Use of Enzymes in Dairy Industry

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OPEN ACCESS

Keywords

Dairy food, Food industry, Enzymes, Microbial, Milk products

How to cite this article:

Waikar, M. A. and Deshmukh, S. V. 2025. Use of Enzymes in Dairy Industry. *Vigyan Varta* 6(3): 108-111.

ABSTRACT

The growing demand for enzymes to create specific products with unique characteristics is evident in the global industrial enzyme market, which was valued at approximately US $3.0 billion in 2008. Microbial enzymes play a vital role in developing milk and dairy products with innovative physical and functional properties in the food industry. Native milk enzymes can be used in various ways during processing, such as monitoring the thermal treatment of milk and enhancing consumer health and food safety by preventing bacterial contamination and growth. In dairy food applications, enzymes like protease are used to reduce the allergic properties of bovine milk products, while lipase helps improve the flavor of cheese.

INTRODUCTION

Enzymes are highly specialized in their function, with each one designed to trigger a particular reaction that leads to a specific outcome (Farkye, 2004). Caseins, which are soluble in acid, are flavourless and can be safely incorporated into beverages and acidic foods through controlled proteolysis. Casein hydrolysates are particularly beneficial for milk-based foods intended for infants allergic to cow's milk (Selamoglu and Khan 2020). Lipolysis plays a key role in shaping the flavour profile of Swiss cheese, while the distinctive peppery taste of blue cheese results from short-chain unsaturated fatty acids and methyl ketones. Several minor enzymes with specialized functions in dairy processes include sulfhydryl oxidase, lactoperoxidase, glucose oxidase, catalase, lysozyme, and superoxide dismutase. Both catalase and glucose oxidase are utilized in food preservation methods. The potential of minor enzymes in dairy products is crucial for enhancing dairy production and advancing dairy technology in the future.

The global market for microbial enzymes in dairy processing is expanding rapidly, although enzyme-producing industries remain limited. The production of enzymes like proteinase, lactase, lipase, and microbial rennet is growing in laboratory and small-scale settings. In the near future, the demand for these enzymes is expected to rise significantly, driven by the need for nutritionally enriched dairy products to combat malnutrition and obesity, as well as the growing preference for low-fat and healthier food options. Enzymes such as esterase, lactase, lipase, protease, and catalase are well-recognized in both dairy and food technology. Various proteases are used to accelerate the aging process of cheese, improve its functionality, and modify milk proteins to reduce allergic reactions in infants consuming cow's milk products (Fox, 2002). Lipase is commonly used during cheese maturation to enhance flavour development. Lactase is typically used to break down lactose into glucose and galactose, improving solubility and adding a sweet flavour to various dairy products. Enzymes from different sources offer diverse applications in food and dairy processing.

Sources of Important Enzymes

Enzyme	Source	Applications
Amylases	*Bacillus and Aspergillus spp.*	Starch liquefaction. baking, brewing, textiles, detergents, etc.
Beta-Glucanases	*Bacillus spp.*	Brewing and animal feedstuff
Bromelain	*Pineapple*	Meat tenderization, chill-proofing of beer
Cellulases	*Trichoderma spp.*	Textile biopolishing, pulp and paper, detergents
Chymosin	*Calf stomach*	Cheese manufacture
Ficin	*Figs*	Meat Tenderization
Glucose	*Bacillus and Streptomyces spp.*	Glucose isomerization to fructose
Lipases	*Pseudomonas spp.*	Detergents, oils and fats, baking, leather, paper, etc.
Papain	*Papaya latex*	Meat tenderization, brewing
Pectinases	*Aspergillus spp.*	Pectin hydrolysis in frut juice clarification
Proteases	*Bacillus and Aspergillus spp.*	Detergents, brewing, Meat tenderization, baking, cleaning, hydrolyze animal's proteins, functional meat proteins, etc.
Pepsin	*Stomach of slaughtered animals*	Digestive aid
Transglutaminases	*Streptomyces spp.*	Protein cross-linking and gelation and meat binding
Trypsin	*Stomach of slaughtered animals*	Digestive aid.

Rennet:

Rennet has traditionally been used to separate milk into solid curds and liquid whey, a crucial step in cheese production. However, the use of calf-derived rennet has become increasingly rare, with less than 5% of cheese in the United States now being made using animal rennet. Today, most cheeses are produced using chymosin derived from bacterial sources (C. Merheb-Dini et al., 2010). Many soft cheeses, such as cream cheese, paneer, rubing, and other acid-set varieties, are made without rennet by coagulating milk with acids like citric acid, vinegar, or the lactic acid produced by souring milk. Acidification can also be achieved through bacterial fermentation, as seen in cultured milk. Vegan cheese alternatives, which do not contain animal milk, are made from plant-based ingredients such as soy, wheat, rice, or cashews, and are coagulated with acids like vinegar or lemon juice. Chymosin, the primary enzyme found in rennet, is typically sourced from animals, microbes, or plants. While microbial chymosin (from fungi or other microorganisms) is available, it may not be as effective for producing cheddar and other hard cheeses.

Lactase:

Lactase is an enzyme produced by various organisms that plays a crucial role in the complete digestion of milk. It breaks down the sugar lactose into its two components: galactose and glucose. Lactase is located in the brush border of the small intestine in humans and other mammals. Individuals who have a lactase deficiency or lack functional lactase may experience symptoms of lactose intolerance after consuming dairy products. Microbial β-galactosidase (commonly referred to as lactase) is available as a food supplement and can be added to milk to create "lactose-free" dairy products. Lactase is typically sourced from Aspergillus fungi species and Kluyveromyces yeast species.

Catalase:

The enzyme catalase has a specific, though limited, application in cheese production. Hydrogen peroxide, a strong oxidizer that is toxic to cells, is sometimes used instead of pasteurization when making certain cheeses, such as Swiss cheese, to preserve the natural milk enzymes that contribute to the cheese's flavour development. These enzymes would be destroyed by the high temperatures used in pasteurization. However, any remaining hydrogen peroxide in the milk would inhibit the bacterial cultures essential for cheese production, so it is critical to remove all traces of it. Catalase enzymes, typically sourced from bovine livers or microorganisms, are added to break down hydrogen peroxide into water and molecular oxygen.

Lipases:

Lipases are enzymes used to break down milk fats and contribute distinctive flavours to cheeses. Strongly flavoured cheeses, such as Romano, an Italian variety, are made using lipases. The characteristic taste comes from the free fatty acids produced during the hydrolysis of milk fats. Animal-derived lipases are typically sourced from kids, calves, and lambs, while microbial lipases are produced through fermentation using the fungus *Mucor meihei*. While microbial lipases are available for cheese production, they tend to be less selective in the fats they hydrolyze. In contrast, animal lipases are more specific, primarily acting on short- and medium-chain fatty acids. The hydrolysis of shorter fats is preferred in cheese production, as it contributes to the desired flavour in many types of cheese. Hydrolysis of longer-chain fatty acids, on the other hand, can result in undesirable flavours, such as soapiness, or no flavour at all.

CONCLUSION:

In conclusion, enzymes play an essential and versatile role in dairy processing, significantly enhancing the production, flavour development, and nutritional qualities of dairy products. From the breakdown of milk proteins by proteases to the hydrolysis of fats by lipases, enzymes are key in shaping the textures, tastes, and digestibility of cheeses, milk-based foods, and other dairy products. The increasing demand for functional dairy products and innovations in enzyme production, such as microbial rennet, lactase, and lipases, highlights the importance of enzymes in meeting consumer preferences for healthier, allergy-friendly, and lactose-free alternatives. As the dairy industry continues to evolve, the potential of enzymes in improving food safety, product quality, and production efficiency will remain a critical area of growth and innovation, contributing to the advancement of dairy technology and the development of new, nutritious products for a global market.

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