

# Low-Fat and Lactose-Free Dairy Products: Trends and Challenges

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## Abstract

*Dairy products play a vital role in human nutrition, providing essential nutrients such as proteins, calcium, vitamins, and fats. However, increasing health concerns related to obesity, cardiovascular diseases, and lactose intolerance have significantly influenced consumer preferences worldwide. As a result, the demand for low-fat and lactose-free dairy products has grown rapidly in recent years, driven by the need for healthier and more digestible alternatives. Low-fat dairy products are developed by reducing or removing milk fat through processes, such as cream separation and standardization, aiming to lower calorie content while retaining nutritional value. On the other hand, lactose-free dairy products are produced primarily enzymatic hydrolysis of lactose using lactase, or through advanced membrane filtration techniques, making them suitable for lactose-intolerant individuals. Technological advancements, including the use of fat replacers, stabilizers, and innovative processing methods, have played a crucial role in improving the sensory and functional properties of these products. Despite these developments, several challenges persist, including alterations in taste and texture, higher production costs, and limited consumer awareness in certain regions. Additionally, maintaining product stability and shelf life remains a significant concern for manufacturers. Looking ahead, ongoing research in enzyme technology, product formulation, and personalized nutrition is expected to drive further innovation in this sector. The expansion of health-conscious consumer markets, especially in developing countries, presents promising opportunities for the growth of low-fat and lactose-free dairy products. Overall, these products represent an important advancement in aligning dairy consumption with modern health and dietary needs.*

**Keywords:** Dairy processing, fat reduction, functional foods, lactose intolerance, lactose-free milk, low-fat dairy

## INTRODUCTION

Dairy products constitute an essential component of the human diet, providing a rich source of high-quality proteins, essential amino acids, calcium, vitamins (such as A, D, and B-complex), and minerals necessary for growth, bone health, and overall physiological functions. Milk and its derivatives, including yogurt, cheese, and butter, have long been recognized for their nutritional density and are widely consumed across all age groups. Their role is particularly significant in supporting skeletal development, maintaining metabolic functions, and preventing nutrient deficiencies [1].

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In recent decades, however, there has been a marked shift in consumer dietary preferences due to increasing awareness of health-related issues such as obesity, cardiovascular diseases, and metabolic disorders. High intake of saturated fats, often associated with full-fat dairy products, has been linked to elevated cholesterol levels and increased risk of heart disease. Consequently, consumers are becoming more health-conscious and are actively seeking low-fat or fat-reduced alternatives that provide similar nutritional benefits without contributing to excess caloric intake [2].

Simultaneously, lactose intolerance has emerged as a major global health concern, affecting a significant proportion of the population, particularly in Asia and Africa. Lactose intolerance results from the deficiency of the enzyme lactase, leading to improper digestion of lactose and causing symptoms such as bloating, diarrhea, and abdominal discomfort. This condition has limited the consumption of conventional dairy products among affected individuals, thereby increasing the demand for lactose-free alternatives that are easier to digest and nutritionally comparable [3].

In response to these evolving dietary needs, the dairy industry has focused on developing low-fat and lactose-free products through various technological interventions. These products aim to cater to both health-conscious consumers and those with lactose intolerance, without compromising on taste, texture, and nutritional value. Advances in processing techniques, ingredient formulation, and enzyme applications have significantly contributed to the diversification of such products in the global market [4].

The objective of this review is to provide a comprehensive overview of low-fat and lactose-free dairy products, including their production technologies, nutritional and sensory characteristics, market trends, and associated challenges. The review also aims to highlight future prospects and research opportunities in this rapidly growing segment of the dairy industry [5].

## LOW-FAT DAIRY PRODUCTS

### Definition and Classification

Low-fat dairy products are those in which the fat content has been partially or completely reduced while maintaining essential nutrients such as proteins, minerals, and vitamins. Based on fat content, milk and dairy products are generally classified into three categories.

- *Full-Fat Milk*: Typically contains around 3.5–6% fat, depending on the source (cow or buffalo milk). It has a rich flavor and creamy texture.
- *Low-Fat Milk*: Contains approximately 1–2% fat. It offers a balance between reduced fat content and acceptable sensory properties.
- *Skimmed Milk (Fat-Free Milk)*: Contains less than 0.5% fat. It has minimal fat content but may lack the richness and mouthfeel of full-fat milk [6].

This classification helps consumers select products based on dietary needs and health goals.

### Methods of Fat Reduction

The production of low-fat dairy products involves the removal or adjustment of milk fat using various processing techniques:

- *Cream Separation*: This is the most common method, where milk is passed through a centrifugal separator to remove cream (fat portion) from whole milk. The remaining liquid is skimmed milk.
- *Standardization Techniques*: After separation, a controlled amount of cream is added back to skimmed milk to achieve the desired fat level (e.g., low-fat milk). This ensures uniformity in fat content and product quality.

These methods allow precise control over fat levels while maintaining consistency in large-scale dairy processing [7].

### Impact on Quality

Reducing fat content significantly influences the sensory and nutritional properties of dairy products

- *Texture, Flavor, and Mouthfeel*: Fat contributes to creaminess, smooth texture, and flavor. Its reduction often results in thinner consistency, less richness, and diminished taste. To compensate, stabilizers and fat replacers are sometimes added.
- *Nutritional Changes*: While protein, calcium, and lactose content remain largely unaffected, fat-soluble vitamins (A, D, E, and K) may decrease with fat removal unless fortified. However, the reduction in fat lowers overall calorie content [8].

## Health Benefits

Low-fat dairy products are widely recommended as part of a balanced diet due to their potential health benefits.

- *Reduced Calorie Intake:* Lower fat content leads to fewer calories, which can aid in weight management and prevention of obesity.
- *Cardiovascular Health Benefits:* Reduced intake of saturated fats is associated with lower blood cholesterol levels, thereby decreasing the risk of heart diseases and related conditions.

Overall, low-fat dairy products provide a practical alternative for individuals seeking to maintain nutritional intake while minimizing health risks associated with high fat consumption.

## LACTOSE-FREE DAIRY PRODUCTS

### Lactose Intolerance

Lactose intolerance is a common digestive disorder caused by the deficiency or reduced activity of the enzyme lactase in the small intestine. Lactase is responsible for breaking down lactose, the primary sugar present in milk, into glucose and galactose for absorption. In its absence, lactose remains undigested and undergoes fermentation by intestinal bacteria.

- *Causes and Symptoms:* Lactose intolerance may be genetic, age-related, or secondary to gastrointestinal diseases. Common symptoms include bloating, abdominal pain, diarrhea, flatulence, and nausea after the consumption of dairy products.
- *Global Prevalence:* The prevalence of lactose intolerance varies widely across populations, with higher rates observed in Asia, Africa, and South America. It is estimated that nearly 65–70% of the global population experiences some degree of lactose malabsorption, making it a significant public health concern [9, 10].

### Production Techniques

Lactose-free dairy products are produced using advanced technologies that either break down or remove lactose from milk.

- *Enzymatic Hydrolysis (Lactase Enzyme):* This is the most widely used method, where the enzyme lactase is added to milk to hydrolyze lactose into glucose and galactose. This not only makes the product digestible for lactose-intolerant individuals but also slightly increases sweetness.
- *Membrane Processing:* Techniques, such as ultrafiltration and nanofiltration, are used to physically remove lactose from milk. These processes separate lactose molecules while retaining proteins and minerals, producing lactose-reduced or lactose-free products [6].

### Types of Products

A wide variety of lactose-free dairy products are now available to meet consumer demand.

- *Lactose-Free Milk:* The most common product, treated with lactase enzyme to eliminate lactose while maintaining nutritional quality.
- *Fermented Products (Yogurt, Cheese, Ice Cream):* Yogurt and some cheeses naturally contain lower lactose due to fermentation. Additionally, specially processed lactose-free versions of yogurt, cheese, and ice cream are produced to cater to sensitive individuals [5].

### Nutritional and Sensory Aspects

- *Sweetness Changes:* Hydrolysis of lactose results in the formation of glucose and galactose, which are sweeter than lactose. Therefore, lactose-free milk often tastes slightly sweeter than regular milk, even without added sugar [11].
- *Digestibility Improvements:* Lactose-free products are easier to digest and do not cause gastrointestinal discomfort in lactose-intolerant individuals. Importantly, these products retain most of the essential nutrients, such as proteins, calcium, and vitamins, making them nutritionally comparable to conventional dairy products.

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### Technological Advancements

Technological innovations have played a crucial role in the development and improvement of low-fat and lactose-free dairy products, enabling manufacturers to enhance both quality and functionality.

- *Use of Enzymes (Lactase):* The application of lactase enzyme is fundamental in producing lactose-free dairy products. It hydrolyzes lactose into simpler sugars, improving digestibility and slightly enhancing sweetness without the need for added sugars [5].
- *Ultrafiltration and Nanofiltration:* These membrane-based technologies are widely used to separate and concentrate milk components. Ultrafiltration helps retain proteins while reducing lactose content, whereas nanofiltration selectively removes smaller molecules like lactose and minerals, contributing to improved product formulation.
- *Fat Replacers (Carbohydrate/Protein-Based):* To compensate for the loss of texture and mouthfeel due to fat reduction, carbohydrate-based (e.g., starches, gums) and protein-based fat replacers (e.g., whey proteins) are used. These ingredients help mimic the creaminess and structural properties of fat [12].
- *Use of Stabilizers and Emulsifiers:* Stabilizers (such as carrageenan and guar gum) and emulsifiers are incorporated to improve texture, prevent phase separation, and enhance product stability, particularly in low-fat dairy products.
- *Innovations in Product Formulation:* Recent advancements include the development of functional dairy products enriched with probiotics, vitamins, and bioactive compounds. Novel formulations also focus on improving sensory quality while maintaining nutritional benefits.

### Market Trends and Consumer Demand

The global dairy market has experienced significant changes due to shifting consumer preferences and increasing health awareness.

- *Increasing Demand for Health-Oriented Products:* Consumers are becoming more conscious of their dietary choices, leading to a growing demand for low-fat, low-calorie, and easily digestible dairy products.
- *Growth of Lactose-Free Segment:* The lactose-free dairy segment has shown rapid growth due to the rising prevalence of lactose intolerance and increased availability of such products in the market.
- *Consumer Perception and Acceptance:* While health benefits drive demand, sensory attributes, such as taste and texture, remain critical factors influencing consumer acceptance. Continuous improvements in product quality have enhanced market acceptance over time.
- *Global and Indian Market Trends:* Globally, developed regions, such as North America and Europe, dominate the lactose-free dairy market. In India, the market is expanding steadily due to urbanization, rising income levels, and growing awareness about digestive health and nutrition [13].

### Challenges in Production and Marketing

Despite advancements, several challenges hinder the widespread adoption and production efficiency of low-fat and lactose-free dairy products.

#### Technical Challenges

- *Maintaining Texture and Taste:* Fat reduction and lactose hydrolysis can negatively impact flavor, texture, and mouthfeel, making it difficult to achieve consumer-acceptable products.
- *Shelf-Life Issues:* Changes in composition may affect product stability and shelf life, requiring careful formulation and preservation techniques.

#### Economic Challenges

- *High Production Cost:* Advanced processing technologies, enzymes, and specialized ingredients increase the overall cost of production.

- *Pricing Issues*: Higher production costs often lead to increased product prices, limiting accessibility for price-sensitive consumers.

### Consumer Challenges

- *Awareness and Misconceptions*: Many consumers lack awareness about lactose intolerance and the benefits of low-fat products, while some hold misconceptions regarding taste and nutritional value.
- *Acceptance of Altered Taste*: Changes in sweetness and texture may affect consumer preference, especially in traditional dairy-consuming populations.

### Regulatory Issues

- *Labeling Standards*: Clear and standardized labeling of “low-fat” and “lactose-free” claims is essential to ensure transparency and consumer trust.
- *Quality Control*: Maintaining consistent quality, safety, and compliance with national and international food regulations remains a critical challenge for manufacturers [14].

### CONCLUSION

Low-fat and lactose-free dairy products have emerged as important innovations in the dairy industry, addressing the dual challenges of health concerns and lactose intolerance. These products provide a viable alternative for consumers seeking to reduce fat intake or avoid digestive discomfort without compromising essential nutritional benefits. Technological advancements, such as enzymatic hydrolysis, membrane filtration, and the use of fat replacers, have significantly improved the quality, functionality, and variety of these products. At the same time, increasing consumer awareness and changing dietary patterns have contributed to their growing demand in global and emerging markets. However, challenges related to sensory quality, production costs, consumer perception, and regulatory compliance continue to limit their widespread adoption. Addressing these issues through research, innovation, and effective marketing strategies is essential for the sustained growth of this sector. Low-fat and lactose-free dairy products represent a dynamic and evolving segment of the dairy industry. With continued technological progress and increasing emphasis on health and nutrition, these products are expected to play a vital role in meeting the dietary needs of diverse populations in the future.

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