4.1: Paneer Manufacture — Traditional and Modern Methods

Paneer is a fresh, non-melting, acid-coagulated milk product widely used in Indian cuisine, particularly in North Indian cooking. Unlike aged or rennet-based cheeses, paneer is unripened and consumed fresh, making its production process relatively simple but sensitive to technique. This chapter examines both traditional household-level and modern commercial methods of paneer manufacture.

4.2 Basic Principle of Paneer Formation

Paneer is formed through acid coagulation of milk proteins (primarily casein):

- Milk is heated and then acidified using a coagulant (traditionally, a food acid such as lemon juice, vinegar, or sour whey).

- The acid lowers the pH of the milk, causing casein micelles to destabilize and aggregate, forming curds (coagulated solid mass) that separate from the liquid whey.

- The curds are then collected, drained, and pressed to form the final paneer block.

This is fundamentally different from rennet-based cheeses, which use enzymatic coagulation rather than acid coagulation, and do not typically undergo the ripening/ageing process associated with many other cheeses.

4.3 Traditional Method of Paneer Manufacture

Process:

1. Heating: fresh whole milk (traditionally cow or buffalo milk) is heated in a large vessel, typically to just below boiling point (around 90°C), with continuous stirring to prevent scorching.

2. Acidification: a food acid — traditionally lemon juice, vinegar, or reserved sour whey from a previous batch — is added gradually to the hot milk while stirring, until distinct curds separate from a clear, greenish-yellow whey.

3. Draining: the curds are strained through a clean muslin cloth, separating solid curd from liquid whey.

4. Pressing: the curd, still wrapped in the cloth, is pressed under weight (traditionally using a heavy stone or similar weight) for a period to expel excess whey and compact the curd into a firm block.

5. Cooling and cutting: the pressed paneer block is cooled, often in cold water, which helps improve texture, before being cut into pieces for use or sale

Characteristics:

- Made in small batches, typically at household or small vendor scale.

- Quality and consistency depend heavily on the skill and judgment of the person making it (e.g., correct milk temperature, acid quantity, pressing time).

- Fresh paneer made this way has a short shelf life and is often intended for same-day or near-term use.

4.4 Modern/Commercial Method of Paneer Manufacture

Commercial paneer production follows the same basic acid-coagulation principle but with standardized, mechanized, and hygienically controlled processes:

1. Standardization: milk is standardized to a specific fat and solids-not-fat (SNF) content to ensure consistent yield and quality across batches.

2. Pasteurization: milk is pasteurized to eliminate pathogenic microorganisms and extend product safety and shelf life, a food safety step not always systematically performed in informal traditional production.

3. Controlled heating and acidification: heating is done in temperature-controlled vats, and acidification (commonly using citric acid solution rather than lemon juice, for consistency) is added under controlled conditions to ensure uniform curd formation.

4. Mechanized draining and pressing: hydraulic presses and mechanized draining systems replace manual cloth-and-stone pressing, producing more uniform blocks at higher throughput.

5. Cooling, cutting, and packaging: rapid cooling (often using chilled water or refrigeration), mechanized cutting into standard sizes, and packaging under hygienic, sometimes vacuum-sealed or modified-atmosphere conditions to extend shelf life.

6. Quality control: parameters such as moisture content, fat content, and microbial safety are tested to ensure consistency and regulatory compliance.

4.5 Comparison: Traditional vs. Modern Paneer Manufacture

Aspect	**Traditional**	**Modern/Commercial**
Scale	Household/small vendor	Industrial
Milk treatment	Often raw, untreated milk	Standardized and pasteurized
Acid used	Lemon juice, vinegar, sour whey	Citric acid solution (standardized)
Consistency	Variable (skill-dependent)	Highly consistent
Pressing method	Manual (cloth and weight)	Mechanized/hydraulic
Shelf life	Short (intended for near-term use)	Extended (through pasteurization, hygienic packaging,

		refrigeration/vacuum packing)
Food safety controls	Limited, informal	Systematic (pasteurization, quality testing)
Yield consistency	Variable	Controlled through standardization

4.6 By-Product: Whey

Both traditional and modern paneer production generate whey as a by-product:

- Traditionally, whey has been reused in Indian households for purposes such as kneading dough, as a starter/coagulant for the next batch of paneer, or in cooking.

- In modern commercial settings, whey may be further processed (e.g., for whey protein products) or, if not utilized, requires proper disposal due to its biological oxygen demand (BOD) load if released untreated into the environment.

5.1: Butter and Ghee Manufacture — Traditional and Modern Methods

Butter and ghee (clarified butter) are two of the most culturally significant milk-fat products in Indian food tradition, used in cooking, religious ritual, and Ayurvedic practice. This chapter examines the traditional and modern methods of producing both, tracing the process from milk/cream through to the finished products.

5.2 Overview of the Production Pathway

The general pathway for both traditional and modern systems follows a similar sequence, though the specific techniques differ:

Milk → Cream separation → Cream ripening (traditional) / direct processing (modern) → Churning → Butter → Clarification (heating) → Ghee

5.3 Traditional Method of Butter Making

Process:

1. Curd formation: whole milk is traditionally first converted to curd (dahi) by fermentation using a starter culture (a small quantity of previous curd), and left to set, typically overnight.

2. Churning (bilona method: the curd is churned using a wooden churner (*bilona* or *madhani*) and a churning rope/cord, rotated by hand to agitate the curd, causing fat globules to coalesce and separate as butter (*makhan*), leaving behind buttermilk (chaas) as the by-product.

3. Collection: the butter that rises and separates is collected by hand, washed to remove residual buttermilk, and can be consumed fresh or used to prepare ghee.

Characteristics:

- The bilona method churns curd (fermented milk) rather than fresh cream, which is a distinguishing feature of the traditional Indian method compared to many Western butter-making traditions that typically churn cream directly.

- Produces both butter and buttermilk (chaas) as usable products.

- Labour-intensive and lower yield per unit of time compared to mechanized churning.

- The fermentation step is thought to contribute to the characteristic flavour of traditionally made butter and the ghee subsequently prepared from it.

5.4 Modern Method of Butter Makin

Process:

1. Cream separation: fresh milk is mechanically separated into cream and skim milk using a centrifugal cream separator, rather than relying on curd formation.

2. Cream pasteurization: cream is pasteurized for safety and shelf life.

3. Cream ripening (optional): in some processes, cream may be ripened with a starter culture to develop flavour (cultured butter), though much commercial butter today uses fresh, unripened cream (sweet cream butter).

4. Mechanized churning: cream is churned in mechanized butter churns, which agitate the cream at controlled speed and temperature until fat globules coalesce into butter grains, separating from buttermilk.

5. Working and packaging: butter grains are washed, "worked" (kneaded) to achieve uniform texture and moisture distribution, salted if required, and mechanically packaged.

Characteristics:

- Higher throughput and yield consistency than traditional bilona churning.

- Cream-based (rather than curd-based) process is more typical of large-scale commercial dairies, including in India.

- Buttermilk generated is often a low-fat by-product distinct in character from traditional chaas (which retains more of the fermented curd characteristics).

5.5 Traditional Method of Ghee Making

Process:

1. Butter (traditionally made via the bilona method, as described above) is heated slowly in a vessel over a controlled flame.

2. As heating continues, moisture evaporates, and milk solids separate and settle, gradually browning at the bottom of the vessel due to Maillard-type reactions.

3. The clear golden liquid fat (ghee) is separated from the browned milk solids (*ghee residue*, sometimes used in cooking or as a flavouring) by straining.

4. The ghee is cooled and stored; the slow, traditional heating process is considered by practitioners to contribute distinctive aroma and flavour characteristics

Characteristics:

- Essentially pure milk fat with virtually all moisture and milk solids removed, giving ghee a very long shelf life compared to butter.

- Traditional bilona ghee, made from curd-churned butter, is often distinguished in the market from ghee made by simply heating cream-churned butter, and is valued for its distinctive flavour profile.

5.6 Modern Method of Ghee Making

Modern/industrial ghee production follows the same basic clarification principle but with process control and scale:

- **Continuous or batch clarification:** butter (often cream-churned, commercial butter) is heated in temperature-controlled vessels, sometimes using continuous clarification systems for large-scale production.

- **Direct cream-to-ghee methods:** some modern processes convert cream directly to ghee without an intermediate butter stage, using specialized separation and heating equipment, improving efficiency at industrial scale.

- **Filtration and quality control:** modern ghee undergoes filtration for clarity and is tested for parameters such as moisture content, free fatty acid levels, and purity, in line with food safety standards.

- **Packaging:** mechanized filling into retail packaging, often with extended shelf-life claims based on controlled processing and packaging conditions.

5.7 Comparison: Traditional vs. Modern Butter and Ghee Making

Aspect	**Traditional**	**Modern/Commercial**
Starting material	Curd (fermented milk) via bilona	Fresh or pasteurized cream via separator
Churning method	Manual (bilona/madhani)	Mechanized churns
By-product	Chaas (fermented buttermilk)	Sweet or cultured buttermilk (less fermented character)
Ghee clarification	Slow, manual heating in open vessel	Controlled/continuous industrial clarification
Flavour profile	Distinctive, considered richer by many traditional consumers	More neutral/consistent

Shelf life	Ghee: long; Butter: shorter	Ghee: long, with standardized quality; Butter: extended via controlled processing
Scale and consistency	Small-scale, variable	Large-scale, standardized

5.8 Cultural and Nutritional Significance

- Ghee holds particular importance in Indian culture — used in religious rituals (havan/yajna offerings), Ayurvedic medicine, and festive/ceremonial cooking, in addition to everyday culinary use

- Nutritionally, ghee is composed almost entirely of fat, including saturated fatty acids and small amounts of fat-soluble vitamins (A, D, E, K) depending on the source milk; it is calorie-dense and is traditionally valued in Ayurveda for specific health properties, though such claims fall outside the scope of nutritional science covered in this textbook.

- Both traditional bilona-method and modern commercially produced ghee and butter continue to coexist in the Indian market, often marketed to different consumer segments (heritage/premium versus mass-market).

6.1: Comparative Analysis — Energy Costs, Efficiency, Yield, Shelf Life, and Nutrient Content

This chapter draws these threads together into a systematic, comparative framework, examining five key parameters — energy cost, processing efficiency, yield, shelf life, and nutrient content — across all these processes. This comparative lens is essential for evaluating traditional and modern food processing methods on a common, objective basis.

6.2 Framework for Comparison

For each food process discussed in this unit, the following parameters are useful for systematic evaluation:

- **Energy cost:** the amount of energy (human, animal, or mechanical/electrical) required per unit of output.

- **Efficiency:** how effectively input material is converted to usable output, including throughput (speed/scale) and consistency.

- **Yield:** the quantity of finished product obtained from a given quantity of raw material.

- **Shelf life:** how long the finished product remains safe and acceptable for consumption.

- **Nutrient content:** the retention or loss of key nutrients (vitamins, minerals, fibre, fatty acids) through processing.

6.3 Energy Costs: Traditional vs. Modern

Process	Traditional Energy Source	Modern Energy Source
Rice milling	Human labour (hand pounding)	Electricity (mechanized mills)
Wheat/corn milling	Human/animal power (chakki)	Electricity (roller mills)
Oil extraction	Animal power (bullock-driven ghani)	Electricity (expellers), plus process energy for solvent recovery and refining
Paneer/butter/ghee	Human labour, fuel for heating (wood/biomass traditionally)	Electricity, controlled industrial heating systems

Key observations:

- Traditional methods rely primarily on renewable human/animal energy but at very low output per unit of energy/time invested (low labour productivity).

- Modern methods rely on concentrated energy sources (electricity, sometimes fossil fuels) that dramatically increase output per unit of time, but at higher absolute energy consumption and associated environmental costs (e.g., electricity generation, industrial heating).

- Direct comparison of "energy cost per unit product" often favours modern mechanized processes in terms of labour-hours saved, but traditional methods have a smaller industrial energy/carbon footprint per batch, reflecting a genuine trade-off rather than a one-sided advantage.

6.4 Efficiency (Throughput and Consistency)

Across all processes examined in this unit, a consistent pattern emerges:

- **Traditional methods:** low throughput, high variability in output quality (dependent on operator skill, weather, raw material variation); well-suited to small-scale, localized, or household-level production.

- **Modern methods:** high throughput, standardized and consistent output due to mechanized, controlled processes; well-suited to meeting large-scale demand (urban populations, commercial food service, export).

6.5 Yield

Process	Traditional Yield Characteristics	Modern Yield Characteristics
Rice milling	Lower, more grain breakage	Higher, controlled breakage
Oil extraction (ghani vs. expeller/solvent)	Lower (oil remains in cake)	Higher (especially solvent extraction, which maximizes recovery)
Paneer	Yield varies with operator skill	Standardized yield through controlled coagulation
Butter/ghee	Lower per unit time (labour-intensive churning)	Higher throughput via mechanized churning/separation

General pattern: modern methods typically achieve higher and more consistent yield per unit of raw material, primarily due to more precise process control and, in some cases (such as solvent extraction), fundamentally more thorough extraction mechanisms.

6.6 Shelf Life

Product	Traditional	Modern
Milled rice (degree of milling)	Brown/less-milled rice: shorter shelf life	White/polished rice: longer shelf life
Wheat flour	Whole wheat (atta): shorter shelf life (germ oil)	Refined flour (maida): longer shelf life
Edible oil	Cold-pressed/ghani oil: shorter shelf life, more natural components	Refined oil: longer shelf life
Paneer	Short shelf life (fresh, unpasteurized milk, minimal packaging)	Extended shelf life (pasteurization, hygienic packaging, refrigeration)
Butter	Shorter (traditional, less controlled processing)	Extended (controlled processing, packaging)
Ghee	Long shelf life in both traditional and modern forms (due to near-total fat content and minimal moisture)	Long shelf life, often with standardized quality parameters

Key pattern: processing steps that remove bran, germ, moisture, or other biologically active/perishable components (as seen consistently across milling, oil extraction, and dairy processing) tend to extend shelf life — but often at some cost to nutrient content, flavour, or both.

6.7 Nutrient Content

This is the parameter most consistently affected by the trade-off pattern seen throughout this unit:

- **Milling:** traditional, less-refined milling retains more bran/germ-associated fibre, B-vitamins, and minerals; modern refined milling removes much of this, though some products are reconstituted or fortified to offset losses.

- **Oil extraction:** traditional cold-pressed (ghani) oil retains more natural antioxidants and heat-sensitive micronutrients; modern refining processes, while improving yield and shelf life, tend to reduce these components.

- **Dairy processing:** pasteurization in modern paneer/butter production, while important for safety, can cause modest changes to certain heat-sensitive nutrients, though the effect is generally much smaller than the bran/germ losses seen in cereal milling and oil refining; the primary nutrient content of paneer, butter, and ghee (protein, fat) is largely intact through both traditional and modern methods, since these processes concentrate rather than fundamentally alter the core macronutrients.

6.8 Overall Synthesis: The Central Trade-Off

Across nearly all processes examined in this unit, a consistent trade-off pattern emerges:

Traditional methods tend to favour: higher retention of natural nutrients, flavour, and aroma; lower industrial energy/carbon footprint per batch; suitability for small-scale/local production — at the cost of lower yield, lower throughput, shorter shelf life, and more variable/inconsistent quality.

Modern methods tend to favour: higher yield, higher throughput, greater consistency, and longer shelf life — at the cost of some nutrient and flavour loss (through refining, prolonged processing, or heat treatment), higher industrial energy input, and reduced suitability for very small-scale/localized production.

This trade-off is central to ongoing discussions in food science and food policy regarding whether and how to combine the benefits of both approaches — for example, through minimally refined products, fortification of refined foods, or hybrid small-scale mechanization that preserves more nutrients while improving throughput over purely manual traditional methods.