FOOD PROCESSING AND PACKAGING TECHNOLOGY

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PREFACE

The book provides the basic and prime information on the various dimensions of food processing. Proper food processing followed by its suitable packaging provides the consumer safe commodities for consumption. It also raises the public health issues involved in food processing and packaging. The hand book is dedicated to Students, researchers and professionals in the field of food processing technology.

Author

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CHAPTER 1

INTRODUCTION

The relatively recent advent of *in vitro* genetic manipulation has extended the range of products that may be produced by microorganisms and has provided new methods for increasing the yields of existing ones. The commercial exploitation of the biochemical diversity of microorganisms has resulted in the development of the fermentation industry and the techniques of genetic manipulation have given this well-established industry the opportunity to develop new processes and to improve existing ones. Microorganisms are capable of growing on a wide range of substrates and can produce a remarkable spectrum of products. Food processing involves the conversion of raw ingredients into more acceptable food forms. Food processing is related to crops after harvesting, animal products prepared after slaughtering of animals and converting these products to appeal the general consumers for market profitability and for increasing the storage life of the finished processed products. Animal and fish feeds are also manufactured by this same mechanism of processing.

Food processing has also gained its importance in the wide variety of diet among people throughout the globe and availability of exotic food items at various places. Processing of food items enhance the taste, flavor and aroma of the food thereby increasing the overall chances of its acceptability among the masses.

The fermentation technology under controlled conditions is an age old practice both in households and industries for food processing and preservation, be it alcoholic beverage products of edible products derived from vegetable, fish and meat sources. Fermentation is brought about by the conversion of sugars into ethanol chemically. The fermentation technology applicable to

food processing sector is also popularly known as zymology or zymurgy. Fermentation is an important and popular technique in food processing technology. It is resulted from the chemical reaction resulting from the breakdown of higher carbohydrates to alcohols and organic acids or alcoholic derivatives.

There are several advantages of proper food processing under controlled and regulated conditions. It implies the decrease or removal of the content of anti-nutritional factors from the food, increase in shelf-life for prolonged preservation, ease in marketing and increase in consumer demands and increment in the quality and consistency of the finished processed food. It also increases the availability of many food items during off-seasons, increases the convenience in transportation of food items over long distances by decreasing the chances of rotting of mainly perishable food items and increasing the safety for consumption by deleting pathogenic microorganisms which cause spoilage. Food processing at certain places can also be used to reduce the conditions of food shortage and by supplementation of nutritious and safe food for the masses.

CHAPTER 2

PATHOGENIC FACTORS INVOLVED AND THEIR ELIMINATION DURING PROCESSING

The modern methods of processing decreases the risk of health hazards to consumers from diabetics, allergies etc. Food processing also involves fortification for the production of neutraceuticals and energy supplements with addition of probiotics, prebiotics, certain important vitamins and mineral elements within standard permissible limits which are rather present in natural food in very scarce quantity.

The production of ethanol is affected by the substrate concentration higher substrate concentration may achieve higher ethanol production, but a longer incubation time was required for higher initial glucose concentrations. Moreover, higher initial glucose concentrations may have actually decreased the ethanol conversion efficiency when the pH value is not controlled, since the higher substrate and production concentrations may have inhibited the process of ethanol fermentation. More substrate did not improve the specific ethanol production rate when the pH value is not controlled. Temperature has an impact on the growth and activity of different strains of yeast. At temperatures of 10 to 15°C, the non-Saccharomyces species have an increased tolerance to alcohol. It has the potential to contribute to the fermentation when the temperature increased; the maximum fermentation time gets shortened. A much higher temperature inhibited the growth of cells and then the fermentation significantly declined. [10] As food processing decreases the population or load of pathogenic microorganisms in food and neutralizes the harmful mycotoxins, if present therein. So, it reduces the chances of food-borne diseases caused by microorganisms like Salmonella etc. which can harbor in raw meat and incidences of mycotoxicoses (majorly, aflatoxicosis, ochratoxicosis and zearalenone) due to

prolonged improper storage of food thereby causing human illnesses.[8] Processing involves various methods among which cooking is a very popular and widely used method which involves the modification by blending etc. of naturally available unprocessed food ingredients. In our nowadays fast paced lifestyle where every family member is on a go for financial security, processed food products have gained its important position in daily livelihood by offering ready prepared wholesome and nutritious meals within short period.

Before deciding which packaging material is to be used, it is necessary to know the packaging requirements of the product i.e. what hazards will cause product deterioration and the conditions to which the packaged product will be subjected throughout its shelf-life. The advancements in food technology and packaging technology have made it possible to extend the shelf-life of these products. Some important packaging considerations, which influence the selection criteria for choosing packaging materials, are highlighted.

CHAPTER 3

FOOD PACKAGING AND PROCESSING

Chemical protection minimizes compositional changes triggered by environmental influences such as exposure to gases (typically oxygen), moisture (gain or loss), or light (visible, IR or UV). [6] Many different packaging materials can provide a chemical barrier. Glass and metals provide a nearly absolute barrier to chemical and other environmental agents, but few packages are purely glass or metal since closure devices are added to facilitate both filling and emptying. Closure devices may contain materials that allow minimal levels of permeability. For example, plastic caps have some permeability to gases and vapors, as do the gasket materials used in caps to facilitate closure and in metal can lids to allow sealing after filling. Plastic packaging offers a large range of barrier properties but is generally more permeable than glass or metal. Proper and ideal food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food. In doing so, packaging provides protection from 3 major classes of external influences: chemical, biological, and physical.

Vacuum packaging involves placing a product in a film of low oxygen permeability, the removal of air from package and the application of a hermetic seal. Exclusion of the air from the package and thus creating a vacuum is, in effect, a certain type of modification of the atmosphere. The little gaseous atmosphere likely to be present in the beginning in the package will undergo changes during storage because of the metabolism of the product and/or action of micro-organisms and all the volatiles produced as a result of the decomposition are sealed within the package. Food processing whenever performed in large mass is comparatively cheaper than

processing and modification of individual ingredients. So, the food processing sector implies a huge margin of profit for processed food manufacturers and retailers in the supply chain.

CHAPTER 4

EFFECT ON FOOD'S PHYSICAL AND CHEMICAL PARAMETERS

This oxidation can reduce the nutritive quality by decreasing the content of essential fatty acids, such as linolenic acid (C18:3) and linoleic acid (C18:2), which are essential fatty acids. The hardness of cereals increased with moisture content for each extrusion temperature. [14] In general, the hardness of extruded cereal exhibited an inverse relationship with extrudate expansion, as observed in several studies on extruded products where hardness was represented by instrumentally measured mechanical properties such as compression modulus and crushing stress. Hardness is greatly affected by the expansion of the extrudates. Fermentation technology is primarily employed for the preservation of different food by production of acids and alcohols, biological fortification and enrichment of food items with potential biogenic products. Lipid oxidation is the major chemical challenge for preservation of food.

Like other heating methods, microwaving converts vitamin B_{12} from an active to inactive form. The amount inactivated depends on the temperature reached, as well as the cooking time. Steamed vegetables tend to maintain more nutrients when microwaved than when cooked on a stovetop. Microwave blanching is 3-4 times more effective than boiled water blanching in the retaining of the water-soluble vitamins folic acid, thiamin and riboflavin, with the exception of ascorbic acid, of which 28.8% is lost (vs. 16% with boiled water blanching). The use of microwave oven provides a convenient way to thaw, cook and reheat foods. However, the safety of the microwaved food has on and off aroused some public interest. Once microwave energy is absorbed, polar molecules and ions inside the food will rotate or collide according to the alternating electromagnetic field and heat is subsequently generated for cooking. Hygiene

protocols for the finished processed food product are evaluated as per HACCP guidelines to minimize the risk of potential health hazards among consumers. Baking is nowadays a more preferable technique of food processing rather than frying on grounds of long-term health benefits and retaining the natural taste and flavor of the finished product. Use of artificial sweeteners and leavening agents also impose long-term serious health risks to regular consumers by acting as diabetics.

Penetration depth of microwaves is dependent on food composition. Lower microwave frequencies with longer wavelengths have more penetrating effect. For cooking or reheating small amounts of food, the microwave oven may use less energy than a cook stove. Although microwave ovens are touted as the most efficient appliance, the energy savings are largely due to the reduced heat mass of the food's container. Microwaves are a form of non-ionizing electromagnetic radiation with a frequency higher than ordinary radio waves but lower than infrared light. Microwaves refer to the electromagnetic waves in the frequency range of 300 to 300,000 MHz. A microwave oven heats food by passing microwave radiation through it. [15, 16]

Processing techniques can be lengthy and time consuming sometimes depending on the type of food being processed and it needs the control and regulation of certain parameters for processing which includes hygiene which is assessed by the microbial load in the processed food product, efficiency in energy utilization, minimum waste generation, effective labour saving and minimization of cleaning requirements.

CHAPTER 5

LIMITATIONS

There exist certain limitations of food processing also. For example, during processing by heating the concentration of vitamin C is reduced, as it is heat-sensitive. Generally, food processing techniques reduce the nutritional quantity in very negligible amount of nearly 5-20%. Food processing involves the use of food additives, which sometimes prove to be detrimental to public health. There exists a specified level of individual feed additive during processing technique and which is approved for safe consumption of human beings and signifies the quantity of the additive to be incorporated in the finished processed food item.

Food processing involves many mechanisms like mixing, grinding, chopping and emulsifying during the whole process of production, which indirectly increase the chances of contamination and admixtures with undesirable foreign elements. Sometimes, packaging containers also pose a threat for public contamination when exposed to thorough procedures of continuous processing by leaching of the chemical components from the containers into the food item to be processed. [13]

In food manufacturing practices, using metal detectors decrease the risk of contamination with metal fragments during the processing technique. In large food processing equipments are fitted with many metal detectors at several positions to negate the chances and risks of metal contamination of processed food products. In 1947, the first industrial purpose metal detector was introduced by Goring Kerr.

CHAPTER 6

Popular processing techniques

The popular processing techniques in food sector are canning, fish processing, industrial rendering, tanneries, meat packing plants, slaughter houses, sugar industries and vegetable packaging plants. There are certain risks and health hazards associated with excess and regular consumption of fermented food products. Currently, extrusion-cooking as a method is used for the manufacture of many foodstuffs, ranging from the simplest expanded snacks to highly-processed meat analogues.

CHAPTER 7

Fermentation technology

Fermentation is a microbial technique and the reaction to be controlled in favorable and desirable conditions for food safety and quality after fermentation, especially in the production of alcoholic premium quality beverages like beer, wine and cider. The same technology is employed in the bred manufacturing industries for leavening activity brought about by the production of carbon dioxide by the microbial or yeast activity. The preservation effect during fermentation is attributed to the production of lactic acid in sour foods such as yoghurt, dry sausages, pickles, sauerkraut and vinegar (extremely diluted acetic acid).

The fermentation technology under controlled conditions is an age old practice both in households and industries for food processing and preservation, be it alcoholic beverage products of edible products derived from vegetable, fish and meat sources. Fermentation is brought about by the conversion of sugars into ethanol chemically. The fermentation technology applicable to food processing sector is also popularly known as zymology or zymurgy. Fermentation is an important and popular technique in food processing technology. It is resulted from the chemical reaction resulting from the breakdown of higher carbohydrates to alcohols and organic acids or alcoholic derivatives.

Microorganisms are capable of growing on a wide range of substrates and can produce a remarkable spectrum of products. The relatively recent advent of *in vitro* genetic manipulation has extended the range of products that may be produced by microorganisms and has provided new methods for increasing the yields of existing ones. The commercial exploitation of the

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CHAPTER 8

Food packaging

Proper and ideal food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food. In doing so, packaging provides protection from 3 major classes of external influences: chemical, biological, and physical. Chemical protection minimizes compositional changes triggered by environmental influences such as exposure to gases (typically oxygen), moisture (gain or loss), or light (visible, IR or UV). Many different packaging materials can provide a chemical barrier. Glass and metals provide a nearly absolute barrier to chemical and other environmental agents, but few packages are purely glass or metal since closure devices are added to facilitate both filling and emptying. Closure devices may contain materials that allow minimal levels of permeability. For example, plastic caps have some permeability to gases and vapors, as do the gasket materials used in caps to facilitate closure and in metal can lids to allow sealing after filling. Plastic packaging offers a large range of barrier properties but is generally more permeable than glass or metal.

CHAPTER 9

Factors regulating the process of fermentation

Temperature has an impact on the growth and activity of different strains of yeast. At temperatures of 10 to 15°C, the non-Saccharomyces species have an increased tolerance to alcohol and therefore have the potential to contribute to the fermentation when the temperature increased, the maximum fermentation time gets shortened, but a much higher temperature inhibited the growth of cells and then the fermentation significantly declined.

The production of ethanol is affected by the substrate concentration higher substrate concentration may achieve higher ethanol production, but a longer incubation time was required for higher initial glucose concentrations. Moreover, higher initial glucose concentrations may have actually decreased the ethanol conversion efficiency when the pH value is not controlled, since the higher substrate and production concentrations may have inhibited the process of ethanol fermentation. More substrate did not improve the specific ethanol production rate when the pH value is not controlled.

The advancements in food technology and packaging technology have made it possible to extend the shelf-life of these products. Before deciding which packaging material is to be used, it is necessary to know the packaging requirements of the product i.e. what hazards will cause product deterioration and the conditions to which the packaged product will be subjected throughout its shelf-life. Some important packaging considerations, which influence the selection criteria for choosing packaging materials, are highlighted.

CHAPTER 10

Physical and chemical factors influencing the process of extrusion

Expansion ratio (ER):

When moisture content of the feeding material increases, there is decrease in the specific mechanical energy (SME), apparent viscosity, and radial ER during extrusion of maize grits. A sharp decrease in volumetric expansion with increased moisture content is found to be evident by the shrinkage and collapse of the extrudate after maximum expansion. Most studies recognize that gelatinized starch plays a major role in expansion by providing the gas-holding capacity to the extrudate melt, whereas other ingredients such as proteins, sugars, fats, and fiber act as diluents or dispersed phase fillers that reduce the stretchability of the starchy matrix.

Water hydration (WH):

WH capacity increased with extrusion temperature and, in general, at any specific extrusion temperature WH decreased with increased moisture content. Higher WH might result from a greater extent of starch gelatinization. WH also is greatly affected by the degree of porosity or expansion of the extrudate, as higher porosity and thinner cell walls in the extrudates lead to greater water absorption.

Lipid oxidation is the major chemical challenge for preservation of food. This oxidation can reduce the nutritive quality by decreasing the content of essential fatty acids, such as linolenic acid (C18:3) and linoleic acid (C18:2), which are essential fatty acids. The hardness of cereals increased with moisture content for each extrusion temperature. In general, the hardness of

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CHAPTER 11

Efficiency of heating in Microwave cooking

Microwaves are a form of non-ionizing electromagnetic radiation with a frequency higher than ordinary radio waves but lower than infrared light. Microwaves refer to the electromagnetic waves in the frequency range of 300 to 300,000 MHz. A microwave oven heats food by passing microwave radiation through it. Penetration depth of microwaves is dependent on food composition. Lower microwave frequencies with longer wavelengths have more penetrating effect. For cooking or reheating small amounts of food, the microwave oven may use less energy than a cook stove. Although microwave ovens are touted as the most efficient appliance, the energy savings are largely due to the reduced heat mass of the food's container.

CHAPTER 12

Influence of microwave cooking on food composition and nutritional value

The use of microwave oven provides a convenient way to thaw, cook and reheat foods. However, the safety of the microwaved food has on and off aroused some public interest. Once microwave energy is absorbed, polar molecules and ions inside the food will rotate or collide according to the alternating electromagnetic field and heat is subsequently generated for cooking. Like other heating methods, microwaving converts vitamin B_{12} from an active to inactive form. The amount inactivated depends on the temperature reached, as well as the cooking time. Steamed vegetables tend to maintain more nutrients when microwaved than when cooked on a stovetop. Microwave blanching is 3-4 times more effective than boiled water blanching in the retaining of the water-soluble vitamins folic acid, thiamin and riboflavin, with the exception of ascorbic acid, of which 28.8% is lost (vs. 16% with boiled water blanching).

CHAPTER 13

Conclusion

There are certain risks and health hazards associated with excess and regular consumption of fermented food products. Currently, extrusion-cooking as a method is used for the manufacture of many foodstuffs, ranging from the simplest expanded snacks to highly-processed meat analogues.

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Dr. Subha Ganguly, B.V.Sc. & A.H. (Gold Medalist), M.V.Sc. (First Rank), NET Qualified, Ph.D. (Microbiology), Executive-MBA (HRM), D.Sc. (Honoris Causa) is currently working as Associate Professor and HEAD of the Department of Veterinary Microbiology at Arawali Veterinary College (affiliated with Rajasthan University of Veterinary and Animal Sciences, Bikaner and managed by Aastha Society, Sikar), V.P.O. Bajor, Dist. Sikar, Rajasthan, India. Dr. Ganguly earlier served as Scientist (Food Microbiology) and Scientist In-charge, Sub-Projects, in the All India Coordinated Research Project on Post Harvest Technology (ICAR) at Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, WB, India. Dr. Ganguly has handled many projects as Team leader funded by Indian Council of Agricultural Research (ICAR), New Delhi. Dr. Ganguly has characterized and identified two novel bacterial strains isolated from fermented fishery product of North-East India which have been registered in NCBI/ GenBank database with Accession numbers KF319057 and KF319058 respectively. Dr. Ganguly has represented the Department of Veterinary Microbiology as Head of the Department during annual inspection for evaluation of standard of teaching, academics and research at Arawali Veterinary College, Sikar by experts from Rajasthan University of Veterinary and Animal Sciences (RAJUVAS), Bikaner regarding sustenance of the affiliation and Veterinary Council of India (VCI), New Delhi for continuing VCI recognition of the college for running B.V.Sc. & A.H. degree programme respectively. Dr. Subha Ganguly has been conferred with the "Young Scientist of the Year Award 2014" in recognition of his Doctoral research in MICROBIOLOGY and scientific expertise in FOOD SCIENCE by the Foundation for Science and Environment, Kolkata, India (Hon'ble President: Prof. Dr. Samir Banerjee, Retd. Dean & Head, Department of Zoology, University of Calcutta, India) in association with Confederation of Indian Universities, New Delhi (Hon'ble President: Chancellor Dr. P.R. Trivedi) and Scientific and Environmental Research Institute, Kolkata, India and "Young Performer Award" by the Association of Pharmacy Professionals, Bhopal, India. For his untiring and relentless hard work in the field of science, education and technology, Dr. Ganguly has been conferred with the distinction "American Order of Merit (AOM)" by the American Biographical Institute, USA, "Bharat Gaurav Award 2015" and "Rashtriya Gaurav Award 2016" in Science and Technology by India International Friendship Society (Regd.), New Delhi, India and "Best Citizens of India Award" by International Publishing House, New Delhi, India with citation published in the book entitled "The Honoured Best Citizens of India" published by International Publishing House, New Delhi. Dr. Ganguly is a recipient of the "Eminent Teacher Award 2015" for his impactful, eminent and luminous teaching career from the Research Scholar Hub Society (Regd.), Gujarat, India and honored with DR. A.P.J. ABDUL KALAM AWARD FOR TEACHING EXCELLENCE 2016 sponsored by Marina Labs (Research and Development), Chennai, India. Dr. Ganguly is also conferred as Honorary Fellow, Society for Applied Biotechnology, India [FSAB], Fellow, Hind Agri-Horticultural Society, India [FHAS], Fellow, International Science Congress Association, India [FISCA] (now renamed as International Science Community Association), Fellow, Institute of Integrative Omics and Applied Biotechnology, India [FIIOAB], Fellow, International Society of BioTechnology, India [FISBT], Fellow, Academy for Environment and Life Sciences, India [FAELS], Fellow, Society for Advancement of Sciences, India [FSASc], Fellow, Society of Education, India [FSOE], Fellow, Science and Education Development Institute, Nigeria [FSEDInst], Fellow, Association of Pharmacy Professionals, India [FAPP], Fellow, Vital Biotech Research & Training Institute, India [FVBRTI], Fellow, Pharmacy & Life Sciences, India [FPLS], Fellow, International Scientific Research Organization for Science, Engineering and Technology, Indore, India [FISROSET], Honorary and Executive Board Member, Pharma Research Library, India (PRL), Executive Committee Member & Fellow (FRSHS), Research Scholar Hub Society, India (RSHS) and Central Executive Committee Member, Society of Researchers and Health Care Professionals, India (SRHCP) and an Honorary eminent scientist by the International Biographical Centre, Cambridge, England and the American Biographical Institute, USA. Dr. Ganguly has many prominent, noteworthy and exemplary scientific and academic achievements in the field of Microbiology, Veterinary, Animal, Fishery & Food Sciences, Post Harvest and Processing technology, Life Sciences, Bio-sciences and Veterinary Public Health.

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