**EVALUATION OF INDUSTRIAL FOOD FERMANTATION TECHNOLOGY**

Submitted by: Navdeep kumar1, Dhan Singh1 and Lalchand Kumawat2, Manish kumar sonkar3,Biplove bala4, Lalit Kumar verma5

Department of Horticulture, School of Agriculture Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland, 797106. India1

Department of Agronomy, School of Agriculture Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland, 797106. India2

Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana, Visva Bharti University, Bolpur West Bengal, 731235. India3

Department of Entomology, School of Agriculture Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland, 797106. India4

Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences (Deemed to be University) Naini Prayagraj UP, 211007. India5

**INTRODUCTION**

Fermented foods are staples of the human diet and have been produced and used up since the development of human civilizations. The process whereby microorganisms and their enzymes bring about these required changes in food materials is known as fermentation. Food fermentation methods can be categorized by the primary metabolites and microorganisms elaboratelactic acid bacteria (LAB) belonging to genera such as *Leuconostoc, Lactobacillus*, and *Streptococcus*. Fermentations can also be defined based on the food substrates, which include meats and fish, dairy, soybeans and other legumes, cereals, and grapes. Raw materials that contain more concentrations of monosaccharides and disaccharides, or in some cases starch, are fermented through lactic acid bacteria. Lactic acid bacteria (LAB) are a cluster of gram-positive, non-sporulating, anaerobic or facultative aerobic cocci or rods, fastidious on artificial media, but they grow gladly in most food substrates and lower the pH rapidly to a point where competing organism are not one longer able to grow, and it is one of the main fermentation products of the carbohydrates metabolism.

HISTORYOF FERMENTATION ARTAND SCIEN CE

Ancient Egyptians were the rst to ferment alcohol and vinegar from malt grains

and fruits juices during the 1700s. However, they had no understanding of con-

tamination in the fermentation process and the role of microorganisms in fermen-

tation, and the use of specic equipment for production was not yet established

(Gaden, 1982).

In the mid-eighteenth century, Louis Pasteur established the role of yeast in wine

fermentation, and from then on a pure culture was used for quality wine, beer, and

vinegar. During the same time, Carlsberg tried isolating single pure yeast cells for

quality alcohol production. In the late eighteenth century and the early nineteenth

century, use of an aerator for vinegar production was started. Vinegar fermentation

also included a known volume of pasteurized, previously fermented vinegar as an

initial substrate to prevent contamination and to serve as an inoculum. Hence, the

process control of fermentation was initiated (Brinberg, 1953; Herrero, 1969).

The importance of fermentation and production of different products gained atten-

tion in the beginning of the nineteenth century and continued through the middle of

the nineteenth century. Several products were produced via fermentation, namely,

glycerol, baker’s yeast, lactic acid, and acetone butanol.

Production of secondary metabolites via fermentation (such as antibiotics, amino

acids, and vitamins) ourished during the late nineteenth century due to the need to

treat soldiers ghting in World War II. Submerged fermentation with larger volumes

under aerobic conditions with moderate process control was established during this

period. In subsequent years, the fermentation industry has seen constant improve-

ment with leaps and bounds on the production of high-value metabolites, including

various antibiotics and growth hormones, using sophisticated bioreactors (Chiao

and Sun, 2007; Formenti et al., 2014; Humer and Schedle, 2016; Li et al., 2015;

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**HISTORY OF FERMENTATION**

Ancient Egyptians were the first to ferment alcohol and vinegar from malt grains and fruits juices during the 1700s. However, they had no understanding of contamination in the fermentation process and the role of microorganisms in fermentation, and the use of specific equipment for production was not yet established (Gaden, 1982). In the mid-eighteenth century, Louis Pasteur established the role of yeast in wine fermentation, and from then on a pure culture was used for quality wine, beer, and vinegar. During the same time, Carlsberg tried isolating single pure yeast cells for quality alcohol production. In the late eighteenth century and the early nineteenth century, use of an aerator for vinegar production was started. Vinegar fermentation also included a known volume of pasteurized, previously fermented vinegar as an initial substrate to prevent contamination and to serve as an inoculum. Hence, the process control of fermentation was initiated (Brinberg, 1953; Herrero, 1969). The importance of fermentation and production of different products gained attention in the beginning of the nineteenth century and continued through the middle of the nineteenth era. Several products were produced via fermentation, namely, glycerol, baker’s yeast, lactic acid, and acetone butanol. Production of secondary metabolites via fermentation (such as antibiotics, amino acids, and vitamins) flourished during the late nineteenth century due to the need to treat soldiers fighting in World War II. Submerged fermentation with larger volumes under aerobic conditions with moderate process control was established during this period. In consequent years, the fermentation industry has seen constant improvement with leaps and bounds on the production of high-value metabolites, including numerous antibiotics and growth hormones, using sophisticated bioreactors (Chiao and Sun, 2007; Formenti*et* al.,2014; Humer and Schedle, 2016; Li *et* al., 2015; Liu *et* al., 2013; Motarjemi and Nout, 1996).

**FERMENTATIONTECHNOLOGY**

microorganisms, grown on a large scale, to produce valuable commercial products or to carry out important chemicaI transformations

**FERMENTATION**

Pasteur's "life without air'', Latin word ***fervere, to boil***

**SOME IMPORTANT FERMENTATION PRODUCTS**

|  |  |  |
| --- | --- | --- |
| **Product** | **Organism** | **Use** |
| Ethanol | *Saccharomyces cerevisiae* | Industrial solvents, beverages |
| Glycerol | *Saccharomyces cerevisiae* | Productionofexplosives |
| Lacticacid | *Lactobacillus bulgaricus* | Food and pharmaceutical |
| Acetoneand butanol | *Clostridium acetobutylicum* | Solvents |
| α-amylase | *Bacillussubtilis* | Starchhydrolysis |

**THE ROLE OF FERMENTATION TO FOOD**

**1. Flavor Enhancement**

* Fermentation makes the food palatable by enhancing its aroma and flavor.
* These organoleptic properties make fermented food further popular than the unfermented one in terms of consumer acceptance.

**2. Nutritional Quality**

* A number of foods especially cereals are poor in nutritional value, and they constitute the main staple diet of the low-income populations. However, Lactic acid bacteria (LAB)fermentation has been shown to improve the nutritional value and digestibility of these foods. The acidic nature of the fermentation products enhances the activity of microbial enzymes at a temperature range of 22-25ºC.
* The enzymes, which include amylases, proteases, phytases and lipases, modify the primary food products through hydrolysis of polysaccharides, proteins, phytates and lipids respectively. Thus, in addition to enhancing the activity of enzymes, Lactic acid bacteria (LAB) fermentation also reduces the levels of anti-nutrients such as phytic acid and tannins in food leading to improved bioavailability of minerals such as iron, protein and simple sugars. The number of vitamins is also increased in the ferment.

**3. Preservative Properties**

* The preservative activity of Lactic acid bacteria (LAB) has been observed in some fermented products such as cereals, and yogurt.
* The lowering the pH to below 4 through acid production, inhibits the growth of pathogenic microorganisms which can cause food spoilage, food poisoning and disease. For example, Lactic acid bacteria (LAB) has antifungal activities. By doing this, the shelf life of fermented food is extended.

**4. Detoxification**

* Detoxification of mycotoxins in food through Lactic acid bacteria (LAB) fermentation has been demonstrated over the years.
* Using Lactic acid bacteria (LAB) fermentation for detoxification is more advantageous in that it is a minor method which preserves the nutritive value and flavor of purified food. In addition to this, Lactic acid bacteria (LAB) fermentation irreversibly degrades mycotoxins without leaving any toxic residues. The detoxifying effect is believed to be through toxin binding effect.

**5. Antibiotic Activities**

* Lactic acid bacteria (LAB) is applied as a hurdle against non-acid tolerant bacteria, which are ecologically eradicated from the medium due to their sensitivity to acidic environment.
* Also, fermentation has been demonstrated to be further effective in the removal of gram negative than the gram-positive bacteria, which are more resistant to fermentation processing.
* As such, fermented food can control diarrheal diseases in children. Moreover, Lactic acid bacteria (LAB)is also known to produce protein antimicrobial agents such as bacteriocins. Bacteriocins are peptides that elicit antimicrobial activity against food spoilage organisms and food borne pathogens but do not affect the producing organisms. Lactic acid bacteria (LAB) also synthesizes other anti-microbial compounds such as, hydrogen peroxide, reuterin, and reutericyclin.
* Other applications of Lactic acid bacteria (LAB) include their use as probiotics that restore the gut flora in patients suffering from diarrhea, following the usage of antibiotics that destroy the normal flora.

**FERMENTATION TECHNIQUES**

**(A) Surface (solid state) techniques.**

Microorganisms cultivated on the surface of a liquid or solid substrate. Complicated and rarely used in industry.

Mushroom, bread, cocoa, tempeh

**(B) Submersiontechniques.**

Microorganisms aregrow in a liquid medium.

Biomass, protein, antibiotics carried out by submersion processes.

**REQUIREMENTS**

**Pureculture:** organism, quantity, physiological state

**Sterilized medium:** for microorganism growth

**Seed fermenter:** inoculums to initiate process

**Production fermenter:** large model

**Equipment**

i)Drawing the culture medium

ii)Cell separation

iii)Collection of cell

iv)product purification

v)Effluent treatment

**TYPES ON THE BASIS OF CULTURE**

**BATCHFERMENTATION**

Sterile nutrient substrate, inoculated, grow until no more of the product is being made, "harvested" andcleaned out for another run.

**lagphase**(adapttotheirsurroundings)

**exponentialgrowth**(growinnumbers)

**stationaryphase**(stopgrowing)

**deathphase**

**CONTINUOUS FERMANTATION**

Substrate is added continuously to the fermenter, and biomass or products are continuously removed at the same rate. Under these conditions the cells remain in the Logarithmic phase of growth

**FED-BATCHFERMENTATION**

Substrate increments as the fermentation progresses. Started as batch wise with a minor substrate concentration. Initial substrate is consumed, addition of fermentation medium

**RANGEOFFERMENTATION TECHNOLOGY**

|  |  |
| --- | --- |
| Microbialcell(Biomass) | Yeast |
| Microbialenzymes | Glucoseisomerase |
| Microbialmetabolites | PeniciIIin |
| Foodproducts | Cheese,yoghurt,vinegar |
| Vitamins | B12,riboflavin |

**EXAMPLES OF FOODS AND FOOD ADDITIVE MANUFACTURED USING INDUSTRIAL FERMANTATION PROCESSES IN DEVELOPING COUNTRIES.**

|  |  |
| --- | --- |
| **FOODS** | **FOOD ADDITIVE MANUFACTURED** |
| Alcoholic beverages | Wines, beer |
| Milk and milk products | Cultured milks, yogurts, cheeses |
| Flavors | Monosodium glutamate, nucleotides |
| Organic acids | Lactic acid, citric acid, acetic acid |
| Amino acids | Lysine, glutamic acid |
| Vitamins | Vitamins A, C and B12, riboflavin |
| Enzymes | Amylases, proteases, invertases |

**From Deshpande and Salunkhe (2000).**

**ADVANTAGES**

* Preserves and enriches food, improves digestibility, and enhances the taste and flavor of foods.
* Potential of enhancing food safety by governing the growth and multiplication of aamount of pathogens in foods.
* Important contribution to human nutrition particularity in developing countries, where economic problems pose a majorbarrierto ensuringfoodsafety.
* Low energy consumption due to the minor operating conditions relatively low capital and operating costs relatively simpletechnologies.
* Theycauseextremelyspecificandcontrolledchangestofoods by using enzymes.
* Preservationanddetoxificationofthefood.
* Wastetreatment.
* Healthassociatedproduct.

**MAJOR CATEGORIES AND EXAMPLES OF FERMANTED MILK PRODUCTS**

|  |  |
| --- | --- |
| Category | Typical examples |
| **I. Lactic fermantations** | |
| a. Mesophilic | Butter milk, Cultured buttermilk, Langofil, Tetmjolk, Ymer |
| b. Thermophilic | Yogurt, laban, zabadi, labneh, skyr, Bulgarian buttermilk |
| c. Therapeutic | Biogarde, Bifighurt, Acidophilus milk, yakult, Cultura- AB |
| II. Yeast – lactic fermantations | Kefir, koumiss, acidophilus – yeast milk |
| III. Mold – lactic fermantation | Viili |

**Source Table 3.1. p. 58. In B. A. Law, editor, 1997. *Microbiology and Biochemistry of cheese and fermented milk, New York: Chapman and Hall.***

**DISADVANTAGES**

* Hazardous microbial contamination alwaysexistin fermented food.
* The irregular distribution of salt in lactic acidfermented fish products and contamination of *Aspergillusflavus* in traditional startercultures forrice wine and soybean sauce resultin severefoodpoisoning occurrences.
* Health(obesity,cancer)

**C.H. LEE, 1989**

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