Understanding to the shelf-life and product stability of foods.

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Abstract

Microorganisms act on the nutrients of the food for their own survival; consequently it involves changes in the food compound like synthesis a new compound which cause spoiling of the food or produced enzymatic changes and contributing off-flavours by mean of breakdown of product. In this regard it is vital to increase the desirable effect by microbes and prevent undesirable product to food such as deterioration of the food by microorganisms by means of Minimize the contact between microorganisms and food, eliminate microorganisms from foods, and understand about preservation of the food. The aim of this paper is extended to indicate the shelf life and stability of foods including injera which is functional for all types of food items. Moreover, food quality loss can be described in terms of a number of compositional factors, such as concentration of reactive species, microorganism levels, catalysts, reaction inhibitors, pH and water activity, as well as environmental factors which include temperature, relative humidity, light, mechanical stress and total pressure. Understanding the properties and composition of food products enables one for a better option for maintaining food quality at desirable level of properties or nature for their maximum benefits in this regard food grade additives and packaging is one of preservation methods which increase the shelf life of foods and ensures food safety.

Keywords: Food, Preservation, Intrinsic factors, Extrinsic factors, Shelf-life stability of food.

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Introduction

Injera is thin, fermented Ethiopian traditional bread made from flour, water and starter, which is a fluid, saved from previously fermented dough. Food preservation is an action or a method of maintaining food at desirable level of properties or nature for their maximum benefits. Using of different preservation techniques alone has a contribution for food preservation. Whereas, a combination of several preservative methods is better to preserve foods from all aspects of microbial stability and safety as well as sensoric and nutritional quality. The shelf-life of a food is the period for which it remains safe and suitable for consumption. This means that the food has not deteriorated in quality or spoiled in any way that the consumer would find unacceptable. Preservatives are additives that primarily contribute to food safety and the prevention of food spoilage. Food additives are generally added to processed foods to prolong the shelf-life by protecting food against deterioration caused by microorganisms. Generally used to inhibit yeast and mould growth, being also effective against a wide range of bacteria. These compounds are most active in foods of low pH value and essentially ineffective in foods at neutral pH values. Generally, maintaining intrinsic and extrinsic factor of the food enable to maintain the shelf life of foods and ensuring food safety [1].

Factors Affecting Shelf Stability of Food

Food quality loss can be described in terms of a number of compositional factors, such as concentration of reactive species, microorganism levels, catalysts, reaction inhibitors, pH and water activity, as well as environmental factors which include temperature, relative humidity, light, mechanical stress and total pressure. Intrinsic factors are influenced by such variables as raw material type and quality, and product formulation and structure. They include the following: Water activity, pH value and total acidity; type of acid; Redox potential (Eh); Available oxygen; Nutrients; Natural microflora and surviving microbiological counts; Natural biochemistry of the product formulation and use of preservatives in product formulation. Extrinsic factors are those factors the final product encounters as it moves through the food chain. They include the following: Time temperature profile during processing; pressure in the headspace; Temperature control during storage and distribution; Relative Humidity (RH) during processing, storage and distribution; Exposure to light during processing, storage and distribution; Environmental microbial counts during processing, storage and distribution; Composition of atmosphere within packaging; Subsequent heat treatment and Consumer handling [2]. All these factors can operate in an interactive and often unpredictable way, and the possibility of interactions must be investigated. A particularly useful type of interaction occurs when factors such as reduced temperature, mild heat treatment, antioxidant action and controlled atmosphere packaging operate in concert to restrict microbial growth, the so-called ‘hurdle effect’. This way of combining factors which, individually, are unable to prevent microbial growth but, in combination, provide a series of hurdles which do so, allows manufacturers to use milder processing techniques which retain more of a product’s sensory and nutritional properties. The interaction of such intrinsic and extrinsic factors as these either inhibits or stimulates a number of processes which limit shelf-life.

Intrinsic factors

Intrinsic parameters are properties that exist as part of the food product itself. These parameters are: pH, moisture content, oxidation-reduction potential (Eh), nutrient content, antimicrobial constituents, and biological structures. Under a set of conditions, these parameters promote microbiological growth.

PH: The growth and metabolism of microorganisms are influenced by pH. pH is an important factor affecting growth of microorganisms in food because it affects: Microbial energy metabolism involving the buildup of hydrogen ion concentration gradients across membrane and Microbial enzyme activity and stability of cellular macromolecules. Bacteria tend to be more fastidious in their relationships to pH than molds and yeasts, with the pathogenic bacteria being the most fastidious. Most foods are at least slightly acidic, since materials with an alkaline pH generally have a rather unpleasant taste. Some foods are characterized by inherent acidity; others owe their acidity or pH to the actions of certain microorganisms. The latter type is referred to as biological acidity and is displayed by products such as fermented milks, sauerkraut, and pickles. The acidity of a product can have important implications for its microbial ecology and the rate and character of its spoilage.

Moisture content: The water requirement of microorganisms is described in terms of the water activity in the environment. This parameter is defined by the ratio of the water vapor pressure of food substrate to the vapor pressure of pure water at the same temperature. It may act as a reactant, or as a solvent, where it may exert a dilution effect on the substrates, thus decreasing the reaction rate. Water may also change the mobility of the reactants by affecting the viscosity of the food systems and form hydrogen bonds or complexes with the reacting species. Thus, a very important practical aspect of aw is controlling undesirable chemical and enzymic reactions that reduce the shelf life of foods [3].

Redox potential: The oxidation-reduction potential is a physicochemical parameter that determines the oxidizing or reducing properties of the medium, and it depends on the composition of the food, pH, temperature, and, to a large extent. Eh plays an important role in the cellular physiology of microorganisms, such as growth capacity, enzyme expression, and thermal resistance. demonstrated that reducing the Eh of orange juice using gas immediately after heat treatment maximized microbial destruction during pasteurization, prevented the development of microorganisms, and stabilized color and ascorbic acid during storage at 15°C. An oxidation-reduction reaction occurs as the result of a transfer of electrons between atoms or molecules. In living cells an ordered sequence of both electron and hydrogen transfer reactions is an essential feature of the electron transport chain and energy generation by oxidative phosphorylation. The tendency of a medium to accept or donate electrons, to oxidize or reduce, is termed as redox potential (O/R potential) which is expressed by the symbol Eh.

Nutrient content: In order to grow and function normally, the microorganisms of concern in the food industry require: water, source of energy, source of nitrogen, vitamins and related growth factors, and minerals. As sources of energy, foodborne microorganisms may utilize sugars, alcohols, and amino acids. Some microorganisms are able to utilize complex carbohydrates such as starches and cellulose as sources of energy by first degrading these compounds to simple sugars. Fats are also used by microorganisms as sources of energy, but these compounds are attacked by a relatively small number of microbes in foods.

Antimicrobial constituents: The stability of some foods against attack by microorganisms is due to the presence of certain naturally occurring substances that have been shown to have antimicrobial activity. As a line of defense to attack by microorganisms, the product tissues may contain antimicrobial components, local concentration of which often increases as a result of physical damage. Many natural constituents of plant tissues such as pigments, alkaloids and resins have antimicrobial properties. Classes of antimicrobials known collectively as phytoalexins are produced by many plants in response to microbial invasion. Antimicrobial components differ in their spectrum of activity and potency, they are present at varying concentrations in the natural product, and are frequently at levels too low to have any effect.

Biological structures: The natural covering of some food sources provides excellent protection against the entry and subsequent damage by spoilage organisms. Examples of such protective structure are testa of seeds, the outer covering of fruits, the shell of nuts, the hide of animals, and the shells of eggs. They are usually a composed of macromolecules relatively resistant to degradation and provides an inhospitable environment for micro-organisms by having a low water activity, a shortage of readily available nutrients.

Extrinsic factors

The extrinsic parameters of foods are not substrate dependent. Extrinsic parameters are those properties of the environment that exist outside of the food product which affect both the foods and their microorganisms. Those of greatest importance to the welfare of food borne organisms are temperature of storage, relative humidity of environment, presence and concentration of gases and presence and activities of other microorganisms.

Temperature of storage: Microorganisms, individually and as a group, grow over a very wide range of temperatures. Therefore, it is well to consider the temperature of growth ranges for organisms in order to select the proper temperature for the storage of different types of foods. Microbial growth can occur over a temperature range from about -8°C up to 100°C, at atmospheric pressure. Microbial growth is accomplished through enzymatic reactions. As temperature influences enzyme reactions it has an important role in microbial growth in food. Microorganisms important in foods are divided into three groups on the basis of their temperature of growth, each group having an optimum temperature and a temperature range of growth: thermophiles, with optimum at 55°C and range 4570°C; mesophiles, with optimum at 35°C and range 10-45°C; and psychrophiIes, with optimum at 15°C and range -5 to 20°C. When the foods are exposed to temperatures beyond the maximum and minimum temperatures of growth, microbial cells die rapidly at higher temperatures and relatively slowly at lower temperatures. Influence of temperature on microbial growth and viability is important in reducing food spoilage, enhancing safety against pathogens, and in food bioprocessing [4].

Relative humidity of environment: The RH of the storage environment is important both from the standpoint of aw within foods and the growth of microorganisms at the surfaces. Relative humidity is essentially a measure of the water activity of the gas phase. When food commodities having a low water, activity are stored in an atmosphere of high relative humidity water will transfer from the gas phase to the food and the foods pick up moisture until equilibrium has been established. Likewise, foods with a high aw lose moisture when placed in an environment of low RH.

Presence and concentration of gases: Oxygen comprises 21% of the earth's atmosphere and is the most important gas in contact with food under normal circumstances. Its presence and its influence on redox potential are important determinants of the microbial associations that develop and their rate of growth. Carbon dioxide is the single most important atmospheric gas that is used to control microorganisms in foods. An increase in the proportion of carbon dioxide and/or a reduction in the proportion of oxygen within specified limits maintain the original product quality and extend the product shelf life. This is achieved by: inhibiting bacterial and mould growth, reducing oxidative changes and controlling biochemical and enzymatic activity to slow down senescence and ripening. CO_2 inhibits microbial activity in two ways: it dissolves in water in the food to form mild carbonic acid and thus lowers the pH of the product; and it has negative effects on enzymic and biochemical activities in cells of both foods and micro-organisms.

Intrinsic	Extrinsic
Microbiological of raw materials	Good manufacturing and hygiene practice
Raw material history	Hazard analysis control point
Food assessment and structure	Food processing
PH	Storage temperature
Types of acid present	Gas atmosphere
Water activity (aw)	Relative humidity
Redox potential (Eh)	Packaging
Biological structure	Retail practices
Oxygen availability	Customer practice
Nutritional content and availability	
Antimicrobial constituent	

Table 1: *Intrinsic and extrinsic properties of the food.*

Shelf-Life Stability

Shelf life of a food product may be defined as the time between the production and packaging of the product and the point at which it becomes unacceptable under defined environmental conditions.

Storage and distribution are necessary links in the food chain. Quality considerations dictate the conditions and maximum duration of these links in the chain although most food deteriorations take place gradually.

A total quality approach must embrace all aspects of a food from its conception, through development and production to its consumption, and for a manufactured food product this will include:

- Product design (including hazard analysis and risk assessment to ensure safety).
- Specification and testing of ingredients and packaging materials.
- Manufacturing processes.
- Transport, storage and retail display
- Storage at home and consumption Since the food must be safe and have an acceptable quality when consumed, the time for which this is maintained the shelf life is therefore an essential aspect of product design the control of which is a requirement of Good Manufacturing Practice (GMP) as well as a requirement of the international standard for quality systems, ISO 9001. Shelf-life determination of a new product often requires storage for significant periods, and includes samples from early development stages as well as initial production runs.

Direct method for shelf-life determination of foods

The most common and direct way of determining shelf-life is to carry out storage trials of the product under controlled conditions that simulate those it is likely to encounter during storage, distribution, retail display and consumer use.

The method involves: Identification of causes for spoilage of food; selection of suitable tests for determining spoilage of food; planning of shelf-life study; running the shelf-life study; determination of the shelf life and monitoring the shelf life.

Indirect methods for determination of shelf life of food

The food industry has a great need to obtain, in a relatively short time. Consequently, procedures have been developed to predict or estimate shelf-lives quickly. Indirect methods attempt to predict the shelf life of a product without running a full-length storage trial; hence, they can be useful for products with long shelf lives. The two most common indirect methods are accelerated shelf-life studies and predictive modeling for shelf life. There are number of approaches to Accelerated Shelf-Life Testing (ASLT) but all are concerned with how to get reliable deterioration data in a short period, what model to use and how eventually to predict the actual shelf-life of the product.

- In principle, accelerated shelf-life testing is applicable to any deterioration process that has a valid kinetic model.
- That process may be biochemical, chemical, microbiological or physical.
- In practice, most accelerated tests have been done on deterioration processes that are chemical in nature.
- The basic idea is that the rate of a shelf-life limiting chemical reaction is increased at an elevated storage temperature.
- The end of shelf-life is thereby reached much quicker and the data obtained can be extrapolated to provide an estimate of the shelf-life at normal or ambient storage conditions, usually by using the Arrhenius relationship.

Accelerated shelf-life testing: Food manufacturers are under increasing pressures to introduce attractive new products into retail outlets with minimum delay, and legislation in many countries demands some form of sell by or use by labelling. While this is feasible for short shelf-life products, the introduction of new long shelf-life products requires knowledge of the storage characteristics over the intended shelf-life period, and can introduce unacceptable delays. The basic premise of an accelerated test is that by changing a storage condition, the chemical or physical process that leads to deterioration is accelerated, and that a predictive shelf-life relationship related to ambient conditions can be defined. The key to this premise is the assumption that the deteriorative process limiting shelf-life remains the same under the two conditions. If this is not the case, and another deteriorative process dominates at the abuse condition, then a valid relationship is not attainable. It is also often assumed that accelerated deterioration can be achieved by raising the storage temperature, using an Arrhenius model.

Predictive models: The food industry has long been interested in ways of predicting rates of deteriorative change resulting from differing combinations of intrinsic and extrinsic factors. With the increasing capabilities and availability of personal computers, predictive modelling, particularly of microbiological behaviour, has become a major area of research. Such models look for statistical and mathematical relationships between three sets of variables: intrinsic (product related) factors; extrinsic (environmental) factors; and implicit factors, the characteristics of the microorganism itself and how it behaves in the presence of combinations of intrinsic and extrinsic factors.

Measuring Shelf-Life

Sensory panels

Measurement of the changes in eating quality on storage requires the use of sensory techniques. There are substantial difficulties in ensuring high quality sensory data over long test periods, and instrumental methods can be an important back-up to sensory methods, provided that their limitations are recognised.

Instrumental methods

Sensory measures of quality changes on storage are an essential measure of perceived quality, but are expensive and time-consuming to operate. They also suffer from high variability when carried out over long time periods, requiring regular panel calibration. If valid instrumental methods are available, they can be of great value in augmenting sensory data.

Physical measurements

The most commonly used physical tests measure the changes in the texture of products. These changes may be the result of chemical reactions occurring in the product, such as those caused by interaction of ingredients or by environmental influences, such as moisture migration through the packaging. Methods of measurement for texture have to be chosen carefully so that the results correlate well with the textural changes as perceived by the use of sensory panels measuring attributes such as hardness, crispness and snap are commonly used during shelf-life testing.

Chemical measurements

Chemical analyses play a vital role in shelf-life testing as they can be used either to measure the end points of chemical reactions occurring in food during storage, or to confirm the results obtained by the sensory panels. Some examples of product deterioration caused by chemical reactions within the food [5].

Microbiological measurements

There are two important aspects to be considered in determining the microbiological stability of a product: Microbial growth, which leads to the spoilage of a food product; and the growth of microbial pathogens that affect the safety of the product. The water activity, storage temperature, time and pH can be used to predict to a large extent the micro-organisms that are likely to grow in the product. The ‘time to spoilage’ can be determined by storing the product at the appropriate temperature and measuring the microbial load at staged intervals. The time to reach a pre-determined level of microbial count will be considered to be the end-point. Since it is advisable to leave a safety margin in setting the shelf-life, generally 70% of the time to spoilage is taken to be the storage life.

Extending of Shelf-Life

There are a range of points in the food chain where manufacturers can influence the mix of intrinsic and extrinsic factors which affect shelf-life. These include: Raw material selection and quality; Product formulation and assembly; the processing environment; processing and preservation techniques; packaging; storage and distribution and consumer handling. While all of these points are important, two of the most dynamic areas of research are in new processing methods and packaging techniques.

Influence of processing

The initial quality of a food product is determined by the quality of the raw materials and the processing methods used during the manufacture of the product. A wide range of processing techniques is used in the food industry to achieve the required level of sensory and microbiological quality. In the case of a perishable product, the extent to which microbial growth can be controlled after processing and packaging determines the final shelf-life.

Packaging

There are many factors to be considered in choosing the optimal packaging form and material for any particular product, including the product characteristics, processing considerations, shelf-life required and overall cost. Advances in packaging materials and techniques have increased the options available for maintaining quality and for improving the shelf-life of foods.

Conclusion

Food preservation is an action or a method of maintaining food at desirable level of properties or nature for their maximum benefits. Preservatives are additives that primarily contribute to food safety and the prevention of food spoilage. Advanced packaging materials also used to maintain quality and for improving the shelf-life of foods. In this regard, both preventive additives and Packaging have recommended to enhancing the shelf- life of food such as Injera.

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