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An Analysis of Microbial Spoilage in Household Food Items and Suggestion to Retard Spoilage

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ABSTRACT

Food spoilage can be defined as "any sensory change (tactile, visual, olfactory or flavor)" which the consumer considers to be unacceptable. Spoilage may occur at any stage along food chain. Spoilage may arise from insect damage, physical damage indigenous enzyme activity in the animal or plant tissue or by microbial infections. Most natural foods have a limited life. Perishable foods such as fish, meat and bread have a short life span. Other food can be kept for a considerably longer time but decomposes eventually. Enzymes can bring about destruction of polymers in some foods while chemical reactions such as oxidation and rancidity decompose others but the main single cause of food spoilage is invasion by microorganisms such as mold, yeast and bacteria. In case of mould spoilage a furry growth covers the food and it becomes soft and often smells bad. Bacterial contamination is more dangerous because very often food does not look bad even though severely infected, it may appear quite normal. The presence of highly dangerous toxins and bacterial spores is often not detected until after an outbreak of food poisoning, laboratory examination uncovers the infecting agent.

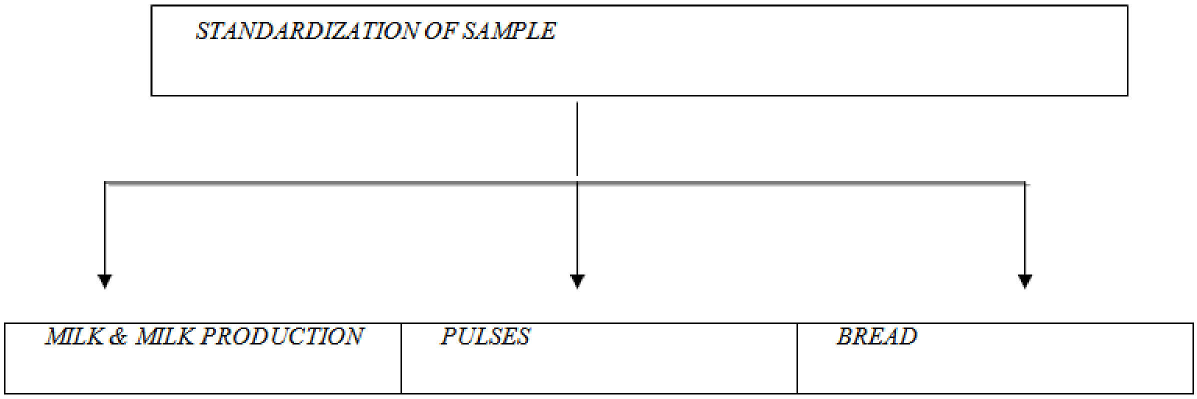
I. INTRODUCTION

Food spoilage is a metabolic process that causes foods to be undesirable or unacceptable for human consumption due to changes in sensory characteristics. Spoiled foods may be safe to eat, i.e. they may not cause illness because there are no pathogens or a toxin present, but changes in texture, smell, taste, or appearance cause them to be rejected. Some ecologists have suggested these virulent smells are produced by microbes to repulse large animals, thereby keeping the food resource for themselves. Food loss, from farm to fork, causes considerable environmental and economic effects. The USDA Economic Research Service estimated that more than ninety-six billion pounds of food in the U.S. were lost by distributor, foodservice and consumers in 1995. Fresh produce and fluid milk each accounted for nearly 20% of this loss while lower percentages were accounted for by grain products (15.2%), caloric sweeteners (12.4%), processed fruits and vegetables (8.6%), meat, poultry and fish (8.5%), and fat and oils (7.1%). Some of this food would have been considered still edible but was discarded because it was perishable, past its sell-by date, or in excess of wants there are also environmental and resource costs associated with food spoilage and loss. If 20% of a crop is lost, then 20% of the fertilizer and irrigation water used to grow that crop was also lost. Shelf life of a food is the time during which it remains stable and retains its desired qualities.

The wide array of available dairy foods challenges the microbiologist, engineer, and technologist to find the best ways to prevent the entry of microorganisms, destroy those that do get in along with their enzymes, and prevent the growth and activities of those that escape processing treatments. Troublesome spoilage microorganisms include aerobic psychotropic Gram-negative bacteria, yeasts, molds, hetero fermentative lactobacilli, and spore-forming bacteria. Psychotropic bacteria can produce large amounts of extracellular hydrolytic enzymes and the extent of recontamination of pasteurized fluid milk products with these bacteria is a major determinant of their shelf life. Fungal spoilage of dairy foods is manifested by the presence of a wide variety of metabolic by-products, causing off order and flavors, in addition to visible changes in color or texture.

II. METHODOLOGY

The present study will be experimental research design. This will be conducted in Nutritional Laboratory of department of Food science and Technology, school for Home science , BBAU, Lucknow for a period of July 2019 to May 2020. The nutritional analysis will be conducted in analysis laboratory of RFRAC (Regional Food Research and Analysis Center) situated in Lucknow.



An analysis of microbial spoilage if household food item and suggestion to retard spoilage

India is the second major producer of fruits and vegetables and ranks next to Brazil and China respectively, in the world. It contributes 10 percent of world fruit production and 14 per cent of world vegetable production. Fruits and vegetables are more prone to spoilage than cereals due to their nature and composition, and this spoilage occurs at the time of harvesting, handling transportation, storage, marketing and processing resulting in waste. Efficient management of these wastes can help in preserving vital nutrients of our foods and feeds, and bringing down the cost of production of processed foods, besides minimizing pollution hazards. According to India Agricultural Research Data Book 2004, the losses in fruits and vegetables are to the tune of 30 per cent. Taking estimated production of fruits and vegetables in India at 150 million tones, the total waste generated comes to 50 million tones per year. The post-harvest technologies for perishable horticultural produce serve as an effective tool for getting better return to the produce and also help in avoiding wastage both at production site and distribution centers, which will help in regulating the market infrastructure.

Like any other food, fruits and vegetables are also prone to microbial spoilage caused by fungi, bacteria, yeast and mold. A significant portion of losses of fruits and vegetables during post-harvest period is attributed to diseases caused by fungi and bacteria. The succulent nature of fruits and vegetables makes them easily invaded by these organisms. Besides attacking fresh fruits and vegetables, these organisms also cause damage to canned and processed products. Many serious post-harvest diseases occur rapidly and cause extensive break down of the commodity, sometimes spoiling the entire package. It is estimated that 36 % of the vegetable decay is caused by soft rot bacteria. Similarly fruit rot in anole and other soft fruits caused by fungi is also very destructive. As far as vegetables are concerned, naturally the source of infection is from the field, water used for cleaning the surface, contact with equipment and storage environment. The most common pathogens causing rots in vegetables and fruits are fungi such as Alter aria, Botrytis, Diploid, Monilinia, Phomopsis, Rhizopus, Pencillium, Fusarium, etc. Among bacteria Ervinia, Pseudomonas, etc. cause extensive damage.

High temperature and relative humidity favor the development of post-harvest decay organisms. More acidic tissue is generally attacked by fungi, while fruits and vegetables having pH above 4.5 are more commonly attacked by bacteria, ego bacterial soft rot of potato caused by Ceratocystis, fimbriation, water soft rot of carrot by Sclerotiniasclerotiorum etc.

In India, there is a vast scope for growing fruit and vegetable throughout the year in one or other part of the country because the climatic conditions are highly suitable for growing various types of fruits and vegetables. Fruit and vegetable is highly perishable but most important commodity for human diet due to their high nutritional value. They are the cheapest and other source of protective food supplied in fresh or processed or preserved form throughout the year for human consumption. Hence the national picture will improve significantly.

Fruit and vegetable are available in surplus only in certain seasons and availability in different regions. In peak season due to improper handling practices, marketing, storage problems around 20-25% fruit and vegetable are spoilt in

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various stages. Fruit and vegetable are living commodities as they respire. Hence, proper post harvest management handling and processing is required in horticulture crops. A variety of fresh fruit and vegetable in India can be made available in plenty due to favorable agro-climatic situations. Hence there is no death for raw material for processing. Product profile being developed in India at present is limited to few fruit and vegetable like mango, pineapple, grapes etc. But there is a wider potentiality for processing of papaya, banana, jack, guava, anole, Carrabolla and other minor fruits. Similarly there is a greater scope for processing cauliflower, carrot, bitter-gourd onion, garlic, watermelon, muskmelon etc.

Proper handling, packaging, transportation and storage reduce the post-harvest losses of fruit and vegetables. For every one percent reduction in loss will save 5 million tons of fruit and vegetable per year. Processing and preservation technology helps. There are about 4000 small and large scale processing units in the country which process only about 2.5% of the total fruit and vegetable as against 40-85% in developed countries.

Major storage Fungi and the Moisture Contents of Commodities at Which Mold Invasion May Occur		
MAJOR STORAGE FUNGI	COMMODITY	MOISTURE (%)
Aspergillusrestrictus (blueeye)	Starchy cereals Soybeans Sunflower ,safflower ,peanuts	14.0-14.5 12.0-12.5 8.5-9.0
Eurotiumglaucus (blue eye)	Starchy cereals Soybeans Sunflower, safflower, peanuts	14.5-15.0 12.5-13.0 9.0-9.5
A.candidus	Starchy cereals Soybeans Sunflower	15.5-16.0 14.5-15.0 9.0-9.5
A.ochraceus	Starchy cereals Soybeans Sunflower	15.5-16.0 14.5-15.0 9.0-9.5
Afflatus	Starchy cereals Soybeans	17.0-18.0 17.0-17.5
Penicillium (blue eye in corn)	Starchy grains Soybeans Sunflower	16.5-20.0 17.0-20.0 10.0-15.0

Food spoilage microorganisms

Chemical reactions that cause offensive sensory changes in foods are mediated by a variety of microbes that use food as a carbon and energy source. These organisms include prokaryotes (bacteria), single-celled organisms lacking defined nuclei and other organelles, and eukaryotes, single-celled (yeasts) and multicellular (molds) organisms with nuclei and other organelles. Some microbes are commonly found in many types of spoiled foods while others are more selective in the foods they consume; multiple species are often identified in a single spoiled food item but there may be one species (a specific spoilage organism, SSO) primarily responsible for production of the compounds causing off odor and flavors. Within a spoiling food, there is often a succession of different populations that rise and fall as different nutrients become available or are exhausted. Some microbes, such as lactic acid bacteria and molds, secrete compounds that inhibit competitors.

Spoilage microbes are often common inhabitants of soil, water, or the intestinal tracts of animals and may be dispersed through the air and water and by the activities of small animals, particularly insects. It should be noted that with the development of new molecular typing methods, the scientific names of some spoilage organisms, particularly the bacteria, have changed in recent years and some older names are no longer in use. Many insects and small mammals also cause deterioration of food but these will not be considered here.

Yeasts

Yeasts are a subset of a large group of organisms called fungi that also includes molds and mushrooms. They are generally single-celled organisms that are adapted for life in specialized, usually liquid, environments and, unlike some molds and mushrooms, do not produce toxic secondary metabolites. Yeasts can grow with or without oxygen (facultative) and are well known for their beneficial fermentation that produces bread and alcoholic drinks. They often colonize foods with a high sugar or salt content and contribute to spoilage of maple syrup, pickles, and sauerkraut. Fruits and juices with a low pH are another target, and there are some yeast that grows on the surfaces of meat and cheese.

There are four main groups of spoilage yeasts: Zygosaccharomyces and related genera tolerate high sugar and high salt concentrations and are the usual spoilage organisms in foods such as honey, dried fruit, jams and soy sauce. They usually grow slowly, producing off-odors and flavors and carbon dioxide that may cause food containers to swell and burst. This group also includes the most important spoilage organisms in salad dressings .Saccharomyces sop are best known for their role in production of bread and wine but some strains also spoil wines and other alcoholic beverages by producing gassiness, turbidity and off flavors associated with hydrogen sulfide and acetic acid. Some species grow on fruits, including yogurt containing fruit, and some are resistant to heat processing

Candida and related genera heterogeneous group of yeasts, some of which also cause human infections. They are involved in spoilage of fruits, some vegetables and dairy products Decked/ Brettanomycesare principally involved in spoilage of fermented foods.

Molds

Molds are filamentous fungi that do not produce large fruiting bodies like mushrooms. Molds are very important for recycling dead plant and animal remains in nature but also attack a wide variety of foods and other materials useful to humans. They are well adapted for growth on and through solid substrates, generally produce airborne spores, and require oxygen for their metabolic processes.
Most molds grow at a pH range of 3 to 8 and some can grow at very low water activity levels (0.7–0.8) on dried foods. Spores can tolerate harsh environmental conditions but most are sensitive to heat treatment.

S.no	Types of spoilage	Spoilages of micro-organism
1.	Bacterial soft rot	Erwinia caratovora, Pseudomonas sps
2.	Gray mold rot	Botrytis cineria
3.	Rhizopus soft rot	Rhizopus nigricans
4.	Anthrachose	Collectotrichum Hindemuthianum
5.	Alternaria rot	Alternaria tenuis
6.	Blue mold rot	Penicillium digitatium
7.	Downey miler	Phytopthora bremia
8	Watery soft rot	Sclerotinia sclerotiorum
9.	Stem end rot	Alternaria, phomopsis,fusarium
10.	Black mold rot	Aspergillus niger
11.	Black rot	Alternaria, ceratostomella, physalospora
12.	Pink mold rot	Trichothecium roseum
13.	Fusarium	Fusarium sps
14.	Green mold rot	Cladosporium, trichoderma
15.	Brown rot	Sclerotinia
16.	Sliminess	Saprophytic bacteria

Spoilage molds can be categorized into four main groups: Zygomycetes are considered relatively primitive fungi but are widespread in nature, growing rapidly on simple carbon sources in soil and plant debris, and their spores are commonly present in indoor air. Generally they require high water activities for growth and are notorious for causing rots in a variety of stored fruits and vegetables, including strawberries and sweet potatoes. Some common bread molds also are zygomycetes. Some zygomycetes are also utilized for production of fermented soy products, enzymes, and organic chemicals. The most common spoilage species are Mucus and Rhizopus. Zygomycetes are not known for producing mycotoxins but there are some reports of toxic compounds produced by a few species.

Penicillium and related genera are present in soils and plant debris from both tropical and Antarctic conditions but tend to dominate spoilage

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in temperate regions. They are distinguished by their reproductive structures that produce chains of conidia. Although they can be useful to humans in producing antibiotics and blue cheese, many species are important spoilage organisms, and some produce potent mycotoxins . Penicillium spp cause visible rots on citrus, pear, and apple fruits and cause enormous losses in these crops. They also spoil other fruits and vegetables, including cereals. Some species can attack refrigerated and processed foods such as jams and margarine.

Aspergillums and related molds generally grow faster and are more resistant to high temperatures and low water activity than Penicilliumspp. and tend to dominate spoilage in warmer climates. Aspergilla spoil a wide variety of food and nonfood items (paper, leather, etc.) but are probably best known for spoilage of grains, dried beans, peanuts, tree nuts, and some spices.

Other molds, belonging to several genera, have been isolated from spoiled food. These generally are not major causes of spoilage but can be a problem for some foods. Fusarium spp. Causes plant diseases and produce several important mycotoxins but are not important spoilage organisms.

Pseudomonas and related genera are aerobic, gram-negative soil bacteria, some of which can degrade a wide variety of unusual compounds. They generally require a high water activity for growth (0.95 or higher) and are inhibited by pH values less than 5.4. Some

Spoilage of dairy products

Milk is an excellent medium for growth for a variety of bacteria. Spoilage bacteria may originate on the farmstead from the environment or milking equipment or in processing plants from equipment, employees, or the air. The principal microbes in raw milk and proliferate if milk is not cooled adequately. When populations reach about 106 cfu/ml, off-flavors develop in milk due to production of lactic acid and other compounds. Refrigeration suppresses growth of LAB and within one day psychrophilic bacteria (Pseudomonas, Enterobacter, Alcaligenesand some spore-formers) grow and can in the end produce rancid odors through the action of lipases and bitter peptides from protease action.

Pasteurization kills the psychrophiles and hemophilic bacteria (LAB), but heat-tolerant breed (Alcaligenes,Microbacterium), and the spore formers Bacillus and Clostridium) survive and may later cause spoilage in milk or other dairy products.

Prevention from food spoilage microorganism

Many food products are perishable by nature and require protection from spoilage during their composition, storage and distribution to give them desired shelf-life. Because food products are now often sold in areas of the world far distant from their production sites, the need for extended safe shelf-life for these products has also enlarged. The development of food preservation processes has been driven by the need to extend the shelf-life of foods. Food preservation is a continual fight against microorganisms spoiling the food or making it unsafe. Several food preservation systems such as heating, refrigeration and addition of antimicrobial compounds can be used to reduce the risk of outbreaks of food poisoning; however, these techniques frequently have associated adverse changes in organoleptic characteristics and loss of nutrients.

Within the disposable arsenal of preservation techniques, the food industry investigates more and more the replacement of orthodox food preservation techniques by new preservation techniques due to the increased consumer demand for tasty, nutritious, natural and easy-to-handle food products. Development in the cold distribution chain has made international trade of perishable foods possible, but refrigeration alone cannot assure the quality and safety of all perishable foods.

The most common long-established preservative agents are the weak organic acids, for example acetic, lactic, benzoic and sorbet acid. These molecules inhibit the outgrowth of both bacterial and fungal cells and sorbet acid is also reported to hinder the germination and protuberance of bacterial spores. In the production of food it is crucial that proper measures are taken to ensure the safety and stability of the product during its whole shelf-life. In particular, modern consumer trends and food legislation have made the successful achievement of this objective much more of a challenge to the food industry. Firstly, consumers require more high quality, preservative-free, safe but soft processed foods with extended shelf-life. For example, this may mean that foods have to be preserved at higher pH values and have to be treated at mild-pasteurization rather than fumigate temperatures. As acidity and sterilization treatments are two important factors in the control of outgrowth of pathogenic spore-forming bacteria, such as Clostridium botulinum, a labeling this consumer need calls for modern approaches to ensure preservation of products. Secondly, law has restricted the use and permitted levels of some directly accepted preservatives in different foods.

This has created problems for the industry because the susceptibility of some microorganisms to most currently used preservatives is falling.

An increasing number of consumers prefer minimum processed foods, prepared without chemical preservatives. Many of these ready-to-eat and novel food types represent new food systems with respect to health threat and spoilage association. Against this background, and relying on refine understanding and knowledge of the complexity of microbial interactions, recent approaches are increasingly directed towards possibilities offered by biological preservation.

The high salt concentration in the serum-in-lipid emulsion of butter limits the growth of contaminating bacteria to the small amount of nutrients trapped within the droplet that contain the microbes.

Chemical preservatives

Chemical preservatives are substances which are added to food just to delay, inhibit or end the activity of microorganisms such as fermentation, putrefaction and decaying of the food. Commonly used preservatives include, common salt, sugar, dextrose, spices, vinegar, ascorbic acid, benzoic acid and its salt, SO_2 and the salts of sulphuric acid, nitrates, ascorbic acid and its salts, prop ionic acid and its salts, lactic acid and its salts.

The features of potassium met bisulphate are (1). It release the SO_2 and it is unstable.

It is used for the fruit which have no water solvent pigment (colorless).

It cannot be used in naturally colored juices such as phase, jaunt because they have the anthocynin pigment.

It cannot be used in the product which is packed in container because it acts on the tin containers and oil.

Hydrogen Supplied unpleasant smell and give a black compound with the base plate of container.

(**Features of sodium benzoate are :**(1) It is salt of benzoic acid and soluble in water.

It delays the fermentation in the juices.

It is commonly used in the product which is having natural color such as anthocynin pigment.

It is more effective against the yeast.

Use of food additives

Food additives are substances or mixture of substances other than primary foodstuffs, which are present in the foods as indicator of any aspects of production, processing, depot, packaging etc. Food additives are (i) **sugar,** (ii) **salt**, (iii) **acids,** (iv **)** **spices**. In case of sugar and salts, they exerts osmotic oppression by water is diffuses from the product through a semi-permeable skin until the concentration reached equilibrium. They kills the microorganisms or do not allow them to multiplication.

Sugar: The concentration of 68-70% is used for preparation of jam, jelly, marmalades etc. sugar act as a preservative by assimilation and not as a true poison for micro organisms. It absorbs most of the available water, so little water available for the growth of micro organisms.

Salt: 15-20% concentration is used for the preparation such as pickles. Salt inhibits enzymatic browning and discoloration and also acts as an anti-oxidant. It exerts its preservative action by: a. Causing high osmotic pressure resulting in the plasmolysis of microbial cells; b. Dehydrating food and micro organisms by tying up the moisture; c. Ionizing to yield the chloride ion which is harmful to micro organisms, and d. Reducing the dissolved of oxygen in water, sensitizing the cells against CO_2.

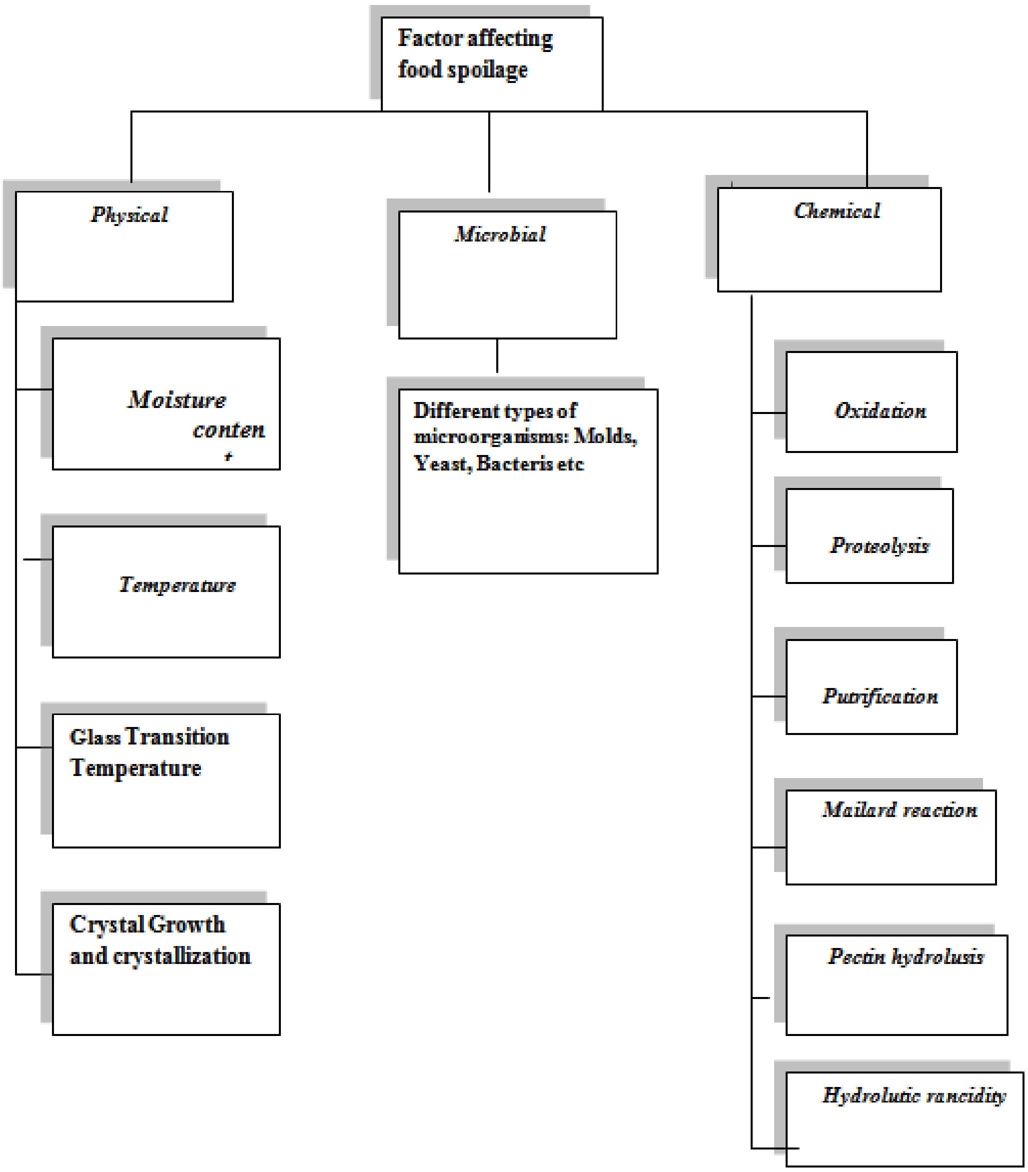
Acids: Many processed foods and beverages needs the addition of acids to relate their characteristic flavor and taste in the final product because acids provides desired flavor and taste. They adjust the sugar and acid ratio in the food. They give proper balance flavor of the food. They also play the role for controlling the gelatin formation. Acetic acid (Vinegar), Citric acid (Lime juice), Lactic acid (Lactose) etc. are used. Acetic acid is commonly used for pickles, chutney, sauce and ketchup, just to inhibit the growth of microorganisms. Citric acid is used for preparation of jam, jelly, squash, nectar etc. just to increase the acidity. Lactic acid: It is used for the formation of curd from milk, raw flavor and specific to pickles. Spices are plant products, are used in flavoring the foods and beverages to increase the food flavor, color and palatability, act as antibacterial and antifungal activity.

Weak carboxylic acids, such as acetic, sorbet and benzoic acids, are generally regarded as safe anti-microbial additives, and have wide application as preservatives in foods and beverages. However, many types of yeast are able to survive, adapt and even grow in the presence of the maximum levels of these preservatives permitted for use in foods. When compared with other fungi and bacteria, yeast is more resistant to weak carboxylic acids.

The explanation of the cytotoxic effects induced by weak acids in yeast, which may compromise cell viability and ultimately result in cell death, can provide further perception into the mechanisms that determine different susceptibilities of yeast to weak carboxylic acids compared to other microorganisms, and will allow the improvement or design of new strategies for food and beverage preservation.

Zygosaccharomycesbailii is a food and potation spoilage yeast that is characterized by a high tolerance to weak carboxylic acids at low pH, where Saccharomyces cerevisiae cannot survive. Thus, these two yeast species have frequently been selected as replica for the study of yeast response to acid stress. In S. cerevisiaeand in Z. bailey acetic acid induced cell death. However, and as is widely known, in Z. bailey this effect was observed at much higher concentrations of the acid. Although individual cells of S. cerevisiae and Z. bailey exhibited different short term intracellular pH responses to acetic acid, in both species the induction of cell death was related with an intracellular acidic action. In Z. bailey, the mechanism of death due to exposure to weak acids remains to be clarified.

Acetic acid in concentrations between 20 and 120 mm induces in exponentially growing S. cerevisiae cells a programmed cell death (PCD) process that displays the most common apoptotic hallmarks, such as chromatin condensation along the nuclear envelope, exposure of phosphatidylserine on the surface of the cytoplasm membrane, and occurrence of internucleosomal DNA .



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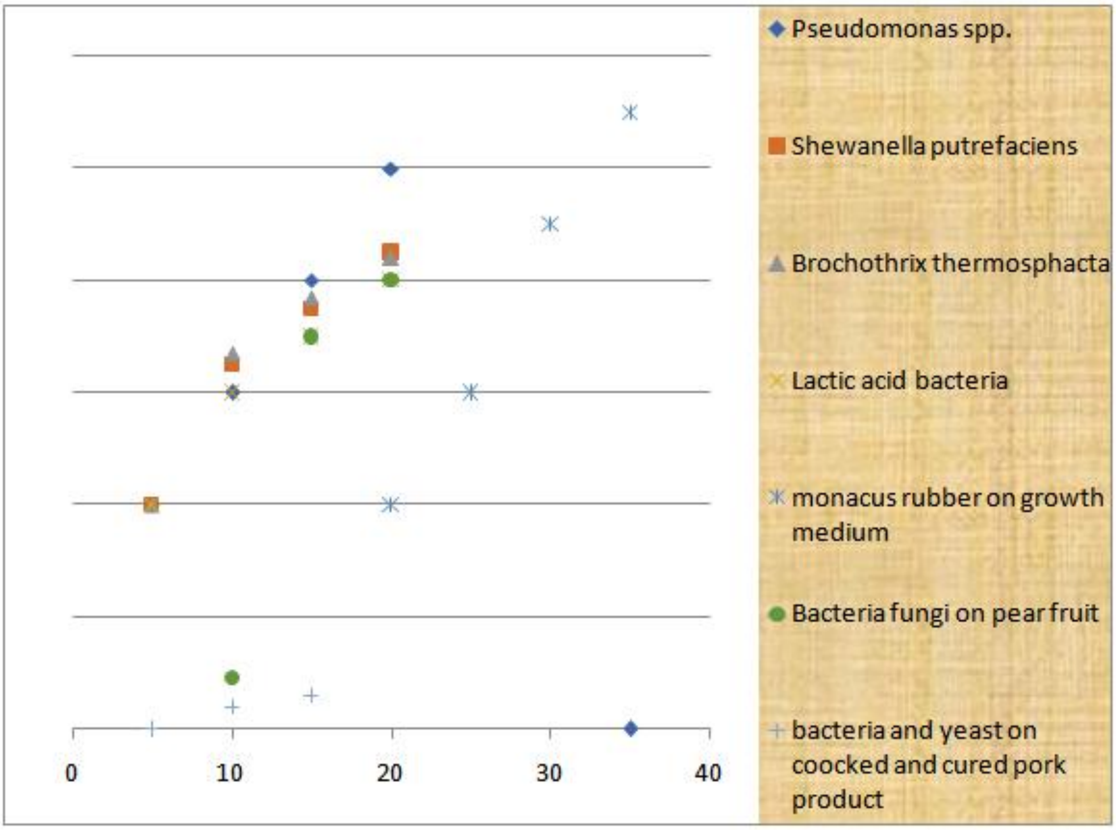
III. RESULT



Temperature(C)

The temperatures depends growth rate of various microbes involved in food spoilage. An exponential curve has been fit the data by using the ordinary square sources . See supplemental table SI for the data source

And statistical method .Abbreviation: C degrees Celsius.

According to the temperature at which they can grow. The growth rates are the highest at the optimum growth temp. The minimum temp. At which the organism can survive fit the data by using the ordinary square sources and replicate its minimum growth temperature.

Cells living in the presence of oxygen need special enzymes to break these down

Organisms can be classified based on their oxygen requirements and oxygen tolerance.

Obligate aerobes Micro aerobic (formally called microaerophilic) if these organism need increased carbon dioxide they are called capnophilic. Facultative anaerobes Obligate anaerobes

Minerals:

Mg ,K ,Fe, Ca, Zn, Mo, Co, M ,Na ,CL Note that there is a battle for iron between the human host and many infectious agents. We make lactoferrin and transferring to capture and hold into iron many bacteria make siderophores to capture and hold onto iron.

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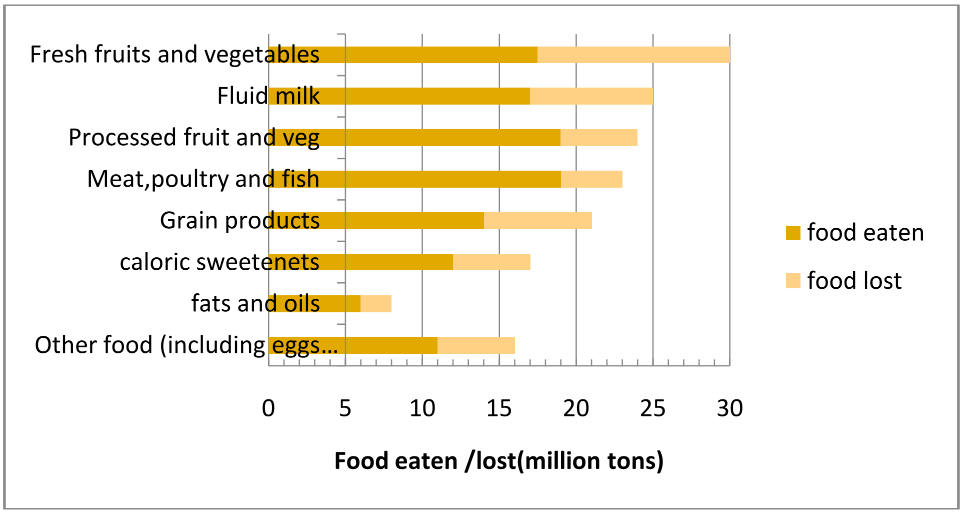

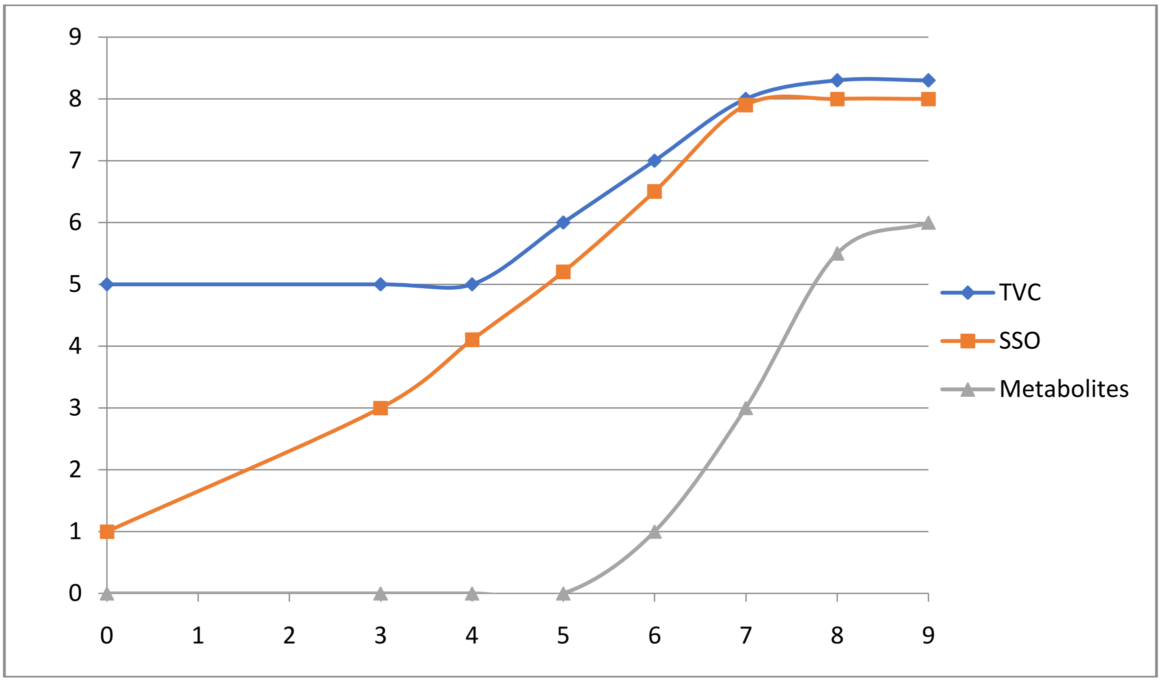

Specific spoilage organism(SSO) concept.

The minimal spoilage level and the chemical spoilage index are, respectively, the number of SSO and the concentration of metabolites determined at that the time of sensory rejection (Dillard 1993)

IV. CONCLUSION

Although food spoilage is a major economical loss, the underlying integrated mechanism is still poorly understood.

There is a need for the identification and control of growth of specific spoilage organism (SSO) present on different food commodities. As yet not many SSO have been identified.

Therefore, the estimation of the quality of a food product still relies on the qualification of total number of microorganisms, which is some cases is a very poor reflection of the quality

In addition to the identification of SSO, a better understanding of the complex interaction between SSO and other microorganisms or their metabolites is needed.

Finally the interaction between microbial spoilage and chemical spoilage has to elucidate.

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