). The Contribution of Readyto-Eat Cereals to Daily Nutrient Intake and Breakfast Quality in a Mediterranean Setting. *J. Am. Coll. Nutr*, 25, 135–143.

Van der Sman, R. G. M., & Renzetti, S. (2019). Understanding functionality of sucrose in biscuits for reformulation purposes. *Critical Reviews in Food Science and Nutrition*, *59*(14), 2225-2239.

Williams, P.G. (2014). The Benefits of Breakfast Cereal Consumption: A Systematic Review of the Evidence Base. *Adv. Nutr*, 5, 636S–673S.

Adebowale, O. J., Ajayi, A., & Ibikunle, T. A. (2013). Quality Assessment of Biscuits from Green Plantain (Musa paradisiaca) and African Breadfruit (Treculia africana) Flours. Journal of Culinary Science & Technology, 11(4), 336-345.

Chapter-5
Spices Technology

Moumita Dev

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: moumitad@svu.ac.in

5.1. Introduction:

Spices are the dry part of a plant, such as seeds roots, fruits, leaves, bark, and flowers whereas herbs are the fresh parts of the plant like green leaves, stem and flowers. Since spices contain essential oils, they are primarily used to enhance color or flavor of foods (Herman,2015). On the other hand, herbs are generally utilized for flavoring or garnish. Sometimes spices are utilized for religious rituals, pharmaceutical, confectionery, perfume or cosmetic production. Spices are used as whole, ground, paste or liquid for flavoring and seasoning foods (Tapsell,2006).Condiments are also plant parts and are made from spices and other ingredients used as food adjuncts to add flavor to food.

5.1.2. Characteristics of spice:

The characteristics of spices are mentioned below (La Torre Jessica Elizabeth et al.,2015)-

- dried and ground to be mixed with other ingredients.
- anti-flatulence and carminative properties.
- flavoring and coloring agent in food.
- therapeutic properties to food, drink and other items.
- shelf-life property by delaying and preventing the spoilage.
- anti-aging agent

5.1.3. Important compounds in spices:

Important compounds (Sajad Ahmad Wani,2022) of the spices are mentioned in the Table 1 below:

Table 1- Active Compounds in Spices

Compound	Description	Compound
Acids	Sour taste, often anti septic	Glutamic acid (Found in many spices like fennel, mustard, fenugreek)
Alkaloids	Bitter taste, based on alkaline nitrogenous compounds.	Pepper- Piperine
Flavones	Sweet or bitter, antiseptic, diuretic and anti-inflammatory	Rosemary, Thyme.

Bitters	Bitter. Iridoide and Sesquiterpenes. Improve digestion.	Turmeric, Fenugreek
Coumarin	Anti-bacterial, Anti-coagulant.	Cinnamon
Anthra quinones	Bitter. Irritant and Laxative. Acts as a dye.	Rhubarb
Glycosides	Bitter compounds. Cardiac glycoside affects the heart rate, respiration, heart construction. Sulphur containing glycosides have anti-biotic effects.	Rhubarb
Gums and mucilage	Sticky or slimy, bland; smooth or soft	Ginger
Resins	Oleoresins Antiseptic and healing	Cardamom
Saponins	Soapy in water, anti-inflammatory and sweet; diuretic	Mustard, Fenugreek
Tannins	Mainly astringent and antiseptic	Vanilla, Cinnamon.
Volatile oils	Antiseptic, fungicidal, aromatic, stimulant; sometimes irritant	Clove, Cinnamon

5.1.4. Spices Classification (Hossain et al., 2020):

Based on the botanical name; duration of the crop; growth habit; part of the plant; and the conventional classification, spices can be classified into different sub-sections. Table 2 represents the classification of spices based on the botanical family.

Table 2. Based on botanical family

Botanical family	Example
Zingiberaceae	Ginger, Turmeric
Maton zingiberaceae	Cardamom
Piperaceae	Pepper
Solanaceae	Capsicum, Chili
Fabaceae	Fenugreek
Lauraceae	Cinnamom, cassia
Apiaceae	Coriander, cumin, fennel, dil, caraway
Caesalpiniaceae	Tamarind
Alliaceae	Garlic
Myrtaceae	Cloves
Orchidaceae	Vanilla
Myristicaceae	Nutmeg, Mace

Cupressaceae	Juniper berry
Lamiaceae	Hyssop, Sage, Rosemary, Savory, Thyme, Oregano
Brassicaceae	Mustard
Illiciaceae	Star Anise

Table 3. Based on the duration of the crops

Duration	Examples
Annual (one year)	Basil, Coriander, Dill
Biennial (Two years)	Caraway, Parsley
Perennial (More than two years)	Curry leaves, Mint, Thyme, Oregano

Table 4. Based on the growth habit

Size	Example
Herbs (Small)	Coriander, mint, oregano, caraway
Shrubs (Medium)	Rosemary, Sage, Thyme
Trees (Large)	Curry leaves, Pimenta

Table 5. Based on the plant part

Plant Part	Examples
Seeds and Nuts	Coriander, Pepper, Mustard, Cumin, Sesame, Cardamom
Bark	Cinnamon, Cassia
Leaves	Curry leaves, Parsley, Rosemary, Mint, Coriander, Sage
Flower bud	Clove
Roots and bulbs	Garlic, Onion, Celery
Flower stigma	Saffron
Aril	Mace, Nutmeg
Berries	Black pepper, Chili
Kernel	Nutmeg
Tubers	Galangal
Rhizome	Turmeric, Ginger

Fruit	Cardamom, Vanilla

Table 6. Conventional classification

Classes	Examples
Hot spices	Chili, pepper, mustard, ginger
Herbs	Dil leaves, bay leaves and thyme
Mild	Coriander, paprika
Aromatic	Cardamom, cinnamom, clove, mace and nutmeg
Aromatic vegetables	Onion, Garlic, Celery

5.1.4. Economic Importance of spices:

Introduction:

India is one of the leading producers and exporters of spice in the world. It contributes about 20-25% of the trade in spice. In India, spices are also being largely used for seasonings and flavouring agents in foods and other products. According to International Organisation for Standardization (ISO), there are around 109 spices recognized worldwide, out of which 50-60 spice crops are grown in India due to varied agro-climatic, tropical, sub-tropical and temperate conditions in India (Hossain et al., 2020). This leads to the growth of variety of spice crops in different regions of the country.

Importance:

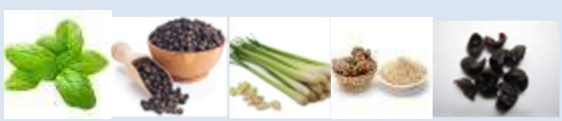
- There is high demand export of value-added spices like oleoresins, spice essential oils etc.
- In bakeries and confectionary industry, spices play an important role in preparation of food products.
- Some spices like pepper, cardamom, saffron, vanilla etc. are considered as high value and low-volume crops, producing high-income per unit. The products of these crops are the good source of raw material for ancillary industries. Thus, the industry provides more employment opportunities.

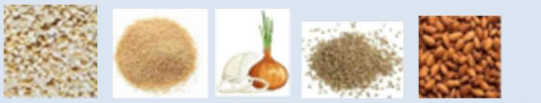
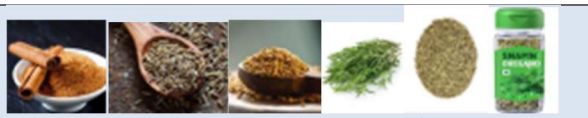
- Essential oils and oleoresins are widely used in seasoning of foods and imparting aroma, flaovur and taste to the food products. These products are also finding unique place in cosmetic and pharmaceutical industries.
- Not only in food industries, but also spices are used as colourant or die in cotton, textile and tobacco industries.
- The import of spices depends upon varied application from country to country. However, in most world markets, pepper is almost invariably the principal or the most important world spice imported in terms of both its volume and value. The only exceptions are Finland, Saudi Arabia and Kuwait (importers of small cardamom), and the Democratic Republic of Yemen (importers of ginger and chillies). Next in order of importance is the capsicum group, consisting of paprika (the leading item), chillies and cayenne pepper.
- Within the markets of North America and Western Europe the spices like nutmeg, mace, cassia and cinnamon are majorly imported. In Eastern Europe and USSR, it is Allspice that is in one of the top ten list of spices.
- In terms of spice seeds, world imports are around 50,000-60,000 tonnes annually. Vanilla, saffron and cardamom are although high unit value spices but they are low in trade. On the other hand, the clove is mainly exported to Indonesia due to its application in "Kretek" cigarette industry.

5.2.1. Functions of Spices- Primary and Secondary

Spices provide flavors, aromas, textures, and colors to food. On the other hand, the secondary functions of spices include preservative, nutritional value, antioxidants and health benefits (Raghavan, 2006). Table 7 displays the functions of spices, as follows:

Table 7: Functions of Spices

Functions	Spices	Images
Flavour and Taste	Black pepper, cardamom, basil, kokum, lemon grass, star anise, fennel, jalapeno, saffron	 Basil Black Pepper Lemongrass Asafetida Kokum
Aroma	Mint, clove, kari leaf, nutmeg, tarragon, sweet basil, saffron, cardamom, cinnamom	 Clove Kari leaf mint Nutmeg Tarragon

1. Texture/Consistency	Poppy, ajwain, poppy, mustard seeds, onion flakes, pepper corn, ajwain seeds, sesame seeds, shallot and candle nut	 Sesame Poppy Onion Ajwan Almonds
Colour	Turmeric, paprika, annatto, parsley, mint, marigold, cilantro, basil	 Annatto Paprika Parsley Turmeric
Antimicrobial	Oregano, cumin, cinnamom, fenugreek, thyme, rosemary, cumin, ginger, chilli peppers, sage	 Cinnamon Cumin Fenugreek Rosemary Thyme Oregano
Antioxidant	Mace, ginger, garlic, clove, rosemary, turmeric, oregano	 Mace
Health	Caraway, garlic, ginger, sage, chilli powder, clove, licorice, cinnamom, fenugreek	 Ginger Garlic sage chili paper Licorice Caraway

❖ **Primary Functions of Spices:**

Colour, aroma, flavour and texture

Spices can add color, flavor, aroma, texture or taste to food or beverages, determining their effectiveness in recipes.

Coloring

There are several spices that add color and flavor to various food products including beverages like turmeric, saffron, paprika, annatto, parsley. Consumers' demand for "natural" coloring can be met by spices (Table 8).

Table 8: Components is Spices that act as Colouring Agents

Spices	Colouring component	Colour
Saffron	Crocin	Yellowish orange
	Crocetin	Dark red
	Beta-carotene	Reddish orange
Paprika	**Carotenoids**	
	Capsanthin	Dark red
	Violaxanthin	Orange
	Cryptoxanthin	Red
	Capsorbin	Purplish red
	Beta-carotene	Reddish orange
	Lutein	Dark red
	Zeaxanthin	Yellow
Chile pepper	Beta-carotene	Reddish orange

	Cryptoxanthin	Red
	Capsanthin	Dark red
	Capsorbin	Purplish red
Turmeric	Curcumin	Orange yellow
Parsley	Chlorophyll	Green
	Lutein	Dark red
	Neoxanthin	Orange yellow
	Violaxanthin	Orange
Annatto	Bixin	Golden yellow
	Norbixin	Orange yellow
Safflower	Carthamin	Orange red
	Saflor Yellow	Yellow

Flavour

Predominantly, spices possess these sensual qualities due to their chemical compositions. Spices can have a variety of flavors based on their chemical compounds. In order to create a spice's distinctive flavor profile, these chemical compounds must be balanced. There is a distinctive taste and aroma associated with spices. Each of these tastes is categorized as sweet, bitter, salty, sour, spicy, and hot (Table 9).

Table 9: Spices- Sensory Characteristics

Sensory Characteristics	Spices
Hot spices	Chili, pepper, mustard, ginger
Sweet	Cardamom, anise, star anise, fennel, cinnamom, allspice
Sour	Caper, tamarind, kokum, pomegranate, sumac, sorel
Mild	Coriander, paprika
Bitter	Fenugreek, clove, mace, nutmeg, thyme, bay leaf, ajowain, oregano, celery
Spicy	Clove, cumin, coriander, ginger, bay leaf, canola
Pungent	Mustard, garlic, onion, horseradish, ginger, galangal
Fruity	Fennel, savory, tamarind, star anise, coriander
Floral	Lemon grass, sweet basil, ginger flower, pandan leaf
Woody	Cassia, cardamom, clove, rosemary, juniper
Piney	Kari leaf, rosemary, thyme, bay leaf

Cooling	Pepper mint, basil, fennel
Earthy	Saffron, black cumin, annatto, turmeric
Herbaceous	Oregano, sage, rosemary, parsley, tarragon, dillweed
Sulfury	Onion, garlic, chives, asafetida
Nutty	Poppy seed, mustard seed, whole seed (cumin), sesame seed

❖ Secondary Functions of Spices

With a growing interest in organic and natural foods and healing methods, spices' secondary effects become increasingly important. The traditional use of spices included stimulating appetite, enhancing digestion, relieving stress, and boosting energy. When spices are used to enhance the taste of processed foods instead of salt, fat, or sugar, they can also contribute to nutrition.

Processed foods can be labeled more "natural" or "friendly" by using spices as preservatives.

Preservative properties of spices

Antimicrobials, preservatives, and antioxidants are all attributes of spices. Many ancient cultures used them to fumigate cities, embalm royalty, preserve food, and prevent diseases and infections. Among these cultures are the Romans, Egyptians, Indians, Chinese, Native Americans and Greeks.

Antimicrobial properties of spices

The use of spices for health and bactericidal purposes goes back a long way. A number of diseases were treated with spices such as cinnamon, garlic, and oregano during the Middle Ages. Among the substances that possess strong antimicrobial activity are terpenes, sulfur and aldehydes, and their derivatives, as well as alcohols and phenols. Specific bacteria are inhibited strongly, moderately, and slightly by spices (Table 10).

Table 10: Antimicrobial properties of spices

Spice	Active component	Microorganism
Mustard	Allyl isothiocyanate	*Escherichia coli*, Pseudomonas spp., *Staphylococcus aureus*
Garlic	Allicin	*Salmonella typhi*, *Shigella dysenteriae*, molds and yeasts

Chile pepper	capsaicin	Mold, bacteria
Clove	Eugenol	*Escherichia coli*, *Staphylococcus aureus*, acinetobacter
Thyme	Thymol	*Vibrio parahaemolyticus*, *Staphylococcus aureus*, Aspergillus spp.
Ginger	Gingerone, gingerol	*Escherichia coli*, Bacillus spp.
Sage	Borneol	*Staphylococcus aureus*, *Bacillus cereus*
Rosemary	Borneol, thymol	*Staphylococcus aureus*, *Bacillus cereus*
Coriander	Dodecenal	Salmonella spp.

Antioxidant Properties of spices

Modern toxins can be combated by spices. Among the factors that cause free radicals to form and grow in the body are heat, radiation, UV light, smoke, and alcohol. During aging, cancer, and memory loss, free radicals damage the human cells. A number of spices contain antioxidants and free radical-fighting propertiesDepending on the food, some spices have higher antioxidant properties. A synergistic effect can be achieved by combining spices and antioxidants (Table 11).

Table 11: Antioxidant Properties of Spices

Spice	Chemical component
Rosemary	Carnosol, rosmanol, carnosoic acid
Sage	Rosmanol, epirosmanol
Turmeric	Curcumin
Clove	Eugenol
Oregano	Caffeic acid, phenolic glucoside, protocatechuic acid,
Mace and nutmeg	Myristphenone
Sesame seed	Sesaminol, sesamol, tocopherol
Ginger	Gingerol, shogoal

Health Function

The spices play an important role from health point of view. Table 12 represents the role of antioxidants in spices on health.

Table 12: Health Aspects of Spices

Spice	Active components	Therapeutic Effects
Turmeric	Curcumin	Anti-inflammatory, antitumor and prevents alzheimers
	Curcumene	antitumor
Ginger	Gingerol, shogaol, gingerberane	Digestive aid for stomach aches and indigestion, stomach ulcers
	Bis-abolenenan	Prevents bloating and vomiting

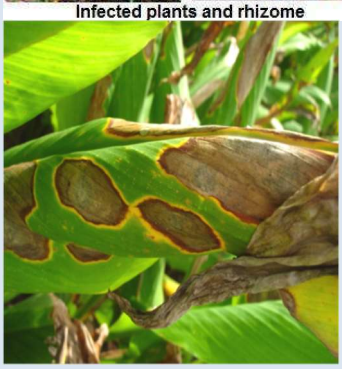
Fenugreek seed	Trigonelline	Arrests cell devision (tumor) and prevents hypoglycemic effects
Garlic	Allicin, diallyl, sulphide s-allyl	Breakdown blood clots inhibiting platelets aggregation
	Glutamyl peptides	Lowers blood pressure
Licorice	Glycirrhizin	Treats gastric and intestinal ulcers, prevents cough and cold, treats chronic fatigue syndrome

5.2.2The importance of biotechnology in improving spice crops:

Some biotechnological methods for conserving, utilizing, and increasing the production of spice include variation of somaclonal, micropropagation, in vitro conservation, novel transgenies and protoplast fusion (Soon Liang Sim,1998).The brief summary of the importance of biotechnology in improving spice production are represent in Table 13.

Table 13:Role of Biotechnology in Improvement of Spice Crops

Species	Constrains	Research Attainments	Pictures
Black Pepper	Phytopthora Foot Rot	Disease management through standardised packages.Biocontrol is recommended after the development of tolerant lines (P24).	 Phytopthora Foot Rot
	Stunt Disease	Plants that have been infected with disease cannot be controlled effectively except by uprooting them.Insects, viruses, and deficiencies of micronutrients are the predominant organisms responsible for the disease.	
	Slow Decline	The problem can be managed effectively except for the source of Radophous similes nematode resistance.	 Decline of Black papper
	Low Productivity	High Production Technology is demonstrated.	
Small Cardamom	Kate Disease, Vein clearing (Kokke Kundu) Virus Disease	The virus' etiology has been determined. A 'Katte' escape has been identified. It is multiplied to increase Katte-tolerance.	

	Low Productivity	Plants that are diseased should be removed. The situation cannot be managed effectively. Social action has prevented the spread of the disease..	 Kate Disease
Ginger, Turmeric	Rhizome Rot	A demonstration of High Production Technology (HPT) is presented. Species of Pythium and soil solarization involved.	 Infected plants and rhizome  Bacterial wilt
	Bacterial Wilt	Organisms responsible for the contamination of soil are identified by solarisation before planting . Trials are being conducted with biocontrol.	
	Nematode Infestation	*There is an organism responsible for the outbreak, Ralstonia solancearum.*The variety is not resistant.*A species of Meloidogyne.* and *Pratylenchus* identified.	
	Low Cucurmin	There are several lines that contain a high amount of curcumin..	
	Low Productivity	It has been developed to manage nutrients integrated with plants (IPNM).	

5.2.3.Adulteration of Spices:

Living beings require food to sustain themselves, and food is an integral part of their lives. Nowadays, however, the quality of food is affected by a variety of adulterants.A substance such as adulteration reduces the nutritional value of food. In order to increase profit and compete with the market, adulterants like metanil yellow (a synthetic color) are added to turmeric powder to enhance its colour. There is a possibility that these adulterants can cause paralysis, stomach disorders, brain damage, and even cancer. Agricultural and harvesting conditions can also contaminate spices. Some diseases have been linked to contaminated spices (Sachin et al.,2020).

Spices	Adulterants	Detection
Turmeric Powder	Coal tar colour, yellow earth, starch or talc coloured yellow with coal tar dye, metanil-yellow, Tapioca starch, yellow aniline	Metanil yellow adulterants can be identified by following method. First sample was taken and then sulphuric acid was added to the

	dyes.	sample.Afterthat the yellow color of the sample solution was disappear.If the color.Next,distilled water was added to above solution.Metanil yellow was present if yellow color returned.
Chilli powder	Starch coloured red with coal tar dye, brick powder, saw dust, artificial colours, sudan dyes.	1.The sample was diluted with nitric acid. Then it was filtered. The filtered sample was then treated with potassium iodide. A yellow precipitate formed to indicate the presence of red lead. 2.An ether solvent sample is added to chilli powder and shake vigorously. Dilute Hydrochloric acid is added to the ether layer and shaken. Detecting oil soluble coal tar in a sample will be indicated by pink to red color of the lower acid layer.Brick powder adulteration 3.A container containing water is filled with chilli powder. The chilli powder floats on the surface of the container.
Asafoetida (Hing)	Foreign Resin,Soap Stone,Starch	1. Use a stainless steel spoon for burning asaphoetide. The pure form of asafoetida burns. A bright flame is not produced by adulterated asafoetida. Add one gram of powdered asafoetida to a glass bottle. Water is added. Shake thoroughly to mix. There are no sediments in pure asafoetida solutions. *2.*The sample was diluted with water and allowed to settle.If it contains sand, it will be visible as sediment. If the sample contains clay or other fine-grained particles, they may be difficult to see. If the sample contains only large particles, such as rocks or pebbles, they will also be visible.
Black Pepper	Papaya Seeds,Light Berries	Add a pinch of black pepper to a cup of water. Pure black pepper sinks at the bottom. On the surface of the water, the seeds of papaya swirl in the adulterated black pepper. Scatter the spice across the white board. Examine the sample's presence with a magnifying device. It smells strongly and has a unique taste. Its surface is wrinkled. The surface of shriveled papaya seeds is smooth and oval in shape. It has a nasty flavour and is green-brown or blackish-brown color.

Cloves	Exhausted Clove	Put a few cloves in a glass of water. Depleted cloves float on the top and pure cloves sink to the bottom of the container.
Common Salt	Chalk	Take some water and add some salt.The solution became white and chalk was settle down with other impurities.

Some guidelines were published (FSSAI) for buyers and consumers on certain things to be aware of before buying a production order:

- ✓ Avoid loose spices sold in powder form.
- ✓ Purchase AGMARK-certified packaged spices from trusted brands.
- ✓ Check the packaging for FSSAI license numbers
- ✓ Spices should be bought whole from reputed stores or dealers and ground at home after cleaning and washing.
- ✓ Avoid spices that are shiny or have bright colors, which may be adulterated
- ✓ Spices with an unpleasant odor and lumpy texture should be avoided
- ✓ Before purchasing spices, check the manufacturing details,manufacturing date, best before date, and labeling information
- ✓ Do not buy damaged ground spices
- ✓ Ensure the organic logo is present when buying organic spices

5.2.4.Sterilization of Spices:

Appearance and flavors are important factors for any spice and must be remain intact in after sterilization (Duncan et al.,2017)..Different sterilization methods are applied for spices.

Fumigation with Ethylene Oxide (ETO)

Irradiation

Steam Treatment

High Hydro static Pressure

Fumigation with Ethylene Oxide (ETO)

- It is used as a fumigant, disinfectant, and insecticide.

- In addition, it helps protect humans from microbial contaminants, such as *Salmonella* and *E.coli*.
- In addition, it is highly effective at reducing and eliminating pathogens, such as mold, fungus, and bacteria.
- In terms of appearance and flavor, it has no significant impact.

Irradiation

- It is essential and effective to decontaminate spices with gamma rays, electron beam X-rays.
- Spices are sterilized with doses of 3-10kGy to ensure their microbial safety.
- Dried herbs, spices, and vegetable seasonings are allowed to be decontaminated.
- Packaging materials may emit volatile or nonvolatile radiolysis products with low molecular weights.

Steam Treatment

- Whole spices are steamed before grinding at high temperatures.
- For mould growth to be prevented, the moisture condensed on the particle's surface needs to be removed.
- Volatile profiles, colors, and physical states may be damaged by the treatment.

High Hydro static Pressure

- Vegetables and fruit products are subjected to high hydrostatic pressures of 100 to 1000 Mpa.
- There is a strong correlation between water activity and the inactivation of microorganisms
- There is no reduction in microbial count in spice samples with water activity less than 0.66.

5.2.5.Decontamination of Spices:

There are several methods for decontaminating spices, including the neutralization of microorganisms including bacteria, fungi, and parasites.

Physical Method

Carbon dioxide under pressure

Under pressure, carbon dioxide is not effective against mold and bacteria.CO2 activates bacteria endospores, resulting in the loss and composition of essential oils.

Microwave

Using microwaves reduces microorganism count while altering essential oil chemical composition.

Extrusion

Temperatures (110-210°C) and pressure (25 MPa) are combined simultaneously in extrusion. Spices are especially unfavorable since this method does not affect their taste,color,or aroma in any significant way.

Steam

Another method is steam which is for decntamination of spices.Here 110-210°C temperature is used.

High Pressure

High pressure technology is used to destroy yeasts,moulds and bacterial growth in spice.310-1100 MPa is used for this technology.

Ionizing radiation

This method is not accepted by socially but is effective and safe .

Infrared radiation

This method is used to decontaminate material and allows for a quick thermal treatment of the surface of the product without heating it deeply. Despite lowering microorganism counts slightly, this technology adversely affects essential oil composition at the same time.

Chemical Method

Following chemical agents are used for decontamination of spices.

- *Methyl bromide*
- *Formaldehyde*
- *Ethyl alcohol*
- *Ozone*
- *Ethylene oxide*

5.3.1.Introduction

The flavour, strength, and colour of raw spices cannot be uniformly achieved with spices oils and oleoresins. Oils and oleoresins from spices are preferred in modern food industries because they are hygienic, soluble, and have high flavor concentrations. Steam or hydrodistillation methods are used to obtain spice oils, which are mostly terpenic in nature. In addition to essential oils, oleoresins contain resinous matter, colour, bite principles, and bite principles are extracted from powdered spices using organic solvents.

5.3.2.Spice oils

Volatiles (essential oils) are responsible for odor or aroma in most spices. Ground spices can be steam-distilled to produce this 'essential oil.' Hydrocarbons such as sesquiterpenes, terpenes and their oxygenated derivatives compose the oil. At a temperature of less than 100°C, steam is used to entrain the oil components from ground spices.

Production:

- Spices are ground in a suitable mill before distillation. It is important to distill crushed materials as soon as possible in order to prevent any loss of oil.
- In order to prevent contamination of food flavoring materials with metallic or other contaminants, stainless steel devices should be used when distilling oil.
- Perforated cages are used to keep the ground spices.
- Steam is injected into the bed of material from an external source.
- A spice's volatile components are entrained by the steam as it passes.
- A water-cooled condenser separates oil and water from the steam with the help of an oil-water separator.
- Due to their light or heavy nature, essential oils can be easily separated from water.

For the best results, it is important to take precautions regarding the temperature of the condensate, steam flow rate and distillation rate. Ensure that all important constituents of the oil are recovered by distilling for an adequate amount of time.

Collection

- Anhydrous sodium sulfate is used to dry oil collected from the separator.
- Usually, the oil is packaged in brown glass bottles or tin cans. Due to the fact that oxygen can cause deterioration, containers must be filled to the brim. After that, the aromatic oils are kept at a room temperature.

Supercritical fluid extraction technology (SCFE):

- In the SCFE system, oil and oleoresins are made through the combustion of carbon dioxide. With this system, various agricultural commodities, including spices, can be processed in a cost-effective way for value addition.

- In the CO2 extraction process, liquid carbon dioxide is used as a selective solvent at low temperatures (0 to + 10°C) and high pressures (8 to 80 atm).
- It is also odourless,non-flammable,colorless,colourless, easily removed without residues, non-polar, and non-odourless when it liquefies.

5.3.3.Spice Oleoresins:

Oleoresins are concentrated flavourings derived from spices. Compared with whole ground spices, they have a very similar taste. The aroma of the spice is primarily derived from spice oils, while the flavor of the spice is derived from spice oleoresins. Oleoresins can be extracted from spices using a variety of solvents, including alcohol,hexane, acetone, ethanol,ethylene dichloride and methylene chloride.Food graded solvents should be used . It is advantageous to use oleoresins because they are flavour stable, require less storage space, and produce uniform flavours.

The process of oleo resin is described below-:

- Spices are **ground** in a grinder
- **Extractions** of oil, flavor, and aroma from the spices are released when they are ground. This helps to bring out the flavor and aroma of the food being prepared.
- **Extraction (distillation) of the miscella** components of spices can be used to produce essential oils. These oils can flavor food, perfumes, and other products.
- **Mixing the final product**

5.3.4. Applications: These oils are used in

- food processing industry as flavoring agent,
- bakery industry as flavor,taste and preservation agent
- Pharmaceutical,cosmetic,perfume industry as flavoring agent

Unit: 5.4

Packaging of Spices

5.4.1.Packaging Requirements

For spices to remain fresh during transportation,handling,distribution,storage, and handling packaging materials must meet both functional and marketing requirements. The following are the general requirements for spice packaging:

• Spills and spoilage are prevented by protecting the product.

• A protection system is designed for protecting against climate conditions such as water vapor,oxygen, temperature, light and heat. It is important that the packaging materials selected have a high barrier to oxygen and water vapor.

• To prevent flavor/aroma losses, packaging material needs to have a highly barrier resistance.

• Aroma/flavor losses and external odors should be prevented by packaging with good barrier properties. Spice products contain volatile oils that react with the inner/inner surfaces.It can lead to a greasy and messy package with smudged printed matter. Grease and oil-resistant packaging is essential.

5.4.2.Types of packaging

- *Bulk Packaging*

It is a ancient method to pack whole spices in gunny sacks or jute bags, with a range of capacities from 10 kilograms to 70 kilograms, which are used for whole spices packaging.

A polyethylene bag may or may not be provided with the jute bags when they are supplied with a loose liner bag.Black pepper is sometimes packaged in double gunny bags.There is an inner polyethylene liner in the double gunny bag.Traders use jute fabrics with different weights and weaves (ends/picks) depending on the quality.The fabric used does not have any standardised quality or type. Jute contamination problems are overcome by the use of plastic-based alternate packaging materials. The plastic bags and liners also keep the spices fresh for longer by retaining their quality.\

One tonne capacity and numerous benefits are offered by these bags:

- Durable, flexible and collapsible bags
- Packages powders, flakes, and granules that flow freely
- This reduces waste , spillage and tampering
- Mechanized handling reduces labor requirements

- Loading and unloading time is saved
- Lightweight bags reduce the costs of freight.
- Provides a working environment free of pollution and eco-friendly

Institutional Packages

The ranging of capacities of institutional packages from 2.1kg to 10.5kg..

Consumer Packages

This type of packages depend upon the following factors-

- The shelf-life duration refers to the level of protection that a product must provide against various issues such as moisture absorption, retention of aroma, discoloration, and so on (particularly with powdered spices).
- Distribution, storage, and transportation conditions
- Market segmentation
- The preferences of consumers
- Aesthetics and printability

The following packages are available in the market in different types:

- Bottles in a variety of sizes and shapes with labels and caps made of metal/plastic.
- Containers printed on tinplate with or without dispensing system.
- Dispensing containers made from composite materials
- Flexible pouches with printed designs - pillow pouches, gusseted pouches, stand-up pouches.
- Carton linings

Recent advances in printing technology have made flexible pouches a very popular product because of their ease of use.It is available, has excellent printability, is light in weight, is machinable, and is cost-effective.Additionally, laminates/films can be tailored to meet specific needs based on marketing and functional requirements.

References:

Duncan, S. E., Moberg, K., Amin, K. N., Wright, M., Newkirk, J. J., Ponder, M. A., Acuff, G. R., & Dickson, J. S. (2017). Processes to Preserve Spice and Herb Quality and Sensory Integrity During Pathogen Inactivation. Journal of Food Science, 82(5), 1208–1215. https://doi.org/10.1111/1750-3841.13702

Embuscado, M. E. (2019). Bioactives from culinary spices and herbs: a review. Journal of Food Bioactives, 6. https://doi.org/10.31665/jfb.2019.6186

Herman,L.(2015). Herb & Spice Companion: The Complete Guide to over 100 Herbs & Spices. Wellfleet Press, New York, NY..

Hossain, M. B., Brunton, N. P., & Rai, D. K. (2020). Herbs, Spices and Medicinal Plants. John Wiley & Sons.

Hossain, M. B., Rai, D. K., & Brunton, N. (2020). Herbs, spices and medicinal plants : processing, health benefits and safety. Wiley-Blackwell.

La Torre Jessica Elizabeth, D., Gassara, F., Kouassi, A. P., Brar, S. K., & Belkacemi, K. (2015). Spice use in food: Properties and benefits. Critical Reviews in Food Science and Nutrition, 57(6), 1078–1088. https://doi.org/10.1080/10408398.2013.858235

Raghavan, S. (2006). Handbook of spices, seasonings, and flavorings. CRC Press.

Sachin,M.,Ashutosh,D.,Nongmaithem,M.,& Niamcha,L.(2020).Adulteration of Spices:A Review.4(5), 42–45. https://doi.org/10.46243/jst.2020.v5.i6.

Sajad Ahmad Wani, Singh, A., & Kumar, P. (2022). Spice Bioactive Compounds. CRC Press.

Soon Liang Sim. (1998). Developments in Biotechnology for Pepper and Other Spices.

Tapsell,L.C., Hemphill,L., Cobiac,L., Sullivan,D. R., Fenech, M., Patch,C. S., Roodenrys,S.,Keogh,J.B., Clifton,P.M.,& Williams,P.G.(2006). Health benefits of herbs and spices, The past, the present, the future. Med. J. 185, 1–24.

Chapter-6
Animal Food Processing

Nabanita Ghosh

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: nabanitag@svu.ac.in

Milk Processing

6.1 Composition and Nutritive Value of Milk

Milk is the optimum nutrition for mammals. Raw milk contains a significant amount of fat, protein, and calcium regardless of species. Milk is a whole, clean, fresh, secretion obtained by milking udders of healthy dairy animals. Milk contains the following major components (Jenkins TC)

- Protein
- Fat Solid Not Fat (SNF)
- Water
- Total Solids (TS)
- Lactose
- Minerals
- Vitamins
- enzymes

6.1.2 Processing of Milk

To enhance the quality of milk, a number of operations are carried out, including the collection of milk from the farm, storage of milk, separation, pasteurization, and homogenization. As a result of all these operations, improved quality milk is produced (Burke, 2018).

Pasteurization: The main motto behind pasteurization was to control tuberculosis causing bacteria. During pasteurization, the heat and holding period destroy an enzyme naturally present in milk called alkaline phosphatase. This enzyme is used to determine whether the pasteurization process is completed or not. The types of pasteurization include continuous high-temperature short time (HTST), higher heat shorter time (HHST), ultra pasteurization, and Ultra High Temperature (UHT).

Homogenization: During this process milk is passed through a small opening under high pressure. It is primarily intended to disperse fat globules evenly throughout the milk by subdividing them into smaller globules. As a result, homogenization prevents fat from floating to the surface.

6.1.3 Milk Products

Milk is used on a daily basis in various forms, such as (Bird J) (Dr Adnan Y 2008)

Cream: Different types of cream are available that contain different fat concentrations like light cream contains 18 % of milk fat, heavy cream normally contains 48 % of milk fat.

Butter: In addition to milk fat, butter contains water and SNF. It appears in yellow or white colour and has a salty taste.

Ghee: Milk or cream is churned and evaporated at a constant rate to make ghee. Ghee is almost entirely butterfat. Due to its low moisture content and SNF content, it inhibits bacterial growth.

Fermented Milk Products: Lactose is the milk sugar which can be fermented with bacteria. The fermentation keeps microorganisms from growing, and preserves the milk for a short period of time. In order to change lactose into lactic acid, LAB (Lactic Acid Bacteria)are used. The fermented milk products are curd, yogurt, kefir etc.

Cheese: The enzyme rennin (known as rennet) and lactic acid bacteria is combined to make cheese from milk. To make cheese, pasteurized milk is heated and after that starter culture is added. Once curd has formed, it is allowed to stand for a few hours. After that the cheese is ripened and as a result of ripening, texture and flavor both are improved.

Condensed Milk: In order to obtain condensed milk, water removed from whole or skimmed milk through heat treatment and concentration.

Evaporated Milk: Evaporated milk is made by partially removing the water from whole or skimmed milk. Generally, they are bacterio logically safe and stable.

Milk Powder: When milk is dehydrated, it becomes dry milk or milk powder.

Casein: It is extracted from skimmed milk by precipitating it with rennet. Casein is a basic protein in milk.

Egg Processing

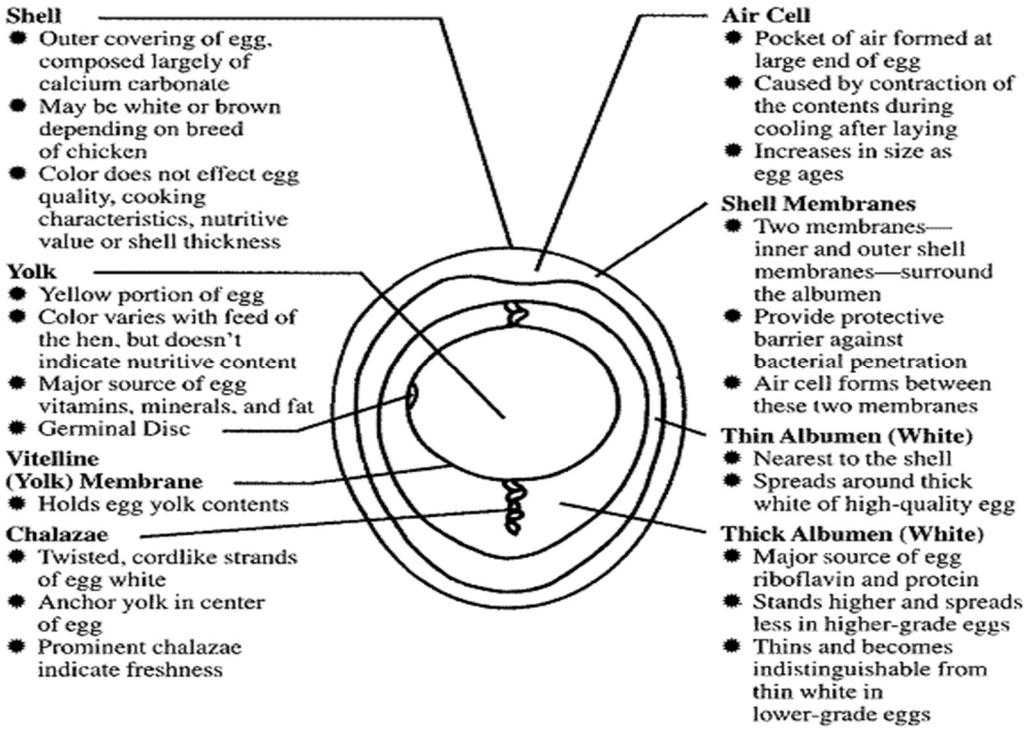
Eggs of all birds are available for consumption, but the most common ones are from hens and ducks. Egg protein consists of all the essential amino acids and it also has the highest biological value. This is why egg proteins are considered as reference protein.

6.2.1 Structure and Composition

There are three major components to a whole egg

a) Shell
b) Egg white
c) Egg yolk

6.2.3. Egg Structure



Source: USDA

Figure: 6.1 Structure of egg

6.2.4Nutritional qualities of egg

Nutritionally, eggs are a complete food and provide 173 calories per 100 grams (Sharma, 2006).

Proteins: Egg protein is a high-quality complete protein as it contains all the necessary amino acids. Egg whites contains 50% Ovalbumin, 13%Conalbumin, 10% Ovomucoid, 3.5% Lysozymes 2% Ovomucin, , Ovoglobulin, and Ovoinhibitor. Egg yolk contains Avidin, a protein that binds to vitamin biotin and makes it unavailable for human body.

Fat: Triglycerides, phospholipids are found as major part of the yolk fat. Lipoproteins are also present with phospholipids. Lecithin present in egg yolks is the primary phospholipid, and cholesterol is the major sterol.

Carbohydrate: There are small amounts of glucose, mannose and galactose present in the egg whites.

Micronutrients: The yolk contains all fat-soluble vitamins A, D, E. As well as iron, phosphorus, zinc, iodine, potassium, sodium, chlorine, and sulfur.

6.2.5. Functional Properties of Egg

Coagulation, emulsification, foaming are some of the properties derived from egg content as a food ingredient. (Forsythe, 1968)

Coagulation

During heating, egg proteins are denatured and aggregate to form gel networks in three dimensions. This makes eggs an effective thickener in many food formulations.

Emulsification

An egg yolk acts as emulsifier which keeps oil suspended in water by phospholipids and certain proteins.

Foaming

Eggs are excellent foaming agents. It generates large volumes of foam that remain stable during cooking. Eggs are thus extensively used to leaven baked goods.

Fish Processing

Early in the nineteenth century, fish were canned as a means of preservation. Fish was dried, salted, pickled, smoked and fermented (Cutting, 1955)

6.3.1 Nutritional Composition

As well as providing high levels of protein and a wide array of vitamins, fish also contains minerals such as iodine, calcium, magnesium, phosphorus, and selenium. Long-chain polyunsaturated n-3 fatty acids are found in fish oil which are important to human nutrition and have been shown to be involved in many metabolic functions as well (Chandravanshi, 2019)

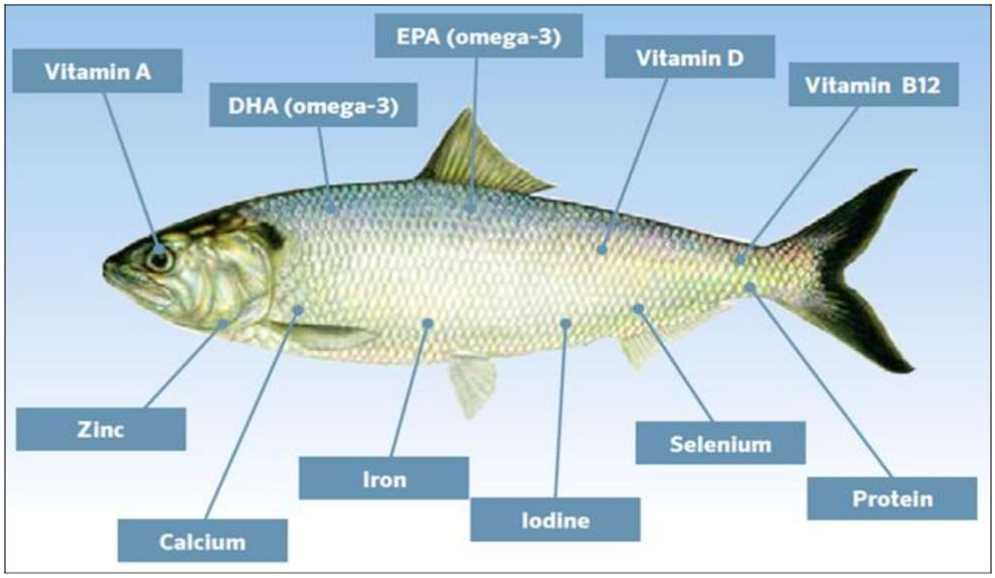


Figure: 6.2 Nutritional Composition of Fish

Source: Chandravanshi, 2019

6.3.2 Processing of Fish

Traditional Processing: In spite of the fact that traditional processes still can preserve fish in excellent quality today, fish is now a day are not preserved extensively by traditional process as quality control is a distinct issue. However, these require little capital expenditure, but they are labour-intensive and time-consuming (Mohan, 2018)

Modern Processing:

Canning: It is a sterilization technique that kills microorganisms and inactivates the degradative enzymes that damage them. A canned of fish is made by sealing it tightly in an air tight container and heating at a high temperature for a specified time period.

Freezing: Freezing reduces the biochemical reactions. There are three types of methods available to freeze fish: immediate cooling, rapid freezing, and cold storage. In the absence free water, the enzymes cannot react and degrade fish. Fish may lose structural integrity if frozen improperly.

Drying: In order to dry fish, three methods are commonly used: air drying, vacuum drying, and vacuum freeze-drying. Sometimes sun drying is also applied but that is not feasible throughout the year. As a product is drying, water evaporates from its surface at a constant rate, while the temperature remains the same during the constant-rate period.

Curing: By adding salt, sugar, or acids fish can be cured. Curing reduces water activity. It is a common way to use dry salting and pickle salting in the fish industry to reduce water activity.

Smoking: To preserve and enhance the flavour fishes are smoked. Smoking is traditionally a combination of drying and adding chemicals from the smoke. Smoking a fish with cold-smoking means that the fish is not cooked and. Smoking with hot-smoking involves both cooking and smoking the fish.

6.3.3. By Products of Fish Processing Industry

Among the traditional fishery by products are fishmeal, fish body and liver oils and fish protein concentrate. Shrimp, crab, waste has been processed into chitin and chitosan, (Bechtel. 2007)

Fish Protein Concentrate: A stable protein concentrate produced from fish or other aquatic animals or parts thereof is called fish protein concentrate (FPC). A protein concentration is increased by removing water, oil, bones and other materials. With the development of FPC, whole fish can be converted into protein concentrates, which differ significantly from the original raw materials, for human consumption.

Gelatin: Fish skin and bones can be used to extract gelatine. It is not possible to use gelatin as a sole protein source for animals or humans since it is lacking in the essential amino acid tryptophan. But it is rich in lysine and methionine, which are deficient in cereal proteins. However, gelatin is used extensively in food as well as in some industrial products.

Chitin and Chitosan: Next to cellulose, chitin is the most abundant biopolymer on earth. There are a number of uses for this inelastic, white, nitrogenous polysaccharide. Shells and head waste from shrimps are the primary source of chitin. Shell waste is deproteinized and demineralized to produce chitin. As chitin deacetylates, it produces chitosan. In addition to its use in industry and medicine, chitosan is a very useful substance.

Meat Processing

As part of the meat processing process, animals and fowl are slaughtered and processed into different forms such as cured, canned, and other meat products, and discarded portions are converted into useful by-products. Curing and preserving of meat involves number of processes, like salting, pickling, drying, and canning. This process prevents microbial spoilage of meat and extends its shelf life.

6.4. 1. Nutritional Composition

Meat is the muscle of warm-blooded four-legged animals. The term meat is used to describe skeletal muscles that are naturally attached to tissue. Meat is almost completely digestible. It is easy to digest, high in protein, and contains essential amino acids. All essential amino acids are obtained from meat and animal protein. Besides vitamins and minerals, meat also contains phosphorus, iron, copper, and trace minerals, as well as B complex vitamins, such as thiamin, riboflavin and niacin (Smet, 2016).

Table 6.1: Nutritional Composition of Meat

Content	Lamb	Chicken	Beef
Fat	7.0	10.1	5.3
Protein	24.6	22.9	33.9
Energy	675	764	766

Source: Nelofar Athar (2006)

6.4.2. Meat Processing:

As the name indicates, the meat-processing industry are consisting of slaughtering different animals, such as cattle, sheep, lambs, and calves, to obtain meat and to sell it or to use in variety of purposes. (Ortega-Rivas, 2014)

Chilling: A common technique for preserving raw and processed meat is chilling. By slowing many chemical and enzymatic reactions, chilling process preserves the muscle tissue by dominating the growth of different microorganisms. The ideal temperature for meat storage is 1 ºC above its freezing point. It is very important to control relative humidity (around 90%) during postmortem cooling and refrigerated storage (Ortega-Rivas, 2014)

Freezing: The freezing process is excellent for preserving meat for long periods of time. By freezing meat can be preserved during transportation over long distances. During rapid freezing, ice crystals are formed both within and outside of the cells, causing little harm to the meat structure. It is necessary to add antifreezing compounds or cryoprotectants to meat formulations to prevent protein quality loss.

Dehydration: As a result of dehydration moisture unavailability not only prevents microbes from growing but also causes their death that results in longer shelf life and higher quality

products. A loss in native structure of proteins, occurs due to denaturation of sarcoplasmic proteins.

Smoking: As a flavor enhancer, aroma enhancer, and preservation aid, smoking is sometimes used with salting and curing to preserve meat and meat products. During smoking, preservative substances added to meat, along with heat, which have a germicidal effect. Drying the meat along with the smoke's chemicals inhibit microbial growth. Smoke is composed of carbonyl compounds, organic acids, phenols, alcohols, and hydrocarbons.

Curing: To increase shelf life and achieve desirable colour and flavour, meat is curried by adding sodium chloride, sodium nitrite, or sodium nitrate. Curing can be performed with or without other ingredients to enhance flavour. As one of the most essential ingredients, sodium chloride (or potassium chloride) inhibits microorganisms' growth. If salt is used alone, it produces a unpalatable dry, harsh, dark-coloured, and salty product. So, it is recommended to use it with sugar, nitrite, and nitrate. By controlling the growth of bacteria, sugar enhances flavour and colour development and also helps increase shelf life.

References:

Jenkins, T. C., & McGuire, M. A. (2006). Major advances in nutrition: Impact of milk composition. Journal of Dairy Science, 89(4), 1302–1310. doi:10.3168/jds.S0022-0302(06)72198-1

Burke, N. et al. (2018). The dairy industry: Process, monitoring, standards, and quality. doi:10.5772/intechopen.80398

Bird, J. (1993). Milk standardisation. International Journal of Dairy Technology, 46(2), 35–37. doi:10.1111/j.1471-0307.1993.tb00856.x

Dr Tamime, A. Y. (2008). Milk processing and quality management. doi:10.1002/9781444301649

Sharma, A. (2006). Food science and technology. Lucknow, India: IBDC Publications.

Khader, V. (2001). Food science and technology. New Delhi: Indian Council of Agricultural Research.

Forsythe, R. H. (1968). The science and technology of egg products manufacture in the United States p. 2.62.- 304 In Egg quality: A study of the hen's egg. Edinburgh: Oliver & Boyd Limited.

.(1955). London, L. Cutting, France: C. L. Fish Saving. Hill Books, Ltd.

Chandravanshi, N., Manisha, Dhruw, P., & Bharti, R. (2019). Nutritional quality of fish food. *International Journal of Fauna and Biological Studies, 6*, 82-86.

Mohan et al. (2018). Fish processing and preservation technologies: An overview. ICAR-Central Institute of Fisheries technology.

Bechtel, P. J. (2007). By-products from seafood processing for aquaculture and animal feeds Woodhead Publishing Series in Food Science, Technology and Nutrition (pp. 435–449). doi:10.1533/9781845692087.3.435

De Smet, S., & Vossen, E. (2016, October 1). Meat: The balance between nutrition and health. A review. Meat Science, 120, 145–156. doi:10.1016/j.meatsci.2016.04.008

Ortega-Rivas, E. (2014). Encyclopedia of food microbiology (2nd ed).

Chapter-7

Food Quality Evaluation

Rupali Dhara Mitra

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: rupalidm@svu.ac.in

7.1: Introduction to quality attributes of Foods

Quality is commonly characterized as the level of excellence and represents an ongoing process of enhancement aimed at fulfilling consumer requirements in the current context. (D. D. Wadikar Scientist, Defence Food Research Laboratory, Mysore). In the realm of food science, quality attributes of food can be categorized as either **visible** or **invisible**. Visible quality attributes pertain to the sensory aspects of food, while invisible or hidden quality attributes encompass the nutritional value of the food.

The quality of food can be described as the combination of features that distinguish individual units of a product, and these features should be significant in determining the level of acceptability for the buyer. Key characteristics of food and food products include color and gloss, viscosity and consistency, size and shape, texture, and flavor. Additionally, nutritive values such as vitamins and minerals are considered hidden attributes. The concealed quality attributes include nutritive components like carbohydrates, proteins, fats, fiber, vitamins, and minerals, along with non-nutritive compounds such as phytates, tannins, pigments (which impact the food's color), oxalates, and certain undesirable substances. Quality, often perceived as a measure of excellence, can be viewed as a set of specifications that need to be adhered to within given tolerances or limits. Quality control is the practice of maintaining quality at levels and tolerances acceptable to the buyer while minimizing costs for the vendor.

Quality determination in the food industry is generally conducted through two broad methods, as outlined below:

Subjective Method: In this approach, individuals are tasked with expressing their judgments on qualitative or quantitative values. This method is commonly known as sensory analysis and relies on the experiential insights of the individual. Various subjective techniques, such as the 9-point Hedonic Scale, Triangular test, or Composite test, are employed for estimation in this method. This evaluation by trained panelists (limited number) is also referred as effective

analysis. Results of such method are fairly reproducible. However, another sensory evaluation called as affective analysis refers to untrained individuals evaluating the food but involves a large group of population. This provides general opinion about the food acceptably.

Objective Methods: These methods rely on established scientific standards and tests applied to any sample of the product, irrespective of its prior history. They embody a contemporary approach to quality control (QC) as they eliminate the influence of human factors in the assessment process. The methods include physical, chemical and microbiological approaches. The physical method mainly covers the appearance, colour, odour and texture of the food item and is done by several instrumental methods assisting the human judgments. While the chemical methods are used for evaluation of include the hidden quality attributes. These are standard food analysis methods. These are used for quantitative evaluation of nutritive value e.g. moisture, specific gravity, fat, oil, protein, carbohydrates, fibre, enzyme, vitamins and pH, Total soluble solids (TSS) etc. The microbiological quality attributes involve analysis mainly to ensure safety aspects of food for human consumption. It is essential to meet standard specifications with respect to total plate count, yeast & mold count and presence of coli forms. Microbiological quality is also used as markers. The importance of each quality attribute differs with the type of product. The appearance is governed by color and ergonomics of the product while the texture is studied depending upon the physical state of the product. The maturity and processing steps involved are the important factors controlling the initial quality of the finished product. Among the other factors influencing the consumer perception to food include psychological status, physiological status, age and social surroundings. There are several instrumental methods for evaluating sensory parameters to avoid human bias; however, on a commercial scale either a trained panel or instrument-based judgments by expert is used to monitor the food quality attributes. monitor certain process quality.

Some of these attributes, alongside factors like the yield of the final product and adherence to legal specifications, including microbial quality, are regarded as quantitative attributes of food quality, commonly essential in commercial contexts.

Food possesses numerous quality attributes, extending beyond sensory qualities. However, this chapter will focus on quality attributes related to the sensory aspects of food. Both raw (fresh) and processed food items exhibit characteristic qualities. In the case of raw or fresh produce, such as nuts, fruits, vegetables, grains, milk, and eggs, quality attributes are influenced by factors like type, variety, place of origin, cultivation practices, and stage of

harvesting, among others. Processed foods, on the other hand, have quality attributes influenced by preparation methods, cooking recipes, food packaging and serving types, and the purpose of processing—whether it's on an industrial scale for preservation suitable for marketable life or on a home scale for immediate consumption. The interpretation or expression of food quality varies among individuals.

A public health professional may simply define good quality food as that which doesn't cause illness. For a food business operator, the quality of food involves characteristics that ensure a uniform end product and efficient manufacturing processes. Authorities responsible for food safety standards and certification define food quality by adherence to specific criteria such as viscosity, density, color, texture, and more. Conversely, consumers, as the ultimate decision-makers, look for products that are not only delicious and safe but also cost-effective. In accordance with explicit regulations, "Quality" pertains to the inherent properties of any processed product, determining its relative level of excellence. This assessment considers the influence of preparation and processing, and it may or may not encompass the impact of packaging or the inclusion of additional ingredients or additives.

Sensory Analysis is a science or discipline that measures, analyze and interprets the reaction of people to products as perceived through the senses of sight, smell, touch, taste and hearing. Sensory analysis is an amalgamation of disciplines such as physiology, psychology, food chemistry, nutrition, and statistics (Stone, H and Sidel, JL 1993, Sensory Evaluation Practices, 2nd edition, Academic Press: San Diego).

Sensory attributes of food have five aspects i.e. Colour (referred as **appearance**), **aroma** (often referred as smell or odor), **taste, texture** (also referred as consistency depending upon the type of food) and **hearing**. The quality attributes related to eating of food are called as sensory attributes/quality because a range of senses are used in the process of eating food from its aroma, sight and actual putting in mouth giving the taste. These senses include the aroma/smell, sight, hearing/sound, taste and touch/hand feel. An amalgamated response from these senses will result into actual quality expression by an individual about a food item.

7.2 COLOUR (Appearance)

Appearance of a food is influenced by several factors. It encompasses the size, shape, ergonomics, colour, gloss/shine, physical state, temperature and surface texture of the food. Appearance is therefore vitally important for the food to be eaten and enjoyed. Various terms,

including firm, dry, crumbly, flat, crisp, lumpy, fizzy, fluffy, smooth, stringy, crystalline, cuboid, fragile, dull, etc., are employed to characterize the appearance of a substance. Most of these properties can be identified by seeing the food and without touching it. The color of food refers to the energy distribution of light either reflected by or transmitted through a specific food item. It constitutes a segment of the input signals reaching the human brain, contributing to the overall perception of its appearance. Our eyes are sensitive to a limited portion of the electromagnetic spectrum, spanning from 380 to 770nm, which represents a small fraction of the entire spectrum. The color of foods varies from different shades of violet to red across the visible range of colors. The color plays an important role product preparation, quality control and determining the quality of certain foods as per the laid standards/law e.g. the color values for tomato products, jams, mustard oil, etc. The assessment of fruit ripeness is influenced by its color. Similarly, the perceived strength of coffee and tea is also determined based on the color of the beverage.

7.2.1 Measurements of the color:

In addition to the subjective evaluation of color by the human eye, color measurements can also be carried out using instrumental methods. Examples of such instruments include the Lovibond Tintometer, Certainly, the role of color in food perception is multifaceted and plays a crucial role in consumer acceptance. Two commonly used color measurement systems are the **Hunter color meter** and those based on the **CIE** (Commission Internationale de l'Eclairage) system. The Hunter color system relies on a color space and defines color using parameters L, a, and b. The L parameter represents brightness or lightness, 'a' indicates redness when positive and greenness when negative, and 'b' denotes yellowness when positive and blueness when negative. In contrast, the CIE system expresses measurements in terms of hue, chroma, and brightness.

Color, along with other aspects of appearance, significantly influences food appreciation and quality, especially from the consumer's perspective. Humans have subjective standards for acceptable ranges and preferred optima for these qualities in almost every food. The color of agricultural commodities and processed foods is of paramount importance, and issues such as discoloration in fruits and vegetables pose challenges. Changes in color can sometimes accompany undesirable alterations in texture, taste, or odor. Consumer recognition of off-color in overaged cheese, beer, meat, and fish is often associated with poor flavor quality. The maturity of many fruits and vegetables is closely linked to color development or changes.

While some color changes may not be detrimental, they can still impact consumer acceptance, as individuals expect certain foods to have specific colors.

Many food items are artificially colored to meet consumer expectations, such as artificially colored butter, mint-flavored ice cream, orange sherbet, maraschino cherries, oranges, syrups, jellies, and candies. Understanding human reactions to color in foods involves considering five functions:

Perception: Color discrimination is crucial for food selection and judgment of food quality.

Motivation: Food color and the color of the environment influence appetite and desire for food.

Emotion: Liking or disliking a food is conditioned by its color; attractive foods are sought out for pleasure, while unattractive ones are avoided.

Learning: Through experience, individuals learn what colors to expect and consider "natural," influencing predictions about a food's properties.

Thinking: Explanation and understanding can alter reactions to unusual properties or new foods.

In summary, the multifaceted role of color in food perception encompasses various psychological and sensory dimensions that significantly impact consumer responses and preferences.

Visual Appeal and Expectations:

Function: Color contributes significantly to the visual appeal of food. Consumers often associate specific colors with certain flavors or qualities in food. For example, ripe tomatoes are expected to be red, and oranges are expected to be orange.

Impact: Deviations from expected colors may create a psychological barrier for consumers, leading to reduced acceptance even if the actual taste or quality remains unchanged. This is why food producers often use artificial coloring to meet consumer expectations.

Freshness and Ripeness Indicators:

Function: Color changes are often indicators of the freshness and ripeness of fruits and vegetables. Consumers rely on color cues to judge the maturity and quality of the produce.

Impact: Discoloration may be perceived as a sign of spoilage or aging, leading to a negative impact on consumer perception. Fresh, vibrant colors are generally associated with higher quality and better taste.

Flavor Expectation:

Function: Consumers may associate certain colors with specific flavors. For example, red may be associated with sweetness or a certain fruit flavor.

Impact: Artificial coloring is often used to align visual cues with expected flavors. This is particularly evident in products like candies and beverages, where color plays a crucial role in shaping flavor expectations.

Cultural and Psychological Associations:

Function: Colors can evoke cultural or psychological associations that influence consumer preferences. For example, bright and vibrant colors may be associated with freshness and positive emotions.

Impact: Food colors can trigger specific responses based on cultural or personal experiences. Understanding these associations is crucial for producers to align their products with consumer preferences.

Quality Perception:

Function: Color is linked to perceptions of overall food quality. Consumers may use color as a quick visual cue to assess the quality of a product.

Impact: Off-colors in products like cheese, meat, or fish may signal potential quality issues, leading to decreased consumer trust. Maintaining the expected color is essential for ensuring that the product is perceived as high-quality.

In conclusion, the role of color in food goes beyond aesthetics, influencing various aspects of consumer perception and acceptance. Producers must carefully consider these functions and align the visual aspects of their products with consumer expectations to ensure success in the market.

Certainly, there is a notable lack of comprehensive understanding regarding the significance of color perception in food acceptance. Observers tend to associate specific colors with acceptance, indifference, or rejection of food items. Although colored lights are employed

to mask color differences and mitigate the impact of color on sensory evaluation, the psychological effects of such colored lights have not been thoroughly measured. These effects can be both direct, influencing the overall appeal of the food, and indirect, affecting thresholds for odor, taste, or texture. Several interrelationships between color perception and food attributes suggest themselves. While the human eye exhibits remarkable qualitative discrimination for color, itlacks quantitative precision. Therefore, the precise measurement of color requires the use of modern instruments. This need is particularly evident in situations where food products are blended to a certain standard from raw materials that inherently differ in their color properties, as seen in the case of tomato ketchup.

The color of raw materials, influenced by factors such as climate and time of harvesting, significantly impacts the color of many processed foods. Understanding and controlling these color variations become crucial, especially in maintaining consistent quality in the production of food items.

7.3 TASTE:

Taste stands as the decisive factor influencing the acceptability of food. This sensory experience is primarily perceived through the tongue. Taste is the outcome of a chemical interaction between substances in the mouth and taste receptor cells, which are primarily located on taste buds situated on the tongue within the oral cavity. Alongside the sense of smell (olfaction) and trigeminal nerve stimulation (sensing texture, pain, and temperature), taste plays a crucial role in shaping the overall flavors experienced with food and other substances.

Human taste receptors, situated on taste buds known as gustatory calyculi, are distributed across various areas, including the upper surface of the tongue and the epiglottis. The tongue has the ability to discern five fundamental tastes: bitter, salt, sour, sweet, and umami. Each taste receptor is concentrated in specific regions of the tongue. For example, sweet receptors are predominantly located at the tip of the tongue, as evidenced by a child's inclination to lick a candy sucker rather than chew it. Sour receptors are mainly found along the sides of the tongue and are particularly responsive to acids. Salt receptors are most prevalent in the tip and upper front portion of the tongue, primarily responding to inorganic salts. Bitter receptors are situated toward the back of the tongue.

While certain areas of the tongue may detect a taste sooner than others, all parts are equally proficient at conveying the perception of all tastes. In practical terms, the assessment

of sensory attributes, especially taste, is crucial, and a trained panel of food testers typically conducts these evaluations. Despite technological advancements such as e-tongue and e-nose, the comprehensive human perception of sensory attributes is challenging to fully capture through instrumental means alone when correlating it specifically to various foods.

7.4 AROMA:

Aroma, in terms of the olfactory system, refers to any property detected by the sense of smell. Other terms used interchangeably for aroma include odor, fragrance, and smell. The significance of the aroma or smell of a food item lies in its ability to evoke a response without visual confirmation and awareness of its location. The aroma of a flavorful food item, such as a ripe mango, freshly fried delicacy, or any product in preparation, can influence your sensory organs, intensifying the desire for that item, particularly due to recognition.

The detection or identification of aroma is attributed to nasal/olfactory glands. Aroma is a highly individualistic characteristic of specific foods, resulting from the release of volatile compounds/aromas. Various aromatic compounds found in natural foods or released during food preparation include esters like ethyl/methyl/octyl acetates and butyrates (found in apple, pineapple, orange) contributing to fruit fragrances; linear terpenes like citral and linalool from fruits; cyclic terpenes such as limonene and menthol; and several volatile compounds from spices, including gingerol and zingiberene from ginger, cinnamaldehyde from cinnamon, cuminaldehyde from cumin, thymol, carvacrol, pinene, cymene, and eugenol from ajwain and clove. These compounds are integral to processed foods, particularly in Indian cuisine where spices play a vital role. Additionally, certain odorous compounds are generated during fermentation processes, as observed in wines, curd, and pickles.

Odors can be characterized by associating them with specific food items, such as herby, cheesy, or fishy. Additionally, the intensity of the odor can be measured and described. The portrayal of odor or aroma can be effectively communicated through a range of descriptive terms, encompassing words such as aromatic, pungent, spicy, floral, bland, tainted, perfumed, rancid, savory, rotten, tart, citrus, acrid, strong, mild, light, musty, scented, fragrant. Additionally, terms like roasted, burnt, and overcooked are utilized to articulate specific odors, especially in the context of processing and the final product.

7.4.1 FLAVOR:

The term "flavor" is commonly used to encompass both the taste and odor of food. Taste and odor work collaboratively to form flavor, and it can be challenging to distinguish the flavors of foods when the sense of smell is compromised, as is the case with a blocked nose. Flavor fundamentally results from the integration of taste, smell/aroma, and sensory elements like astringency or bite, which are notably pronounced in spices, wine, and coffee. In essence, flavor is the result of the combined perceptions of taste and aroma, encompassing the senses of taste, smell, and a composite sensation known as mouthfeel.Taste, focusing on sensations perceived by the tongue, is confined to sweet, sour, salty, and bitter. The chemical dimensions of these tastes can be measured and correlated with consumer preferences. Smell or odor, a pivotal component of flavor, can be assessed through gas chromatography and associated with flavor acceptability. Aroma, in contrast, is the outcome of olfactory senses being activated by volatile organic compounds. Aromas may present as fragrant, acidic, burnt, pungent, enzymatic, or indicative of spoilage

7.5. TEXTURE:

Texture refers to the qualities of a food item that are perceived through both visual inspection and the sensations experienced by the skin and muscles in the mouth. This encompasses characteristics such as roughness, smoothness, graininess, and more. The texture or mouthfeel of liquid foods, particularly those displaying Newtonian fluid behavior, is intricately linked to their viscosity. Assessments by trained panels on the sliminess of gum solutions have indicated a correlation between mouthfeel ratings and viscosity. Various instruments, measuring compression, resistance to penetration, or the force required for shearing, have been utilized to assess the texture of fruits and vegetables. The Magness pressure tester, widely used for gauging the maturity of deciduous fruits, involves the penetration of a fruit's flesh by a steel plunger of specified diameter. Penetrometers, developed for the objective evaluation of texture in cooked, canned, and frozen foods, have seen extensive use.

Researchers concentrating on peaches have emphasized the importance of texture in consumer acceptance, elucidating the connection between changes in pectin and alterations in texture. The transition of protopectin to water-soluble pectin during ripening is a contributing factor to softening. Processing time reduction influences the firm texture of both cling and freestone peaches, leading to a diminished retention of protopectin.

The consistency of a food item, expressed as its texture, is primarily influenced by its physical state, especially in the case of liquid or semisolid foods. This texture significantly contributes to the overall visual appeal of the food, complementing its color, and is subject to visual evaluation. However, the tactile experience, particularly the touch by hand and the responses from the oral cavity, plays a pivotal role in the assessment of food texture. As the food enters the mouth, the tongue and other sensitive skin in the oral cavity react to the surface of the food, giving rise to what is commonly known as mouth-feel. Various sensations unfold during the chewing process, and the resistance encountered during this activity influences elements of texture, such as chewiness and springiness.

A wide array of terms is used to describe the various textures of foods, encompassing characteristics such as brittle, rubbery, gritty, bubbly, sandy, tender, waxy, soft, firm, flaky, crisp, fluffy, dry, crumbly, lumpy, smooth, hard, mushy or soggy, sticky, chalky, grainy, and fibrous. It's noteworthy that certain descriptors, like sandy and chalky, not only convey texture but are also utilized to express taste.

The concept of consistency is closely linked to the viscosity attributes of liquid and semisolid foods, utilizing terms like runny, thick, watery, or fluid. Additionally, temperature emerges as a crucial factor influencing food texture, with the mouth capable of discerning temperature variations, such as the coldness of ice cream, the warmth of bread, the heat of soup or coffee, and the chill of beverages. These temperature-related attributes play a pivotal role in determining the quality of food when served, thereby significantly impacting consumer reactions.

In summary, texture is a comprehensive evaluation that encompasses tactile sensations experienced through both touch and mouthfeel. Three main categories of textural characteristics are identified: mechanical characteristics, which pertain to a food's response to stress; geometrical characteristics, which involve the size, shape, and orientation of particles within the food; and other characteristics related to the perception of moisture and fat contents in the food

Texture parameter: The texture related parameter measuring instruments are Universal Texturometer, Brookfield Viscometer, Roto-viscometer, Shear press (Cutting force measurement equipment), Penetrometer (grain tester), Digital Texture analyzer, Rapid visco analyzer (RVA) etc. Other factors affecting the human perception of quality attributes

Although the senses play an important role in determining our food preferences, and helping us to evaluate food, other factors are also involved.

The psychological and physiological status of an individual plays a major role in his response to a particular food. The several factors involved in individual expression about the quality attribute of a food material include**: a. Previous experiences with food**: if a particular food consumed was disliked earlier, the next response prior to consuming it will start with reduced acceptance. Or if the product is your favorite fruit or dish, the response in expressing its quality will likely to have its effect**. b. Hunger and satiety**: The food craving of an individual depends upon the physiological status of energy level in the body and emptiness of stomach. **c. Mood**: it refers to the psychological status **d. Surroundings**: It refers to the locations and ambience where the food is being served or being eaten, e.g. home, canteen, picnic**. e. Beliefs and values**: The preferences and reactions to the food are also dependent on individuals, e.g. religion, culture, tradition and eating habits . **f. social aspects**: Social aspects such as special occasions, events, and parties also influence the expression about the quality attributes of food. The time of tasting a particular product is also important e.g. eating ice-cream early morning may not be very pleasant while the icecream post dinner may be more enjoyable. Therefore commercial food testing is recommended to carry out in sensory laboratories with uniform surroundings to all the testers. Other factors affecting the quality attributes of food: The initial quality of any food item is governed by certain factors. These are genetics or origin of the food, Pre-harvest environment, Harvesting practices, and Post Harvest handling.

The suitability of specific recommended cultivars varies across different regions, even within the same state or area. While high visual quality is generally sought after for various processing methods, the fruit's composition concerning flavor, texture, color, and nutritional value holds paramount importance. Several pre-harvest factors, including irrigation, sunlight exposure, and hygiene, play a crucial role. In citrus fruits like oranges, mandarins, and lemons, excessive irrigation can lead to high acidity, while moisture deficiency may result in reduced fruit size, diminished juice content, and increased peel thickness.

Harvesting factors, such as the method of slaughtering in meat products (halaal or zatka), stage of maturity in cereals and pulses, ripeness, and physiological age in fruits and vegetables, as well as the method of milking dairy animals, are significant determinants affecting overall quality. These considerations emphasize the importance of tailoring cultivation and harvesting practices to specific local conditions for optimal outcomes.

The mechanical characteristics are further classified into primary properties, including Hardness, Cohesiveness, Viscosity, Adhesiveness, etc.:

Cohesiveness: The degree to which the sample deforms before rupturing when bitten with molars.

Hardness: The force required to deform the product to a given distance, such as the force to compress between molars, bite through with incisors, or compress between the tongue and palate.

Viscosity: The force required for drawing a liquid from a spoon over the tongue.

The secondary properties involve terms like brittleness, chewiness, gumminess, fracturability, firmness, softness, juiciness, greasiness, etc.

Denseness: Compactness of the cross-section of the sample after biting completely with the molars.

Dryness: The degree to which the sample feels dry in the mouth.

Fracturability: The force with which the sample crumbles, cracks, or shatters. Fracturability encompasses crumbliness, crispiness, crunchiness, and brittleness.

Graininess: The degree to which a sample contains small grainy particles

Gumminess: Energy required for disintegrating a semi-solid food to a state ready for swallowing.

Roughness: The degree of abrasiveness of the product's surface perceived by the tongue.

Heaviness: Weight of the product perceived when first placed on the tongue. Moisture absorption: The amount of saliva absorbed by the product. Moisture release: The amount of wetness/juiciness released from the sample.

Mouth coating: Type and degree of coating in the mouth after mastication.

Slipperiness: The degree to which the product slides over the tongue.

Smoothness: Absence of any particles, lumps, bumps, etc., in the product.

Uniformity: The degree to which the sample is even throughout.

Uniformity of Chew: The degree to which the chewing characteristics of the product are even throughout mastication.

Uniformity of Bite: Evenness of force through the bite.

Wetness: The amount of moisture perceived on the product's surface.

7.6. Methods of Sensory Evaluation:

Mouth-feel refers to the physical and chemical interactions a product has in the mouth. This sensation encompasses various aspects, including astringency, heat, cold, and cooling effects. The concept of mouth-feel is applied in diverse areas related to the testing and evaluation of food products, such as wine-tasting and bread rheology. It is assessed from the initial perception on the palate to the first bite, through the process of chewing, swallowing, and the aftertaste. In wine-tasting, for instance, mouth-feel is often used with modifiers (big, sweet, tannic, chewy, etc.) to describe the overall sensation of the wine in the mouth. Numerous instrumental methods are available for measuring these attributes, and these measurements can be correlated with consumer preferences.

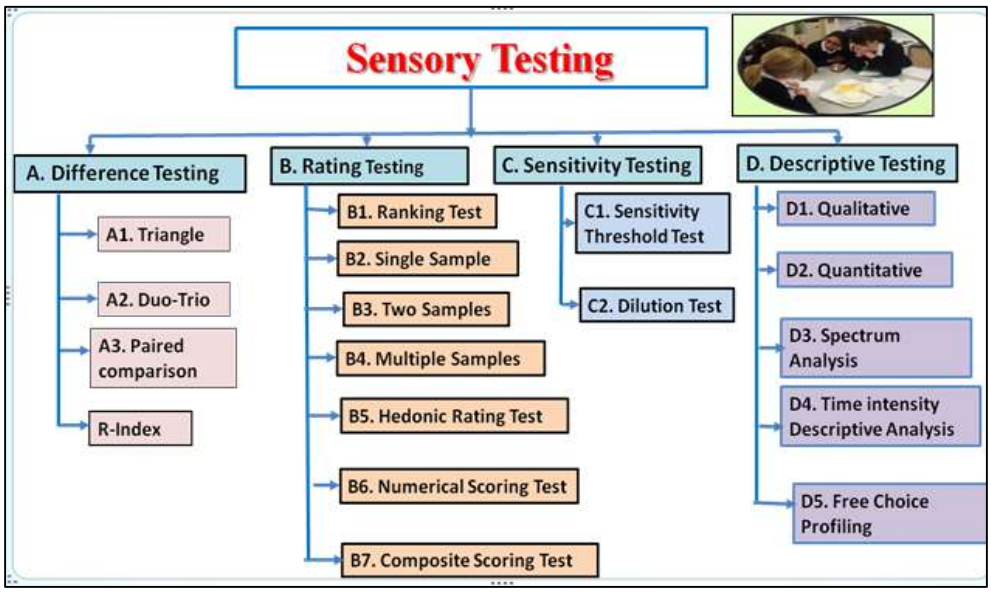
Sensory Analysis is a scientific discipline that involves the measurement, analysis, and interpretation of people's reactions to products as perceived through the senses of sight, smell, touch, taste, and hearing (Stone, H and Sidel, JL 1993, Sensory Evaluation Practices, 2nd edition, Academic Press: San Diego). Sensory evaluation is a combination of **physiology, psychology, food chemistry, nutrition, and statistics.**

Application of sensory analysis in food industry: Sensory evaluation is basically applied in Quality Control (QC), Product Development and in other applications like psychophysics, senses, and rheological properties

Quality Control (QC)- It is done to monitor quality of all raw materials and products, for checking regular samples against specification (SOPs). It also refers to detect differences between products from different runs or batches and to describe specific characteristics of their products. Quality control also includes profiling the characteristics of new products and evaluates the product throughout storage life. It improves the quality of products by modification of ingredients. It also determines the acceptability of the new product to the customer. It evaluates and compares competitor’s products and demonstrates new products to marketing team. It promotes new or reformulates products to the customers. Is is also done for cost reduction exercise.

For sensory evaluation sensory Lab is used. The laboratory should have separation of test places by partition walls, air conditioning, controlled light installation, washing facilities with cold and hot water.

Types of scale used in sensory evaluation



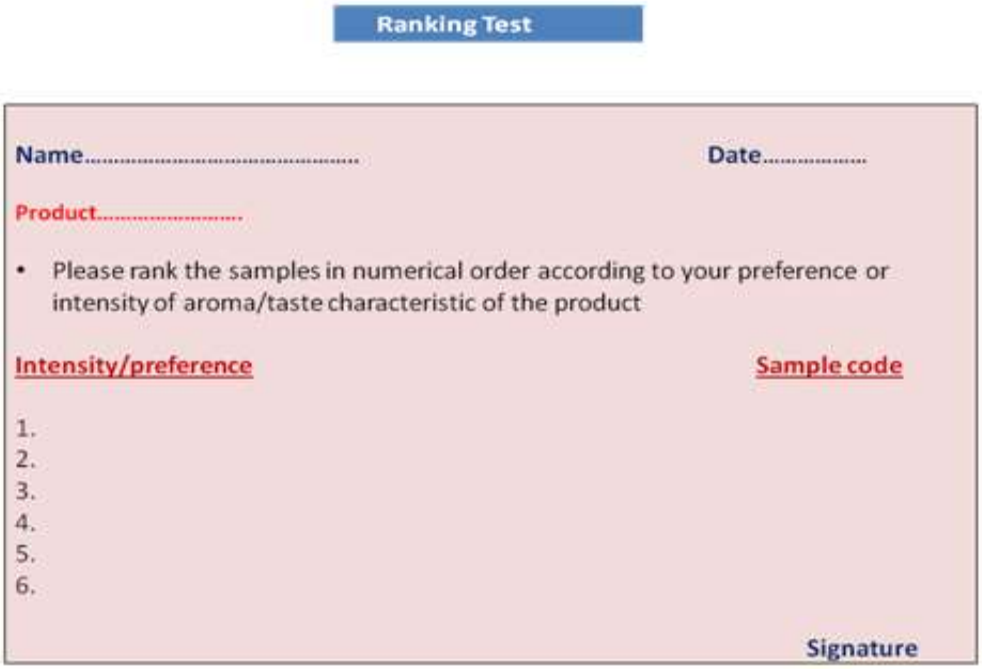
A. Difference Testing

- **A1. Triangle-**Here, three samples are given to taste, where two are from the same product. Panelists are requested to determine the sample of the different product
- **A2. Duo-Trio**- First, reference sample from manufacturer is tasted, then two additional sample one from manufacturer and other from a different product are tasted. The panelist must then identify which sample from the second set matches with the reference one.
- **A3. Paired Comparison**- Here, two samples are taken and panelists are asked to answer a set of questions for the two. Finally, they are asked which sample they prefer most**.**
- **A4. R-Index**-This is a rapid test and describe as short-cut signal-detection method. Test sample is compared against the standard

B. Rating Test

B1. Ranking Test

The method you're describing is known as a Ranking Test, a sensory analysis technique used to assess how multiple samples differ based on a single attribute. In this test, panelists are presented with all samples, each assigned a code number, and are then asked to rank them in order of preference. Panelists assign numerical ranks such as 1, 2, 3, and so on, indicating their preference for each coded sample. This method helps determine the relative preferences of the samples based on the specified attribute



B2. Single Sample Difference Test

The description you provided aligns with the description of a Difference Test, specifically a Paired Comparison Test. In this test, a pair of single samples is presented to each taster, and the goal is to measure the degree of difference in a particular characteristic. Each taster is served one sample, and both the test samples are compared to a standard. Judges then assess the degree of difference on a scale, often ranging from zero (representing no difference) to 3 (representing an extreme difference). It's important to note that no guessing is allowed, except when a coded duplicate standard is included in two samples, helping to control for bias and enhance the reliability of the test.

B3. Two Sample Difference Test

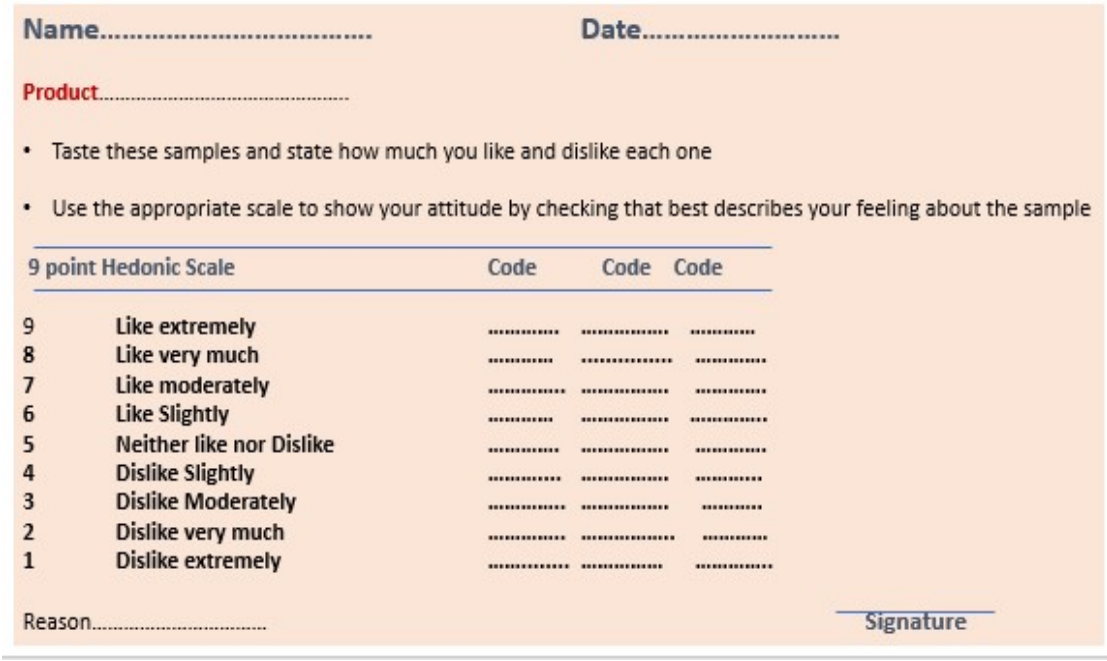
The method you are describing is known as the Duo-Trio Test, a variation of the paired comparison test. In the Duo-Trio Test, each taster is presented with four pairs of samples. Two of these pairs consist of duplicate samples, and the other two pairs are test samples. The test samples are compared to a standard, and tasters judge the degree of difference on a scale ranging from zero (indicating no difference) to 3 (representing an extreme difference). Importantly, no guessing is allowed, except through the coded duplicate standard included in two pairs. This helps control for bias and ensures a more accurate assessment of the perceived differences in the characteristic being evaluated.

B4. Multiple Sample Difference Test

The method you're describing is known as the Triangle Test. In this sensory analysis approach, panelists are presented with a set of samples (typically between 3 and 6) to prevent exhaustion. Each sample is coded, and among them, one serves as a control or standard sample. One of the other coded samples is a duplicate of the control sample. Panelists are then tasked with identifying the sample that is different from the control. Importantly, guessing is not allowed, and panelists are also required to judge the direction and degree of the perceived difference, if any. The Triangle Test is widely used to determine if there is a detectable difference between the control and the test samples.

B5. Hedonic Rating Test

This test measures the consumer acceptability for a series of products. The taster assesses each product in turn. These are scored on a range which has 5 or 9 point scale. It may be a text box system from 1 (**dislike very much**) to 5 **(like very much**) in 5 point scale or 1 (dislike extremely) to 9 **(like extremely)** in 9 point scale. Remarks about product acceptance, smell, taste and texture can be entered. Flavor, and texture can be provided in the form of comments. The results are analyzed to decide which sample is preferred



Name..... Date.....

Product.....

- Taste these samples and state how much you like and dislike each one
- Use the appropriate scale to show your attitude by checking that best describes your feeling about the sample

9 point Hedonic Scale		Code	Code	Code
9	Like extremely	.....	.....	.....
8	Like very much	.....	.....	.....
7	Like moderately	.....	.....	.....
6	Like Slightly	.....	.....	.....
5	Neither like nor Dislike	.....	.....	.....
4	Dislike Slightly	.....	.....	.....
3	Dislike Moderately	.....	.....	.....
2	Dislike very much	.....	.....	.....
1	Dislike extremely	.....	.....	.....

Reason..... Signature

B6. Numerical Scoring

Each panelist is presented with one or more samples, and they assess each sample based on a designated scale that corresponds to specific characteristics, providing a rating for each sample. Panelists undergo training to adhere to the sensory characteristics associated with agreed-upon quality descriptions and scoring criteria.

B7. Composite Scoring Test

This method is used to **grade products**. The method compares **quality attributes** by indicating which characteristic is at **fault in a poor product**. **flavor** is considered to be the most important and highest score is allotted to this attribute . It is better method for providing more information than any other numerical method.

C. **Sensitivity Test**

C1. Sensitivity Threshold Test

T This approach establishes the sensitivity limit by determining the absolute threshold through perceptual observations. Three widely employed methods for assessing sensory thresholds include: (a) Method of Limits, with subcategories of (I) Descending sequence

(stepwise decrease in concentration) and (II) Ascending sequence (gradual increase in stimulus intensity from subthreshold to easily detectable), (b) Method of Constant Stimuli, and (c) Adaptive Method.

C2. The Dilution Test

These tests aim to determine the minimum quantity of an unfamiliar substance created as a replacement for a standard product. The quality of the test material is denoted by its dilution number, with a higher dilution number indicating better quality for the test material.

Table 1: No of panel members and samples required for sensory test

Sl.No.	Method	Panellists		No. of sample tests
		Type	Number	
5.	Hedonic	Semi-Trained	10-25	5-10
6.	Numerical scoring	Un- Trained Trained	72-80 5-12	1-4 1-6 5-10
7.	Composite	Trained	5-12	1-4
C.	Sensitivity			
1.	Threshold	Un- Trained	--	5-10
2.	Dilution	Trained	12-24	5-10
D	Descriptive			
	Flavour Profile	Trained	3-6	1-5
		Specially in the technique		

Sl.No.	Method	Panellists		No. of sample tests
		Type	Number	
A.	Difference			
1.	Paired Comparison	Trained Untrained	5-12 72-80	2
2.	Duo-Trio	Trained	5-12	3(2identical and 1 different)
3.	Triangle	Trained	5-12	3(2identical and 1 different)
B.	Rating			
1.	Ranking	Trained Semi-Trained Un-Trained	5-12 10-15 72-80	2-7
2	Single sample	Trained Un-Trained	6-25 72-80	1
3.	Two sample difference	Trained	6-25	4 pairs of Unknown and control sample

D. Descriptive Analysis

Descriptive analysis focuses on offering a detailed portrayal of the sensory characteristics of food. It serves various purposes, including long-term studies in Research and Development,

new product development, setting specifications for Quality Assurance (Q/A) and Quality Control (QC), defining product attributes according to consumer taste, monitoring sensory changes over time, studying long-term changes for shelf life and packaging, and conducting short-term intensity measurements for specific attributes. Descriptive analysis encompasses different methods: **D1. Qualitative** (Flavor and texture profile); **D2. Quantitative**; **D3**. **Spectrum analysis; D4. Time-intensity descriptive analysis; D5**. **Free-choice profiling**.

D1. **Qualitative (Flavor and texture profile)**

Color: Hue, chroma, uniformity, depth

Surface Texture: Shine, smoothness/roughness, Size and shape, dimensions, geometry
Interactions among particles -Stickiness, agglomeration, loose particles

Nasal feelings: Cool, pungent

Aroma Characteristics –

(a) Fragrance : Vanilla, fruity, floral, skunk

(b)Flavor characteristics (food): Vanilla, fruity, floral, chocolate, skunky, rancid, etc.

Methodology: Utilizes panels of 4-6 trained panelists. Panelists sit around a table, evaluate one sample at a time, and record ratings. Panel then engages in a discussion to arrive at a consensus

Disadvantages of Consensus Method: (i) Risk of bias from dominant personalities (ii)Danger of lack of consistency and reproducibility

Taste sensations- salty, sweety, sour, bitter, umami(meatiness)

Texture profile-

Oral texture characteristics – The mechanical aspects, reflecting how products respond to stress, include parameters like hardness, viscosity, and deformation/fracturability. Geometrical characteristics involve considerations of size, shape, and particle orientation in products, determining features such as grittiness, flakiness, or graininess. Fat/moisture parameters assess the presence or release of fat, indicating qualities like oiliness, greasiness,

juiciness, or moisture. The determination of a texture profile follows a procedure similar to a flavor profile but incorporates a broader range of scaling techniques. Results can be obtained through either the consensus method or statistical analysis. Panel training requires an understanding of mechanical principles and experience with a diverse range of textural attributes.

Mechanical parameters (reaction of products to stress)-thickness, ease to spread, slipperiness, denseness, **Geometrical parameters(size, shape and orientation of particles)**-gritty, foamy, flaky

-**Fat/ moisture parameters (presence/release of fat, oil, water)**-greasy, oily, dry, wet

D2. Quantitative Descriptive Analysis- Panelists develop agreed terminology beforehand. Panelists evaluate products one at a time in separate booths. Panelists are discouraged from discussing results afterwards. Scoring is by marking on a line. The results are analyzed statistically. Can lead to inconsistency of results

Quantitative aspects of descriptive analysis- The quantitative aspect or intensity expresses the **degree to which a characteristic is present** and is expressed by assigning a value on a scale**.** The validity and the reliability of the analysis is dependent on the.

D3. Spectrum Descriptive Analysis- This characterization offers details on the perceived sensory attributes, including characters or notes, along with their corresponding levels or intensities. A comprehensive set of standard descriptors is available for evaluation. Scoring involves both selecting a descriptive term and marking a position on a line. Perceived intensities are documented with reference to absolute or universal scales, enabling the comparison of relative intensities among attributes within a product and across various products tested.

D4. Time-intensity analysis- Panelists assess the intensity of a specific attribute at intervals throughout a given timeframe, leading to the creation of a Time-Intensity Response Curve. This testing method proves valuable for measuring attributes that persist over extended periods, such as pungency and bitterness. Successful implementation necessitates a well-trained panel with expertise in evaluating sensory attributes over time.

D5. Free-choice Profiling- Panelists have the freedom to create their own terms for describing the sensory attributes of a set of samples, all belonging to the same category of products. Panelists design their individual scoresheets with the goal of identifying terms that seem to measure the same attribute. The training requirements for the panel are minimal in this approach.

References:

Fennema O.R. (1985). Food Chemistry. New York: Marcel Dekker, Inc.

Bender A.E. (1984). Health Problems in Food. Quality Control in the Food Industry (ed. S.M. Herschdoerfer). London, New York: Academic Press.

Codex Alimentarius CODEX STAN 1-1991 (1991). Codex General Standard for Labeling of Prepackaged Foods. Volume 1.

Codex Alimentarius. Council Directive 379 L 0112 (1978).

International Commission on Microbiological Specifications for Foods (1980). Microbial Ecology of Foods, Vols I. and II. London, New York: Academic Press.

International Trade Center, UNCTAD/GATT (1991). Quality Control for the Food Industry: An Introductory Handbook. Geneva.

Molnár, P.J. (1983). A Theoretical Model to Describe Food Quality. Journal of Food Quality 12, 1–11.

Molnár, P.J. (1984). The Design and Practical Use of an Overall Quality Index for Food Products. Acta Alimentaria 13, 215–218.

Mossel, D.A.A. *et al.* (1984). Microbiological Quality Control. Quality Control in the Food Industry (ed. S.M. Herschdoerfer). London, New York.

Chapter-8
Basic Concept of Food Preservation

Jagannath Ghosh

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: jagannathg@svu.ac.in

8.1.Introduction:

There are many different ways to prevent food from spoiling, due to the fact that food preservation simply means any of the methods used to prevent food from spoiling, which are used to preserve food.

Food preservation usually means inhibiting the growth of bacteria, fungus, or yeasts and postponing the oxidation of lipids that causes rancidity. Techniques that avoid visual degradation during the preparation of food, like the enzymatic browning response that happens in chopped apples, can also be used in food preservation (Potter and Hotchkiss, 1995).

Several novel preservation techniques are being developed to fulfill consumer demands for economical preservation as well as sensory and nutritional values, affordability, cost, safety, and environmental safety. Understanding the effects of each food preservation method in every aspect has become crucial (Prokopov and Tanchev, 2007).

8.2.Food

Food is mostly made up of proteins, carbs, and fats. It provides energy and is a necessary source of nutrition for an organism's growth, repair, and other vital biological processes (De, and Tulipa, 2019).

Figure 1: Food

Because food contains a wide variety of vital nutrients, it might become contaminated by different microbes. One way that contamination can happen is:

- Natural Contamination: This occurs when food products are naturally contaminated by bacteria. For example, when yeast ferments the carbohydrates in fruits, it might taint the fruit.
- Artificial Contamination: This type of contamination takes place during the handling or processing of food. An example is the introduction of faecal bacteria into food due to improper handling procedures (Tropea, 2022; Lorenzo *et al*., 2017).

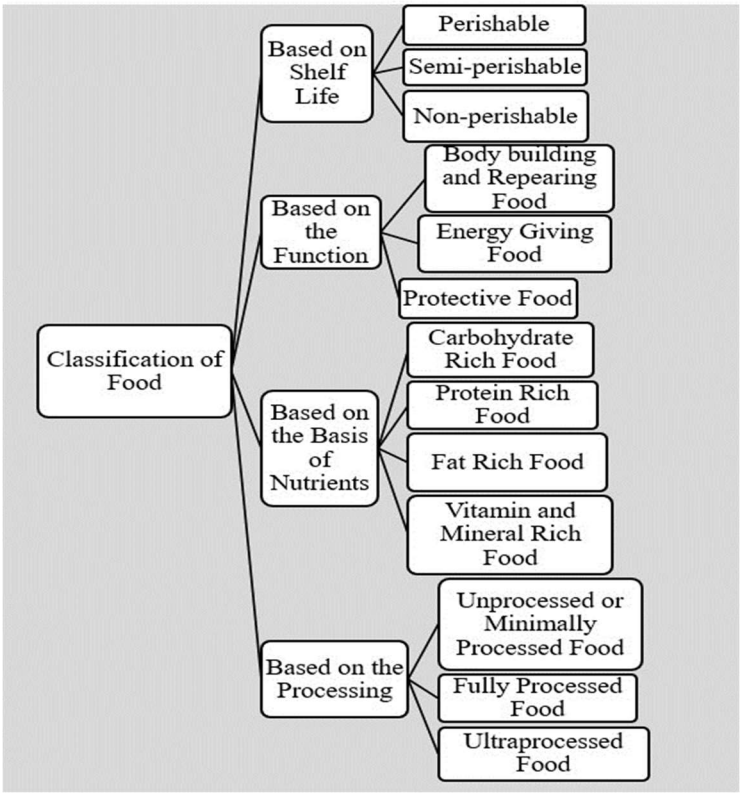


Figure 2: Classification of Food

Given the diverse array of essential nutrients in food, there is a susceptibility to contamination by various microorganisms. Contamination can occur through:

- Natural Contamination: This happens when microorganisms naturally adhere to food items. For instance, fruits may become contaminated with yeast as yeast ferments the carbohydrates present in them.
- Artificial Contamination: This type of contamination takes place during the handling or processing of food. An example is the introduction of faecal bacteria into food due to improper handling procedures (Tropea, 2022; Lorenzo et al, 2017).

8.2.1. Food spoilage

Food begins to deteriorate immediately after harvesting due to the following factors:

- Temperature
- Intrinsic enzyme
- Moisture
- Insects and vermin

The risk of spoilage is one of the main factors that lead to much of the food being processed to increase its availability. As soon as a food has been stabilized in terms of safety and quality, it is considered to be preserved (Desai, 2000).

Food undergoes various classes of changes that contribute to its deterioration, including:

- Enzymatic Processes: In animals, enzymatic processes like proteolysis occur within the flesh postmortem. However, in plants, different changes take place. For example, in harvested corn, sugars swiftly convert to starch.
- Chemical Reactions with the Environment: Common abiotic chemical reactions involve oxidation by air. An instance is lipid autoxidation, which produces rancid Odors.
- Microbiological Processes: Contamination of food by microbes leads to the production of a variety of chemical products.

Therefore, the term 'food spoilage' specifically refers to microbial changes that make a product unsuitable or unpleasant for consumption. Many different microorganisms thrive in most foodstuffs. As these microorganisms grow, they induce alterations in the appearance, flavour, Odor, and other qualities of the food (Steele, 2004).

The degradation process can manifest in various ways:

- Putrefaction: Protein-rich foods, when exposed to proteolytic microbes, undergo changes to amino acids, ammonia, amines, and hydrogen sulphide.
- Fermentation: Carbohydrate-rich foods, in the presence of carbohydrate-fermenting microbes, result in the production of acids, alcohol, and gases.
- Rancidity: Fatty foods, when affected by lipolytic microbes, lead to the formation of fatty acids and glycerol.

Different types of food spoil in distinctive ways, influenced by factors such as their nutrient content, environmental conditions, and microbial species.

8.3. Food preservation

Preservation of food is the practice of treating and managing food to halt or decelerate spoilage induced or hastened by microorganisms. Preservation commonly entails inhibiting the proliferation of bacteria, fungi, and other microorganisms, while also impeding the fat oxidation that can lead to rancidity (Lianou *et al.,* 2016; Sancho-Madriz, 2003).

8.3.1. Principles of food preservation

- **Prevention of Microbial Decomposition:**
  - Asepsis: Excluding microorganisms to maintain a sterile environment.
  - Removal of Microorganisms: Eliminating microorganisms from the food.
  - Inhibition of Microorganism Growth: Achieved through methods such as drying, anaerobic conditions, low temperatures, or the use of chemicals.
  - Microorganism Elimination: Destroying microorganisms, for example, through heat or radiation (Potter and Hotchkiss, 1999).
- **Prevention of Self-Decomposition of the Food:**

  Enzyme Control: Destroying or deactivating food enzymes, often accomplished through blanching. Chemical Reaction Prevention: Using antioxidants to prevent or delay chemical reactions leading to self-decomposition of the food.

8.3.2. Food Preservation Methods

Food preservation techniques can be divided based on their mode of action: (1) slowing down microbial growth and chemical deterioration, (2) directly inactivating bacteria, yeasts, molds, or enzymes, and (3) preventing recontamination before and after processing (Gould, 1989; Gould, 1995). Traditional preservation practices typically involve one or more of these approaches. However, recent efforts focus on enhancing food quality to meet consumer demands, avoiding over-reliance on a single technique.

The preservation process initiates when harvested foods are separated from their immediate growth medium, or when meat is obtained from slaughtered animals, or milk is collected from mammalian glands. The term "raw food" refers to foods that have not been processed except for cleaning and size grading if they are derived from plants. A postharvest technology preserves the original quality, freshness, and integrity of harvested foods during their handling, preservation, and storage.

Different preservation methods are used for different types of foods, especially those originating from plants or animals. Plant-based foods require effective packing, storage, and transport systems as well as controlled environmental factors like humidity and gas composition. precooling, temperature treatments, Chemical treatments involve fumigation, disinfection, and dipping (Salatin, 2013).

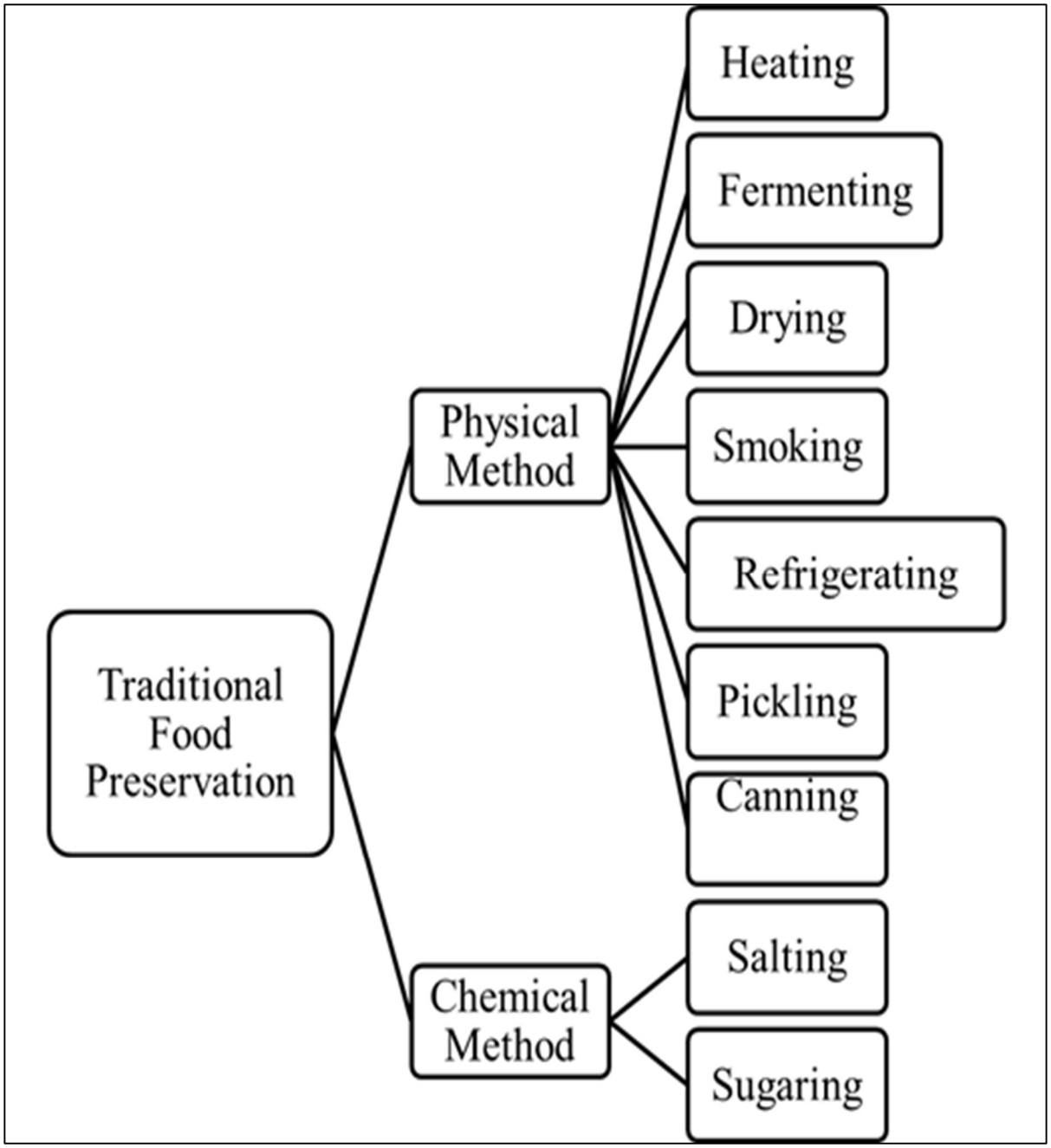


Figure 3: Traditional Food Preservation Methods

The preservation of food is achieved through the application of various methods, including physical, chemical, and/or biological approaches (Rahman & Velez-Ruiz, 2007).

These methods are as follows:

8.3.3. Traditional preservation methods

- ***Preservation by heat treatment***

Heat is the most often used method of food preservation. Pasteurization and sterilization are the terminology used to describe the various heating degrees of preservation that ultimately decide the type of finished product generated. To ensure the death of hazardous and non-pathogenic bacteria, however, strict temperature and timing controls must be applied for these methods to be successful. These same variables also lead to some destructions and the thermal inactivation of dietary enzymes (Heldman and Lund, 1992).

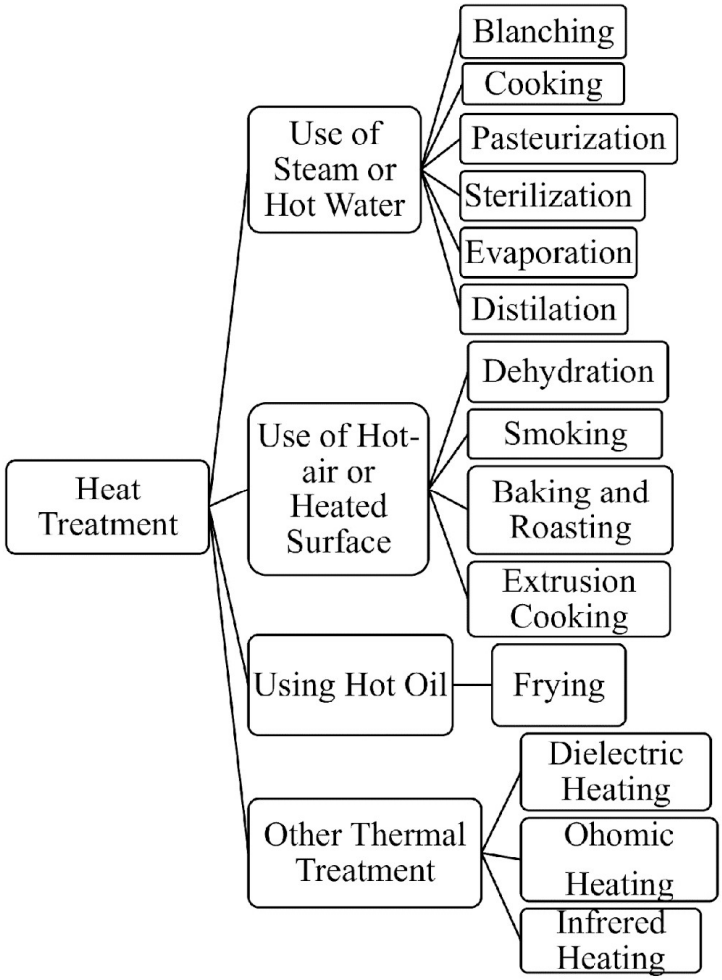


Figure 4: Various kinds of Heating Preservation Methods

- ***Fermenting***

The enzymatic breakdown of complex organic materials into simpler chemicals is known as fermentation, and it is aided by yeasts, molds and bacteria. This old procedure, which is similar to "pre-digestion," took place long before people were aware of it.

The variety of fermentation techniques varies according on the material being fermented. Some foods, such as raw dairy, spontaneously ferment because they contain a lot of live lactobacilli. On the other hand, because pasteurization destroys lactobacilli, pasteurized dairy requires the inclusion of a starting agent. There is enough lactobacilli in foods like cabbage for fermentation, but the procedure involves extracting the natural juices and adding salt to prevent the growth of undesirable bacteria.

Food fermentation is mostly dependent on the enzymatic activities of bacteria, yeasts, and/or molds. The end products offer rich flavours and act as natural preservatives, preserving food and its nutrients for an extended period of time. These products include alcohol, lactic acid, and acetic acid. This method of preservation was essential for keeping food fresh and nutrient-rich during lean periods before refrigeration.

Beyond preservation, foods that have undergone fermentation are more easily digested, provide more energy, and may even produce new nutrients—most notably B-vitamins. Additionally, by adding good bacteria or giving existing bacteria genetic information, fermented meals improve gut health. Though they might not have grasped the science, older societies were aware of the useful advantages of fermented foods, such as increased shelf life, improved flavour, and general health (Nummer, 2002).

- ***Drying***

One of the oldest and most reliable methods for preserving food is the extraction of moisture. The capacity to control fire goes back a million years for hominids and at least 400,000 years for Neanderthals. This ability allowed early humans to dry food more quickly.

People used the sun, wind, fire, and open air to naturally dehydrate food before food dehydrators were invented. Optimizing air exposure for even circulation, preserving homogeneous thickness, guaranteeing steady temperatures, and controlling humidity levels (lower humidity being generally preferred) were important factors to take into account. Salt was added to meat or fish to aid in flavour and preservation while also serving as a bug deterrent. These characteristics were less important when fire was used (Singh *et al.,* 2010).

Removing enough moisture creates a barrier to prevent the growth of bacteria. Microscopic contaminants become less likely to represent a hazard, even though neighbours or rats still might. It usually suffices to reach a water activity of 0.76 or less. Dried beef might provide a person with long-lasting nourishment for extended periods of time when combined with rendered fat and maybe some fruit (Verma *et al*., 2010).

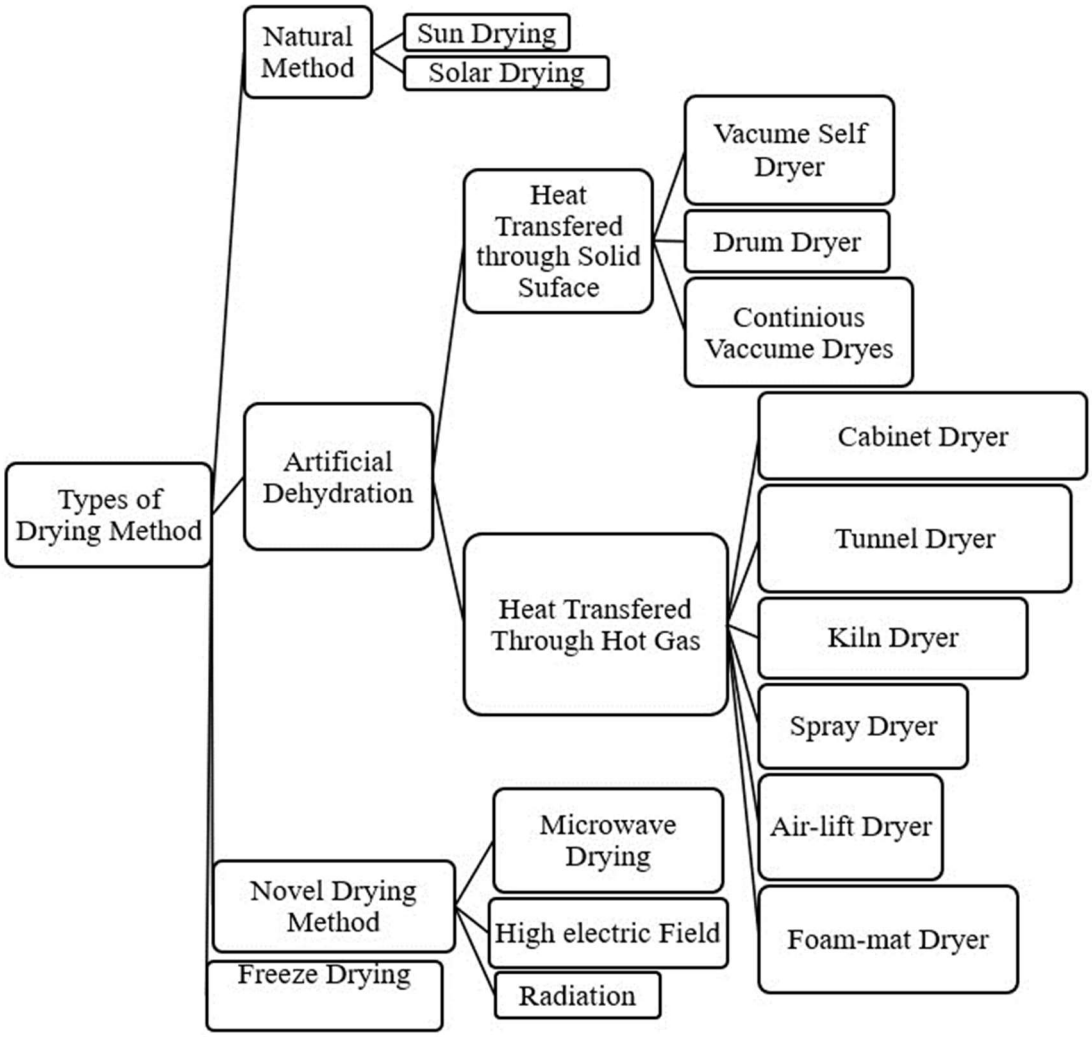


Figure 5: Drying Types

- ***Salt curing***

The simple but useful method of preserving meat or fish with a lot of salt was discovered in ancient times. This osmosis-based technique uses salt to extract water from microbial cells, killing microbes and preventing spoiling. The flesh simultaneously becomes less wet, which makes the surrounding conditions less conducive to bacterial colonization.

The only ingredients needed for the old preservation method were salt, time, and ideal storage conditions. Sugar helped lactobacilli develop, and since they feed on sugar, the meat

was further altered. Nitrates are widely used in modern curing to keep the preserved meat's pink colour.

This was a low-tech way to preserve priceless meat for long periods of time. In addition to keeping the meat fresh, the salt reaches the tissue and progressively desaturates the proteins. Glutamate is produced during this process, which intensifies the Savory flavour and concentrates the meaty flavour. The meat's preservability is enhanced and intriguing, complex flavours are produced by the gradual fermentation that lactobacilli induce. In a little amount of research, patients responded better to conventionally cured pastured pig than to fresh pastured pork, suggesting possible health benefits.

Figure 6: Salting

(Source: Arora and Kaur, 2022)

- ***Smoking***

Smoke is frequently present in areas where there is fire, and historically, smoking meat has been a regular practice. For example, the scent from an all-you-can-eat Korean BBQ restaurant clings to you and makes you smell like meat, which is great for dogs but could be troublesome for vegetarians. Although the idea that our Paleolithic predecessors smoked meat for preservation is unproven, it would seem to make sense.

Strips of fish and pork were simultaneously exposed to air and a lot of smoke in a traditional procedure used by Native Americans. Since the fire only produced smoke and not heat, this method fulfilled the twin purposes of smoking and dehydrating the food without really cooking it. On the other hand, "hot smoking" cooks and flavours the meat by utilizing both heat and smoke.

Smoking uses two different processes to preserve. Initially, it reduces moisture and inhibits bacterial colonization by drying out the meat or fish by direct heating or indirect heat, protecting the meal. Second, phenolic chemicals found in smoke bond to the surface of food and function as antioxidants. Owing to their antioxidant qualities, these phenolics aid in preventing rancidity and oxidation. According to one study, smoking, especially with alder wood, contains phenolic chemicals that have potential health benefits in addition to serving as preservatives. Nevertheless, the protection is only effective on the surface provided smoking doesn't completely dehydrate the flesh (Arora and Kaur, 2022).

- ***Refrigeration***

The process of refrigeration involves using labour to move heat from one place to another. Refrigeration is often powered by mechanical means, although it can also be powered by heat, electricity, magnetism, lasers, or other sources. Its many uses include air conditioning, cryogenics, industrial freezers, and refrigerators in homes. Similar to refrigeration devices, heat pumps can be made to be reversible and can utilize the process's heat output.

The addition of refrigerators to kitchens has completely changed the way that food is stored, making it possible to safely preserve meats and seafood for long periods of time and to have fresh salads available all year round. Perishable food should be stored at a temperature between 3 and 5 °C (37 and 41 °F).

A recent finding highlighted the necessity of refrigerating eggs during transportation rather than waiting until they reach at the grocery store, as dairy items need to be refrigerated constantly. Before being offered for sale to consumers, meats, poultry, and fish must be kept in climate-controlled conditions. Refrigeration contributes to the year-round availability and diversity of the modern diet by extending the edible life of fruits and vegetables while also guaranteeing their safety.

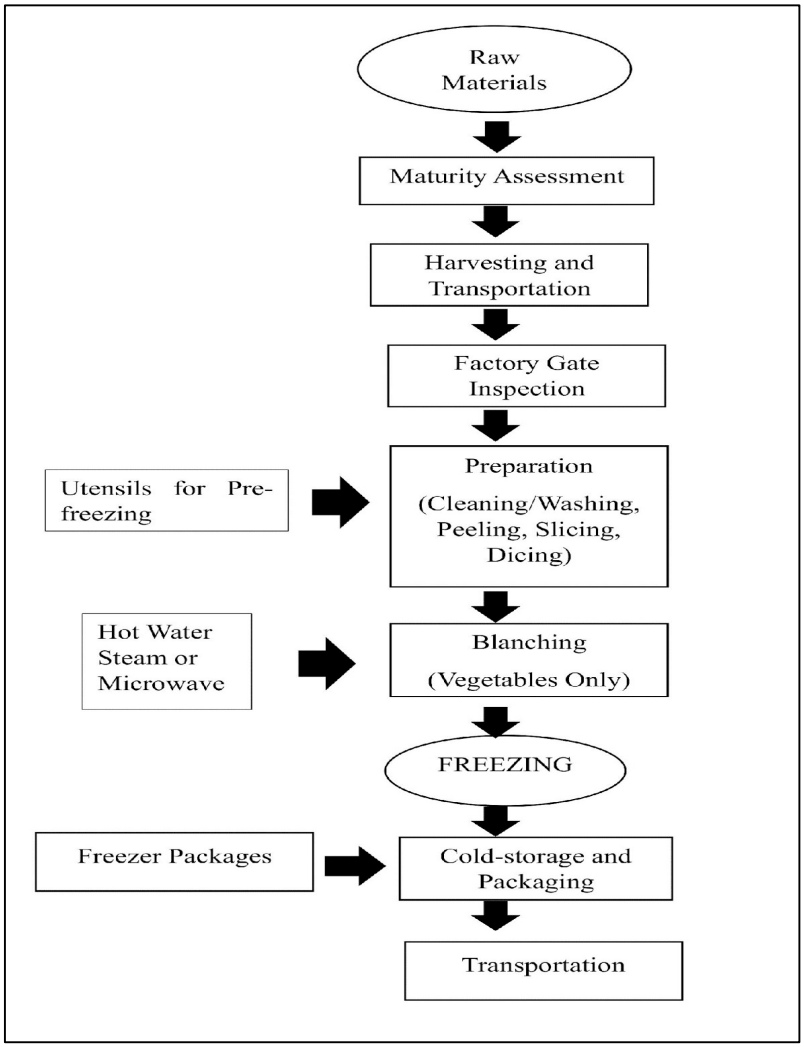


Figure 7: Preservation of Fruits and Vegetables by Freezing

- ***Sugaring***

Similar to pickling, sugaring is a method of food preservation that includes dehydrating food and then packing it with pure sugar to desiccate it. This sugar can be found as a high-density liquid like honey, syrup, or molasses, or it can be found as crystalline forms like table or raw sugar.

The main goal of sugaring is to create an environment that is unfriendly to microbiological life in order to stop food from spoiling. Sugaring is frequently used to preserve fruits and vegetables, like ginger, but it can also be used for non-food preservation. Honey, for example, was used in several ancient Egyptian mummification practices.

But one significant concern associated with sugaring is the sugar's propensity to draw moisture. When the environment's native yeast reaches a certain moisture content, it can activate and start the fermentation of carbohydrates into carbon dioxide and alcohol. While controlled fermentation can be a purposeful food preservation technique, uncontrolled fermentation can have unfavourable effects (Nummer, 2002).

Figure 8: Sugaring

Source: https://food52.com/recipes/6064-sugar-preserved-citruses

- ***Pickling***

The culinary product known as a pickle is produced using the preservation technique of pickling, which involves anaerobic fermentation in vinegar or brine. This process gives the preserved food a unique and intriguing flavor. In East Asia, the pickling medium is vinaigrette, which is a blend of vinegar and vegetable oil.

A pH of 4.6 or below, which successfully kills most bacteria and prolongs the shelf life of perishable foods, is a distinguishing feature of pickled foods. Antimicrobial herbs and spices including cloves, cinnamon, mustard seed, and garlic are frequently added to improve preservation. All you need to do to make a pickling brine is add dry salt if the item has enough moisture. For instance, to make Korean kimchi and German sauerkraut, vegetables are slated to remove excess water. The required acidity is produced via lactic acid bacteria-assisted natural fermentation at room temperature. As an alternative, some pickles require submerging veggies straight in vinegar.

Pickling, which involves fermentation, does not necessitate that the food be entirely sterile prior to sealing, in contrast to canning. The final pickled product's flavor and features are influenced by a number of factors, including the concentration of particular microorganisms, the solution's acidity or salinity, the temperature during fermentation, and the absence of oxygen.

Temperature and salt content both affect the dominating bacteria species throughout the pickling process. *Leuconostoc mesenteroides* thrives in low salt concentration and temperature environments, generating a blend of acids, alcohol, and fragrance chemicals. Rising temperatures lead to the dominance of Lactobacillus plantarum, which mainly produces lactic acid. When the acidity rises, Lactobacillus replaces *Leuconostoc* in many pickles.

Fermented in brine, traditional crafted pickles are a good source of beneficial probiotic microorganisms. Beneficial microbes proliferate as a result of the spontaneous fermentation process. But because the vinegar-based approach does not entail the same natural fermentation as conventional brine pickling, pickles made with vinegar lack this probiotic property (Sharif et al*.,* 2017).

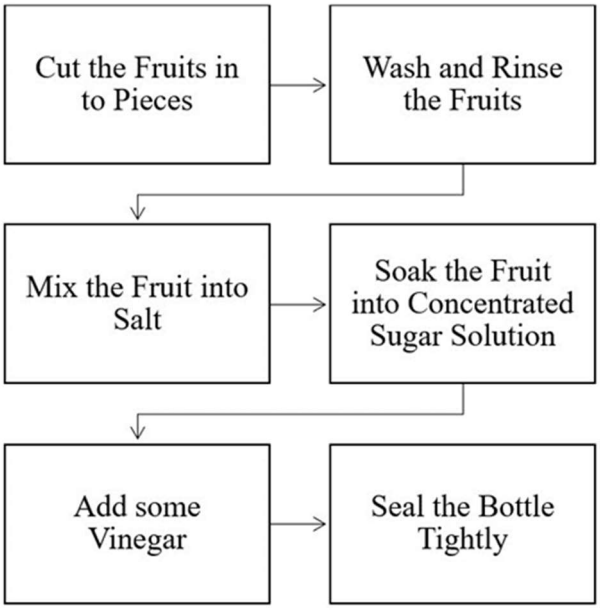


Figure 9: Pickling Process

- ***Canning***

Canning treats food contents by processing them and sealing them in an airtight container, giving them a shelf life of up to five years, with a longer shelf life under certain circumstances. Products that have been freeze-dried, such as dry lentils in a can, can stay edible for up to 30 years.

By acting as a barrier, the airtight container stops bacteria from penetrating and growing within. vacuum treatment, very sugary solutions), and other microbially-challenging conditions are some of the techniques used to prevent spoilage during and after containment.

While there is no 100% failsafe preservation technique, sterilization is the most dependable. But other microbes, like the botulism-causing Clostridium botulinum, are only destroyed at temperatures higher than boiling. Foods with low acidity (p^H greater than 4.6) must be sterilized

at high temperatures (116–130 °C) for the public's safety. This can be done with a pressure canner. For most vegetables, meat, fish, poultry, and dairy goods, pressure canning is necessary. A standard boiling water bath can be used to safely can foods with high acidity (p^H less than 4.6), such as fruits, pickled vegetables, or foods with additional acidic components (Nummer, 2002).

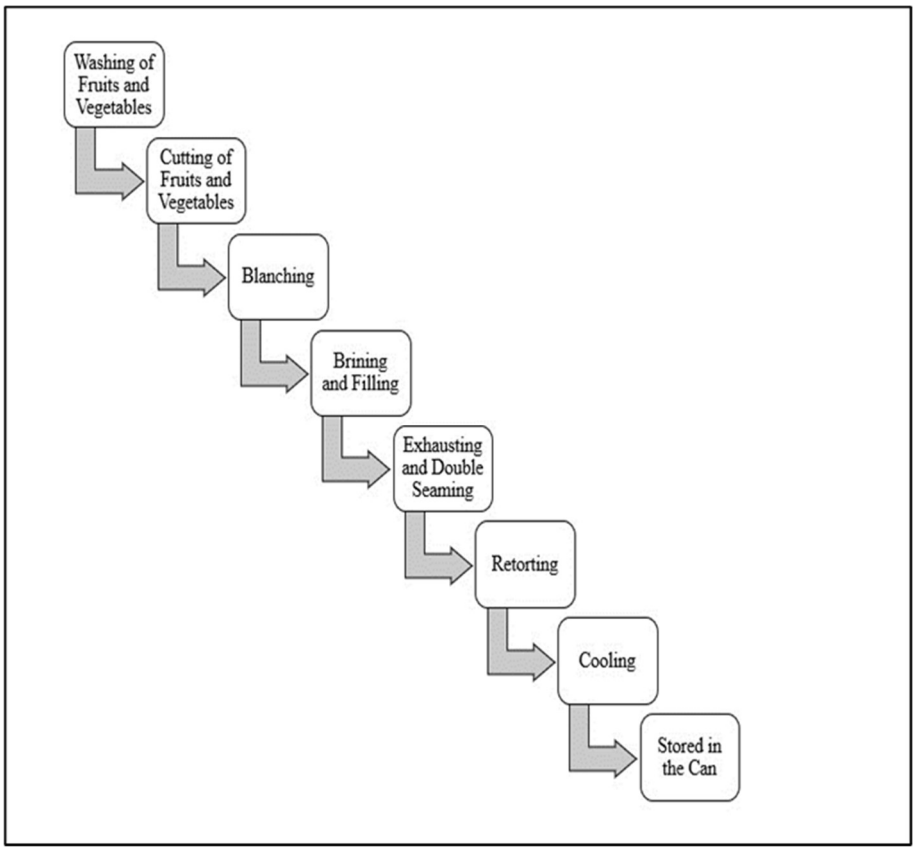


Figure 10: Canning Process

8.3.4. Benefits of Food Preservation

Food preservation prolongs the shelf life of products, lowers food waste, and improves food safety, among other benefits. Food preservation can help us import less food, boosting regional farmers and strengthening our country's resilience.

Food preservation has many benefits, such as:

REDUCING FOOD WASTE: Food preservation increases shelf life, minimizes environmental effect, and lessens the need to throw out ruined food.

EXTENDING THE LOCAL PRODUCE'S SHELF LIFE: Methods of preservation including canning, drying, and freezing extend the shelf life of fresh products.

INCREASING FOOD SAFETY: By lowering the possibility of pathogen contamination, preservation methods like canning and pickling can ensure safer consumption.

ENHANCING FLAVORS: Pickles and spicy sauces are examples of the unique and specialized products that can be produced using specific preservation methods like pickling or fermentation.

SUPPORTING LOCAL ECONOMIES: Food preservation boosts the local economy by encouraging the use of in-season, fresh ingredients and lowering the demand for imported food.

REDUCING PACKAGING WASTE: When compared to imported, processed foods, preservation techniques typically require less packing, which lowers costs and has positive environmental effects.

INCREASING RESILIENCY: Communities can become less dependent on imported food and more self-sufficient by preserving food, which increases their resilience to interruptions in the food supply chain.

Food preservation is not without its difficulties and drawbacks, though, including the possibility of losing some of its nutritional and sensory value, the possibility of chemical and physical risks, and the time-consuming nature of some preservation techniques.

Notwithstanding these difficulties, food preservation is still a crucial procedure for guaranteeing food safety, cutting waste, and encouraging environmentally friendly eating habits (Loaharanu & Ahmed, 1991).

8.3.5. Challenges of food preservation

Food preservation has many advantages, but it also has drawbacks that may compromise its efficacy, acceptability, and safety. The possibility of chemical and physical hazards that might arise during preservation, such as the use of excessive amounts of sugar, salt, or preservatives, or exposure to high radiation or heat levels, is one of the key concerns. These risks can damage the food's safety and nutritional content. In order to reduce the potential of risks, it is crucial to employ safe and appropriate preservation techniques and ingredients as well as to adhere to excellent manufacturing and hygiene procedures.

A further obstacle is the possibility of losing the food's nutritional value and sensory appeal during preservation, particularly when using techniques like canning or radiation that require high heat or lengthy storage times. Changes in the food's colour, texture, flavour, and nutrient content may arise from this, thereby impacting its acceptability and potential health advantages. In order to reduce quality loss and improve the food's nutritional content and

sensory qualities, it is crucial to optimize the preservation techniques and environments (Kourkoutas & Proestos, 2020).

References:

Desai, B. B. (2000). *Handbook of nutrition and diet*. Marcel Dekker, Inc.

Prokopov, T., & Tanchev, S. (2007). Methods of food preservation. *Kristbergsson University of Icelanddepartment food sciencefaculty of ScienceHjarðarhaga* 2, *6107*. Reykjavík, Iceland.

Potter, N. N., & Hotchkiss, J. H. (1995). *Food science*. Chapman & Hall.

Heldman, D. R., & Lund, D. B. (1992). *Handbook of food engineering*. Marcel Dekker.

Food definition and meaning | Collins English dictionary. *Archived from the original on 1 May 2021*. http://www.collinsdictionary.com. Retrieved August 21, 2021.

Sharif, Z. I. M., Mustapha, F. A., Jai, J., Mohd Yusof, N. M., & Zaki, N. A. M. (2017). Review on methods for preservation and natural preservatives for extending the food longevity. *Chemical Engineering Research Bulletin*, *19*, 145–153. https://doi.org/10.3329/cerb.v19i0.33809

Nummer, B. A. (2002). *Historical origins of food preservation*. National Centre for Home Food Preservation.

Salatin, J. (2013). *Fields of farmers: Interning, mentoring, partnering, germinating*. Chelesea Green Publishing.

Steele, R. (2002). "Historical Origins of Food Preservation. *Understanding and measuring the shelf-life of food* (1st ed). http://nchfp.uga.edu/publications/nchfp/factsheets/food_pres_hist.html. Retrieved May 5, 2014. Woodhead Publishing Limited; 2004(B).

Gould, G. W. (1989) [Introduction]. In G. W. Gould (Ed.). *Mechanisms of action of food preservation procedures* (pp. 1–10). Elsevier Applied Science.

Gould, G. W. (1995). Overview. In G. W. Gould (Ed.), *New methods of food preservation*. Blackie Academic & Professional.

Tropea, A. (2022). Microbial contamination and public health: An overview. *International Journal of Environmental Research and Public Health*, *19*(12), 7441. https://doi.org/10.3390/ijerph19127441

Lorenzo, J. M., Munekata, P. E., Dominguez, R., Pateiro, M., Saraiva, J. A., & Franco, D. (2018). Main groups of microorganisms of relevance for food safety and stability. *Innovative Technologies for Food Preservation*, 53–107.

Loaharanu, P., & Ahmed, M. (1991). Advantages and disadvantages of the use of irradiation for food preservation. *Journal of Agricultural and Environmental Ethics*, *4*(1), 14–30. https://doi.org/10.1007/BF02229144

Kourkoutas, Y., & Proestos, C. (2020). Food preservation: Challenges and efforts for the future. *Foods*, *9*(4), 391. https://doi.org/10.3390/foods9040391

De, L. C., & De, T. (2019). Healthy food for healthy life. *Journal of Global Biosciences*, *8*(9), 6453–6468.

Sancho-Madriz, M. F. (2003). Preservation of food. In B. Caballero (Ed.), *Encyclopedia of Food Science and Nutrition* (2nd ed). Elsevier Science Ltd. Publisher.

Lianou, A., Panagou, E. Z., & Nychas, G. J. E. (2016). Microbiological spoilage of foods and beverages. In P. Subramanian (Ed.), *The stability and shelf life of food* (2nd ed) (pp. 3–42). Woodhead Publishing.

Rahman, M. S., & Velez-Ruiz, J. F. (2007). Food preservation by freezing. In *Handbook of food preservation* (pp. 653–684). CRC Press.

Potter, N. N., & Hotchkiss, J. H. (1999). *Food science* (5th ed). Springer.

Singh, B., Gupta, V., Bansal, P., Singh, R., & Kumar, D. (2010). Pharmacological potential of plant used as aphrodisiacs. *International Journal of Pharmaceutical Sciences Review and Research*.

Verma, K. G., Kaushik, B. K., & Singh, R. (2010). Propagation delay variation due to process induced threshold voltage variation. In *Communications in Computer and Information Science*, 520–524. https://doi.org/10.1007/978-3-642-15766-0_87

Chapter-9

Food Service Management

Shreyasi Das

Assistant Professor, Department of Food and Nutrition
Swami Vivekananda University, Barrackpore, W.B., India.
e-mail: shreyasid@svu.ac.in

9.1. Introduction:

The segment of the economy that provides meals outside of homes is referred to as "food service."The Australian Bureau of Statistics (2009). The industry is very diverse; generally speaking, it includes lodging, dining establishments, hotels, pubs, and health care facilities. (Department of Food, Agriculture, and Rural Affairs, 2007)

Meals are getting consumed outside of homes more and more frequently across the globe.This trend can be linked to people seeking pleasure (at restaurants, for example) or being forced to go places they might not otherwise desire to go (in hospitals, for example). Similar distinctions can be made between "functional meal provision," which provides meals within the framework of work regulations, and "domestic meal provision," which provides meals primarily to satisfy personal needs, preferences, and comforts (Williams, 2009).

In addition to hospitals, this latter group includes a wide variety of food services that fall under the concept of institutional settings. These services include the following:

- Prisons oOther healthcare settings, such as nursing homes
- Educators and nursery facilities
- Military environments (combat rations and canteens)
- Meals delivered to homes
- Canteens at work (Williams, 2009).

The unique living conditions in institutions have a big impact on the meal experience. In fact, some experiences—where food is served but social and psychological settings of eating are absent—may not even qualify as "meals" (de Raeve, 1994). However, there are two distinct objectives that all of these settings share with other meal service settings:

(a) satisfying customer needs and expectations (e.g., protection, taste, price, and service); and (b) offering physical survival (e.g., feelings of fullness and nourishment) (Williams, 2009).

9.1.1Definition:

The distribution of food and beverages for people where this intake constitutes the bulk of their regular needs, or where people are at risk and/or have particular requirements, is referred to as foodservice. Dietitians' responsibilities will differ based on the product or service delivery model, consumer expectations, and applicable laws (Dall'Oglio et al. 2015).

One of the oldest medical texts, called Hwang Ti Nei-chang Su Wen (The Yellow Emperor's Classic of Internal Medicine, 722–721 BC), discusses the value of hospital food services and the use of food as medicine. In 1859, Florence Nightingale expressed concern about the potential impact of food on patients' recuperation when she stated in her Says on Nursing that "the essential office of the nurses, after she has taken responsibility for people's air, is to take care of studying the outcomes of his food." With numerous interconnected aspects influencing the entire process, hospital food service is frequently regarded as the most complex procedure in the hospitality industry. It might present particularly complex features. Hospital ward layouts, which frequently place them far from the kitchen, increase the logistical burden and, as a result, increase the likelihood of delays in the processes of production, service, delivery, and consuming. Every hospital foodservice manager faces a dilemma when it comes to the potential detrimental impacts of this stretched out never-ending, and staggered food cycle on food safety and quality. Williams (2009)

In the latter part of the 20th century, food service systems began to shift from nursing staff serving meals from mass delivery carts in the ward areas to centralised meal plating and individual tray distribution by foodservice personnel. There has been a recent reversal of this tendency, with multiple studies attempting to bring back bulk food carts, especially in assisted living facilities. Although there may be less waste and more patient satisfaction with these systems, it is unknown how they impact dietary intake (Williams, 2009).

Meal experiences in institutions are significantly impacted by living arrangements (Sydner and Fjellström, 2005). Indeed, it has been claimed that some experiences, such as Meals on Wheels, are better characterised as situations in which food is delivered but the societal and psychological context of eating is not present (de Raeve, 1994). However, the two main goals that all meal service settings have in common are (1) meeting customer expectations and requests (like safety, flavour, cost, and service) and (2) providing physical sustenance (like satiation and nourishment). Nonetheless, the aims and objectives of the meal service in

institutional settings may also be influenced by three other important functions that come under the 3 "M's": morale, manners, or medicine.

9.1.2. Morale-centred meals

In morale-centered meal services, it is extremely vital to plan a food service to prevent boredom, provide familiar and maybe calming meals to those in otherwise destitute circumstances, or demonstrate that the organisation truly cares about the well-being of the clients. This type of service includes the provision of food to military personnel working in combat zones and certain workplace canteens, particularly in remote or isolated locations (such as remote coal mining shelters or offshore oil platforms) if the food selections available at work are the only or very few options available. Prisons also use some of the components of morale-based programmes. Being able to cook some home-cooked, culturally-specific food is greatly valued, and meals become crucial social events in jail as a way to flee from the monotony of daily life (Godderis, 2006a). Dissatisfaction in prisons can often be centred around complaints regarding the cuisine. Because meals are periods when prisoners can gather and socialise, most prison riots start around meal times in canteens (Valentine and Longstaff, 1998). Ensuring that minimal standards of service quality are met is crucial to preserving a peaceful atmosphere.

9.1.3.Manners-centred meals

One of the stated purposes of mealtimes in a manners-centered meal service is to make sure that proper behaviour is reinforced and taught, and that improper behaviour is addressed. In child care and school settings, for example, one of the stated objectives of the meal occasions may be to provide children with the opportunity to sample a variety of foods, to learn and observe acceptable social skills, and even to acquire some culinary preparation and serving skills. Similar to schools, prisons frequently employ their convicts to prepare and serve meals. Mealtime exchanges can also serve as a basis for socialisation and rehabilitation programmes. On the other hand, it is possible to see prisoners' not having control over their meals as a means of reiterating their identities and lack of authority within the prison (Godderis, 2006b). Women's prisons especially have occasionally complained that if they are not participating in food service, they may lose confidence and critical home management skills (Smith, 2002). However, worries about cost containment and security can severely restrict the menu, preparation of food, and meal delivery options in correctional facilities (Stein, 2000; Gater, 2003).The standards of appropriate behaviour during meal times can be taught even in healthcare environments. It has been observed that senior care recipients make an effort to act

during meals in a way that they believe is appropriate for an institution. To enable them to eat freely and with dignity, Patients may be given adapted equipment if their impairments or disabilities prevent them from handling regular plates and silverware (Sidenvall, 1999).

9.1.4.Medicine-centred meals

This type of meal is provided by hospitals, retirement homes, including home-delivered feeding programmes like Meal on Wheels. From Hippocrates in the 4th century BC to Florence Nightingale's work during the nineteenth, feeding sick people adequate food has been recognised as an essential part of their care. In hospitals, feeding patients is more than just a hotel perk (like household duties and laundry); it's a vital part of the healthcare that they receive, therefore it's important to strive for excellent meals that meet each patient's specific nutritional needs (Allison, 1999). If one views food as medicine, then eating may become more uncomfortable when one makes the necessary dietary adjustments (puréed or liquid foods, low-sodium or low-protein meals, etc.). It is recognised that in some circumstances, the necessity of medical attention must come before gastronomic expectations.

Meals at institutions differ significantly from those at commercial foodservices in a number of important ways. The parts that follow go over a few of the more significant ones.

	Institutional	**Commercial**
Meals served	All meals provided to clients each day	Commonly just one meal a day for a customer
Meals scheduled	Restricted or unchanging boundaries	Adaptable and more extensive variety
Where to eat meal	Maybe in a private room or on a bed.	Usually at the cafeteria or dining area
Type of menu	Usually, cycle menus are utilised	The daily menu or À la carte

Menu selection	Occasionally, just a few options during a meal	The importance of giving customers options
System of foodservice	Convenience or cook-chill systems are more common.	Typically, Prepare food freshly.
Workers in manufacturing	Possibly lacking in professional experience	Typically, professionally qualified
Spending Plan	maybe restricted by owners	Only constrained by the readiness of the client to pay
Customers	A significant percentage might require special diets.	Average population
Laws or other external guidelines	Strict regulations, particularly with regards to nutrition standards	Standards for food safety are the only ones that matter.
Cash	Meals included in a service or employment package	Meals paid for by the client when they are consumed
Sufficient amount of food waste	Elevated	Minimal

9.2.Meals served in institutions

There are several methods in which meals can be provided to customers or clients in an institutional setting.

9.2.1.Cafeteria-style service

Commercial cafeterias, many military-based colleges and some educational institutions, nursing homes, and jails usually serve meals in a traditional cafeteria style (either

with serving staff or self-service options). This enables patrons to select their meals immediately before ingestion. The benefits of this approach include the ability to present the final menu options for the consumer to study and evaluate, as well as the ability to accommodate specific customer requests about the amount and combination of meal elements (e.g., adding or removing sauces).

9.2.2. Commercial meals served in institutions

Every meal served to clients every day often just one meal each day for a customer Meals scheduled Restricted or unchanging boundaries adaptable and more extensive variety Dinner may be served in a secluded room or on the bed.

Usually at the cafeteria or dining area Type of menu À la cart or regular menus are typically utilised in cycle menus.

Sometimes the menu is limited, with a focus on offering consumers options for each meal. Food service system Cook-chill or practicality? Generally speaking, cook-fresh systems are more common.

Workers in production might not have much professional Typically, professional training Owners may set a budget limit. Only constrained by the readiness of the client to pay Customers .

A large percentage might have typical population's unique nutritional requirements Governed by law or another extremely regulated, particularly Only requirements for food safety external benchmarksNutritional parameters that need to be taken into consideration Meals provided as part of a service package or as payment meals that the client pays for while they are employed Permissible level of food waste: High Low There may be offers of assistance with eating. Not available to keep food at the proper temperature between serving and eating. Since written menus aren't given out before to mealtime, it makes it simple to make last-minute menu adjustments.

This type of service's primary drawback is that the options will always be restricted to what can be shown within the service region that is available. Additionally, food is typically not prepared to order, and if hot foods are kept warm for extended periods of time prior to service, the quality of the cuisine may suffer.

9.2.3.Meal trays that were delivered

Meals are often brought to patients' beds or adjacent eating areas on individual trays in medical facilities.

Meals can be provided from a bulk food cart inside the ward, or they can be served from a central kitchen area where plated meal trolleys are brought to the patient rooms.

Patients who are unable to move around or who must be kept apart from other patients for medical reasons are best suited for this arrangement.

The ability to offer a far wider variety of menu options is one of the main benefits of the centralised plating system, especially when a cook-chill as well as cook-freeze menu system is used.

A fixed à la carte menus with many options (up to thirty entrée choices, for example) is utilised in certain healthcare facilities with this system, allowing patients to choose from a broad variety of meals that are appropriate for their present appetite and/or health.

Centralised meal delivery does have a number of drawbacks, despite the fact that it may offer a wider selection of menu items and possibly more meticulous oversight of the accuracy of the service—a crucial component of many special diets.

For the majority of tray delivery services, keeping the food at a safe and suitable temperature (both hot and cold) is the biggest issue. The ward area and a central service area within the kitchen are frequently separated by significant distances. In addition, there is a presumption that every patient will receive a certain meal within a time restriction that has been specified (usually an hour).

The issue of sustaining meal temperatures has been solved in three primary ways:

(1) Insulated dish covers or trays that maintain food temperature steadily without the need for active cooling. These methods might work perfectly for half an hour.

(2) Food delivery trolleys that are equipped with heating and cooling capabilities; the components for both hot and cold dishes are built individually on the tray right before serving.
(3) Reheating tray service and cold meal components in the ward areas.

Additionally, there are several methods for reheating food, including traditional convection ovens, infrared, and induction heating. Unlike cafeteria assistance, and whenever a meal tray is presented, all necessary items (napkins, condiments, cutlery and beverages) have

to be provided at the outset of service. Higher waste levels could result from this. For example, portions of salt, pepper, and sugar are often provided, even to customers who decline to use them.

Additionally, there are several methods for reheating food, including traditional convection ovens, infrared, and induction heating. Unlike cafeteria assistance, and whenever a meal tray is presented, all necessary items (napkins, condiments, cutlery and beverages) have to be provided at the outset of service. Higher waste levels could result from this. For example, portions of salt, pepper, and sugar are often provided, even to customers who decline to use them.

The requirement for consistent portion sizes and the amount of food on plates is the third disadvantage of pre-plated tray service techniques that use the cook-chill approach; for instance, baked potatoes may need to be chopped into smaller pieces to allow for additional reheating (Light and Walker, 1990). Options on the menu could also alter. To keep meats from drying out, they almost always need to be served with sauces or gravy on top. Wet entrées that reheated nicely are generally preferred over foods like barbecue meats or eggs, which have a greater tendency to dry up, when cook-chill system are used.

For these reasons, healthcare facilities using cook-fresh systems are said to be significantly more likely to offer alternatives for extra sauces and gravy with meat in addition to quantity sizes, when compared to cook-chill hospitals (McClelland and Williams, 2003). The last major drawback associated with the tray service approach is the physical difficulties patients have when attempting to consume food in bed, especially if they have limb or movement issues. It is acknowledged in a healthcare context that distributing and consuming food is an essential component of providing care and promoting healing. Nonetheless, issues have been brought up regarding the role's declining significance, particularly for nursing staff and the assignment of non-nursing duties to other employees.

"Tray meals—which are provided by food service personnel who come and goes—are quite different from the primarily social gatherings of meals in the past. They come in standardised portion sizes, reusable containers of butter including jam, and tight seals on milk capsules." Pearson (1994) on page 325. Patients may not be able to consume all of the food offered if they have difficulty reaching their trays or opening the little portion control packaging that are frequently used for things like beverages, milk, jams, and butter.

Two solutions have been tried to alleviate these problems and give patients more assistance when eating: (1) giving mobile patients the choice to eat in the dining area (Edwards and Hartwell, 2004); and (2) recruiting volunteers to assist patients at time of meal (Simmons et al., 2001; Walton et al., 2008).

9.3.Food rations

Whenever possible, military personnel receive group meals in a cafeteria-style setting. Nonetheless, plenty of research has been conducted to identify the factors that influence food acceptance (Meiselman and Schutz, 2003) as well as to create customised army ration packs, or battle rations, that can be used in situations where group consumption is impeded by operational or goal-related factors (Rock et al., 1998). Local food is usually prohibited from being used in field feeding procedures due to safety concerns (USARIEM, 2006).The rations consist of dried products, canned goods, and foil pouches that can be heated for single meals. These can be consumed either warm or cold, and speciality varieties are designed to meet the increased dietary requirements that arise from exposure to adverse conditions (such as extremely cold temperatures). They must serve meals that are comparable to what is prepared from home and be robust and portable in a range of environments. One particular problem with such meals is that the monotony of eating the same item all the time could lead to inadequate nutrient intakes over time (Hirsch et al., 2005).

The rations consist of dried products, canned goods, and foil pouches that can be heated for single meals. These can be consumed either warm or cold, and speciality varieties are designed to meet the increased dietary requirements that arise from exposure to adverse conditions (such as extremely cold temperatures). They must serve meals that are comparable to what is prepared from home and be robust and portable in a range of environments. One particular problem with such meals is that the monotony of eating the same item all the time could lead to inadequate nutrient intakes over time (Hirsch et al., 2005).

An Australian survey revealed that most hospitals fed their patients three midday meals a day: 98% offered teas in the morning, 99% offered teas in the late afternoon, 95% fed dinner, and 19% even offered a hot beverage prior to breakfasts in the early hours of the morning. Williams and Mibey (2002).

In addition to the typical fare served over these mid-meal intervals (caffeine, coffee or tea, dairy beverages, biscuits, cake), individuals who need more dietary supervision are frequently provided specially enriched nutritional supplements. Though hot versions (soups)

are also offered, these are mostly commercially packaged milk-based cold beverages that are meant to be drank from a pack using a straw. Although these nutrients can be taken on a regular basis during mealtimes, or during a medicine round, nurses may provide them in lesser prescribed quantities to encourage adherence to their use. Although these supplements can greatly enhance nutrient intakes, they are not usually considered meals, perhaps because they are not served by kitchen staff from foodservice.

In one trial, people who were considered nutritionally vulnerable were given a 120 mL sip supplied three times a day, which provided over 2200 kJ and 22 g protein. This led to significantly higher intakes of calories and weight growth (Potter et al., 2001).

9.4. Menus

Breakfast, lunch, and dinner are the three main meals of the day that are typically served in institutions that serve all of the clients' meals (such as boarding schools and hospitals), in addition to an assortment of mid-meal and snacking choices. The latter can be brought about the ward areas in a beverages and snack cart, or it can be served on trays.

While mid-meals are less frequently served in other institutions, communal dining facilities may have self-service items available. Nowadays, a growing number of hospitals solely provide a continental breakfast. Evidence suggests that patients may consume fewer nutrients when a hot meal is unavailable, therefore this tendency is still cause for concern (Coote and Williams, 1993). Some hospitals now offer up to five meals a day instead of the three main meals that was formerly the norm (Puckett, 2004).

Since all hot products can be prepared during one cook's working shift. The majority of institution's foodservices have cycle menus, which are weekly or longer-term sets of daily meals, or a la carte menus, which offer a range of alternatives but are daily fixed.

Cycle menus are widely used in prison, healthcare, and educational settings to offer variety and a certain level of regularity for buying things financial management, and production scheduling (Spears and Gregoire, 2007). One- or two-week cycles are common in acute hospitals, but three- to four-week cycles are more common in longer-term care facilities.

9.4.1. Techniques for meal timing

For institutions' financial and performance management, counting meals is a crucial point of control. Meals per full-time equivalent employee and expenses per meal are two common performance metrics that may call for an estimate of the amount of meals consumed.

Most healthcare facilities try to maintain a daily tally of the total amount of meals served to both patients as well as non-patients.

The most precise method is to figure out how many trays are actually being prepared for each meal, as recommended by Puckett (2004). This approach is labor-intensive and ignores other choices, such as giving vitamin or additional refreshments at every unit rather than on delivery trays.

In healthcare settings, when patients receive numerous supplemental nutrients in addition to their regular main meals, the term "meal equivalent" is frequently utilised. It has been proposed that a sufficient amount of meal equivalents can be obtained by dividing the total amount of nourishment by six (Spears, 2000). Another standard method is to construct four standard'meal unit equivalence' per occupied bed day, taking into account that each person receives three mid-meals (which altogether may be equivalent in cost with a single main meal) with three main meals (Institute of Hospital Catering, 1995).

Even though these counterparts don't always fit into the traditional idea of a meal, performance reports use them to assess efficiency changes over time and allow institutions to compare themselves to one another without having to go through the hassle of tediously recording meal counts. The number of non-patient meals that are delivered each day varies amongst institutions and is dependent on the kind of payment mechanism that is in place (e.g., a cash payment system as well, whether staff purchase every month meal coupons, or provided completely free of claims to certain groups).

In a cafeteria that accepts cash payments, a tray census method might be used, but it doesn't distinguish between customers who are buying a full meal and those who are just getting a drink or snack.One popular method for determining the everyday food equivalent is to divide the total of the regular cash sales by the average cost each meal (Sneed & Kresse, 1989). The price of the midday meal's access, vegetables, salad, and desert-like portions can be averaged to calculate the value of the standard meal. Alternatively, the amount of the regular meal can be found in employment awards, which set the price at which employees must be fed a standard meal.

9.5. Kitchen Layouts and Designs

Around World War I, modern designs began to emerge. They had geometric shapes, flat surfaces, and little to no embellishment. Modern kitchens can be broadly classified as more contemporary and less conventional. Every modern design has a distinct historical, stylistic,

and inspirational foundation. Contemporary kitchen designs consistently push the boundaries of creativity and societal norms.

The distinguishing features of the latest kitchen design are listed below (HGTV, 2020).

- Room and illumination.

- Contemporary Kitchen Doors.

- Contemporary Kitchen Designs.

- Benchtops and Cabinets for the Kitchen.

Effective kitchen design integrates surfaces, appliances, arrangement techniques, and design elements to create a cooking space that is enjoyable to use. It also involves figuring out the homeowners' own style and making the most of the space at hand and capabilities (Grundig, 2019).

9.5.1. Modern Kitchen Design Types

Whether the kitchen is vast and spacious or small and cramped, designing a kitchen layout correctly is thought to be the most significant component in guaranteeing a practical and useful kitchen area. A well-thought-out arrangement enables designers to maximise available space.

There's much more to designing than merely arranging furniture and cabinets, particularly in kitchen design. Some important considerations are: - Ergonomics: plays a major part in this.

Achieving the proper heights.

- Ensuring adequate room for ease of mobility.

- Location of appliances.

- Practicality.

The extent to which the user appreciates their kitchen is influenced by each of these factors. (Grundig, 2019)

9.5.1.1. The Kitchen Layouts

The engineer must consider even the tiniest elements to create a functional and aesthetically pleasing integrated kitchen. Selecting a particular kind of the kitchen is considered to be one of the most vital design steps. Kitchen design is highly important to work on.

The six most prevalent types of kitchens will be explained in this section. The categories include: - Single-wall kitchens (kitchens with one wall).

- The galley kitchenette.

- An L-shaped kitchen.

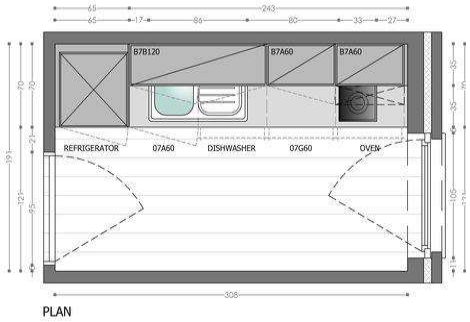
- A U-shaped kitchen.

- An island kitchen.

- A G-shaped kitchen, often known as a Peninsula kitchen.

9.5.1.1.1. The One Wall Kitchen, or the Kitchen with Just One Wall

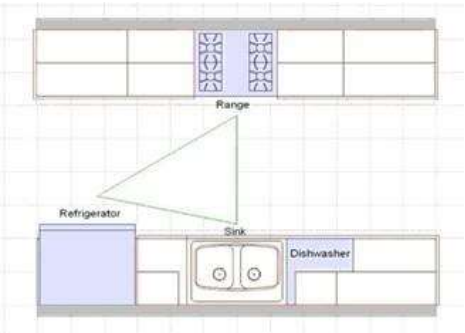
All of the counters, cupboards, and appliances in a kitchen are arranged along a single linear wall, which is referred to as a "single wall kitchen". A minimum of 2.4 metres is required for a one-wall kitchen (The Spruce, 2019).



Source: The kitchen layout with a single wall, (The Spruce, 2019).

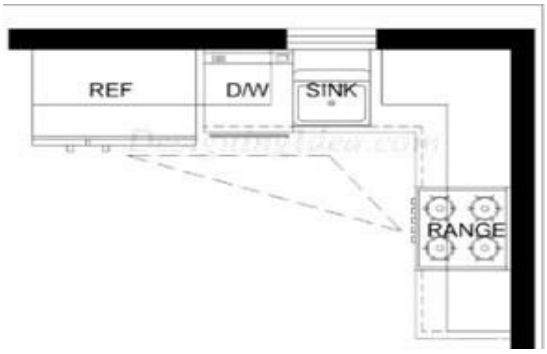
9.5.1.1.2. The galley kitchen

A long, narrow area with base cabinets, the counters, walls cabinets, and additional amenities arranged on one or the other side of the central aisle is the galley kitchen, as seen in Figure 15. The usual width and linear length of this structure are 1.2-1.8 m and 2.1-3.8 m, respectively (Build, 2020).



Source: The kitchen layout for the galley (Build, 2020)

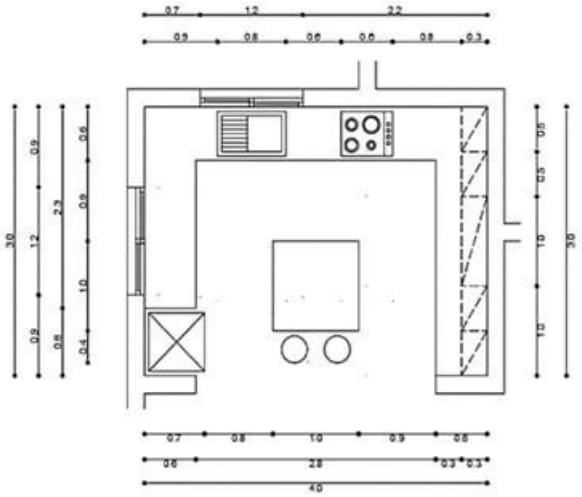
9.5.1.1.3. The L-shaped Kitchen is among the most useful kitchen layouts for a modern home. L-shaped kitchens offer a practical and efficient work environment because of their central open space and right-angled walls, which allow cabinets and equipment to be arranged. An L-plan arrangement might be easily accommodated in a 3 x 3 m the kitchen area, that is still the criterion for calculating the pricing of cabinetry and worktops (Kaboodle, 2020).



The kitchen layout in the L form, (Pinterest, 2020)

9.5.1.1.4. The U-shaped kitchen

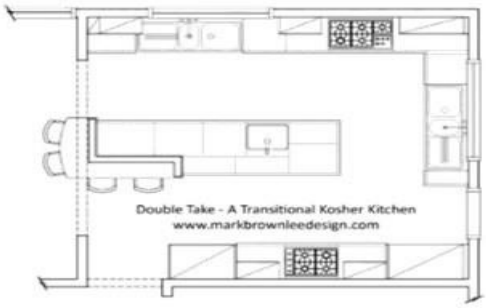
The U-shaped cabinets in the kitchen are set up on all three sides, having the top part of the 'U' kept open to fit an entrance or an opened-concept living room. It can be combined with eating areas like a kitchen island if the room's width allows. U-shape kitchens can have bespoke depths and width that range from 2.7 to 3.7 m, as per Home Designing (2020).



Source: *The island kitchen plan with standard dimensions, by using the AutoCAD program, (By author, 2020)*

9.5.1.1.5. The Island Kitchen

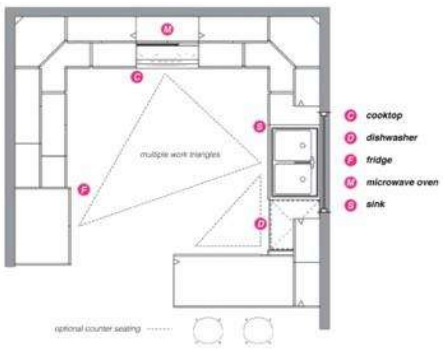
An island kitchen is an extra countertop area in a kitchen that is made possible by freestanding cabinetry. An extra dining area isn't quite as popular as raised stools. While island designs are not limited in size or shape, a stationary island must be at least 1 × 1 m in size, and the island Kitchen must be at least 3.6 m long and 2.4 m deep (The Free Dictionary, 2020).



Source: The Island kitchen plan, (HGTV,2020)

9.5.1.1.6. The G-shaped Kitchen or Peninsula Kitchen

The G-shaped kitchen, sometimes called the "peninsula" kitchen, is a structure with a workspace that is similar to an island except that instead of standing independently in the middle of your kitchen, one end of the unit is fixed to the wall. According to Wren Kitchens (2020), the G-shaped kitchens have an overall width of 3 to 4 metres and a depth of 3.7 to 4.6 metres.



Source: The G-shaped kitchen plan, (Pinterest, 2020)

9.6. Upcoming trends

In the latter half of the 20th century, patients' meal services in the ward areas—which involved nursing staff delivering food in bulk delivery trolleys—was replaced by central meal planning and individualised tray circulation by food service professionals.

This tendency has recently reversed, with numerous studies seeking to reinstate bulk food carts, particularly in senior care institutions. Although there may be less waste and more patient satisfaction with these kinds of systems, it is unknown how they impact the amount of nutrients that patients consume (Kelly, 1999; Shatenstein and Ferland, 2000; Wilson et al., 2001; Hickson et al., 2007).

A handful of centres are also testing alternatives to selective paper-based menus, such as bedside spoken meal orders. Following clinical interviews, foodservice employees enter the orders straight into hand-held electronic devices (Folio et al., 2002). This eliminates the requirement for manual meal order tallying and enables food selections considerably closer to mealtime.

A far more drastic (and costly) option would be to offer hotel-style meal service, where customers may place an order with a restaurant-style menu at any time of day, have their meals prepared as requested, and have them delivered in 45 minutes.

These kinds of systems are being put in place to increase patient satisfaction and offer a more client-centered service (Sheehan-Smith, 2006).

Long-term residents' dining experiences in hospital settings are receiving more consideration when it comes to the atmosphere of the meals. It has been demonstrated that

alterations to the physical environment—such as adding flowers to tables or playing background music—meal service procedures—such as taking trays and covers off dining tables and serving a single dish at a time—and nursing practices—such as having nurses sit at tables with patients and removing medications from meal times—all considerably improve the health and quality of life of their clients (Mathey et al., 2001).

There is a global tendency in school settings to place more limitations on the food that is available for consumption during meal times and in between meals.

In the UK (Golley and Clark, 2007) as well as Australia (New South Wales Department of Health, 2006), policies restricting the types of foods sold in canteens are being put into place. In the USA, studies are showing that restricting access to high-energy snack foods has positive effects on dietary outcomes (Cullen et al., 2000; Cullen et al., 2008).

Concurrently, there is a push to modernise school foodservices by introducing authentic ethnic food that acknowledges the population's diversity of cultures and healthier food options (Schuster, 2007).

From the perspective of menu planning, the increased accessibility of innovative functional foods in institutional settings may open up new possibilities for more effectively matching the foods served to clients with their unique nutritional requirements (Williams, 2005).

The addition of well-known brand menu items to institutional menus has been another trend. In a study on established stereotypes (Cardello et al., 1996), participants were asked about their expected acceptance of two identical portions of sweet corn; the non-branded sample was rated less for their anticipated and genuine acceptability. Product branding is frequently interpreted as a sign of quality.

In several US hospitals, branded menu items like Pizza Hut pizzas are now available. Finally, there is a growing customer desire in all foodservice settings for a closer look at the food's environmental impact and nutritional value (Euromonitor International, 2007; Sloan, 2007a).

Hospitals are now starting to offer organic menus, and environmental concerns could have long-term effects on the technologies used in meal preparation and delivery. The increased use of cook-chill foodservices, portioned packaged foods, and disposable trays (to cut down on dishwashing) in recent times has not been done with much consideration for the effects on energy use or the environment. These are aspects that are expected to become more

and more prominent, with demands for more energy efficiency, recycling, and the usage of food that is sourced more locally (Sloan, 2007b).

References:

Allison S (1999), *Hospital food as treatment*, Maidenhead, British Association for Parenteral and Enteral Nutrition.

Aquinas P G, 2009, Human Resource Management Pricniples and Practice, Vikas Publishing House Pvt ltd, New Delhi

Army', *Appetite*, **40**, 199–216United States Army Research Institute of Environmental Medicine (USARIEM) (2006). 'Military rations', Accessed 15 January 2008. Available at: http://www.usariem.army.mil/ nutri/milrat.htm

Build. (2020). Single wall kitchens. Retrieved November 20, 2020 from https://build.com.au/single-wall kitchens#:~:text=Also%20known%20as%20a%20'single,entirely%20along%20a%2single%20wal l.&text=A%20single%20wall%20kitchen%20layout,arm's%20reach%20at%20most%20times

Cardello A, Bell R and Kramer M (1996), 'Attitudes of consumers toward military and other institutional foods', *Food Qual Pref*, **7**, 7–20.

Center, Natick MA.Meiselman HL and Schutz HG (2003), 'History of food acceptance research in the US

Coote and Williams P (1993), 'The nutritional implications of introducing a continental breakfast in a public hospital: a pilot study', *Aust J Nutr Diet*, **50**, 99–103

Cullen K, Eagen J, Baranowski T, Owens E and de Moor C (2000), 'Effect of à la carte and snack bar foods at a school on children's lunchtime intake of fruits and vegetables', *J Am Diet Assoc*, **100**, 1482–1486.

Cullen K, Watson K and Zakeri I (2008), 'Improvements in middle school dietary intake after implementation of the Texas public school nutrition policy', *Am J Public Health*, **98**, 111–117.

Dall'Oglio, I., Nicolò, R., Di Ciommo, V., Bianchi, N., Ciliento, G., Gawronski, O., Pomponi, M., Roberti, M., Tiozzo, E., & Raponi, M. (2015). A Systematic Review of Hospital Foodservice Patient Satisfaction Studies. *Journal of the Academy of Nutrition and Dietetics*, *115*(4), 567–584. https://doi.org/10.1016/j.jand.2014.11.013

De Raeve, L. (1994). To feed or to nourish? Thoughts on the moral significance of meals in hospital. *Nursing Ethics*, *1*(4), 237–241. https://doi.org/10.1177/096973309400100408

Department for Environment, Food and Rural Affairs, UK Food Service and Eating (2007)

Edwards J and Hartwell H (2004), 'A comparison of energy intake between eating positions in a NHS hospital – a pilot study', *Appetite*, **43**, 323–325.

Euromonitor International (2007), 'Top ten food trends for 2007', Accessed 17 January2008.Availableat:http://www.euromonitor.com/Top_ten_food_trends_for_207.

Folio D, O'Sullivan-Maillett J and Touger-Decker R (2002), 'The spoken menu concept of patient food service delivery systems increases overall patient satisfaction, therapeutic and tray accuracy, and is cost neutral for food and labor', *J Am Diet Assoc*, **102**, 546– 548.

Gater L (2003), 'Costs and security are top issues in corrections foodservice today', *Corrections Forum*, **12**, 22–25.

Godderis R (2006b), 'Food for thought: an analysis of power and identity in prison food narratives', Berkeley J Sociol, 50, 61–75.

Golley R and Clark H (2007), 'The transformation of school food in England – the role and activities of the School Food Trust', *Nutr Bull*, **32**, 392–397.

Grundig. (2019). Top tips to get the kitchen layout you need. Retrieved November 20, 2020 from https://www.grundig.com/ktchnmag/blog/the-complete-guide-to-kitchen-layouts/

HGTV. (2020). Kitchen Island Plans. Retrieved November 20,2020 from https://www.hgtv.com/design/rooms/kitchens/kitchen-island-plans

HGTV. (2020). Modern Kitchen Design. Retrieved November 20, 2020 from https://www.hgtv.com/design/rooms/kitchens/modern-kitchen-design

Hickson M, Fearnley L, Thomas J and Evans S (2007), 'Does a new steam meal catering system meet patient requirements in hospital?' *J Hum Nutr Diet*, **20**, 476–485.

Hirsch ES, Kramer FM, Meiselman HL (2005), 'Effects of food attributes and feeding environment on acceptance, consumption and body weight: lessons learned in a twenty year program of military ration research US Army Research (Part 2)', *Appetite,* **44**, 33–45.

Home Designing. (2020). 50 Unique U-Shaped Kitchens and Tips You Can Use from Them. Retrieved November 20, 2020 fromhttp://www.homedesigning.com/u-shaped-kitchen-design-

ideasinspiration
tipsphotos#:~:text=The%20u%2Dshaped%20layout%20places,width%20of%20the%20room%20allows.
Institute of Hospital Catering (1995), *Meal unit methodology,* Sydney, Institute of Hospital Catering.
Jill Dyche, 2003, The CRM handbook, Pearson Publications, New Delhi
Kaboodle. (2020). Advantages of L-shaped kitchens. Retrieved November 20, 2020fromhttps://www.kaboodle.com.au/design-blog/advantages-of-l-shapedkitchens#:~:text=A%20common%20kitchen%20layout%20in,is%20the%20L%2Dshaped%20kitchen.&text=One%20of%20the%20most%20efficient,open%20area%20in%20the%20centre.
Kelly L (1999), 'Audit of food wastage: differences between a plated and bulk system of meal provision', *J Hum Nutr Diet*, **12**, 415–424.
Light N and Walker A (1990), *Cook-Chill Catering: Technology and Management*, London, Elsevier Applied Science.
Mathey M, Venneste V, de Graff C, de Groot L and Van Staveren W (2001), 'Health effect of improved meal ambience in a Dutch nursing home: a 1-year intervention study', *Prev Med*, **32**, 416–423.
McClelland A and Williams P (2003), 'Trend to better nutrition on Australian hospital menus 1986–2001 and the impact of cook–chill food service systems', *J Hum Nutr Diet*, **16**, 245–256.
Mibey R and Williams P (2002), 'Food services trends in New South Wales hospitals, 1993–2001', *Food Serv Technol*, **2**, 95–103.
Mihalache, O. A., Møretrø, T., Borda, D., Dumitrașcu, L., Neagu, C., Nguyen-Thé, C., Maître, I., Didier, P., Teixeira, P., Junqueira, L., Trüninger, M., Izsó, T., Kasza, G., Skuland, S. E., Langsrud, S., & Nicolau, A. I. (2022). Kitchen layouts and consumers' food hygiene practices: Ergonomics versus safety. *Food Control*, *131*, 108433. https://doi.org/10.1016/j.foodcont.2021.108433
New South Wales Department of Health (2006), *Fresh Tastes @ School. NSW Healthy School Canteen Strategy*, (2nd ed). Accessed 30 January 2008. Available at:https://www.det.nsw.edu.au/policies/student_serv/student_health/canteen_gu/CMPlanner.pdf.
Pearson A (1994), 'Eat, drink and be merry', *J Clin Nurs*, **3**, 325–326.
Pinterest. (2020). 37 L-Shaped Kitchen Designs & Layouts (Pictures). Retrieved November 20, 2020 from https://www.pinterest.com/pin/566468459374009456/
Pinterest. (2020). G shaped kitchen layout. Retrieved November 20, 2020 from https://www.pinterest.com/pin/839076974299582886/
Potter J, Roberts M, McColl J and Reilly J (2001), 'Protein energy supplements in unwell elderly patients: a randomised controlled trial', *JPEN*, **25**, 323–329
Pravin Durai, 2010, Human Resource Management, Pearson Publications, New Delhi
Puckett RP (2004), *Food service manual for health care institutions* (3rd ed), San Francisco CA, Jossey-Bass.
Rock KL, Lesher LL, Aylward J and Harrington MS (1998), 'Field acceptance and nutritional intake of the meal, ready-to-eat and heat and serve ration', *Technical Report Natick TR-98/022*, US Army Natick Research, Development and Engineering
Rodgers, S. (2011). Food service research: An integrated approach. *International Journal of Hospitality Management*, *30*(2), 477–483. https://doi.org/10.1016/j.ijhm.2010.05.002
Schuster K (2007), 'Making it Authentic, Making it Ethnic', *Food Manag* **42**(4), 42–52.
Shatenstein B and Ferland G (2000), 'Absence of nutritional or clinical consequences of decentralized bulk food portioning in elderly nursing home residents with dementia in Montreal', *J Am Diet Assoc*, **100**, 1354–1360.
Sheehan-Smith L (2006), 'Key facilitators and best practices of hotel-style room service in hospitals', *J Am Diet Assoc*, **106**, 581–586.
Sidenvall B (1999), 'Meal procedures in institutions for elderly people: a theoretical interpretation', *J Adv Nurs*, **30**, 319–328.
Simmons S, Osterweil D and Schnelle J (2001), 'Improving food intake in nursing home residents with feeding assistance: a staffing analysis', *J Gerontol*, **56A**, M790–M794
Sloan A (2007a), 'New shades of green', *Food Technol*, **61**, 16.
Sloan A (2007b), 'Top 10 food trends', *Food Technol*, **61**, 22–39.
Smith C (2002), 'Punishment and pleasure: women, food and the imprisoned body', *Sociol Rev*, **50**, 197–215.
Sneed J and Kresse K (1989), *Understanding Foodservice Financial Management*, Rockville, Aspen.
Spears M (2000), *Foodservice organizations: a managerial and systems approach* (4th ed), Upper Saddle River NJ, Prentice–Hall.

Spears M and Gregoire M (2007), *Foodservice Organizations. A managerial and systems approach* (6th ed), Upper Saddle River NJ, Prentice Hall.

Stein K (2000), 'Foodservice in correctional facilities', *J Am Diet Assoc*, **100**, 508–509

Sydner Y and Fjellström C (2005), 'Food provision and the meal situation in elderly care – outcomes in different social contexts', J Hum Nutr Diet, 18, 45–52.

Tarboush, R. M., & Erçin, Ç. (2021). User's need in architectural spaces development, existing kitchen design in Northern Cyprus. *European Journal of Sustainable Development*, *10*(2), 13–32. https://doi.org/10.14207/ejsd.2021.v10n2p13

The Spruce. (2019). What Is a Galley Kitchen? Retrieved 21.November 20, 2020 from https://www.thespruce.com/make-galley-kitchen-work-for-you-1822121#:~:text=A%20galley%20kitchen%20is%20a,cabinetry%20and%20other%20functional%20items.

The Free Dictionary. (2020). kitchen island. Retrieved November 20, 2020 from https://www.thefreedictionary.com/kitchen+island

The Spruce. (2019). What Is a Galley Kitchen? Retrieved November 20, 2020 fromhttps://www.thespruce.com/make-galley-kitchen-work-for-you 1822121#:~:text=A%20galley %20kitchen%20is%20a,cabinetry%20and%20other%20functional%20items

The Spruce. (2020). 1960s Kitchens: From Jet-Age to Funkadelic. Retrieved December 23, 2020 from https://www.thespruce.com/1960s-kitchens-from-jet-age-to-funkadelic-1821187

Valentine G and Longstaff B (1998), 'Doing porridge', *J Mater Cult*, **3**,

Vranesevic T and Stancec R. (2003), 'The effect of the brand on perceived quality of food products', *Br Food J*, **105**, 811–825.

Walton K, Williams P and Tapsell L (2006), 'What do stakeholders consider the key issues affecting the quality of food service provision for long stay patients?' *J Foodserv*, **17**, 212–225.

Walton K, Williams P, Bracks J, Zhang Q, Pond L, Smoothy R, Tapsell L, Batterham M and Vari L (2008), 'A volunteer feeding assistance program can improve dietary intakes of elderly patients – a pilot study', *Appetite*, **51**(2), 244–248

Walton K, Williams P, Tapsell L and Batterham M (2007), 'Rehabilitation inpatients are not meeting their energy and protein needs', *e-SPEN e-J Clin Nutr Metab*, **2**,e120– e126

William J. Rothwell and H.C. Kazanas, 2006, Planning and Managing Human Resources, 2nd edition, Jaico Publishing house, Delhi

Williams P (2005), 'The place of functional foods within hospitality – an opportunity?' *J R Soc Health*, **125**, 108–9.

Williams, P. (2009). Foodservice perspective in institutions. In *Elsevier eBooks* (pp. 50–65). https://doi.org/10.1533/9781845695712.2.50

Wilson A, Evans S, Frost G and Dore C (2001), 'The effect of changes in meal service systems on macronutrient intake in acute hospitalized patients', *Food Serv Technol*, **1**, 121–122.