

Daria Shlieina
Dmytro Motorny Tavria State
Agrotechnological University
Language adviser: Senior Lecturer Iryna Kryvonos

MODERN TECHNOLOGIES FOR ENSURING FOOD QUALITY AND SAFETY. FERMENTATION AS A TECHNOLOGY OF THE FUTURE

Since ancient times, humans have faced a problem in their daily lives: food spoils faster than it can be eaten. Fresh produce—meat, milk, fish, vegetables, and fruit—loses its quality within a matter of hours or days and becomes unfit for consumption, and sometimes even life-threatening [1]. The cause is microorganisms: bacteria, yeast, and mould, for which food provides an ideal breeding ground. Some of these are relatively harmless, but pathogens such as Salmonella, Listeria, E. coli, or botulism can cause severe food poisoning. The World Health Organization cites striking statistics: every year, around 600 million cases of food poisoning are recorded worldwide, of which almost half a million are fatal. It is, therefore, no surprise that maintaining the quality and safety of food products is one of the most pressing issues in modern science and production [2].

In the 21st century, food quality and safety have become particularly significant. Market globalisation, population growth, climate change, and consumers' heightened demands for natural and environmentally friendly products are forcing the food industry to seek new, effective, and safe food preservation technologies. Modern methods now go beyond traditional preservation, encompassing innovative approaches that not only extend shelf life but also preserve or even enhance the nutritional value of products [2].

Here are some of the so-called traditional methods, which have evolved over centuries and are based on simple physical or chemical principles: reducing water activity, lowering temperature, or creating conditions unfavourable to the growth of microorganisms [1]. They are chilling and freezing, drying, pickling and marinating, and preservation (sterilization and pasteurization).

Although traditional methods are effective, they do not always meet modern standards for quality, safety, and the preservation of nutritional value. This is why innovative preservation technologies are being actively developed in the food industry. These technologies include: high hydrostatic pressure, pulsed electric fields, and biopreservation.

Today, fermentation is regarded not only as a traditional method of preserving food but also as one of the most promising technologies of the future.

Fermentation is a biochemical process during which microorganisms (bacteria, yeast, or fungi) convert organic substances, particularly sugars, into other compounds—organic acids, gases, or alcohols. This creates an environment unfavourable to the growth of pathogenic microorganisms, thereby ensuring the product's natural preservation.

The mechanism of fermentation involves lowering the pH level (through the formation of lactic or acetic acid) and the production of antimicrobial substances. This not only extends the product's shelf life but also enhances its safety.

The advantages of fermentation lie in its natural, eco-friendly nature, as it does not require artificial preservatives. Furthermore, the fermentation process enhances the nutritional value of foods: probiotics are produced, nutrient absorption improves, and the content of certain vitamins, particularly those of the B group, increases. Fermented products also have distinctive tastes and aromas, making them popular with consumers. Examples of fermented products include fermented milk products (yoghurt, kefir), pickled vegetables, sourdough bread, and various beverages. They are widely used in the diets of various people around the world [3].

In today's world, fermentation is actively being combined with scientific and technological advances. In particular, so-called precision fermentation is developing, enabling the production of proteins, enzymes, and other beneficial substances using specifically selected or genetically modified microorganisms [4]. This opens up opportunities to create alternative products, including meat and milk substitutes.

Therefore, maintaining the quality and safety of food products is an extremely important task for modern science and industry. Traditional methods, such as chilling,

drying, pickling, and canning, remain effective and are widely used, but they have certain drawbacks, including nutrient loss and changes in product properties [5]. In this context, innovative technologies such as high hydrostatic pressure, pulsed electric fields and biopreservation are being actively developed. They enable improved food safety whilst better preserving nutritional value and natural properties.

Fermentation occupies a special place among modern approaches, combining the functions of preserving and enhancing product quality. It is a natural, safe, and promising technology that meets contemporary nutritional requirements. Thus, the combination of traditional and innovative methods, along with advances in fermentation, will shape the main directions for future advancement in food technology.

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