

Environmental, Health, and Safety Guidelines for Dairy Processing

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)¹. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account.

¹ Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to,

The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Dairy Processing facilities applies to the reception, storage, and industrial processing of raw milk and the handling and storage of processed milk and dairy products. Annex A contains a full description of industry activities for this sector. This document does not cover farming activities or collection of raw milk from farmers, which are covered in the EHS Guidelines for Mammalian Livestock Production.

This document is organized according to the following sections:

- Section 1.0 — Industry-Specific Impacts and Management
- Section 2.0 — Performance Indicators and Monitoring
- Section 3.0 — References
- Annex A — General Description of Industry Activities

varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with dairy processing facilities that occur during the operational phase, along with recommendations for their management. Recommendations for the management of EHS issues common to most large industrial facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues specifically associated with dairy processing facilities include the following:

- Wastewater
- Solid waste
- Emissions to air
- Energy consumption

Wastewater

Industrial Process Wastewater

Due to the presence of milk solids (e.g. protein, fat, carbohydrates, and lactose), untreated wastewater from dairy processing facilities may have a significant organic content, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). Whey may also contribute to high organic loads in wastewater. Salting activities during cheese production may result in high salinity levels in wastewater. Wastewater may also contain acids, alkali, and detergents with a number of active ingredients, and disinfectants, including chlorine compounds, hydrogen peroxide, and quaternary ammonia compounds. Wastewater may have a significant microbiological load and may also contain pathogenic viruses and bacteria.

The following recommended techniques can be used to prevent the contamination of the wastewater stream:

- Avoid milk, product, and by-product losses (e.g. from spills, leaks, excessive changeovers, and shut downs) through the adoption of good manufacturing procedures and facility maintenance;
- Separate and collect product waste, including rinse waters and by-products, to facilitate recycling or further processing for subsequent use, sale, or disposal (e.g. whey and casein);
- Install grids to reduce or avoid the introduction of solid materials into the wastewater drainage system;
- Process and foul drains should be separate in process areas and should discharge directly to a treatment plant and / or municipal sewerage system;
- Pipes and tanks should be self-draining, with appropriate procedures for product discharge prior to, or integral with, cleaning procedures;
- Subject to sanitary requirements, recycle process water, including condensate from evaporation processes, for preheating and heat-recovery systems for heating and cooling processes, to minimize water and energy consumption;
- Adopt best-practice methods for facility cleaning, which may involve manual or automated Clean In Place (CIP)² systems, using approved chemicals and / or detergents with minimal environmental impact and compatibility with subsequent wastewater treatment processes.

² Automated CIP systems reduce chemical, water, and energy consumption and facilitate rinse recovery but may not be appropriate for all applications.

Process Wastewater treatment

Techniques for treating industrial process wastewater in this sector include grease traps, skimmers or oil water separators for separation of floatable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers; biological treatment, typically anaerobic followed by aerobic treatment, for reduction of soluble organic matter (BOD); biological nutrient removal for reduction in nitrogen and phosphorus; chlorination of effluent when disinfection is required; dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible. Additional engineering controls may be required to contain and neutralize nuisance odors. Source segregation and alternate treatment methods are typically used for high salinity streams that contribute to elevated TDS levels in the wastewater.

Management of industrial wastewater and examples of treatment approaches are discussed in the **General EHS Guidelines**. Through use of these technologies and good practice techniques for wastewater management, facilities should meet the Guideline Values for wastewater discharge as indicated in the relevant table of Section 2 of this industry sector document.

Other Wastewater Streams & Water Consumption

Guidance on the management of non-contaminated wastewater from utility operations, non-contaminated stormwater, and sanitary sewage is provided in the **General EHS Guidelines**. Contaminated streams should be routed to the treatment system for industrial process wastewater. Dairy processing facilities use considerable quantities of potable water for processing and for cleaning of equipment, process areas, and vehicles. Recommendations to reduce water consumption, especially

where it may be a limited natural resource, are provided in the **General EHS Guidelines**.

Solid Waste

Solid organic waste in dairy processing facilities mainly originates from production processes and includes non-conforming products and product losses (e.g. milk spillages liquid whey and buttermilk), grid and filter residues, sludge from centrifugal separators and wastewater treatment, and packaging waste (e.g. discarded cuts, spent ripening bags, wax residues from cheese production) arising from incoming raw materials and production line damage.

Recommended measures to reduce and manage solid waste include the following:

- Where possible and subject to sanitary requirements, segregate solid process waste and non-conforming products for reprocessing into commercial products and by-products (e.g. butter oil, processed cheese, animal feed, soap stock, or other technical-grade materials);
- Optimize product filling and packaging equipment to avoid product- and packaging-material waste;
- Optimize the design of packaging material to reduce the volume of waste (e.g. by using recycled materials and by reducing the thickness without compromising food safety criteria). If PET bottles are blown on site, plastic waste cuttings can be reused, or should be sorted as plastic waste for off-site recycling or disposal;
- Use uncontaminated sludge from on-site wastewater treatment for agricultural fertilizer or production of biogas.
- Remaining waste should be managed and disposed of according to the recommendations for industrial waste in the **General EHS Guidelines**.

Air Emissions

Exhaust Gases

Exhaust gas emissions (carbon dioxide [CO₂], nitrogen oxides [NO_x] and carbon monoxide [CO]) in the dairy processing sector result from the combustion of gas and fuel oil or diesel in turbines, boilers, compressors and other engines for power and heat generation. Guidance for the management of small combustion source emissions with a capacity of up to 50 megawatt thermal (MWth), including air emission standards for exhaust emissions, is provided in the **General EHS Guidelines**. For combustion source emissions with a capacity of greater than 50 MWth refer to the **EHS Guidelines for Thermal Power**.

Dust

Emissions of dust during dairy processing activities include fine milk powder residues in the exhaust air from the spray drying systems and bagging of product. Recommended measures to prevent and control dust emissions mainly consist of the installation of exhaust ventilation equipped with dry powder retention systems (e.g. cyclones or bag filters). Bag filters are generally favored over wet scrubbing methods, as they use significantly less energy, generate less or no wastewater, and produce less noise. The presence of hot air and fine dust creates fire and explosion impacts. All modern spray dryers should be equipped with explosion release mechanisms and fire prevention systems.

Odor

The major sources of odor emissions in dairy processing facilities are related to on-site wastewater treatment facilities, in addition to fugitive odor emissions from filling / emptying milk tankers and storage silos. Recommended management techniques to prevent and control odor emissions include the following:

- Ensure wastewater treatment facilities are properly designed and maintained for the anticipated wastewater load;
- Keep all working and storage areas clean;
- Empty and clean the fat trap frequently (e.g. daily emptying and weekly cleaning);
- Minimize stock of waste and by-products and store for short periods in cold, closed, and well-ventilated rooms;
- Enclose production activities that cause odor and operate under vacuum.

Energy Consumption

Dairy processing facilities consume considerable amounts of energy. Typically, approximately eighty percent of the energy requirements are for thermal uses to generate hot water and produce steam for process applications (e.g. pasteurization, evaporation, and milk drying) and cleaning purposes. The remaining 20 percent is used as electricity to drive processing machinery, refrigeration, ventilation, and lighting. In addition to recommendations to increase energy efficiency discussed in the **General EHS Guidelines**, the following industry-specific measures are recommended:

- Reduce heat loss by :
 - Using continuous, instead of batch, pasteurizers
 - Partially homogenizing milk to reduce the size of heat exchangers
 - Using multistaged evaporators
 - Insulating steam, water, and air pipes / tubes
 - Eliminating steam leakage and using thermostatically controlled steam and water blending valves
- Improve cooling efficiency by:
 - Insulating refrigerated room / areas
 - Installing automatic door closing (e.g. with microswitches) and applying airlocks and alarms;

- Employ heat recovery for both heating and cooling operations in milk pasteurizers and heat exchangers (e.g. regenerative countercurrent flow);
- Investigate the means to recover waste heat, including:
 - Recovering waste heat from refrigeration plant, exhaust, and compressors (e.g. to preheat hot water)
 - Recovering evaporative energy
 - Employing heat recovery from air compressors and boilers (e.g. waste gas exchanger)
- Provide workers with training in the proper use of equipment (including the proper use of machine safety devices) and personal protective equipment (PPE), such as hearing protection;
- Ensure that the process layout reduces opportunities for process activities to cross paths, thus avoiding collisions and falls;
- Demarcate transport corridors and working areas and ensure the proper placement of handrails on platforms, ladders, and stairs;
- Ground all electrical equipment and installations in wet rooms.

1.2 Occupational Health and Safety

Occupational health and safety hazards for dairy processing facilities are similar to those of other industrial facilities and recommendations for the management of these issues can be found in the **General EHS Guidelines**. In addition, occupational health and safety issues that may be specifically associated with dairy processing operations include the following:

- Physical hazards
- Biological hazards
- Chemical hazards
- Exposure to heat, cold, and radiation

Physical Hazards

Physical hazards include exposure to same-level fall hazards due to slippery conditions, the use of machines and tools, and collisions with internal transport equipment (e.g. forklift trucks and containers). Guidance on general workplace conditions, including design and maintenance of working and walking surfaces to prevent slips and falls, is presented in the **General EHS Guidelines**. Additional, industry-specific recommendations are presented below.

- Maintain walking and working surfaces clean and dry and provide workers with antislip footwear;

Lifting, Repetitive Work, and Work Posture Injuries

Dairy processing activities may include a variety of situations in which workers can be exposed to lifting, carrying, repetitive work, and work-posture injuries. Such injuries may result from heavy manual lifting and repetitive work, including the operation of slicing and vacuum-packing machines and poor working postures caused by inadequate workstation and process activity design. Recommended management approaches, including the use of mechanical equipment where necessary (e.g. to move pallets of milk carton) to reduce these injuries are discussed in the **General EHS Guidelines**.

Biological Hazards

Exposure to biological and microbiological agents may be associated with inhalation and ingestion of dust and aerosols, particularly in milk powder operations. Dust from the ingredients used in dairy processing and high levels of humidity may cause skin irritation or other allergic reactions.

In addition to the guidance included in the **General EHS Guidelines**, recommendations for the prevention and control of exposures to biological hazards specific to dairy processing include the following:

- Avoid dust- and aerosol-generating activities (e.g. use of compressed air or high-pressure water for cleaning) and, where they cannot be avoided, provide proper ventilation of enclosed or semi-enclosed areas to reduce or eliminate exposure to dust and aerosols;
- Install exhaust ventilation equipped with filters and / or cyclones, at sources of dust;
- Provide workers with PPE that is appropriate for the process activity;
- Ensure physical segregation of work and welfare facilities to maintain worker personal hygiene;
- Avoid direct contact with non-conforming dairy products.

Chemical Hazards

Exposure to chemicals (including gases and vapors) typically involves chemical-handling activities related to cleaning operations and disinfection of process areas, in addition to the maintenance of heating (thermal oils) and cooling systems (ammonia). Recommended measures to prevent and control exposure to chemicals are discussed in the **General EHS Guidelines**.

Heat and Cold

Workers at dairy processing facilities may be exposed to heat from process activities and to cold in refrigeration areas and rooms. Recommendations for the management of exposure to heat and cold are presented in the **General EHS Guidelines**.

Noise and Vibrations

The main sources of noise in a dairy processing facility are centrifuges, homogenizers, spray towers, and filling and packing machinery which are all typically located in enclosed buildings. Recommendations for the management of exposure to noise and vibration are presented in the **General EHS Guidelines**.

1.3 Community Health and Safety

Community health and safety impacts during the construction of dairy processing plants are common to those from the construction of other industrial facilities and are discussed in the **General EHS Guidelines**. During the facility's planning phase, the location of the processing facility should be designated at an appropriate distance from neighbors, and access roads should be assessed for suitable use in food transport. Community health and safety impacts during the operation phase that are common to most industry sectors, including those related to traffic safety during transport of raw materials and finished product, are discussed in the **General EHS Guidelines**. Industry-specific issues with the potential to impact the community or the public at large are those associated with pathogens or microbial contaminants, as well as other chemical or physical impacts, associated with processed dairy products.

Food Safety Impacts and Management

A food product recall caused by contaminated or adulterated food products can damage a viable business. If a company can trace its products to specific lot numbers, then recall is a matter of removing all foods associated with those numbers. With a robust food safety program in place, a company can protect itself from product adulteration, contamination, and the impacts of food recalls.

Dairy processing should be undertaken according to internationally recognized food safety standards consistent with the principles and practice of HACCP³ and Codex Alimentarius.⁴ Recommended food safety principles include the following:

- Respect "clean" and "dirty" zoning, designed in accordance with HACCP prerequisites (e.g. sanitary standard operating procedures), as discussed below;

³ ISO (2005).

⁴ FAO and WHO (1962–2005).

- Ensure the cooling chain is unbroken for sensitive products requiring refrigeration;
- As far as possible, ensure full traceability of all materials and products throughout the supply chain;
- Ensure adequate veterinary inspection, including examination of vaccination certificates for the animals in the supply chain;
- Comply with veterinary regulations and precautions for management of waste, sludge, and by-products;
- Institutionalize all HACCP prerequisites, including
 - Sanitation
 - Good-management practices
 - Implementation of integrated pest and vector management programs and maximization of pest and vector control through mechanical means (e.g. traps and use mesh on doors and windows to reduce the need for chemical pest and vector control)
 - Chemical control
 - Allergen control
 - Customer complaints mechanism
 - Traceability and recall

2.0 Performance Indicators and Monitoring

2.1 Environment

Effluent Guidelines

Table 1 presents effluent guidelines for this sector. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. These guidelines are achievable under normal operating conditions in appropriately

designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guidelines**.

Emissions guidelines are applicable to process emissions. Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the **EHS Guidelines for Thermal Power**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Table 1. Effluent levels dairy processing

Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD ₅	mg/l	50
COD	mg/l	250
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Temperature increase	°C	<3 ^b
Total coliform bacteria	MPN ^a / 100 ml	400
Active Ingredients / Antibiotics	To be determined on a case specific basis	
Notes: ^a MPN = Most Probable Number ^b At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity		

Within the group of market milk producers, the production of butter slightly increases energy consumption.

Table 2. Waste generation in the dairy sector

Product range	Total solid waste (kg/1000 l)
Market milk and cultured products	1.7–14 ^a
Cheese, whey, and powder	0.5–10 ^b
Ice cream	35–58 ^c
^a Based on results from 13 dairies. ^b Based on results from 17 dairies. ^c Based on results from 4 dairies. Source: Nordic Council of Ministers (2001).	

Resource Use and Waste Generation

Tables 2 and 3 present information on resource use and waste generation in the dairy processing sector, which can be considered as indicators of this sector's efficiency and may be used to track performance changes over time. Table 3 presents energy and resource consumption data for dairy processing facilities. The table shows that the variation is large, mainly because of differences in product variety and batch sizes. The quantity of wastewater is generally smaller compared with the consumption of freshwater. This is in part because some of the water used for cooling condensers evaporates and in part because some of the unpolluted, spent cooling water is not monitored during discharge into the surroundings.

The variation in the energy consumption figures is the result of the differing proportions of energy-consuming products (e.g., powder) within the product range. Plants with powder production generally have higher energy consumption than in other plants.

Table 3. Resource and energy consumption.

Inputs per unit of product	Mass load unit	European dairies ^a	Swedish dairies ^b	Danish dairies ^b	Finnish dairies ^b	Norwegian dairies ^b	Industry benchmark ^c
Water							
Market milk and cultured products	L/L processed milk		0.96–2.8	0.60–0.97	1.2–2.9	4.1	1.0–1.5
Cheese and whey	L/L processed milk		2.0–2.5	1.2–1.7	2.0–3.1	2.5–3.8	1.4–2.0
Milk powder, cheese, and (or) liquid products	L/L processed milk		1.7–4.0	0.69–1.9	1.4–4.6	4.6–6.3	0.8–1.7
Ice cream	L/kg icecream						4.0–5.0
Energy							
Market milk and cultured products	kWh/L processed milk	0.09–1.11	0.11–0.34	0.07–0.09	0.16–0.28	0.45	0.1–0.2
Cheese and whey	kWh/L processed milk	0.06–2.08	0.15–0.34	0.12–0.18	0.27–0.82	0.21	0.2–0.3
Milk powder, cheese, and (or) liquid products	kWh/L processed milk	0.85–6.47	0.18–0.65	0.30–0.71	0.28–0.92	0.29–0.34	0.3–0.4
Ice cream	KWh/kg ice cream		0.75–1.6				0.8–1.2
Wastewater discharge							
Market milk and cultured products	Liters/L processed milk		0.8–2.5	0.83–0.94	1.2–2.4	2.6	0.9–1.4
Cheese and whey	Liters/L processed milk		1.4–2.0	0.77–1.4	1.5–3.2	3.2	1.2–1.8
Milk powder, cheese, and (or) liquid products	liters/L processed milk		1.2–4.3	0.75–1.5	1.9–3.9	2.0–3.3	0.8–1.5
Ice cream	L/kg ice cream		2.7–4.4	-	5.6	3.0–7.8	2.7– 4.0
<p>a European Dairy Association (2002), cited in EC (2006). b Nordic Council of Ministers (2001). The numbers in brackets refer to the number of dairies in the sample. c Nordic Council of Ministers (2001).</p>							

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment during normal operations and upset conditions. Environmental-monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),⁵ the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),⁶ Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United

States (OSHA),⁷ Indicative Occupational Exposure Limit Values published by European Union member states,⁸ or other similar sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)⁹.

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals¹⁰ as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

⁵ Available at: <http://www.acgih.org/TLV/> and <http://www.acgih.org/store/>

⁶ Available at: <http://www.cdc.gov/niosh/npg/>

⁷ Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

⁸ Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

⁹ Available at: <http://www.bls.gov/iif/> and <http://www.hse.gov.uk/statistics/index.htm>

¹⁰ Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

The dairy sector converts raw milk into safe products for human consumption. Products range from pasteurized and ultra high temperature processing (UHT) milk to value-added dairy products such as yoghurt, butter and cheese. In the past, liquid milk and fresh dairy product plants tended to be located in or near urban centers. The modern trend is for plants to be situated close to the raw milk supply, especially those producing long life products (e.g. UHT, cheese, and milk powders). The current trend toward large processing plants has provided companies with more automated and efficient equipment. This development tends to increase the environmental impact in some areas, mainly due to high concentration of waste and increased traffic. Dairy processing plants can be divided into two categories:

- Fluid milk processing involving the pasteurization and processing of raw milk into liquid milk for direct consumption, as well as cream, flavored milk, and fermented products such as buttermilk and yogurt.
- Industrial milk processing involving the pasteurization and processing of raw milk into value-added dairy products such as cheese and casein, butter and other milk fats, milk powder and condensed milk, whey powder and other dairy ingredients, and ice cream and other frozen dairy products.

Dairy processing is continuously improving. New filtration and drying processes have increased recovery of milk solids that were previously discharged. Processes have become significantly more energy efficient and the use of electronic monitoring, control, and regulation systems has improved processing effectiveness and reduced product loss considerably.

Figure A-1 presents a simplified schematic diagram of the processes in a notional dairy, each of which is further described below.

Raw Milk Collection, Reception and Storage

The first steps in preserving the quality of milk should be taken at the farm. To achieve the best quality raw milk at intake, milking conditions must be as hygienic as possible. The milk must be chilled to below + 4°C immediately after milking and be kept at this temperature during transport to the dairy.

Best practice indicates that farms or intermediate collection centers be equipped with stainless steel refrigerated bulk storage tanks. Raw milk is collected and transported to the processing plant in stainless steel insulated or refrigerated bulk tank cars of up to 30,000 liters. Markets with a predominance of small farmers may still use aluminum or stainless steel cans of 30-50 liters which are collected by, or delivered to, the processing plant.

Where water and electricity is not available the milk should be delivered to a central collecting point with cooling facilities or delivered to the dairy for processing immediately after milking. Bulk tanks or cans should be cleaned and sanitized immediately after discharge at the dairy. Water is used to rinse and clean the reception lines, road tankers, and cans. Modern plants may employ Clean in Place systems (CIP) and automated can washers.

At the reception point, the raw milk is sampled for quality analysis and, after acceptance, measured by volume or by weight and cooled to a temperature below +4°C. After cooling, the milk is stored in a silo to await processing. Ice water is normally used for cooling.

Separation and Standardization

Centrifugal separation and clarification is common in dairy processing to ensure further processing of standard products avoiding quality variations. In most dairies, the cream separation and clarification is carried out using self-cleaning separators. The separator also discharges sediment consisting of dirt particles,

udder cells, and bacteria, and leucocytes, which normally is collected or led to the wastewater drain.

Standardization of the dry matter for fat, protein, and lactose content of the milk usually takes place in the production phase of most dairy products. The most common techniques include mixing of skimmed milk and cream, evaporation, and membrane filtration.

Homogenization

The aim of homogenization is to prevent gravity separation of the fat in the product and to improve the syneresis stability of mainly cultured products. The homogenizer consists of a high-pressure pump and homogenizing valve driven by a powerful electric motor.

Heat Treatment and Cooling of Milk Products

Regardless of what the end product will be, the milk is usually heat treated to ensure that all pathogenic¹¹ microorganisms are removed. This is achieved by pasteurization or sterilization, a heating procedure that is required by law in most countries with the exception of some types of cheese made from unpasteurized milk¹². To save energy, the pasteurization process should involve regenerative heat exchange, which means that the already pasteurized milk is used as a heating medium for the incoming cold milk. After heating, the milk is cooled down to a temperature suitable for subsequent processing or storage.

Milk and Dairy Product Production

Cheese Production

Cheese is obtained by coagulation of milk and consists mainly of the protein and fat fractions of the milk. Cheese production involves several steps common to most types of cheese and includes coagulation and separation of curd, pressing, salting, ripening, and packaging. Depending on the type of cheese produced, 85–90

percent of the original milk volume is separated as a residual liquid by-product called whey which contains the lactose fraction of the milk and some proteins. Whey can be further processed by concentration and drying to produce powders, whey protein concentrates, lactose and animal feeds. It may also be sold directly as animal feed. Membrane filtration can be used in cheese production as an effective means of limiting the loss of milk solids, but membrane cleaning requires large quantities of water, heat, and cleaning agents.

Butter Production

Butter can be produced as batches in churns or continuously in a continuous butter-making machine. Although churns are still used today, most of them have been replaced by continuous machines. The churning step produces buttermilk, which represents a potential waste stream unless collected for sale. Emptying and cleaning of butter-making equipment and packaging machines generate waste and wastewater containing fat.

Condensed Milk, Milk Powder, and Dairy Ingredients

For these products, evaporation or membrane filtration issued to pre-concentrate skimmed milk, whole milk, buttermilk, and whey before final processing. The final drying is usually achieved by spray drying, in which an atomizer disperses the pre-concentrated milk as a fog-like mist into a large chamber through which hot air is drawn in a spiral pattern. The water in the milk spray evaporates instantly to form powder particles. Alternatively, the older drum drying process may be used, in which the water evaporates on rotating, steam-heated drums.

Ice Cream

Ice cream manufacture involves the handling of both dry and liquid raw materials including reception of milk, cream, sugar and other

¹¹ A pathogenic organism is one which causes disease, sickness or toxicity.

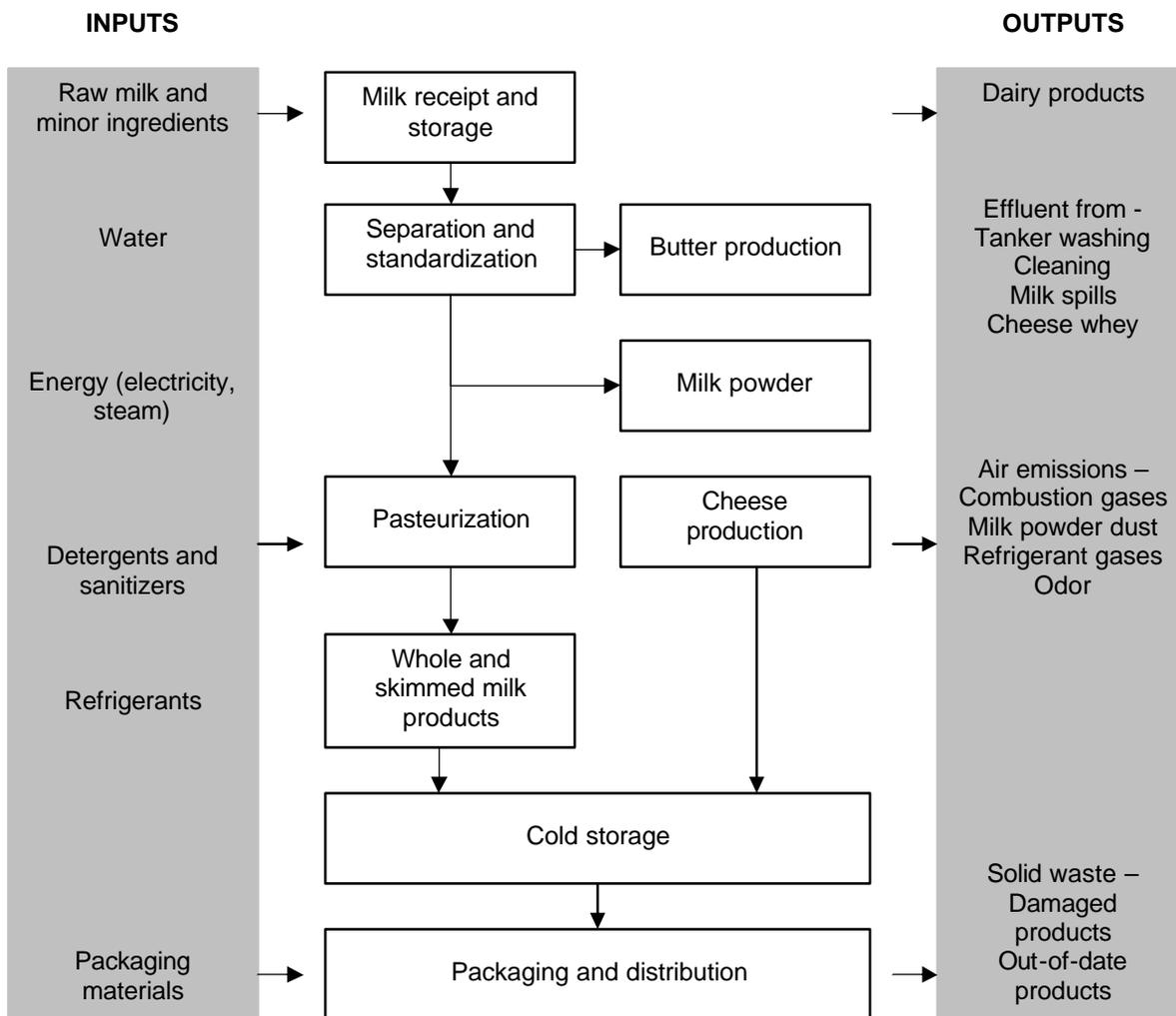
¹² Not permitted in all jurisdictions

ingredients; mixing operations; pasteurizing, freezing and hardening; packaging; and storage at temperatures below -18°C.

Packaging of Milk and Dairy Products

Packaging protects the product from bacteriological, light, and oxygen contamination. Liquid milk products may be packed in a beverage carton, which is mainly paperboard covered by a thin layer of food-grade polyethylene on either side. Milk cartons for long-life milk have an additional layer of aluminum foil. Many other packaging materials are also used, ranging from simple plastic pouches to glass bottles, PET laminates and PVC bottles. PET laminates are becoming increasingly popular and are blown at the plant from granulates, generating small amounts of plastic waste when the neck of the container is cut off. Cultured products are packed in beverage cartons or plastic cups and bottles with lids of aluminum foil or paper. In some cases the containers are wrapped together in a carton as multipacks.

Figure A-1. Dairy Processing Activities



Source: Adapted from English Dairy Board (2004)