

# FOOD STORAGE AND PRESERVATION

## Abstract

Foods eaten for nutritional purposes are organic substances derived from the origin of plants and animals containing minerals, lipids, carbohydrates, moisture, and protein with different organic substances. In order to preserve food from spoilage it should be stored as the nutritional information on the label suggests to intact its physical, chemical, sensory, and microbiological characteristics in a given period of time. Preserving and processing food is an essential part to increase shelf life, quality maintaining, and good morphological conditions management so that taste will not be changed and humans can safely consume it. According to the shelf-life food is divided into 3 types perishable, semi-perishable, and nonperishable. Various reactions lead to the deterioration of the quality of food that includes chemical, physical, microbial, and enzymatic reactions. Spoilage due to these reactions that microorganisms caused can be avoided to a large extent by using various types of food preservative techniques that slow down the growth of microbes and prevent food from spoilage including canning, freezing, fermentation, drying, pasteurization, food irradiation, pulsed electric field, food additives, pickling, salting, heat treatment, and hurdle technology, etc. There are various factors that affect the food spoilage rate including microorganisms such as fungi & bacteria, storage temperature, pH, water availability, load of microbes, and the processing of food. There are 3 types of spoilage mechanisms that include physical spoilage such as temperature, moisture content, crystal growth & crystallization, and glass transition temperature and emulsion breakdown, Chemical spoilage such as oxidation, proteolysis, pectin hydrolysis, non-enzymatic browning, and hydrolytic rancidity, and Microbial spoilage by the various kinds of microorganisms that include moulds, bacteria, and yeasts along with the recent trends is explained in this chapter.

**Keywords:** Shelf Life, Preservatives, Additives, Spoilage, Processing.

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## I. INTRODUCTION

Foods eaten for nutritional purposes are organic substances derived from the origin of plants and animals containing minerals, lipids, carbohydrates, moisture, and protein with different organic substances (Amit et al, 2017). According to Gross food is defined as the substances required by people that are edible and help to maintain better growth and development in life. However, the physiological requirements of the body are fulfilled by the food and are accepted by society and the cultural beliefs of people, and quality, quantity with proper safety also meet the requirements of targeted people (Gross et al 2000). India is the highest producer of food grain with about 80 percent of the land used for agricultural activity to cultivate food (Mobolade et al, 2019). In addition to this, one-third of the total food that is produced worldwide is get wasted, and that approximately accounts for \$ 400 billion is really surprising (Bello and Abubakar 2021).

Food spoilage is defined as food that is unfit or unhealthy to consume by humans due to the presence of various factors that includes contamination by insects or infestation, microorganisms, or other factors such as degradation due to enzyme activity results in food spoilage (Tumuluru 2023). The main reason behind food spoilage depends on three major factors such as physical, microbial, or chemical action of food that deteriorate the quality of food by changing its color, nutritional values, edibility, and texture of food that leads to spoilage (Amit et al, 2017). Food spoilage causes various health problems that lay stress on people according to the recent scenario that was faced by the world, stating that during the Covid-19 outbreak, more stress has developed on people and undernutrition becomes a major health problem in more people. However, 1.5 billion or more people didn't fulfill the basic needs of nutrients due to the high costs of a healthy diet which are accessible to some specific population (Saini et al, 2021). Including the people who produce food to the people who consume it, food spoilage leads to food insecurity and results in an economical loss that affects all the people comes in the hierarchical chain (Saini et al, 2021).

According to Sadiku, food preservation is a way in which food is treated by using various techniques to slow down the process of food deterioration in order to avoid food spoilage for a longer period of time to increase shelf life (Sadiku et al, 2019). Shelf life can be described as the time in which food is good to consume without causing any health problems while stored in good environmental conditions (Haouet et al, 2018). Shelf life is generally of three different kinds which are categorized as perishable in which vegetables and fruits category is involved, nonperishable group in which nuts, sugar along with other food groups such as pulses and grains are included, and semi-perishable food groups are the different types of shelf life (Sagar and Pareek 2020). In order to preserve food from spoilage it should be stored as the nutritional information on the label suggests to intact its physical, chemical, sensory, and microbiological characteristics in a given period of time (Dominic, 2002). The major cause of food deterioration is due to the effects of microbial contamination that lead to food spoilage (Prokopov and Tanchey 2007). Preserving and processing food is an essential part to increase shelf life, quality maintaining, and good morphological conditions management so that taste will not be changed (Amit et al, 2017), and humans can safely consume it (Tumuluru 2023). Effective preservative technique with the proper way of storage helps to keep the food quality intact and also inhibits insects and the growth of pathogens (Sagar and Pareek 2020). Techniques of food preservation are also changing with time in primitive times common techniques like drying in the sun have been used and now

various new techniques have emerged over time. Although, there is a wide variety of additives or chemicals with various other processing methods that have been used to preserve food from spoilage by controlling the pH of food (Rahman 2020).

## II. CLASSIFICATION OF FOOD GROUPS BASED ON SHELF LIFE

Demand for good quality food products with better shelf life is increasing day by day (Rasooli 2007). According to the shelf-life food is divided into 3 types:

**Table 1: Categorise based on the Shelf Life of Various Food Products**

Name	Shelf life	Spoilage due to Microorganisms	Common examples	Reference
Perishable	Ranges from a few days to 3 weeks	Highly susceptible	Poultry Milk and dairy products Meat Eggs seafood	Created from (Doyle 2009) & (Rasooli 2007).
Semi perishable	Up to 6 months	Highly susceptible	Fruits Vegetables Potatoes Cheese	Created from (Doyle 2009) & (Pandiselvam et al, 2019).
Nonperishable	Indefinite	Not susceptible	Canned fruits Canned vegetables Nuts Dry beans Flour Mayonnaise	Created from (Doyle 2009)

The first food group is referred to as **perishable** in which the shelf life of food products is between several days that lasts for around 3 weeks is commonly called perishable foods such as poultry, seafood, egg, and dairy products like milk, and meat are common perishable foods products (Doyle 2009). These food items required special care during the preparation to increase shelf life and better storage conditions to delay the spoilage process (Rasooli 2007).

The second group is referred to as **Semi perishable** in which if better storage conditions are provided then various food products or items can be stored for up to 6 months are commonly called semi-perishable foods such as potatoes, cheese, vegetables, and fruits are commonly semi perishable food products (Doyle 2009). According to Pandiselvam vegetables and fruits can be easily spoiled due to microorganisms as they are susceptible to food spoilage (Pandiselvam et al, 2019).

The third category is referred to as **nonperishable** or can be referred to as shelf-stable in which food items have an indefinite shelf life as various foods are natural and processed and possesses indefinite shelf life that is stored for many years without any damage caused by microorganisms. However, it includes sugar, nuts, dry beans, flour, mayonnaise, vegetables, and fruits that are canned (Doyle 2009).

### III. TRADITIONAL AND MODERN METHODS OF FOOD PRESERVATION AND PROCESSING

Various reactions lead to the deterioration of the quality of food that includes chemical, physical, microbial, and enzymatic reactions. Spoilage due to these reactions that microorganisms caused can be avoided to a large extent by using various types of food preservative techniques that slow down the growth of microbes and prevent food from spoilage including canning, freezing, fermentation, drying, pasteurization, food irradiation, pulsed electric field, food additives, pickling, salting, heat treatment, and hurdle technology, etc (Gould 2000). In order to achieve microbiologically safe and stable food then decreasing the microbial load with the help of better preservative techniques can be achieved (Augusto et al, 2018).

- 1. Canning:** Canning or canned foods can be described as food preserved in a hermetically sealed such as in water and can be in an airtight container stored in non-refrigerated condition (McGlynn 2003). Nicholas Apert explained the concept of a container that is hermetically sealed in 1810 for the first time (Naczka and Artyukhova 2020). Sterilization of wholesome foods that are ready to eat is preserved by using a canning technique that ensures safety at room temperature (Teixeira 2014). The stability of food storage is the main concern that is considered mainly by the canning industry and their main goal is to produce microbiology better and highly nutritious food by using saturated steam for the process of sterilization to pack food products (Naczka and Artyukhova 2020).
- 2. Freezing:** Freezing simply implies storing food products at low temperatures (Nida and Anandharamakrishnan 2021). Physical reactions or biochemical reactions are not stopped due to freezing however it slows down the food deterioration process (George 1993). The shelf life of various food products is increased by using freezing techniques that help to preserve food at low temperatures effectively. The freezing technique is still emerging continuously apart from the reason that it is better than other techniques of food preservation such as pulsed electric field and infrared irradiation and is considered an essential technique. At low temperatures, it changes the physical form of liquid into solid form as ice. However, with the help of a phase diagram or cooling curve process of freezing can be seen and at the storage level temperature is decreased to 18 degrees Celsius (Rahman and Velez 2007).
- 3. Drying:** Drying is the oldest method of food preservation in which liquid is dehydrated or excluded from substances such as foods, coal, or biomass (Michailidis and Krokida 2014). There are 2 types that show the presence of water in various food products that are held with each other by a physical and chemical water bond and during the process of drying only physical water held is excluded. Water is excluded so that food storage and preservation can be achieved by the process of drying and safely stored to use food in the future (Bolaji 2005). Many techniques such as microwave drying or flash and hot air

drying along with traditional techniques of drying that include vacuum drying have been used and still emerging methods such as sonic drying, and infrared drying are used to enhance the quality by providing low economic conditions as compared to high-cost techniques (Michailidis and Krokida 2014).

4. **Salting:** Salting is an old method used in ancient times to preserve food that was used individually or combined with different methods that include lowering pH and air drying (Chitralt et al, 2001). Salt is available at a lower cost in the market and used by food industries as a method of food additive. Salt has the property to decrease water activity due to its sodium chloride capacity which acts as a preservative and has antimicrobial effects that lead to control of the process of food spoilage (Albarracin et al, 2011).
5. **Fermentation:** Fermentation is a process that occurs when oxygen is not present or required for preservation instead of oxygen sugar is consumed during the process of fermentation. However, products such as alcohol, organic acids, or gases are formed during the process of fermentation and it occurs in bacteria or yeast where oxygen is absent in muscle cells during the fermentation of lactic acid (Mani 2018). The safety of fermented food is ensured by the principles based on acidification, water activity, oxygen presence, and salting. The fermentation process depends upon the kind of microbes activity that has been added to the starter culture (Perez et al, 2017). Fermentation is an effective technique that has been used to increase the shelf life of food products and in ancient times food preservation is done by using natural fermentation methods (Ross et al, 2002). Some examples of fermented food items are cheese, yogurt, milk, bread, and beverages (Raj et al, 2021).
6. **Pickling:** According to Nummer & Brian pickling is a process in which preservation is done by adding vinegar, common salt, and different acids that are produced by the fermentation of sugar and starches to alcohol which is then oxidized and converted into acetic acids with the help of specific bacteria (Nummer and Brian 2002). Pickling is an old method for preserving vegetables and fruits by adding vinegar and salt in it along with other spices and pickle is a common example of pickling that has low calories and is consumed by people as an appetizer (Sharif et al, 2017).
7. **Pasteurization:** Pasteurization is a method of food preservation in which heat is applied to kill the microorganisms (Panchal et al, 2018). Nutritional quality of food is not affected much during the process of pasteurization by heat (Gasperi et al, 2018). This process is used to increase the shelf life by inactivating bacteria (Teixeira 2014), the term pasteurization is coined by Louis Pasteur suggests that heating at low temperatures enhances keeping the quality of liquid while storage (Holsinger et al, 1997). However, preservation by pasteurization technique can improve shelf life for a few days (Ramesh 2020) and other non-thermal techniques that include ultraviolet exposure and membrane filtration are also better methods for liquid preservation of foods (Chen and Rupasinghe 2013). Commonly used to preserve milk (Panchal et al, 2018) and fruit juices (Chen and Rupasinghe 2013).
8. **Food Additives:** Food additives can be understood as the substances that are incorporated in foods so that their taste, flavor, and appearance along with other qualities will be enhanced or preserved (Awuchi et al., 2020) and to ensure the safety of food while

enhancing shelf life (Kilic-Akyilmaz and Gulsunoglu 2015). In terms of safety or toxicity essential nutritional additives, preservatives, flavoring, and coloring agents are identified in which natural food additives become popular and provide better health benefits (Carocho et al, 2014) and according to the INS system, there are 3 types of preservatives that include antioxidants, antimicrobial & antibrowning agents are included (Branen et al, 2001).

The term GRAS was introduced during the hour of need that is “Generally recognized as safe” that brings or assures the safety of food ingredients for the consumers (Burdock & Carabin 2004). Food additives that are plant-based as compared to synthetic additives are becoming popular and catching attention as they are providing better health, along with green safety, and providing a new direction for the future of the food industry (Zang et al, 2022).

**9. Food Irradiation:** According to Loaharanu & Ahmed food irradiation is described as a method that includes the processing of food by using physical methods such as canning and freezing (Loaharanu and Ahmed 1991). Irradiation is considered to be one of the best methods for processed food (Homayouni et al, 2015) that destroyed the harmful bacteria along with other microorganisms that are present in poultry, seafood, or meat (Joshua 2020). It has the quality of disinfecting dry food products to avoid loss during storage along with vegetables and fruits for the purpose of exporting. It also decontaminates foods from pathogens and makes safe food available for the consumers (Loaharanu and Ahmed 1991).

**10. Pulsed Electric Field:** Pulsed electric field is a technique that is used to inactivate the microorganisms by nonthermal methods of processing. (Jeyamkondan et al, 1999) while causing only minimal harmful effects on the quality of food (Mohamed & Eissa 2012). It is based on an application of novel food preserving technique in which treatment is done by exposing food to the pulsed electric field where permeability in biological cells is induced resulting in destroying microorganisms (Gerlach et al, 2008). Higher temperatures such as at 40 degrees Celsius have been shown to improve and increase lethality in the process of the pulsed electric field with an increase in the shelf life of food (Toepfl et al, 2007). Studies have shown that innovative techniques of pulse high voltage can decrease the cost as well as make this technique more competitive with other methods of thermal processing (Jeyamkondan et al, 1999). In 1980 and 1990 various food products were processed that includes peach, apple, orange juices, skim milk, beaten eggs, and pea soup successfully (Vega-Mercado 1997).

**11. Bio- Preservatives:** Bio- preservation is a process in which the shelf life of the foods is increased by the use of controlled or natural microbiota. Beneficial bacteria along with fermented products are chosen so that spoilage can be controlled and the pathogen can inactivate (Singh 2018). To increase the shelf life of food antimicrobial peptides are used separately or with combination, polymeric nanoparticles and essential oils are used (Rai et al, 2016). The metabolites that are antimicrobially active include hydrogen peroxide, bacteriocins and organic acids such as acetic and lactic acid have the highest potential that can be used as bio preservatives and inhibit the growth of unwanted microorganisms in culture (Dey and Nagababu 2022).

- 12. Heat Treatment:** Heat treatment is one of the oldest methods of food preservation that is also known as thermal processing which ensures food safety and shelf stability (Ramaswamy & Chen 2002). If proper time and suitable temperature are provided to the food then the products did not cause any health-related issues and ensure safety (Holdsworth 2004).
- 13. Refrigerator:** Active and passive refrigeration techniques can help to achieve food preservation even if the power grid is not accessible that uses an energy source to operate the process of refrigeration. However, technologies such as active refrigeration have the most potential but improvement is still required (Aste et al 2017).
- 14. Hurdle Technology:** According to Leistner hurdle technology is based on an application in which more than one approach is combined that ensures the preservation of food products by the control of the pathogens (Leistner 2007). Hurdle technology is a very effective method of preservation that is widely used by developing countries (Leistner 2000) and during processing at high temperatures, storage during low temperatures and acidity increase is the hurdles in a system. The quality, stability along with the safety of food preservation depends on the application of empirically combined methods used for the process of preservation that brings healthy and nutritious food worldwide through gentle as well as effective technique of food preservation (Leistner 2007) as their principles for preservative factors and interaction becomes known such as PH, competitive flora, temperature, and Eh (Singh and Shalini 2016). According to Leistner the ultimate goal of multitarget preservation will soon be achieved for the highest safety preservation of food products (Leistner 2007).

#### IV. MECHANISM OF FOOD SPOILAGE

Food spoilage occurs when the growth of microorganisms occurs in food due to the activity caused by metabolic reactions (Hamad 2012) and the quality of food starts to deteriorate which can be seen through changes in their organoleptic properties during processing. There are various factors that affect the food spoilage rate including microorganisms such as fungi & bacteria, storage temperature, pH, water availability, load of microbes, and the processing of food (Odeyemi et al, 2020).

There are 3 types of spoilage mechanisms that include physical spoilage such as temperature, moisture content, crystal growth & crystallization, and glass transition temperature and emulsion breakdown (Singh and Anderson 2004), Chemical spoilage such as oxidation, proteolysis, pectine hydrolysis, non-enzymatic browning, and hydrolytic rancidity (Amit et al, 2017), and Microbial spoilage by the various kinds of microorganisms such as molds, bacteria, and yeasts (Singh and Anderson 2004).

- 1. Temperature:** Temperature plays a crucial role in maintaining the quality of freshly available fruits and vegetables. An optimal temperature is required for slow ripening and to increase its life after postharvest and it can be achieved by reducing ethylene that results in slow ripening. Tropical vegetables and fruits show sensitivity to the chilling injury process that happens before freezing at 5 – 15 degrees Celsius (Steele 2004).

2. **Moisture Content** : Excess moisture is bad for the integrity of quality food products while packaging specially in the case of raw and freshly produced food when water activity is high (Gaikwad et al, 2019). The amount of water present in food products influences the flavors in food, appearance, and texture (El-sayd and Makawy 2010). The process of moisture transfer in different materials that includes food is a complicated process in which many mechanisms can happen and the process of removing moisture by drying is useful for improving the stability and shelf life of food products (Srikiatden and Roberts 2007).
3. **Crystal Growth and Crystallization**: Freezing leads to the deterioration of food products in which slow freezing results in severe crystal growth or ice growth that is extracellular while rapid ice freezing inside food cells is highly stable. Foods that contain sugar form sugar crystals due to the presence of moisture or high temperature that causes a white appearance on the surface of food products that can be controlled by using starch or fructose to delay the process of food spoilage (Amit et al, 2017).
4. **Glass Transition Temperature**: The values of glass transition temperature to polymers that are reacted partially can be dependent on thermal sample history and measurements that are used by heating rate, owing to the enthalpy relaxation (Pascualt and Williams 1990). The glass transition temperature when changes then affect the food moisture and influence the shelf life of food products (Singh and Anderson 2004). The critical values of the water content along with the water activity show the water plasticization level that leads to the glass transition in the storage of food. The noncrystalline solid along with amorphous are typically of low water content and foods that are frozen. The reversible glass transition forms the solid glassy state that is formed during the processing of foods (Roos 2010).
5. **Emulsion Breakdown**: Physical deterioration occurs in food products that include salad dressing, mayonnaise, and margarine due to emulsion breakdown. To achieve stability for a longer time then it will depend on which type of emulsifier is used and on how the phase is dispersed. An example of an emulsifier is the egg yolk (Singh and Anderson 2004).
6. **Oxidation**: The oxidation process occurs when oxygen is present and amino acids get converted into organic acids along with ammonia. Fresh fish and meat that is refrigerated oxidation act as a primary spoilage reaction in that. Lipid oxidation in which lipids react with oxygen can be term as rancidification that results in a bad taste of food, a change in color, and the formation of toxins (Amit et al, 2017).
7. **Proteolysis**: According to Agarwal Protein breakdown for which the enzyme system is responsible is an essential part of better health and development that is started from endopeptidase by which internal peptide bonds hydrolyzed inside the proteins and finished with exopeptidases that remove the sequence of amino acids from protein fragments end that is important for physiological regulations (Agarwal 1990). Some amino acids have a sweet taste that includes glycine, L-alanine, D- Tryptophan, D-histidine, D-leucine, D- tyrosine, D- phenylalanine and some have a bitter taste that includes L- Tryptophan, L- tyrosine, L-leucine, L- phenylalanine and L- Glutamic acid have a unique taste (Solms 1969).



The process of spoilage is slowed down due to the low bacterial proteolysis in the flesh foods that are irradiated. However, it is evaluated by the levels of bacterial protease after seeing the growth in control as well as in the irradiated fish proteins by the use of a substrate that is hemoglobin that shows an effective decrease in the secretion of protease during bacterium proliferated which is seen in irritated proteins of fish (Alur et. Al 1993).

- 8. Pectin Hydrolysis:** Pectin is a unique group of polymers of carbohydrates that is made up of units of galacturonic acid in which the raw materials such as citrus peels and apple pomace are there by which pectin is made by using the process of extraction or hydrolysis through acid and by precipitating through the use of aluminum salts or alcohol (May 1990). The various changes in properties and characteristics of food products such as vegetables and fruits during ripening, storing, and canning are due to the physicochemical changes caused by pectin enzymes (Nikolic and Mojovic 2007). Pectin is an old gelling agent that was used for making jellies and jams and its applications also increased in the food industry as well (May 1990).
- 9. Non-Enzymatic Browning:** The non-enzymatic browning occurs due to various chemical reactions when food is prepared or stored that causes browning in food (Croguennec 2016). The non-enzymatic browning that happens due to heat treatment involves various reactions such as caramelization, Maillard reaction, etc (Garza et al, 1999). This reaction happens in the presence of amino acids that are subunits of protein and in reducing sugars leading to a decrease in the solubility of the protein and the development of bitter flavor and also decreases the nutritional value in foods (Amit et al, 2017). In food processing and during storage of food non-enzymatic browning causes reactions like changes in the color of food due to undesirable enzymatic reaction that shows a negative impact on the quality of food (Garza et al, 1999).
- 10. Hydrolytic Rancidity:** Hydrolytic rancidity is caused due to the deterioration or degradation of milk lipids by hydrolytic lipase catalyzed and forms the free fatty acids that lead to the unpleasant rancid, bitter, astringent, and soapy flavor of foods. It's of 2 types that include microbial origin along with endogenous milk enzyme (Deeth and Fitz-Gerald 1995). Hydrolysis of lipids due to the presence of free fatty acids causes harmful effects on the quality of milk and its products that changes its properties this process is lipolysis (Deeth and Fitz-Gerald 2006). In the case of whole grains rancidity caused due to the enzyme activity can prevent harmful changes in the lipids at -20 degrees Celsius and increase the shelf life (Chen et al, 2019).
- 11. Microbiological Spoilage:** Microbiological spoilage harms the host through cellular lytic enzymes which decay the polymer and remove water along with different intracellular constituents to utilize nutrients to grow (Barth et al, 2009). Moulds that spoil bread are commonly *Rhizopus stolonifera* and in low humid conditions retard the growth of microorganisms. Genus *Bacillus* is responsible for the bacterial spoilage in breads that is called rope and consumption of these breads causes food-borne diseases. The safety of products such as bread and cookies against fungi attached is due to the help of preservatives that reduce food wastage that is caused by microorganisms (Saranraj & Geetha 2012). Spoilage in fish products that are lightly preserved is caused by the action of microbes (Gram & Huss 1996).

**Bacteria** are of various types such as Salmonella spp., Bacillus cereus, Clostridium, Campylobacter jejuni, Vibrio spp., and Listeria monocytogenes that are responsible for various types of illness that is caused due to food spoilage by these bacteria. Another type of microorganism that causes illness and spoils food products is yeast which is also used in the fermentation process. **Yeast** is of many types such as Dekkera spp., Saccharomyces spp., Zygosaccharomyces spp., and Candida spp., these are singled-celled fungi of size 3-5 microns and **moulds** are also the microorganisms such as Penicillium spp., Rhizopus spp., Fusarium spp., and Aspergillus spp., which can produce aflatoxins that causes diseases (Singh and Anderson 2004).

## V. RECENT TRENDS IN THE FIELD OF FOOD STORAGE AND PRESERVATION

As the lifestyle of people changes the demand for safe and healthy food products is also gaining a lot of popularity among consumers so the concept of minimally processed fruits and vegetables (MPFVs) is increasing in the markets. MPFVs need to be stored in refrigerators to ensure shelf life along with safety for consumers. The main cited method of physical preservation such as irradiation, thermal treatment, high pressure, etc. are the advanced technologies in packaging development of products, initiating required changes that are desirable and interacts with the consumers are the new trends in the area of MPFVs (Gomes et al, 2023).

There are a huge number of articles published to show the stability of moist food and how it affects the mechanism of food spoilage. Research is also done to study food-borne diseases by the action of pathogens such as the Cryptosporidium parvum which is a parasite that was found to cause illness in drinking water and that aims to provide healthy and safe food for consumers (Singh and Anderson 2004). Various challenges are faced in the process of food preservation that includes fewer facilities, less technical support and important knowledge which reduce the systems performance (Joardder et al 2019). Techniques of food preservative for the various food products such as meat, grains, fish, vegetables and fruits in which wastage happens from contamination, transportation, and low processing quality. However, in order to overcome these problems innovative techniques present solution that includes advanced techniques of preservation and for implementation process (Joardder and Masud 2019).

Essential oils also gained popularity as natural preservatives that potentially are the best natural antibacterial along with antimicrobial agents enhancing the shelf life of food is the new trend among researchers. Natural essential oils that are extracted from plants are safe as well as eco-friendly food preservatives that are easily biodegraded (Rout et al, 2022). Preservation of food products through packaging has various health benefits as there are recent advancements in the field of packaging, biotechnology as well as material science to fulfill consumer demand and it helps to increase the shelf life and maintains the nutritional quality of food products by providing food safety (Bhat et al, 2012).

## VI. CONCLUSION

It is concluded from the chapter that food spoilage harms health due to various reasons that include contamination by microorganisms along with other factors and food preservative techniques have shown effective results in controlling food spoilage along with health benefits. Recent trends attracted nowadays to the food industry to increase the shelf life of perishable foods in a more advanced way so that they can increase the shelf life of the product and increase their income by reducing the cost of wastage by the process of refrigeration and by adding additives preservatives and more different methods has been elaborately explained in the chapter so that the readers can understand all the concepts behind the food storage and preservation.

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