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Moses Oswin
M. Tech Student, Department of Processing and Food Engineering, Sam Higginbottom university of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Kailash Chandra Yadav
Assistant Professor, Department of Processing and Food Engineering, Sam Higginbottom university of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Moses Oswin
M. Tech Student, Department of Processing and Food Engineering, Sam Higginbottom university of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Yogurt: Processing and economic evaluation

Moses Oswin and Kailash Chandra Yadav

Abstract
yogurt or yoghourt is a food produced by bacterial fermentation of milk. The bacteria used to make yogurt are known as yogurt cultures. Fermentation of sugars in the milk by these bacteria produces lactic acid, which acts on milk protein to give yogurt its texture and characteristic tart flavor. Cow's milk is the milk is mostly used to make yogurt. Milk from water buffalo, goats, ewes, mares, camels, and yaks are also used to produce yogurt. The milk used may be homogenized or not. It may be pasteurized or raw. Each type of milk produces substantially different results. Yogurt is produced using a culture of Lactobacillus bulgaricus and Streptococcus thermophilus bacteria. In addition, other *lactobacilli* and *bifidobacterial* are sometimes added during or after culturing.

Keywords: Yogurt, milk, lactobacillus bulgaricus, Streptococcus thermophilus bacteria

1. Introduction
Yogurt is a fermented dairy product made by adding live bacteria cultures to milk. These bacteria ferment the lactose in the milk, producing lactic acid, which gives yogurt its tangy flavor and thick texture. Yogurt is a rich source of protein, calcium, and probiotics, which are beneficial
bacteria that can improve gut health. It can be enjoyed on its own or used in cooking and baking. Homemade yogurt can be made by heating milk, adding a small amount of store-bought yogurt as a starter culture, and incubating the mixture at a warm temperature for several hours until it thickens.

2. Origin and History
The word "yogurt" is believed to have originated from the Turkish word "yogurmak", which means "to thicken" or "to curdle". Yogurt has a rich history that dates back thousands of years. Its origins can be traced to the Neolithic period, around 5000 BCE, in the Middle East and Central Asia. This fermentation process helped preserve the milk and made it easier to digest. Yogurt was also a staple in ancient Indian, Persian, and Greek diets. In India, yogurt was used in Ayurvedic medicine and was considered a sacred food. Today, yogurt is enjoyed worldwide and comes in a variety of flavors and forms, including Greek yogurt, which is strained to remove whey and has a thicker consistency, and probiotic yogurt, which contains live bacteria cultures that are believed to promote gut health.

3. Technology of yogurt production
A. Equipment
- **Homogenizer:** Homogenizer is frequently used to mix naturally immiscible materials fully. The purpose of homogenization is to reduce particle size, breach the cell wall and/or cell membrane, destruction of pathogens, and facilitate stable emulsions and dispersions. A classical illustration of this is the homogenization of milk, which distributes and shrinks the milk fat globules so that they are evenly dispersed throughout the remaining milk.
- **Pasteurizer:** A pasteurizer is an equipment used in the food industry, including yogurt production, to heat liquids to a specific temperature for a predetermined amount of time to kill harmful bacteria and enzymes that could spoil the product. In yogurt production, pasteurization is an essential step to ensure the safety and quality of the final product.
- **Fermentation Tank:** This is where the milk is inoculated with live bacterial cultures (usually Lactobacillus bulgaricus and Streptococcus thermophilus) and allowed to ferment at a controlled temperature (usually around 40-45 °C) for several hours. This process converts lactose into lactic acid, which gives yogurt its tangy flavor and thick texture.

- **Incubation Chamber:** After fermentation, the yogurt is transferred to an incubation chamber, where it is held at a specific temperature (usually around 40-45°C) for several hours to allow the bacteria to continue fermenting and thicken the yogurt.
- **Cooling Tank:** Once the yogurt has reached the desired consistency, it is cooled rapidly to stop the fermentation process and prevent over-acidification.
- **Equipment for quality control analysis:** Various instruments are used to monitor the quality of the yogurt, including pH meters, viscosity meters, and sensory evaluation tools.

B. Processing of Yogurt

- **Pasteurization:** The first step in yogurt processing is pasteurization, which involves heating the milk to a specific temperature (usually around 85-90°C) for a certain period (The usually 15-30 minutes) to kill harmful bacteria and enzymes that could spoil the yogurt. This process also helps to denature the whey proteins, which contributes to the yogurt's texture.
- **Homogenization:** Homogenization is the process where the size of fat globules is reduced.
- This step prevents creaming (separation of a fat enriched layer from the aqueous phase). Thus, it will give a uniform and smooth texture. The homogenization pressure for yogurt is 20-25 MPa.
- **Cooling:** After pasteurization, the milk is rapidly cooled to the desired fermentation temperature (usually around 40-45°C) to prepare it for inoculation with bacterial cultures.
- **Inoculation:** The cooled milk is inoculated with a small amount of starter culture containing live bacterial cultures, usually *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. These bacteria ferment the lactose in the milk, producing lactic acid, which gives yogurt its tangy flavor and thick texture.
- **Fermentation:** The inoculated milk is transferred to fermentation tanks or incubation chambers, where it is allowed to ferment at the desired temperature (usually around 40-45 °C) for several hours. During fermentation, the bacteria convert lactose into lactic acid, which lowers the pH of the milk and causes it to thicken.
- **Cooling and Stabilization:** Once the yogurt has reached the desired consistency and acidity, it is cooled rapidly to stop the fermentation process and prevent over-acidification. Some yogurts may also undergo stabilization, which involves adding stabilizers such as pectin or gelatin to improve the texture and prevent syneresis (the separation of whey from the yogurt).
- **Packaging:** The yogurt is then packaged into containers, which can range from small single-serving cups to large bulk containers. The packaging equipment may include filling machines, sealing machines, and labeling machines.

C. Flowchart diagram of yogurt production process

4. Types and nutritional values of yogurts

Increased consumer income, improved consumer understanding of the role of healthier kinds of nutrition, and enhanced consumer expectations, are resulting in a shift within the perception of the role of diet in individuals' lifestyle. Global health systems in developed and developing countries have begun to shift emphasis Health system changes involve shifting from managing infectious dis case to managing the challenges presented by increases in mortality caused by chronic diseases including cardiovascular diseases, diabetes, and cancer. Because some consumers use the phrase "We are what we eat" to describe their dietary preferences, it's crucial for bakers to at least be aware of the variety of consumer preferences and dietary requirements that define this bakery product industry.

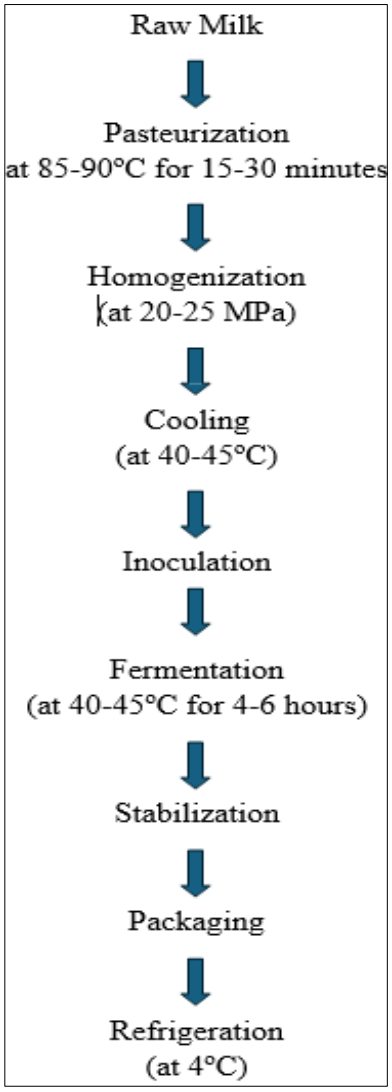

Fig 1: General flow diagram for Yogurt Production

A. Greek Yogurt: Greek yogurt is one of the fastest growing products in the dairy industry. It is also known as strained yogurt, which is obtained after draining the whey. As a result of the draining process, Greek yogurt has higher total solids and lower lactose than regular yogurt. Since it is a concentrated yogurt, its sensory characteristics are different from regular yogurt. However, there is little information about factors influencing the quality of Greek yogurt and sensory evaluation techniques applied to Greek yogurt (Robin Gyawali *et al*. 2022) [2].

Table 1: Nutritional value of Greek Yogurt (per 100g)

Total Energy	120 kcal
Carbohydrate	6.4 g
Fat	8 g

Flowchart diagram of Greek yogurt

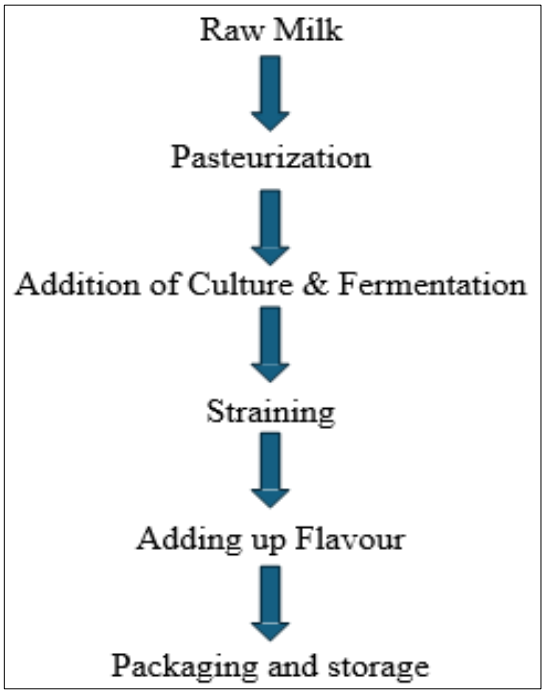

Fig 2: Flow diagram of Greek Yogurt Production

B. Probiotic Yogurt: In recent years, there has been a trend for more consumers to be health conscious and seek foods with functional properties additional to their nutritional value. Probiotic dairy products are considered to have functional properties because the probiotic bacteria added to the regular fermentation cultures provide therapeutic benefits such as modification of the immune system, reduction in cholesterol, alleviation from lactose intolerance, faster relief from diarrhea, and restoration of a healthy vaginal microbiota (Evagelia Marinaki *et al*. 2016) [5].

Table 2: Nutritional Value of Probiotic Yogurt (per 100g)

Total Energy	61 kcal
Carbohydrate	4.7 g
Fat	3.3 g

Flowchart Diagram of Probiotic Yogurt

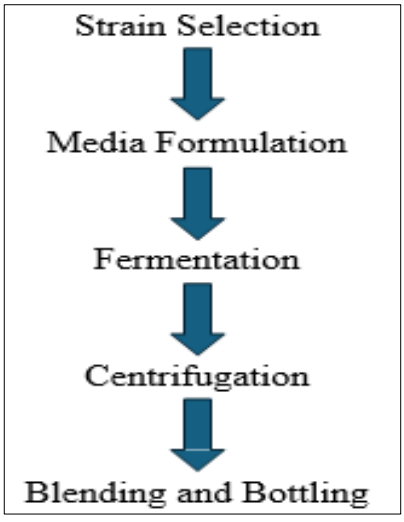

Fig 3: Flow diagram of Probiotic Yogurt Production

C. Low-fat and fat-free yogurt: Health-conscious consumers often opt for low-fat or fat-free yogurt options to reduce their calorie and fat intake. These yogurts are perceived as healthier alternatives to full-fat yogurts. Low-fat or fat-free yogurt is made by fermenting toned or skimmed milk and offers you all the health benefits of regular yogurt. In fact, it provides you with all the nutrients from superior quality animal protein to calcium without the extra calories from fat, making it a perfect snack for people trying to lose or manage weight (W.A.D.V. Weerathilake *et al.* 2014) [11].

Table 3: Nutritional value of low fat and fat free yogurt (per 100g)

Total Energy	63 kcal
Carbohydrate	7.04 g
Fat	1.55 g

Flowchart diagram of low-fat and fat-free yogurt

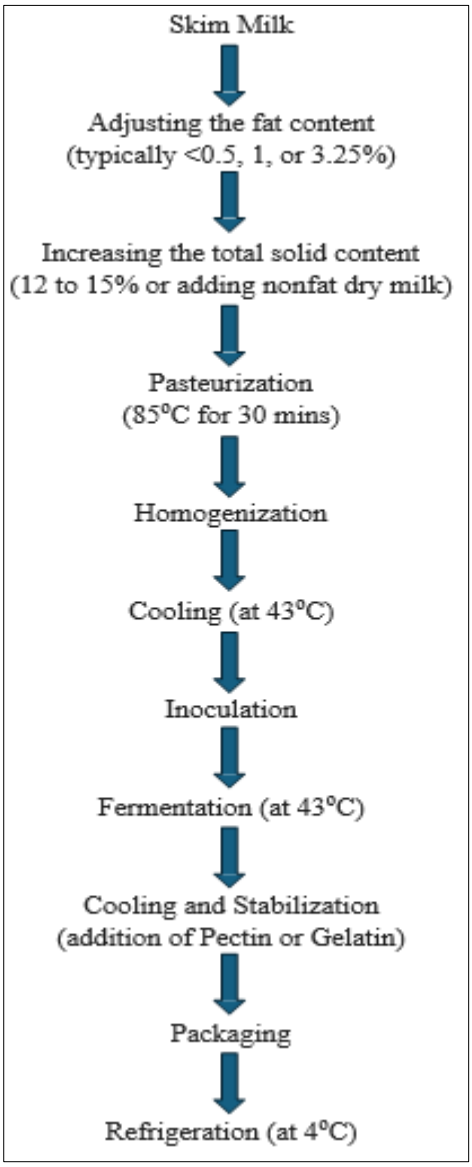

Fig 4: Flow diagram of low-fat and fat-free yogurt production

D. Flavored Yogurt: While plain yogurt remains popular, flavoured yogurts, especially those with natural fruit flavors and lower sugar content, are in demand. Consumers are looking for healthier options without artificial flavors or excessive added sugars. Fruit flavored yogurt and plain

samples (no fruit juice added) were analyzed for physico-chemical and microbial quality and sensorial acceptance. Addition of fruit juice concentrations significantly ($p<0.05$) affected the physico-chemical and sensorial properties and microbial quality of fruit flavored yoghurt samples. There were significant differences between control yogurt and fruit flavored yogurt in the pH, titratable acidity, ash, fat, protein, and total solid content (Getenesh Teshome *et al*. 2017) [10].

Table 4: Nutritional Value of Flavored Yogurt (per 100g)

Total Energy	127 kcal
Carbohydrate	21.6 g
Fat	3.6 g

Flowchart Diagram of Flavored Yogurt

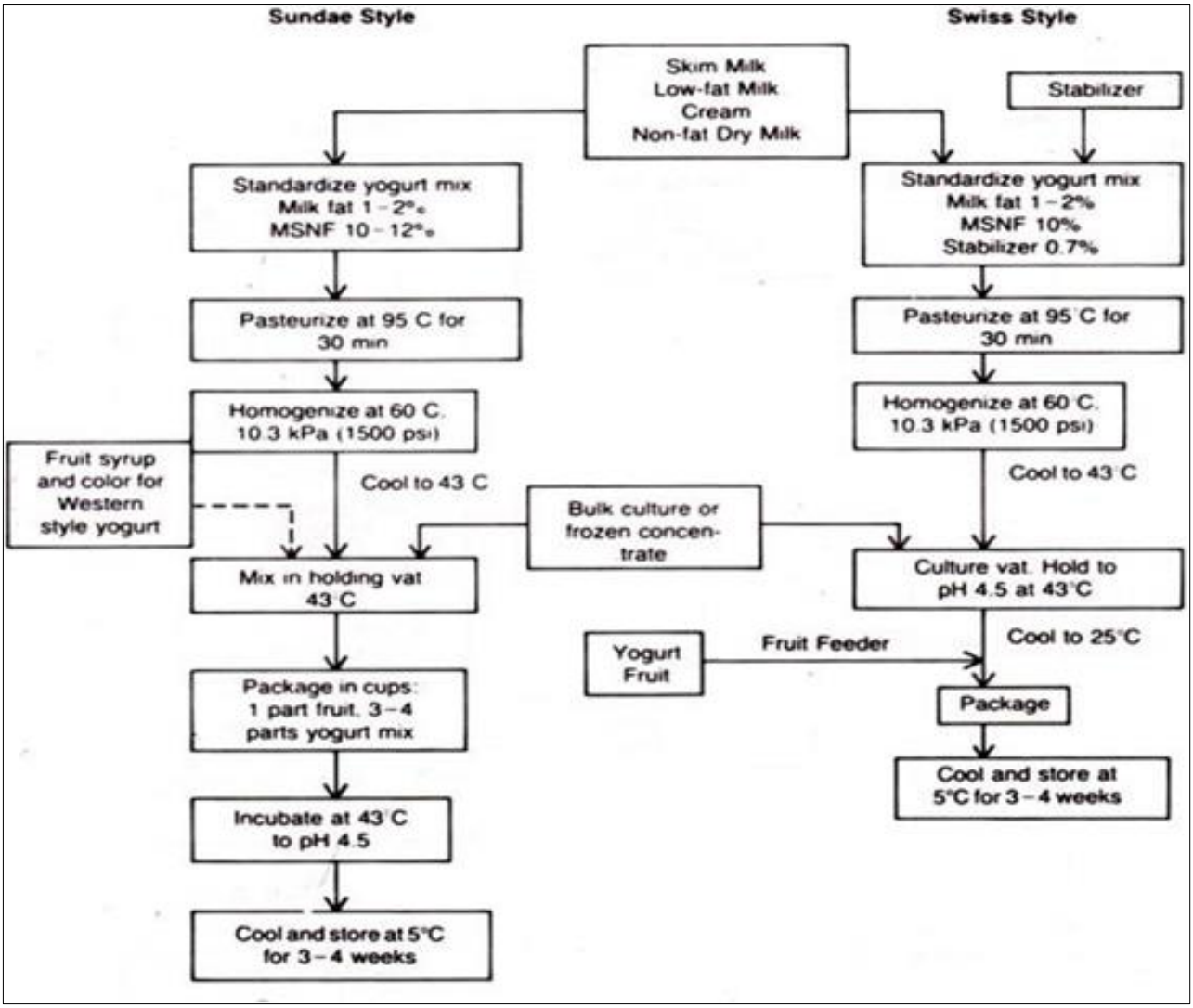

Fig 5: Flow diagram of flavored yogurt production

E. Frozen Yogurt: Frozen yogurt, also known as frogurt or Froyo, is a frozen dessert made with yogurt and sometimes other dairy and non-dairy products. It contains the same basic ingredients as ice cream but includes live bacterial cultures. It's usually more tart than ice cream due to the lactic acid in the yogurt and lower in fat because it uses milk instead of cream (Jacob Smith 2023) [4].

Table 5: Nutritional Value of Frozen Yogurt (per 100g)

Total Energy	107 kcal
Carbohydrate	19.62 g
Fat	1.47 g

Flowchart Diagram of Frozen Yogurt

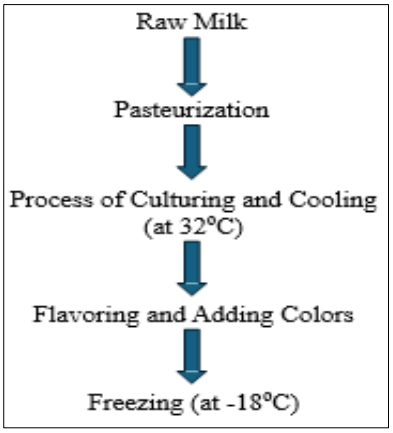

Fig 6: Flow diagram of Frozen Yogurt Production

Techno-economic feasibility of yogurt

The technical aspect relates to production input and output. Input is the initial process or provision, while output is the result or final product. The parts analyzed in technical aspects were the production process, determining the amount of yield, specifications of equipment machines, production capacity, machines and equipment, production layout and determining the number of workers (Indriati *et al*. 2021) [3].

Fixed cost: Fixed are costs that are fixed and do not depend on the amount of production. Fixed costs consist of maintenance costs for machines, Staff salaries for labour and building rent. Variable cost: Variable costs are those costs whose amount change with the total production capacity. Variable cost consists of raw materials, Electricity Charges.

Table 6: Fixed cost and variable cost

A		Fixed Cost	Cost (in ₹)	
	Depreciation on Equipment's @10% p.a.		100000	
	Interest on capital investment @12% p.a.		150000	
	Building rent per month		150000	
	Fixed cost per annum		500000	
	Total fixed cost per day (A)		4660	
B		**Variable cost**	**Quantity required per batch (500 kg)**	**Cost (in ₹)**
	Raw Material			
	1. Mixed milk for yogurt preparation (26/kg)		470 kg	12220
	2. Skim milk powder (250/kg)		10 kg	2500
	3. Culture (300/kg)		15 kg	4500
	4. Encapsulated Resveratrol Powder		5 kg	11000
	Total			30220
	Labour @ 302/Day for unskilled and 367/day for skilled (1 man = 8Hr)		Unskilled = 20, Skilled = 5	7875
	Packaging Material		5000	5000
	Electricity @ 8/unit		200	1600
	Laboratory charges @ 0.2% of raw materials			60
	Cleaning and sanitizing materials @ 0.1% of raw material			30
	Total variable cost per day (per batch) (B)			44785
	Total cost of the batch = A+B			49445
	Returns from batch			
C	Yield per batch Total cost per kg (49445/500kg)		500 kg	98.89
D	Sale price per kg			220
	Profit per kg (before taxes)			121.11
	Gross returns			110000
	Total cost (Fixed + Variable)			49445
	Net returns			60555
	BC ratio (Gross returns/Total cost)			2.22
	Margin of safety (Percent)			92.85

Break Even Point (BEP)

The break-even point is an analysis to determine and finds the numbers of goods and services that must be sold to consumers at a certain price to cover costs that arise and get a profit (Indriati 2021) [3].

$$\textbf{Break Even Quality} = \frac{Total\ fixed\ cost}{Cost\ of\ per\ pack - Variable\ cost\ per\ pack}$$

$$\text{Break Even Quality} = \frac{93200}{220 - 8.957} = 441$$

$$\text{Break Even Quality} = 441$$

$$\textbf{Break Even Sales} = \frac{Total\ fixed\ cost}{Cost\ of\ per\ pack - Variable\ cost\ per\ pack} X\ Cost\ of\ per\ pack$$

$$\text{Break Even Sale} = \frac{93200}{220 - 8.957}\ X\ 220$$

$$\text{Break Even Sale} = 97{,}020$$

Table 7: Cost of Production

Description	Unit	Total
Production	Pack / month	100000
Total Fixed cost	Rs / month	93200
Total variable cost	Rs / month	895700
Total cost	Rs / month	988900
Cost of production	Rs / Packs100 gm	9.89
Selling price	Rs / pack 100 gm	22
BEP (per month)	Rs / month	10483
Break Even Quantity	Unit / month	7147
Break Even Sale	Pack/month	157240

5. Conclusion

Yogurt, often known as yoghurt, is one of the most popular fermented dairy products in the world, with a wide range of health advantages in addition to basic nutrition. In general, yogurt is a nutrient-dense food because of its nutritional profile, and it is a high-calcium source that supplies considerable amounts of calcium in bio-available form. Furthermore, it contains milk proteins with a higher biological value as well as nearly all of the essential amino acids required for optimal health. Yogurt is a probiotic carrier food that may transfer large numbers of probiotic bacteria into the body, providing unique health benefits such as digestive health if consumed. Yogurt is rich in nutrients such as calcium, vitamin B, phosphorus, magnesium, potassium and is high in protein. It also boost immune system, hearth health, weight management and bone health.

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