Prevention of
pollution in the
Dairy industry

Regional Activity Centre for Cleaner Production (RAC/CP)
Mediterranean Action Plan

UNEP

MAP

Regional Activity Centre
for Cleaner Production

Ministry of the Environment
Spain

Government of Catalonia
Ministry of the Environment

If you consider that some part of this study could be improved or there is any lack of precision, we would appreciate very much receiving notification of it.

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1. INTRODUCTION. OBJECTIVES AND METHODOLOGY

The **study on the prevention and reduction of pollution at the source in the dairy industry in the countries of the Mediterranean Action Plan (MAP)** (the **DAIRY/CP PROJECT**) by the **Regional Activity Centre for Cleaner Production (RAC/CP)** was one of the recommendations of the RAC/CP National Focal Points.

RAC/CP has carried out the study with the support of experts on the environment and industrial food and agriculture processes of the Spanish Instituto Tecnológico Agroalimentario (AINIA), located in Paterna (Valencia).

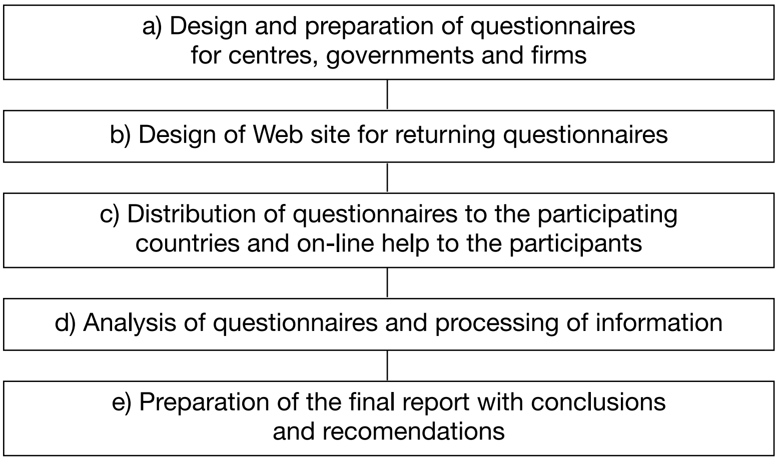
This centre was chosen in 1997 by the Spanish government for carrying out the project for dissemination and promotion of Council Directive IPCC 96/61/EC and exchange of information about Best Available Techniques (BATs) in the dairy sector.

The main objectives of the DAIRY/CP study are to describe the status of the dairy industry in the MAP countries, the main production processes, secondary operations, products of the dairy industry and related environmental effects and to describe the main opportunities to prevent or reduce pollution at the source through the presentation of concrete cases, conclusions and recommendations. The following countries are members of MAP: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey.

Monaco and Slovenia have not been included in the study because no background material was available or information was lacking on the dairy industry.

The methodology used for the study is given in the following figure.

Figure 1
METHODOLOGY



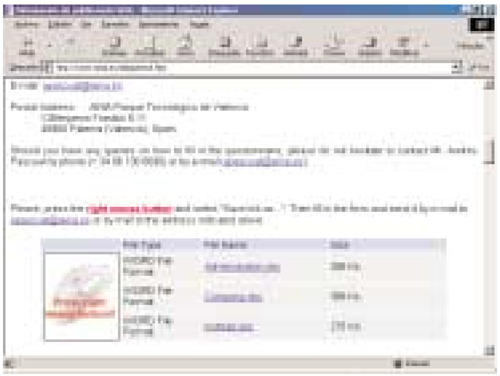
a) Three types of questionnaires were drawn up to be completed by three types of respondents:

- A questionnaire for the GOVERNMENT: ministries of industry, the environment, food, agriculture, etc. (annex I), including questions on structure, production, consumption, exports and imports of the dairy sector, as well as policies for the prevention of pollution;
- A questionnaire for CENTRES: technological, research or teaching (annex II), including questions on products, cleaner production activities (good practices, clean technologies, recycling at the source);
- A questionnaire for FIRMS in the dairy sector (annex III), including questions primarily on processes and equipment.

A minimum experience of five years as technician in the dairy or environmental sectors was required for the person completing the questionnaire.

b) Once the questionnaires were drawn up, a Web site in three languages was created so that the participants could download the questionnaires in Word format and obtain information about any doubts that might occur during the filling-out of the questionnaire. The questionnaire was also sent by e-mail and fax to several countries.

Figure 2
WEB SITE DAIRY/CP PROJECT



c) During the DAIRY/CP PROJECT, more than 250 contacts were made with governments, centres and enterprises in the countries participating in the study. Completed questionnaires were received from the countries, providing sufficient information in order to give content to the study. The difficulty of standardizing data and information from countries with quite different cultures and resources should be pointed out. Participation of the Focal Points was a key to the success of the study's objectives.

d) Once the completed questionnaires were received, the data were processed and the final report was written. The main source of information used for description of the situation in each country has been the data provided by the Focal Points, contrasted and/or completed with data from USDA. This last source of information is mentioned as reference through the study with the aim of giving it an homogeneous dimension. This has not implied substitution of the data source, which has remained the information provided by the Focal Points. The philosophy behind the study is to provide a tool to improve the prevention of pollution through practical proposals whose application is possible for dairy firms in the MAP countries.

2. STATUS OF THE DAIRY INDUSTRY IN THE MAP COUNTRIES

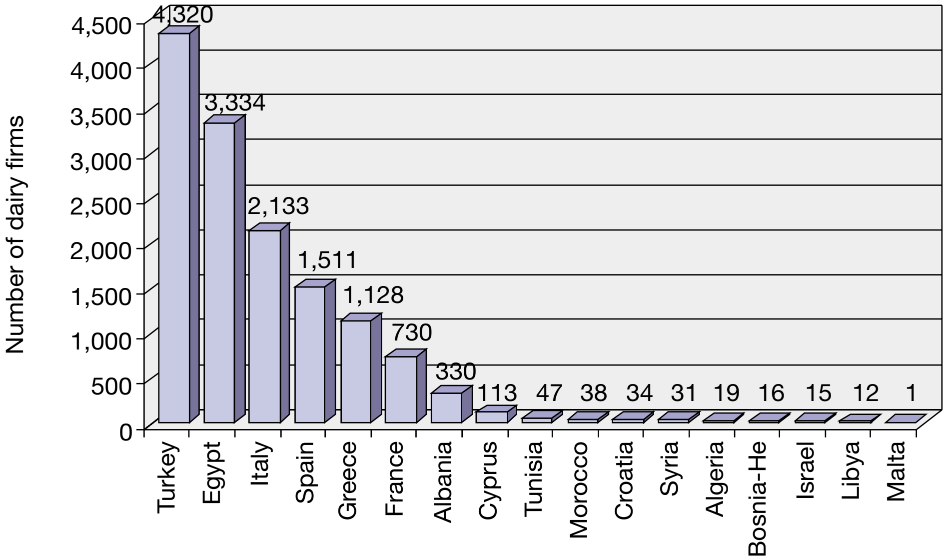
2.1. OVERALL status of the dairy sector in the Mediterranean countries

2.1.1. General information on the food and dairy sector

In the Mediterranean countries, the food and agricultural sector represents between 10 and 20 per cent of total industrial activity. Only Algeria with 2 per cent and Egypt with about 31 per cent are outside this range. There are approximately 100,000 food and agricultural firms whose distribution throughout the Mediterranean countries varies enormously, owing to differences in population and level of industrial development.

In all these countries, dairy firms usually represent between 10 and 30 per cent of total food and agricultural enterprises. The Egyptian dairy sector is very important and includes 47 per cent of all food and agricultural enterprises. In all, there are about 14,000 firms, which employ more than 160,000 persons, but there are also large differences between countries, as is shown in figures 3 and 10.

Figure 3
RANKING OF MEDITERRANEAN COUNTRIES BY NUMBER OF DAIRY FIRMS[1]



Only six countries, Turkey, Egypt, Italy, Spain, Greece and France, have more than 500 dairy firms.

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[1] The data from Lebanon is not available.

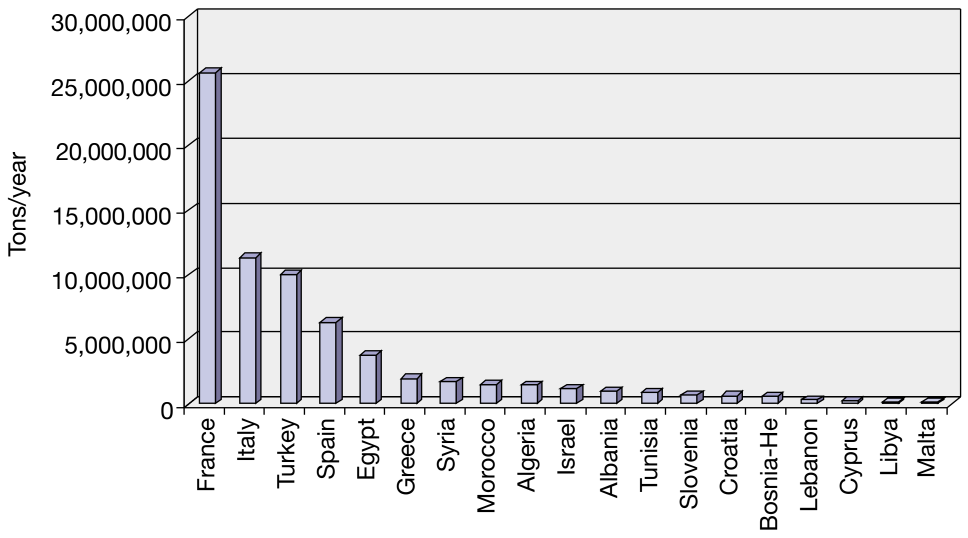
In most of the countries, dairy firms are small with fewer than 10 workers. The average number of small firms reaches 77.9 per cent. These firms are usually traditional and produce a volume of milk and dairy products that is always less than 50 tons/day.

In many Mediterranean countries, especially in those where the dairy sector is poorly developed, there are a few enterprises that absorb most of the production in addition to the small enterprises. They are operations with more than 100 workers and with a high level of production of more than 100 tons/day. Occasionally, these enterprises are state controlled.

2.1.2. National milk production

Total national milk production in the Mediterranean countries is 68.8 million tons (see figures 4 and 11). The 25.6 million tons/year produced by France is the largest amount and represents 37 per cent of total production in the Mediterranean. The five major producers, France, Italy, Turkey, Spain and Egypt, share 83 per cent of total production.

Figure 4
MAIN MEDITERRANEAN MILK-PRODUCING COUNTRIES



Cow’s milk is the most important milk throughout the Mediterranean region and represents 88.5 per cent of total production. The rest of the production is made up of about 5.2 per cent sheep’s milk, 3.3 per cent buffalo’s milk and another 3.0 per cent of goat’s milk.

Figure 5
MILK PRODUCTION BY TYPE

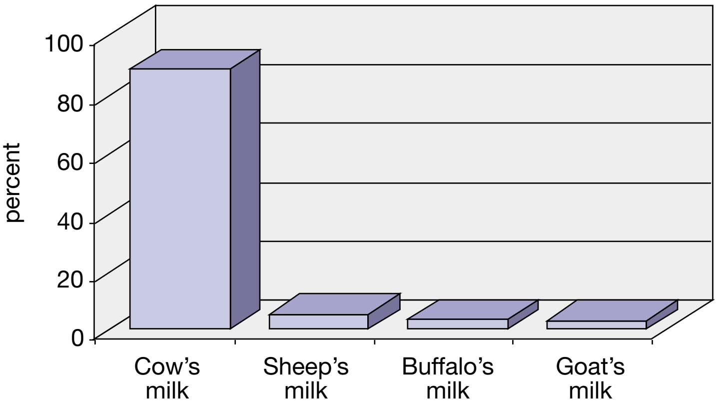


Table 1: National milk production

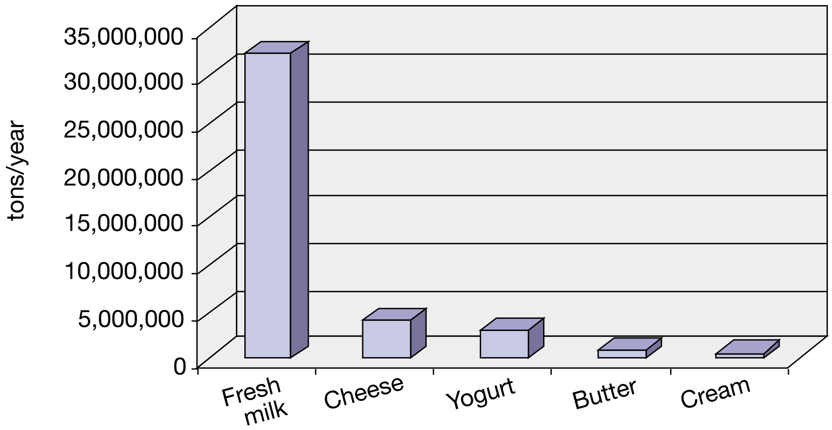
COUNTRY	TOTAL (tons/year)	Per cent	COW'S milk (tons/year)	Per cent	SHEEP'S milk (tons/year)	Per cent	GOAT'S milk (tons/year)	Per cent
ALBANIA	907,962	1.3	761,340	1.3	73,556	2.1	73,066	3.6
ALGERIA	1,409,354	2.1	1,039,854	1.7	220,000	6.2	143,000	7.0
BOSNIA-HERZEGOVINA	565,815	0.8	552,247	0.9	9,640	0.3	3,928	0.2
CROATIA	603,000	0.9	603,000	1.0				
CYPRUS	173,000	0.3	130,000	0.2	21,500	0.6	21,500	1.1
EGYPT	3,723,080	5.4	1,596,880	2.6	93,000	2.6	15,000	0.7
FRANCE	25,631,650	37.4	24,892,000	41.0	243,850	6.8	496,800	24.3
GREECE	1,910,045	2.8	790,000	1.3	670,000	18.8	450,000	22.0
ISRAEL	1,112,000	1.6	1,100,000	1.8	8,700	0.2	3,300	0.2
ITALY	11,312,088	16.5	10,402,799	17.1	638,092	17.9	121,197	5.9
LEBANON	272,300	0.4	201,000	0.3	33,800	0.9	37,500	1.8
LIBYA	74,800	0.1	73,000	0.1			1,800	0.1
MALTA	50,800	0.1	46,400	0.1	2,600	0.1	1,800	0.1
MOROCCO	1,445,000	2.1	1,410,000	2.3			35,000	1.7
SLOVENIA	634,448	0.9	634,448	1.0				
SPAIN	6,281,300	9.2	5,685,400	9.4	278,200	7.8	317,700	15.5
SYRIA	1,656,085	2.4	1,143,423	1.9	445,913	12.5	65,853	3.2
TUNISIA	830,000	1.2	800,000	1.3	17,000	0.5	12,000	0.6
TURKEY	9,970,000	14.5	8,832,000	14.6	813,000	22.8	245,000	12.0
TOTAL	**68,562,727**	**100.0**	**60,693,791**	**100.0**	**3,568,851**	**100.0**	**2,044,444**	**100.0**

Apart from cow's, sheep's and goat's milk, 2,248,200 tons of buffalo's milk are also produced chiefly in three countries, among which Egypt is clearly the most important, producing 89.7 per cent, followed by Italy (6.7 per cent) and Turkey (3.6 per cent). Other types of milk (camel and miscellaneous) are produced in insignificant amounts.

2.1.3. Production of milk and dairy products

The main dairy product is fresh milk (32.3 million tons/year), followed by cheese (4.1 million tons/year), yogurt and other fermented milks (2.8 million tons/year), small quantities of butter (0.8 million tons/year) and cream (0.5 million tons/year).

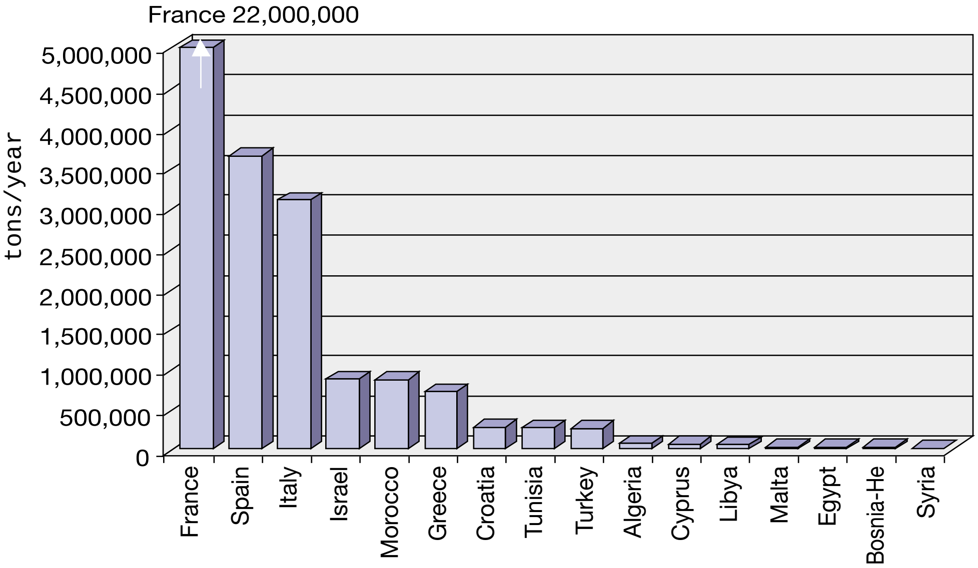
Figure 6
DISTRIBUTION OF DAIRY PRODUCTS



The main producers of fresh milk are France (22 million tons/year), Spain (3.6 million tons/year), Italy (3.1 million tons/year) and Israel (0.9 million tons/year), which together produce 92 per cent of overall production (see figures 7 and 12).

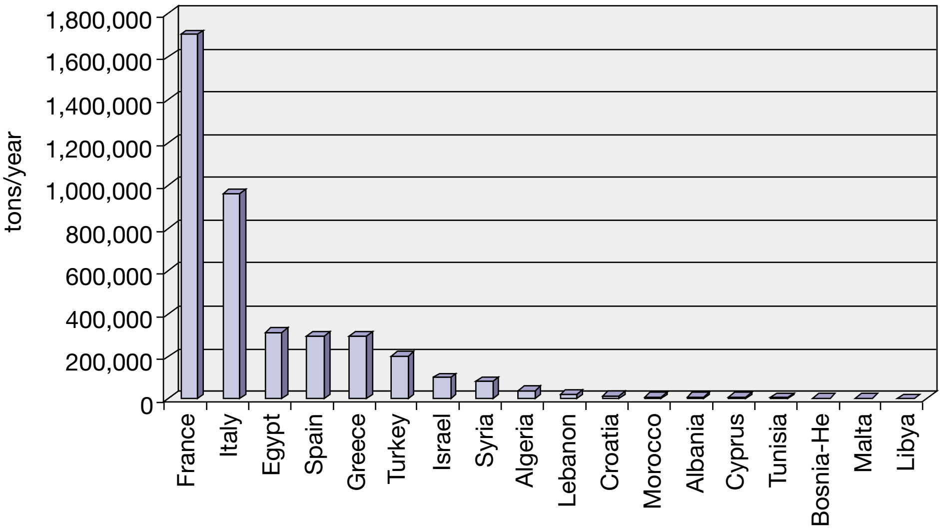
Several countries that have an important local production, such as Turkey and Egypt, have a rather low national production of fresh milk. Milk consumption is lower than that of other dairy products, especially cheese, although the main reason for this in both cases is found in the very important role of local consumption on dairy farms and direct sales to consumers.

Figure 7
RANKING OF FRESH MILK PRODUCERS



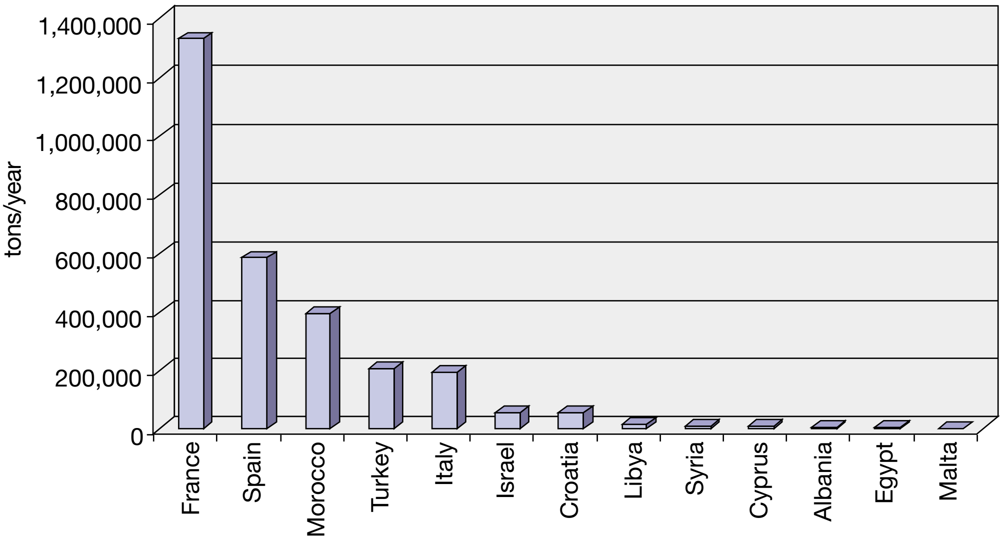
There is a wide variety of cheeses manufactured in the Mediterranean countries, primarily from cow's milk but also, to a lesser extent, from sheep's milk, goat's milk or a mixture of milks. The largest producer is France with 1.7 million tons/year, followed by Italy with 1.0 million tons/year (see figures 8 and 14).

Figure 8
RANKING DE CHEESE PRODUCERS



A total of 2.8 million tons/year of yogurt and other fermented milks are produced in the Mediterranean countries (see figures 9 and 13), among which France clearly stands out, with approximately half of the overall production (46.8 per cent), along with Spain (20.4 per cent) and Morocco (13.7 per cent).

Figure 9
RANKING OF PRODUCERS OF YOGURT AND OTHER FERMENTED MILKS[2]



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[2] The data concerning production of yogurt and other fermented milks in the following countries is not available: Greece, Lebanon, Tunisia, Algeria and Bosnia & Herzegovina.

Table 2: Milk and dairy product production in the Mediterranean countries[3]

COUNTRY	FRESH MILK tons/year	Per cent	YOGURT and other fermented milks tons/year	Per cent	CHEESE tons/year	Per cent	BUTTER tons/year	Per cent	CREAM tons/year	Per cent
ALBANIA	10,242	0.0	5,310	0.2	8,403	0.2	440	0.1	1	0.0
ALGERIA	72,730	0.2			37,024	0.9	10,000	1.3	5,000	1.0
BOSNIA-HERZEG.	24,802	0.1			4,311	0.1	1,179	0.1	897	0.2
CROATIA	271,116	0.8	54,178	1.9	15,282	0.4	1,743	0.2	1,147	0.2
CYPRUS	61,664	0.2	6,820	0.2	7,956	0.2	440	0.1	792	0.2
EGYPT	30,000	0.1	2,500	0.1	310,000	7.6	130,000	16.5		
FRANCE	22,000,000	68.1	1,330,000	46.8	1,700,000	42.0	450,000	57.2	300,000	59.8
GREECE	713,536	2.2			293,503	7.2	11,906	1.5	28,568	5.7
ISRAEL	872,927	2.7	56,152	2.0	100,000	2.5	5,235	0.7	77,686	15.5
ITALY	3,100,000	9.6	190,000	6.7	958,062	23.6	105,000	13.4		
LEBANON	4,042	0.0			21,091	0.5				
LIBYA	57,000	0.2	14,000	0.5	100	0.0				
MALTA	30,200	0.1	1,510	0.1	2,300	0.1			360	0.1
MOROCCO	860,000	2.7	390,000	13.7	10,686	0.3	10,000	1.3	66	0.0
SPAIN	3,645,400	11.3	581,600	20.4	293,800	7.3	36,200	4.6	86,000	17.1
SYRIA	14,111	0.0	7,030	0.2	82,170	2.0	3,356	0.4		
TUNISIA	262,480	0.8			6,420	0.2	5,008	0.6		
TURKEY	251,632	0.8	204,961	7.2	201,260	5.0	15,771	2.0	1,383	0.3
TOTAL	**32,281,882**	**100.0**	**2,844,061**	**100.0**	**4,052,368**	**100.0**	**786.278**	**100.0**	**501,900**	**100.0**

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[3] Blank boxes refer either to countries with no production or to non-available information.

Figure 10
DAIRY FIRMS IN THE MEDITERRANEAN COUNTRIES

Figure 11
NATIONAL MILK PRODUCTION IN THE MEDITERRANEAN COUNTRIES

Figure 12
MAIN PRODUCERS OF FRESH MILK

Figure 13
MAIN PRODUCERS OF YOGURT AND OTHER FERMENTED MILKS

Figure 14

MAIN CHEESE PRODUCERS

2.2. SPECIFIC status of national dairy sectors in the Mediterranean countries

 **ALBANIA**	POPULATION: 3,413,904
	AREA: 28,750 km^2
	NUMBER OF DAIRY FIRMS: 330
	MILK PRODUCTION: 907,962 metric tons/year

The reforms begun in Albania in 1992 completely changed the structure of the agrarian sector, and the whole productive structure was changed through reform of agriculture and livestock farms. Land was distributed in small farms of 1-2 hectares, and cattle in cooperatives and on state farms were distributed to the new farms in groups of 1-3 cows. These changes led to the loss of centralized milk production in Albania.

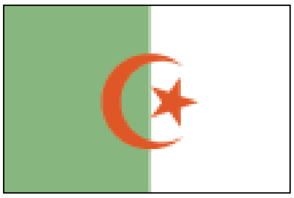
There are currently 330 dairy firms in Albania, which employ 970 workers. Most of these firms (80 per cent) are traditional and employ fewer than 10 workers (INSTAT, 1999; Food Research Institute, 2000).

Total annual milk production was 907,962 tons: primarily cow's milk (761,340 tons) and to a lesser extent sheep's milk (73,556 tons) and goat's milk (73,066 tons). As for the production of dairy products, the following products were produced: 10,242 tons of fresh milk, 5,310 tons of yogurt, 8,403 tons of cheese, 440 tons of butter and 1 ton of cream. Practically all the production is used for domestic consumption (Food Research Institute, 1999).

Only 25 per cent of the milk consumed directly is pasteurized in dairy industries. The rest is usually sold on farms directly to consumers who boil it before use.

Yogurt is usually made from cow's milk and is a traditional product in Albania. Cheese is made from cow's milk, sheep's milk or a mixture of both. There are soft cheeses (Feta, Teleme, Tip83) and hard cheeses (Vize and Kasher). Southern Albania produces the best quality of cheeses.

Policies for preventing pollution are poorly developed in Albania. Currently, there is no source of national subsidy for development of projects to prevent pollution. The Albanian Ministry of the Environment is preparing a list of dumping limits for the main pollutants in industrial waste.

	POPULATION: 28,539,321
	AREA: 2,381,740 km^2
	NUMBER OF DAIRY FIRMS: 19
ALGERIA	MILK PRODUCTION: 1,409,354 metric tons/year

The food and agricultural sector, some 96 firms, represents about only 2 per cent of total Algerian industrial activity. Of that, the dairy subsector represents 20 per cent, spread among 19 firms, which employ a total of 19,000 workers.

These firms belong to the state industrial group Giplait (Groupe Industriel pour la Production de Lait), which controls most of the production of pasteurized milk for direct consumption. The number of workers is greater than 250 in 70 per cent of these plants, while the number of employees in other firms ranges between 100 and 250 (Holdings, Ministry of Industry, 2001).

Algeria is a net importer because it produces only 40 per cent of the dairy products that it consumes. One of the main causes of the weakness of the dairy sector is poor development of the distribution network of fresh milk from farms. Despite the subsidized sale of milk to industrial production plants, only 7 per cent of the milk produced on farms is used for this. The rest is consumed locally on the farms or is sold directly to consumers at higher prices than those fixed by the government.

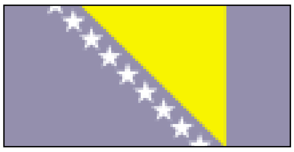
Fresh milk in Algeria is reconstituted milk obtained primarily from imported powered skim milk. Production is 859,206 tons/year, while the dairy-product sector (cheese, butter and cream) produces 52,024 tons/year (Holdings, Ministry of Industry, 2001). All of the production is consumed domestically.

Giplait prefers to use fresh milk collected in Algeria for the production of dairy products such as cheese, yogurt and butter. The private sector (small traditional enterprises) is not reflected statistically in this document but has specialized in the manufacture of these products.

Local production of cheese is soft cheese, Brie and Camembert. These types of cheese are manufactured from fresh milk and sometimes from powered milk. Nonetheless, the most popular and least expensive cheese in Algeria is a spread cheese prepared from imported cheddar.

As already mentioned, fresh milk is rarely available on the market and consumers normally buy reconstituted milk or whole powered milk ready for consumption (26 per cent milk fat content).

A programme of financing has been set up in Algeria that will help enterprises reduce pollution. The most important projects are related to the installation of wastewater treatment plants. Projects have also been planned for the use of whey in the form of carbonated beverages, although the projects are currently stopped.



BOSNIA-HERZEGOVINA

POPULATION: 3,835,777

AREA: 51,129 km^2

NUMBER OF DAIRY FIRMS: 16

MILK PRODUCTION: 565,815 metric tons/year

Bosnia and Herzegovina is currently composed of two entities with broad autonomy: the Federation of Bosnia and Herzegovina and the Republic of Srpska. The Federation of Bosnia and Herzegovina is a decentralized entity divided into ten cantons with governments that have a high degree of autonomy. The Republic of Srpska is a centralized entity divided into seven regions, where local administration exists only at the municipality level. The Republic of Srpska is responsible for providing environment protection, and the municipalities ensure law enforcement.

In 1991, before the war, total national production of cow's milk was 874,000 tons, which contrasts with 413,837 tons in 1997 as a result of the loss of half the dairy herd during the conflict (USDA, 2000). After the war, steps were taken to rebuild livestock, but that process has not yet been completed. Rebuilding of the dairy herd is being financed with the help of several programmes of the World Bank, the European Union and other governmental and non-governmental organizations.

In 1999, total national production of cow's milk was 552,247 tons, with 286,522 tons produced in the Federation of Bosnia and Herzegovina and 265,725 tons in the Republic of Srpska. As for sheep's milk, the total was 9,640 tons: the Federation of Bosnia and Herzegovina (7,355 tons) and the Republic of Srpska (2,285 tons). The production of goat's milk in Bosnia and Herzegovina was 3,928 tons.

Nonetheless, the amount of milk sold to industry is insufficient to meet demand. Thus, Bosnia and Herzegovina cannot produce sufficient fresh milk and dairy products and, therefore, must import large amounts. The most important sources of imported milk for Bosnia and Herzegovina are Slovenia, Croatia, Germany and Hungary, while the Republic of Serbia (Yugoslavia) is the most important source for the Republic of Srpska. It should be pointed out that illegal milk imports are a problem for the governments of the Federation of Bosnia and Herzegovina and the Republic of Srpska. Even before the war, state farms produced only 25 per cent of the milk needed by industry. On the other hand, private farms were small (80 per cent, with one or two cows per farm) and only 6-7 per cent of the milk was sold to the dairy industry with the rest being consumed on the farms. After the conflict, this situation became further distorted because of a lack of supply, but supply to industry has been progressively improving since 1997.

From 1997 until 1999, there was an increase in the purchase of milk from private farms because of price incentives created by local administrations and subsidies for construction of new production plants.

In 1999, there were 16 dairy industries in Bosnia and Herzegovina with a productive capacity of 200,000 tons/year (135,000 tons/year in the Federation of Bosnia and Herzegovina and 65,000 tons/year in the Republic of Srpska) (USDA, 2000). These industries employ between 25 and 100 workers and have good industrial equipment. All of them produce fewer than 50 tons/day, because only 25 per cent of capacity is used (22.6 per cent in the Federation of Bosnia and Herzegovina and 32 per cent in the Republic of Srpska).

The production of milk and dairy products in Bosnia and Herzegovina will improve in the coming years with the recovery of herds, the introduction of more productive breeds, price incentives at the source in order to increase the volume of domestic fresh milk sold to industries, and the construction of new production plants, thus reducing demand for imported dairy products.

Currently, there is neither financing nor significant projects for the prevention of pollution. Limits on the dumping of industrial wastewater date from before the war.

CROATIA

POPULATION: 4,282,216

AREA: 56,538 km^2

NUMBER OF DAIRY FIRMS: 34

MILK PRODUCTION: 603,000 metric tons/year

In Croatia, there are 34 dairy firms, which employ a total of 3,900 workers-18 firms that employ fewer than 10 workers, 13 with between 10 and 250 workers and 3 with more than 250 workers (Central Bureau of Statistics, 1999). The larger firms produce more than 200 tons of milk and dairy products daily.

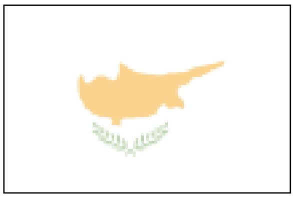
Annual production of cow's milk reached 603,000 tons (Central Bureau of Statistics, 1999). The following amounts of dairy products were produced: 271,116 tons of fresh milk, 54,178 tons of yogurt, 15,282 tons of cheese, 1,743 tons of butter and 1,147 tons of cream. In addition, 6,650 tons of condensed milk and 971 tons of powered milk were produced (Central Bureau of Statistics and Faculty of Agriculture, University of Zagreb, 1999).

It should be pointed out that 14,500 tons of fresh milk, 6,070 tons of yogurt, 2,240 tons of cheese and 460 tons of butter were exported to other countries. The rest of the production was consumed in Croatia. The annual consumption of milk and dairy products in Croatia is 125 litres per capita, of which fresh milk corresponds to 92 litres per capita (Household Consumption Survey).

Currently, there are plans costing about euro 2 million for projects related to the protection of surface and ground water, air, noise, soil and nature, and for the management of waste in the amount of euro 100,000.

There are limitations on dumping of industrial wastewater. The maximum amount of COD is 125 mg O_2/litre for dumping into rivers and 700 mg O_2/litre for dumping into the sewage system.

Several firms have taken steps to reduce the consumption of water through reuse of treated wastewater in several production operations or through changes in the refrigeration system, including replacing compressors with closed circuits.



CYPRUS

POPULATION: 758,363

AREA: 9,250 km^2

NUMBER OF DAIRY FIRMS: 113

MILK PRODUCTION: 173,000 metric tons/year

In 2000, there were 997 food and agricultural enterprises in Cyprus (16 per cent of all industry), of which 11 per cent, about 113, were dairy firms. The number of employees in the dairy sector was 1,285, which means employment of 12.5 per cent of the workers in the food and agricultural sector (Industrial Statistics, 2000).

About 87 per cent of the dairy firms employ fewer than 10 workers, about 9 per cent between 10 and 50 workers, and about 4 per cent more than 50 workers. Ninety-eight per cent of Cypriot dairy firms produce less than 50 tons/day and only about 2 per cent produce between 50 and 200 tons/day.

National production of cow's milk in 2000 was 130,000 tons, with half being used as fresh milk and the other half for the preparation of dairy products. As for sheep's and goat's milk, all the production, namely 43,000 tons, is completely used for the manufacture of dairy products (Cyprus Organisation of Dairy Products, 2000).

Annual industrial production of milk may be broken down as follows: 61,664 tons of pasteurized milk, 6,820 tons of yogurt, 7,956 tons of cheese, 440 tons of butter and 792 tons of cream. All of the production is consumed domestically except for 2,519 tons of cheese that is exported (Industrial Statistics, 1999).

The most important local cheeses are halloumi, of which 5,200 tons were manufactured in 1999, and feta (776 tons).

There are programmes in Cyprus for financing environmental projects related to cleaner technologies, minimization, recycling, treatment of wastewater and control. Subventions are usually 30 per cent of the cost of these projects (Ministry of Commerce, Industry and Tourism, 2001).

The government has constructed a central wastewater treatment plant to which small industries (including dairy firms) can take their waste. The plant has facilities for secondary and tertiary treatments that use the latest technologies. This makes it possible to solve the problem of waste from small enterprises that are unable to have their own wastewater treatment plants. Dumping of COD is limited to 18,000 mg O_2/litre, and dumping without prior treatment is permitted.

Among the most important dairy firms in Cyprus, one has its own wastewater treatment plant, while another expects that pre-treatment installations will be completed during 2001 and that this partially treated wastewater will then be emptied into the public sewer to be treated together with domestic sewage at the local wastewater treatment plant.

In addition, the government is subsidizing pig farms to convert their current dry feeding systems into wet systems that will make it possible to use whey from the dairy industry. By the end of 2001, it is hoped that 85 per cent of the liquid whey will be used to feed pigs.

 **EGYPT**	POPULATION: 69,536,644
	AREA: 1,001,450 km^2
	NUMBER OF DAIRY FIRMS: 3,334
	MILK PRODUCTION: 3,723,080 metric tons/year

The food and agricultural sector is made up of 7,531 food and agricultural enterprises, which means 31 per cent of all Egyptian industry. Almost half (3,334), 47 per cent, are dairy firms, which employ 12,136 workers (Statistics Year Book, 2000). As a result, the dairy industry is the most important subsector of the food and agricultural sector.

It is important to point out that 97 per cent of these enterprises employ fewer than 10 workers. The remaining 3 per cent, some 86 enterprises, are divided among the 51 that have between 10 and 25 workers, 33 that employ between 25 and 100, 2 enterprises with between 100 and 250 workers and 1 with more than 250 workers.

It is estimated that 85 per cent are traditional enterprises, 11 per cent are industries and 4 per cent operate with a high level of technology. Approximately, 93 per cent of the firms have a level of daily production of less than 50 tons and only about 2 per cent produce more than 200 tons/day.

There is a high degree of foreign capital, as 6 of the 12 largest enterprises are controlled by multinationals (AECI, 1999).

Total national milk production in 1999 was 3.7 million tons, an increase of 6.7 per cent in relation to the previous year. This growth is due primarily to the expansion of modern farms with imported high-yield cattle (USDA, 2000).

Out of the total milk production in Egypt in 1998, about 20 per cent was consumed directly on the farms, about 70 per cent was processed by small firms to produce milk (25 per cent), cheese (60 per cent) and other products (15 per cent), while modern industries processed only the remaining 10 per cent into fresh milk (23 per cent), soft cheeses (70 per cent) and other products (7 per cent) (AECI, 1999).

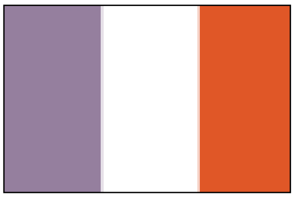
As can be seen from the above, cheese is the most important dairy product in Egypt. Almost 50 per cent of milk production and imports of skimmed powered milk are used for producing cheese. Annual cheese production totals 310,000 tons. Almost all the cheese produced (75 per cent) is feta. Cheese is an important part of the Egyptian diet and is consumed daily either directly or with bread. The consumption of cheese is estimated to be 6 kilos/year/inhabitant.

The rest of the annual production of dairy products is divided among 30,000 tons of milk (pasteurized), 2,500 tons of yogurt and 130,000 tons of butter.

There are plans or environmental projects in Egypt for reducing pollution by dairy firms, whose principles are biological treatment of wastewater, reuse of water, minimization of water use through CIP systems and monitoring and control of operations.

For environmental projects, financing is usually available for between 20 and 30 per cent of the value of projects for cleaner technologies, minimization, reuse, energy and control. About 50 per cent of available financing is used for wastewater treatment projects (EPAP, EEAA, 2001).

Limitations on the content of wastewater are 600 mg O_2/litres of COD for dumping into the sewage system, 30 mg O_2/litre into rivers and 60 mg O_2/litre into the sea (Law 93/62 48/82 4194).



FRANCE

POPULATION: 59,551,227

AREA: 547,030 km^2

NUMBER OF DAIRY FIRMS: 730

MILK PRODUCTION: 25,631,650 metric tons/year

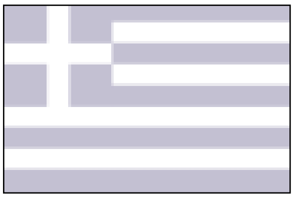
France has 3,500 food and agricultural enterprises, representing 7 per cent of total French industrial activity, which employ 400,000 workers (10 per cent of the total labour force). The dairy subsector is formed by 730 enterprises, namely 20 per cent of all the food and agricultural enterprises and 15 per cent of food and agricultural employment (60,000 workers) (MA, 2000).

France is the most important country for production of milk and dairy products in the Mediterranean region. Nonetheless, by number of enterprises it ranks sixth, which indicates that the enterprises are larger than in other Mediterranean countries.

About 66 per cent of dairy firms produce less than 50 tons/year, 18 per cent between 50 and 100 tons/year and 16 per cent more than 200 tons/year.
Annual national milk production reached 25,631,650 tons, of which 24,892,000 tons were cow's milk, 243,850 tons sheep's milk and 496,800 tons goat's milk (USDA, 1999).

Production of dairy products is distributed as follows: fresh milk (22,000,000 tons), yogurt (1,330,000 tons), cheese (1,700,100 tons), butter (450,000 tons) and cream (300,000 tons). Apart from these products, 737,132 tons of powered milk and 620,000 tons of powered whey are produced.

France exported 750,000 tons of liquid milk, 300,000 tons of powered milk, 480,000 tons of cheese and 75,000 tons of butter (USDA, 2000).

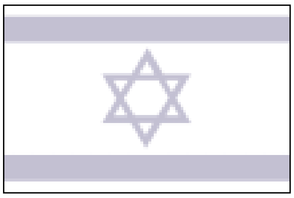
 **GREECE**	POPULATION: 10,623,835
	AREA: 131,940 km^2
	NUMBER OF DAIRY FIRMS: 1,128
	MILK PRODUCTION: 1,910,045 metric tons/year

In Greece, there are a total of 1,128 dairy firms, including 28 pasteurization plants, 800 cheese producers and 300 small firms in which yogurt is produced. Four producers process 80 per cent of the pasteurized milk.

The sector has structural deficiencies compared to the other countries of the European Union, especially as regards the production of cow's milk. The average Greek farm has 5.6 cows, compared to the European average of 19.6. In Greece, there are only 220,000 dairy cows compared with 6.5 million head of sheep and 3.9 million head of goats with a low yield of milk per animal. The value of imported dairy products is euro 340 million (Greek Ministry of Agriculture, 1997).

Annual national milk production reached 1,910,045 tons in 1999, of which 790,000 tons were cow's milk, 670,000 tons of sheep's milk and 450,000 tons of goat's milk (USDA, 1999).

Annual production of fresh milk was 713,536 tons of cow's milk, 293,503 tons of cheese, 11,906 tons of butter and 28,568 tons of cream (USDA, 1999).

 **ISRAEL**	POPULATION: 5,938,903
	AREA: 20,770 km^2
	NUMBER OF DAIRY FIRMS: 15
	MILK PRODUCTION: 1,112,000 metric tons/year

In Israel, there are about 300 food and agricultural enterprises, of which 5 per cent, some 15 enterprises, form the dairy sector that provides employment to 5,300 workers (Manufacturers Association of Israel, 2000).

Eighty per cent of the production of dairy products takes place in large and modern enterprises with a high level of technology and with more than 250 employees. Sixty per cent of the enterprises produce large volumes of more than 50 tons/day.

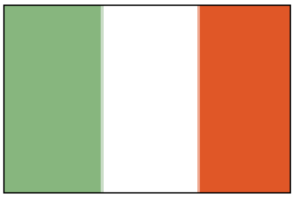
Annual fresh milk production is 872,927 tons, primarily cow's milk (99 per cent). The rest of the production is broken down as follows: 56,152 tons of yogurt, 100,000 tons of cheese, 5,235 tons of butter and 77,686 tons of cream (MAI, 2000).

It is important to point out that almost 80 per cent of the fresh milk produced in Israel is exported to other countries.

Among the important environmental projects, one for the separation, storage and transportation of brine to authorized dumping points stands out. It should be mentioned that salt and salt brine are large sources of high pollution in Israel, and their dumping into the sewage system is prohibited.

Other projects underway deal with pre-treatment of wastewater to meet government standards, limits on atmospheric emissions, and the recycling of packaging and packing waste. The government does not subsidize any of these projects.

Maximum COD for dumping into the sewage system is 2,000 mg O_2/litre, while that into the river is 70 mg O_2/litre (MAI, 2000).

	POPULATION: 57,679,825
	AREA: 301,230 km^2
	NUMBER OF DAIRY FIRMS: 2,133
ITALY	MILK PRODUCTION: 11,312,088 metric tons/year

In Italy, there are 20,125 food and agricultural enterprises, namely 12.4 per cent of total Italian industries. The dairy industry is formed by 2,133 enterprises and makes up 11 per cent of the food and agricultural sector. The dairy subsector employs 39,851 workers, representing 16 per cent of the employment in the food and agricultural industry (ISTAT, 1996).

Sixty-five per cent of the dairy firms have fewer than 10 workers, 20 per cent between 10 and 25 workers, 13 per cent between 25 and 100 workers and the remaining 2 per cent have more than 100 workers.

Annual milk production was 11,312,088 tons: cow's milk (10,402,799 tons), sheep's milk (638,092 tons), goat's milk (121,197 tons) and buffalo's milk (150,000 tons) (Rapporto Assolatte Industria Lattiero-Casearia Italiana, 2000).

Annual production of dairy products was fresh milk (3,100,000 tons), yogurt (190,000 tons), cheese (958,062 tons) and butter (105,000 tons) (Rapporto Assolatte Industria Lattiero-Casearia Italiana, 2000).

Italy exported its dairy products to many countries, primarily to Germany and the United States of America, including 1,758,357 tons of raw milk,168,925 tons of cheese and, of less importance, 12,297 tons of butter, 5,672 tons of fresh milk and 5,852 tons of yogurt.

In addition, Italy imported 347,179 tons of cheese and 347,362 tons of fresh milk.

The best-known cheeses in Italy are Grana Padano and Parmigiano Reggiano, which represent 25 per cent of total production. Soft cheeses (primarily Mozzarella) represent a volume of 39 per cent.

Other important cheeses are Pecorino (7 per cent) and Gorgonzola (4.5 per cent) (Rapporto Assolatte Industria Lattiero-Casearia, 2000).

Maximum permitted levels for COD are 500 mg O_2/litre for dumping into the sewage system and 160 mg O_2/litre for dumping into rivers and the sea.

LEBANON

POPULATION: 3,578,036

AREA: 10,400 km^2

NUMBER OF DAIRY FIRMS: -

MILK PRODUCTION: 272,300 metric tons/year

The main problem that the Lebanese dairy industry is facing is the low quality of fresh milk produced. Several factors are the causes of this problem, including inadequate design and the conditions of installations for dairy herds, poor hygiene and lack of refrigeration during storage and transportation.

Improvement of dairy production on the farms is difficult because of the low prices paid for milk, which are below production costs at several times of the year.

Current production of dairy industries in Lebanon is below capacity. The large producers want to increase milk supply in the country if quality is improved. And, for this, programmes to provide refrigeration vats to farms interested in receiving higher prices for better-quality fresh milk should be carried out.

The quantity of milk produced in Lebanon in 1999 was 272,300 tons: 201,000 tons of cow's milk, 33,800 tons of sheep's milk and 37,500 tons of goat's milk.

LIBYA

POPULATION: 5,240,599

AREA: 1,759,540 km^2

NUMBER OF DAIRY FIRMS: 12

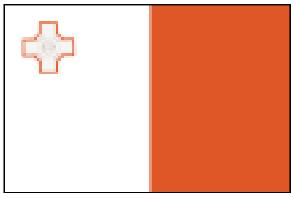
MILK PRODUCTION: 74,800 metric tons/year

In Libya, there are 87 food and agricultural enterprises that employ 11,000 workers. The dairy sector is formed by 12 enterprises (14 per cent), employing 2,400 workers (22 per cent). Most of these firms are owned by the government (General Dairy Product, 2000). These statistics do not take into account the more than 200 small private traditional enterprises.

Twenty per cent of these enterprises employ between 25 and 100 workers and the rest of the firms employ between 100 and 200 workers.

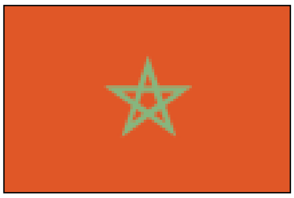
Annual milk production in Libya was 74,800 tons: 73,000 tons of cow's milk and 1,800 tons of goat's milk. The production of dairy products is distributed between fresh milk (57,000 tons/year), yogurt (14,000 tons/year) and cheese (100 tons/year) (GDP, 2000). All the production is for the domestic market.

Only a few enterprises have wastewater treatment plants.

 **MALTA**	POPULATION: 394,583
	AREA: 316 km^2
	NUMBER OF DAIRY FIRMS: 1
	MILK PRODUCTION: 50,800 metric tons/year

In Malta, there is only one large dairy firm, which employs 166 workers, including 10 managers, 15 technicians and 141 workers. This firm produces more than 50 tons of dairy products per day and has an annual sales volume of euro 26.3 million.

In 2000, total milk production in Malta was 50,800 tons, primarily cow's milk (46,400 tons) and to a lesser extent, sheep's milk (2,600 tons) and goat's milk (1,800 tons). About 30,200 tons of fresh milk, 1,510 tons of yogurt, 2,300 tons of cheese and 360 tons of cream were produced (Malta Dairy Products Ltd., 2000). All the production is for the domestic market.

 **MOROCCO**	POPULATION: 30,645,605
	AREA: 446,550 km^2
	NUMBER OF DAIRY FIRMS: 38
	MILK PRODUCTION: 1,445,000 metric tons/year

In Morocco, there are 1,642 food and agricultural enterprises, representing 25 per cent of total Moroccan industrial activity. The dairy firms make up 2.3 per cent of the food and agricultural sector (some 38 enterprises) and employ 8,984 workers (Centre Marocain de Production Propre).

70 per cent of the firms forming the Moroccan dairy sector can be considered large firms due to both their number of workers and production. Some of them are multinationals and others owned by large industrial national groups. Enterprises with more than 250 workers represent 41 per cent, those with a number of workers between 100 and 250, 15 per cent, and finally, those employing between 25 and 100 workers, represent 13 per cent.

The rest, namely 30 per cent, is primarily made up of cooperatives as well as small and medium-sized production units. There have been considered as such firms with a number of workers between 10 and 25 (18 per cent of the total) and those employing less than 10 workers, which represent 13 per cent of all the dairy firms.

The most important region with regard to milk production is El Jadida, followed by Khémisset, Settat, Meknes and Oujda.

As for the average annual production of milk and/or dairy products in tons/day, 30 per cent of the firms produce less than 50 tons/day, 50 per cent produce between 50 and 200 tons/day and the rest, 20 per cent, produce over 200 tons/day.

National milk production reached 1,445,000 tons, distributed between 1,410,000 tons of cow's milk and 35,000 tons of goat's milk.

Despite the high level of national milk production, the volume of fresh milk is rather low because of local consumption and direct sales on farms. Total production of fresh milk was 860,000 tons, while that of cheese and butter was 10,686 tons and 10,000 tons respectively. Production of yogurt and other fermented milks reached 390,000 tons.

As it can be observed, production of fresh milk predominates over the rest of dairy products, due to seasonal nature of national milk production. There are two seasons: one of high production (from February until August) and another of low production. During the season of high production, processing firms work at full capacity and milk surplus is used for production of dairy products. During low production season, industries only produce fresh milk; small-sized firms work below capacity, while large enterprises reconstitute powered milk produced during the season of high production.

Financing of environmental projects usually reaches 40 per cent of the total cost in projects concerning cleaner technologies, 20 per cent in minimization projects and 40 per cent in wastewater treatment projects.

In Morocco, there is a fund for reducing industrial pollution (Fonds de Dépollution Industrielle, FODEP), which finances projects reducing both water consumption and environmental pollution. Under the framework of FODEP, 15 projects (out of 30 presented) have been carried out throughout the year 2001, 8 focusing on treatment of liquid effluents, 5 on treatment of gas effluents and 2 on solid waste. The 15 projects represented an overall investment of Dirham 104.55 million (euro 10,170,960), of which financing was Dirham 78.20 million (euro 7,607,547). Projects related to liquid effluents represented more than 50 per cent of the total cost. 60 per cent of these projects are from the dairy industry.

As for limitations concerning dumping of wastewater, there is no law specifying them. Nonetheless, there are attempts of controlling dumping at the regional level by using as a reference number the average amounts of dumping for each industrial zone.

SPAIN

POPULATION: 40,037,995

AREA: 504,782 km^2

NUMBER OF DAIRY FIRMS: 1,511

MILK PRODUCTION: 6,281,300 metric tons/year

Spain has 33,105 food and agricultural enterprises, representing 14 per cent of total Spanish industrial activity, which employ 368,750 workers (19 per cent). The dairy subsector has 1,511 enterprises, about 5 per cent of all the food and agricultural enterprises and 7 per cent of food and agricultural employment (27,745 workers) (Ministerio de Agricultura, Pesca y Alimentación, FIAB, 1999).

Eighty-five per cent of the enterprises have fewer than 10 employees, 11 per cent between 10 and 25, 2 per cent between 25 and 100 and the remaining 2 per cent more than 100 workers (FIAB, 1999).

Annual national milk production was 6,281,300 tons, of which 5,685,400 tons were cow's milk, 278,200 tons of sheep's milk and 317,700 tons of goat's milk (FENIL, 1999).

The production of dairy products is broken down as follows: fresh milk (3,645,400 tons), yogurt (581,600 tons), cheese (293,800 tons), butter (36,200 tons) and cream (86,000 tons) (FENIL, 1999). In 1999, Spain imported 400,729 tons of liquid, condensed or powered milk, 119,985 tons of yogurt and other fermented milks, 110,862 tons of cheese, 9,237 tons of butter and 10,789 tons of cream (Departamento de Aduanas, 1999).

On the other hand, in 1999 Spain exported 200,494 tons of liquid, condensed, concentrated or powered milk, 33,422 tons of yogurt and other fermented milks, 36,099 tons of cheese, 8,477 tons of butter and 18,411 tons of cream (Departamento de Aduanas, 1999).

Per capita consumption was 108 kilos/inhabitant/year of fresh milk, 9.2 kilos/inhabitant/year of cheese, 16.2 kilos/inhabitant/year of yogurt, 0.47 kilos/inhabitant/year of butter and 2.3 kilos/inhabitant/year of cream (MAPA, 1999).

SYRIA

POPULATION: 16,728,808

AREA: 185,180 km^2

NUMBER OF DAIRY FIRMS: 31

MILK PRODUCTION: 1,656,085 metric tons/year

In Syria, there are 1,250 food and agricultural enterprises, of which 2.5 per cent, some 31 enterprises, make up the dairy sector (Statistics of the Food Association, 2001) (Arab Federation for Food Industries, 2001).

Forty per cent of the enterprises employ between 10 and 25 workers, while the rest, 60 per cent, employ between 25 and 100 workers. Seventy per cent of the enterprises are traditional. Ninety-nine per cent of the enterprises produce fewer than 50 tons/year.

There is an important number of small domestic firms, chiefly in rural areas, which produce considerable amounts of both yogurt and cheese for domestic consumption. Data on the subject is not included since there is no reliable statistics concerning these productions.

Total national milk production in Syria was 1,656,085 tons: 1,143,423 tons of cow's milk, 445,913 tons of sheep's milk, 65,853 tons of goat's milk and 896 tons of buffalo's milk.

This high volume of production contrasts with the low level of production of dairy products by a small number of enterprises. Annual production of fresh milk was 14,111 tons of cow's milk. The rest of the production is broken down as follows: 7,030 tons of yogurt, 82,170 tons of cheese and 3,356 tons of butter (Ministry of Industry, 2000).

The main environmental project in the dairy sector is a short-term project for reuse of whey.

The maximum amount of COD authorized for dumping into the sewage system is 3,000 mg O_2/litre (Syrian Standard, 1995).

TUNISIA

POPULATION: 9,593,402

AREA: 163,310 km^2

NUMBER OF DAIRY FIRMS: 47

MILK PRODUCTION: 830,000 metric tons/year

There are 47 dairy firms, including eight fresh milk production plants, 14 plants producing yogurt and 25 producing cheese.

Milk production in Tunisia is increasing thanks to improvement of the feeding and breeding of dairy cows. The amount of imported powered milk has been dramatically reduced recently, and the country currently almost covers its dairy needs and is almost self-sufficient.

Total national milk production reached 830,000 tons, including 800,000 tons of cow's milk, 17,000 tons of sheep's milk and 12,000 tons of goat's milk.

Production of fresh milk in 1996 reached 262,480 tons, while 550 million jars of yogurt, 6,420 tons of various types of cheese and 5,008 tons of butter were produced (USDA, 2000).

Industrial production of yogurt and cheese is increasing along with development of the dairy sector.

 **TURKEY**	POPULATION: 66,493,470
	AREA: 780,580 km^2
	NUMBER OF DAIRY FIRMS: 4,320
	MILK PRODUCTION: 9,970,000 metric tons/year

The Turkish food and agricultural sector has 24,000 enterprises, of which 18 per cent, some 4,320 enterprises, are in the dairy sector (Republic of Turkey, Ministry of Agriculture and Rural Affairs, 1999).

Seventy per cent of these enterprises are traditional with fewer than 10 workers. About 29.5 per cent employ between 10 and 250 workers, and about 0.5 per cent use modern technology and employ more than 250 persons.

Annual milk production in Turkey is 9,970,000 tons distributed among cow's milk (8,832,000 tons), sheep's milk (813,000 tons), goat's milk (245,000 tons) and buffalo's milk (80,000 tons) (Republic of Turkey, Ministry of Agriculture and Rural Affairs, 1998).

Annual production of diary products can be broken down into fresh milk (251,632 tons), yogurt (204,961 tons), cheese (201,260 tons), butter (15,771 tons) and cream (1,383 tons). Almost all production is for the domestic market, except for 5,006 tons of cheese that are exported (Republic of Turkey, Ministry of Agriculture and Rural Affairs, 1999).

The main environmental projects carried out in Turkey to reduce pollution in the dairy industry are collection and spray drying of cheese whey, the recycling of solid waste, the reduction of water consumption and use of low-energy-consuming machinery.

Maximum BOD for dumping wastewater in Turkey is 40 mg O_2/litre into the sewage system, rivers or the sea (Turkish National Water Pollution Control Act, 1988).

3. THE MAIN PRODUCTION PROCESSES USED IN THE DAIRY INDUSTRY AND RELATED ENVIRONMENTAL EFFECTS

This chapter describes the most representative production processes for the main groups of dairy products and subsidiary operations:

- Fresh milk;
- Products obtained from milk fat (cream and butter);
- Fermented milks (yogurt);
- Cheeses (ripened and soft);
- Secondary operations.

For each of these production processes and subsidiary operations, the main related environmental effects are described and ranked semi-qualitatively in function of their relative importance in overall production. The ranking used has three levels: primary, secondary and insignificant (see following table).

Table 3: Criteria for ranking environmental effects

PRIMARY	An important effect with regard to the overall impact of the activity
SECONDARY	A secondary effect with regard to the overall impact of the activity
INSIGNIFICANT	An insignificant effect with regard to the overall impact of the activity

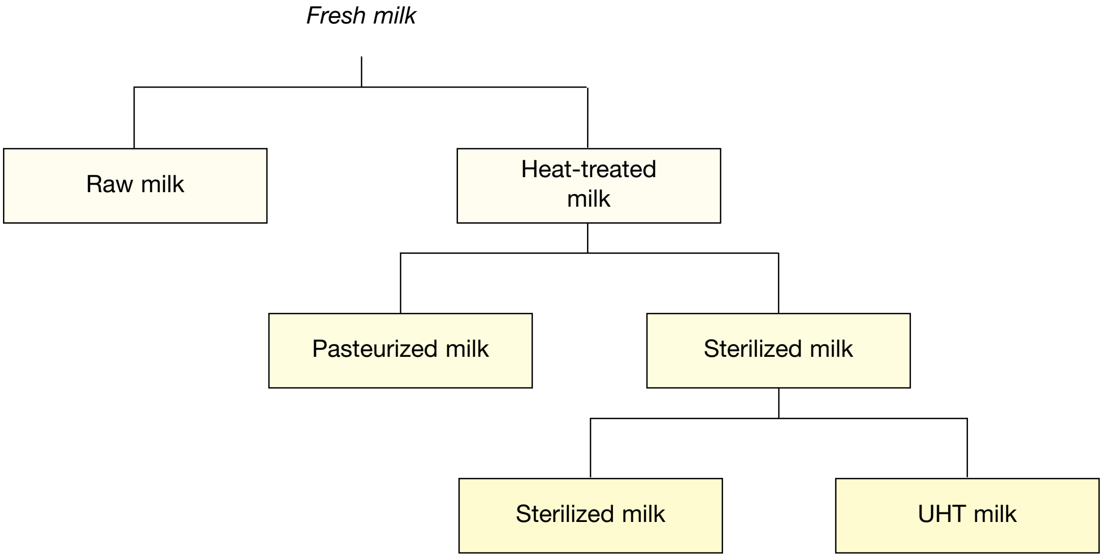
3.1. Processing of fresh milk

Milk used for human consumption can be divided into two categories:

- Raw milk. Raw milk without any processing has been consumed as a natural product since antiquity, and in many countries it continues to be a very frequent form for consuming milk.

- Heat-treated milk (pasteurized or sterilized). The ease with which milk can rapidly deteriorate and be altered by all types of pollution make it necessary to submit milk to a specific treatment to increase its conservation and eliminate possible pollution before consumption. In many countries, this treatment is required by law.

Figure 15
CLASSIFICATION OF FRESH MILK



Although in some areas of the Mediterranean raw milk is commonly sold and later treated with heat in homes before consumption, most of the fresh milk on the market that is consumed directly is milk that is industrially heat-treated.

Because this type of milk is more widespread and its processing has important environmental repercussions, the industrial processing of this type of milk is described below.

3.1.1. The processing of heat-treated milk

The general process for heat-treating milk can be summarized as follows.

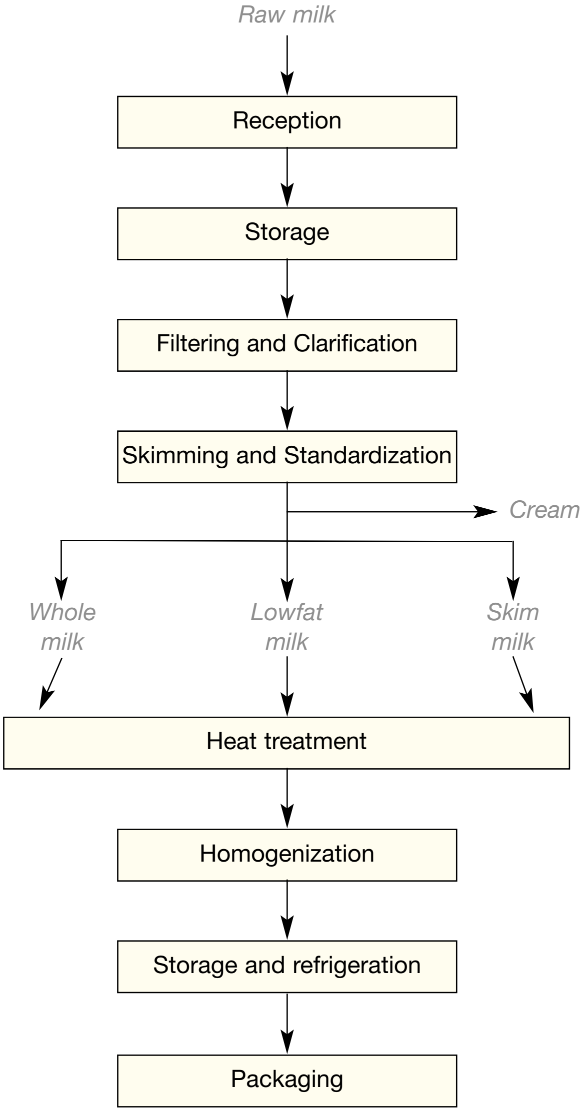
Upon reception, milk is temporarily stored in refrigerated tanks until processing begins. The milk is then filtered in order to eliminate visible foreign solids and clarified by the removal of dirt and protein coagulates.

Next, skimming separates the cream from the milk, and standardization is carried out in order to establish the final milk fat content of the milk. Once the milk fat content is standardized, the milk is homogenized in order to reduce the size of the milk fat particles and distribute them uniformly thus improving their emulsion.

Finally, heat treatment for microbiological stabilization takes place with either pasteurization, sterilization or UHT treatment, depending on the length and temperature of the heat treatment. After heat treatment, the milk is stored under refrigeration until final packaging.

The following flow chart describes the processing of heat-treated milk.

Figure 16
FLOW CHART OF THE HEAT-TREATED MILK



3.1.2. Processing operations and environmental considerations

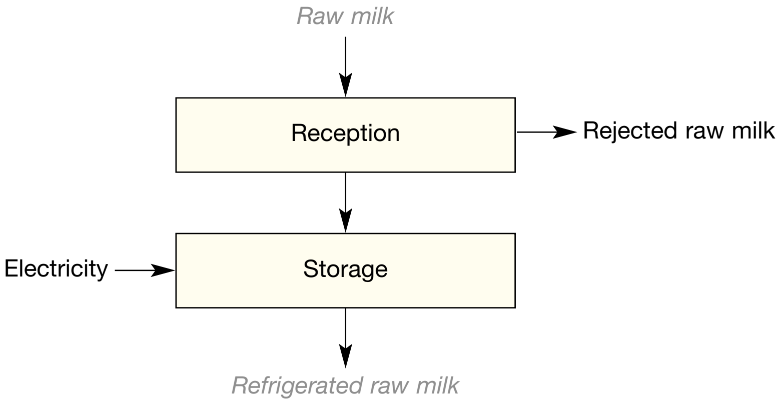
3.1.2.1. Reception

Normally, milk arrives at the processing plant in tank lorries, tanks or milk containers. The containers are made from stainless steel, aluminium or in some cases can even be plastic. Their capacity varies considerably. Samples are usually taken in order to analyse quality and determine milk fat and protein content.

Sometimes, the price of milk varies according to its composition. After reception, the milk is stored under refrigeration in order to ensure conservation until processing. This step is of special importance when the milk must remain in storage before being treated because of irregular supply flow.

At this time, the milk lorries and collection tanks are cleaned before transporting more milk. The cleaning of the lorries and tanks is described in greater detail in the section on cleaning operations where there is also a description of the environmental effects of this operation.

Figure 17
RECEPTION AND STORAGE OF RAW MILK



During this stage, there is a loss of milk caused by emptying and filling the storage tanks. This loss of milk can reach the wastewater system, thus contributing to an increase in the organic load of pollutants. Storage is a large consumer of electricity.

During this stage, milk can be analysed and possibly rejected if it does not meet quality requirements.

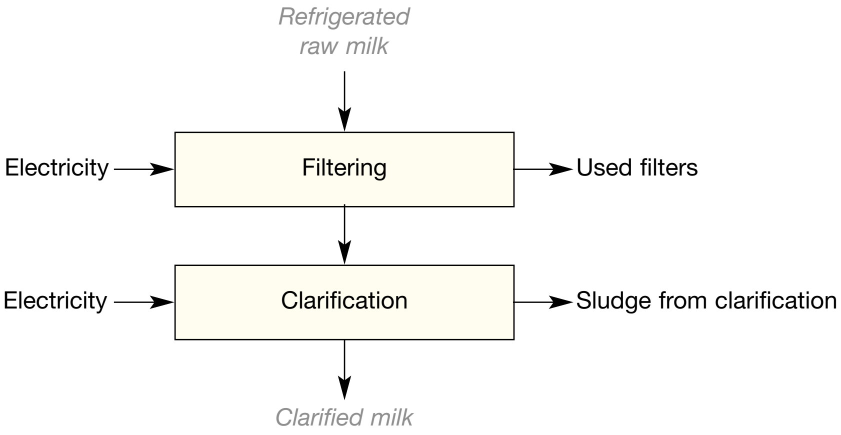
The rinsing and cleaning of lorries, hoses, pipes and storage tanks consumes water that is then dumped into the sewage system. This effect is described in detail farther along in reports on each cleaning operation.

3.1.2.2. Filtering and clarification

Next, any organic and inorganic particles of dirt in the milk that entered during the milking of the cows or transportation are eliminated. The agglomerates of proteins (coagulates) that are formed in the milk are also eliminated.

The degree of impurities in the milk can vary in function of the milking techniques used and handling on the farms and during transportation. Purification is an unavoidable step in the industrial processing of milk.

Figure 18
FILTERING AND CLARIFICATION OF MILK



This operation generates the so-called “clarification sludge”, which is semi-soft waste formed by particles of dirt, blood components, germs and other substances, primarily proteins. If they are dumped with the final effluent, they can produce large increases in pollution in the sewage system creating problems for the environment. There is also a loss of milk that can be carried away with wastewater into the sewage system. Filtering produces waste composed of the filters used in this stage.

In both filtering and clarification, electricity is consumed.

3.1.2.3. Skimming and standardization

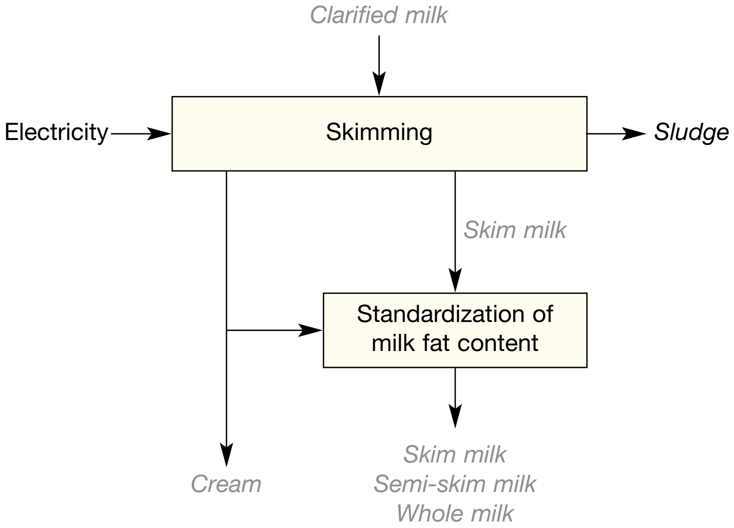
During the skimming process, the milk fat (cream) is separated from the rest of the milk components (skim milk). This is usually done using centrifuges that separate the cream, with approximately 40 per cent of milk fat, from the milk, with approximately 0.5 per cent of milk fat.

The milk fat content of the milk is then standardized, through the addition of cream to the skim milk in different proportions in function of whether the desired product is whole, low-fat or skim milk. The remaining cream is used in the production of other products such as cream or butter.

The centrifuges used for skimming can simultaneously clarify and skim the milk and, as a result, are widely used. These centrifuges can also contain equipment for homogenization of the milk’s milk fat content.

The following figure presents the environmental effects of this operation.

Figure 19
SKIMMING AND STANDARDIZATION OF MILK



The process of separating cream by centrifugation creates sludge with a lower content of blood components and bacteria than in the case of raw milk. Nonetheless, emptying of the sludge directly into the final effluent produces a considerable increase in the organic load of that waste.

During this stage, electricity is also consumed by the skimming centrifuges.

3.1.2.4. Heat treatment

Heat treatment almost completely destroys the microorganisms contained in the milk. An additional effect is partial inactivation of milk enzymes.

In function of the characteristics of the combination of temperature and time used in the heat treatment, we can differentiate between:

- Pasteurization. This is heat treatment capable of destroying the agent that transmits tuberculosis with time-temperature values that range between 15-30 seconds at 72-85 °C. Pasteurization does not guarantee destruction of all germs in the milk, which must be kept refrigerated for conservation until consumption.

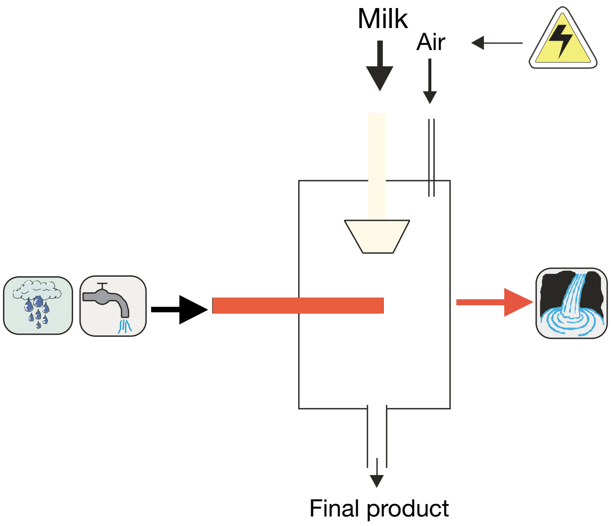
- Sterilization. There are two types of sterilization:
  - Sterilization strictly speaking is heat treatment capable of destroying all the pathogenic microorganisms and inactivating enzymes. It is carried out at 100-120 °C during 20 minutes.
  - UHT treatment (ultra-pasteurization or sterilization at ultra-high temperatures) is based on the application of a very high temperature (135-150 °C) during a short period of time (2.5 seconds) producing a very high germicide effect.

After one of the sterilization treatments, milk can be conserved at room temperature for a long period of time, as long as the packaging process is aseptic. These treatments are used primarily to process fresh milk for long conservation and to aromatize milk.

The system of heat-treatment can be separated into systems of direct or indirect heating.

Systems for the direct heating of milk cause it to enter into direct contact with a high-temperature fluid (steam). The milk should enter the exchanger at a temperature of 70-80 °C, before entering into contact with the steam. The milk then passes through a vacuum evaporator that eliminates the water added during sterilization. This evaporation rapidly reduces the temperature of the milk to about 80 °C.

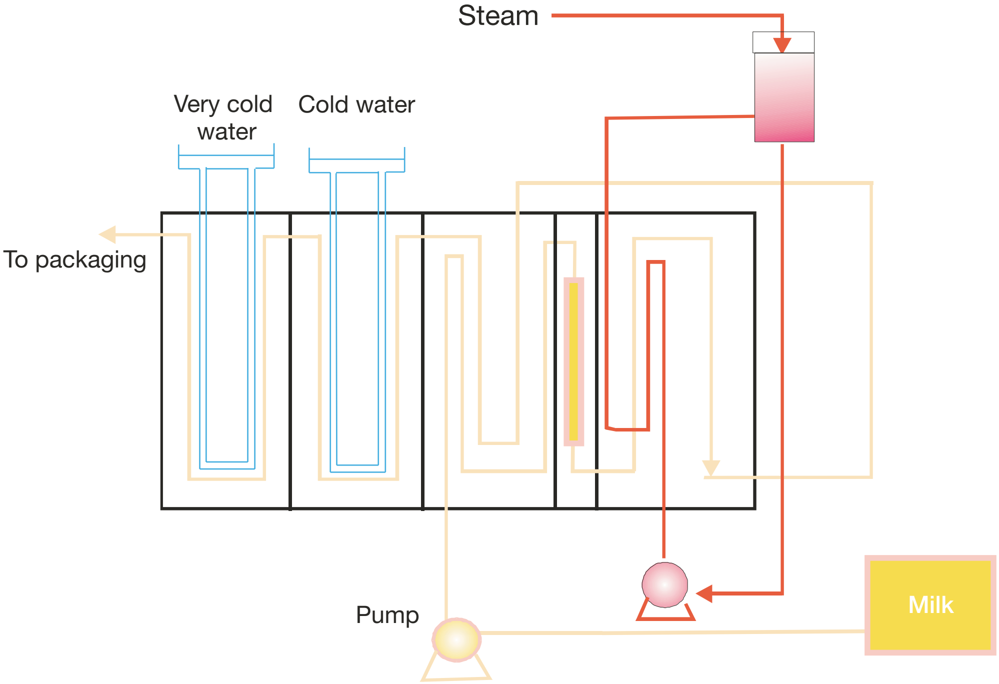
Figure 20
EXCHANGER USING DIRECT HEAT BY STEAM INJECTION



The advantage offered by this system lies in the short period of heating, which implies very moderate treatment of the product. A disadvantage is the need of high-quality steam. The capacity for recovery of thermal energy is only 40-50 per cent.

Systems for the indirect heating of milk transfer heat through plate or tubular exchangers, or a combination of both, with a high-temperature fluid (steam, hot water or overheated water) do not enter into contact with the milk.

Figure 21
INDIRECT PLATE HEAT EXCHANGER

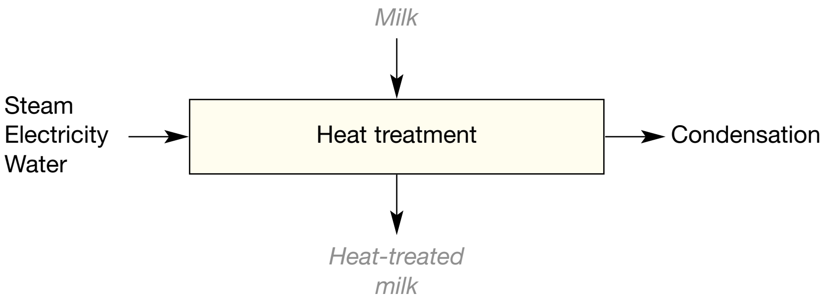


This heating system has the advantage of permitting high recuperation of heat (80-90 per cent). The main inconveniences are the possibility of damaging the product from overheating and the difficulty of cleaning deposits on the exchangers.

In general, systems of indirect heating are used for pasteurization and sterilization, while direct or indirect systems are used for UHT treatment.

The following figure shows the most important environmental effects of this operation.

Figure 22
HEAT TREATMENT OF MILK



This operation consumes a large amount of energy, although consumption decreases in function of the amount of heat recovered.

In systems of direct heating, the milk is passed through a vacuum evaporator to eliminate water added during the direct heat treatment with steam. The released vapour is condensed and if evacuated it is considered to be a waste.

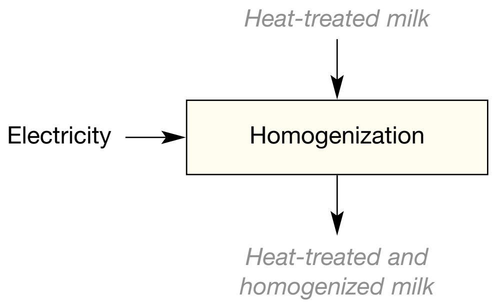
3.1.2.5. Homogenization

Homogenization takes place either before or after heat treatment. This process reduces the size of fat globules thus favouring uniform distribution of the milk fat. At the same time, separation of the cream is avoided.

Homogenization also reduces the stability of the proteins when subjected to heat so that when milk is exposed to high temperatures, homogenization is carried out after heat treatment.

During homogenization milk is passed at high pressure through slots narrower than the fat globules in order to reduce the diameter of the fat globules, thus keeping them in suspension.

Figure 23
HOMOGENIZATION OF MILK

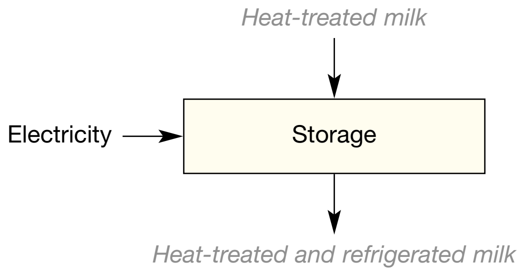


In this operation, electricity is consumed because of the functioning of the homogenization equipment.

3.1.2.6. Refrigerated storage

Once treated and refrigerated, milk is stored in tanks until packaging. This refrigerated storage makes it possible to control the quality of the milk before packaging and makes packaging independent from the rest of the processing.

Figure 24
STORAGE BEFORE PACKAGING



The main environmental effects produced during this stage are the consumption of energy necessary to maintain the milk refrigerated and possible losses of milk that can happen during storage in tanks.

3.1.2.7. Packaging

Packaging is the final stage in the process and consists of filling packaging with the product. The indispensable condition for conservation of the product during a long period is to maintain aseptic conditions during the packaging.

At the time of choosing a certain kind of packaging, both aspects related to the conservation of the product as well as economic and environmental effects should be taken into account.

The most common types of packaging for milk are glass, plastic and cardboard.

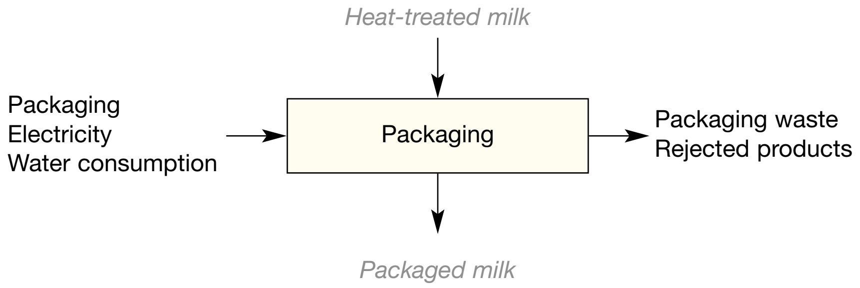
- Glass bottles are important because they are reusable, although they have the inconvenience of their heavy weight and fragility. They also present problems for the conservation of long-life milk because sunlight can lead to degradation of the fat and milk proteins.

- Plastic bags, usually from polythene, have the inconvenience that they are difficult to handle because of their instability and once opened for consumption they require a recipient for handling.

- Plastic bottles use materials such as polystyrene and polythene of high and low density. This packaging is used most of all in the packaging of sterilized milk.

- Cardboard boxes, such as TetraBrik with a laminated cardboard or paper base and often covered with plastic, paraffin or aluminium, are used above all for UHT milk.

Figure 25
MILK PACKAGING

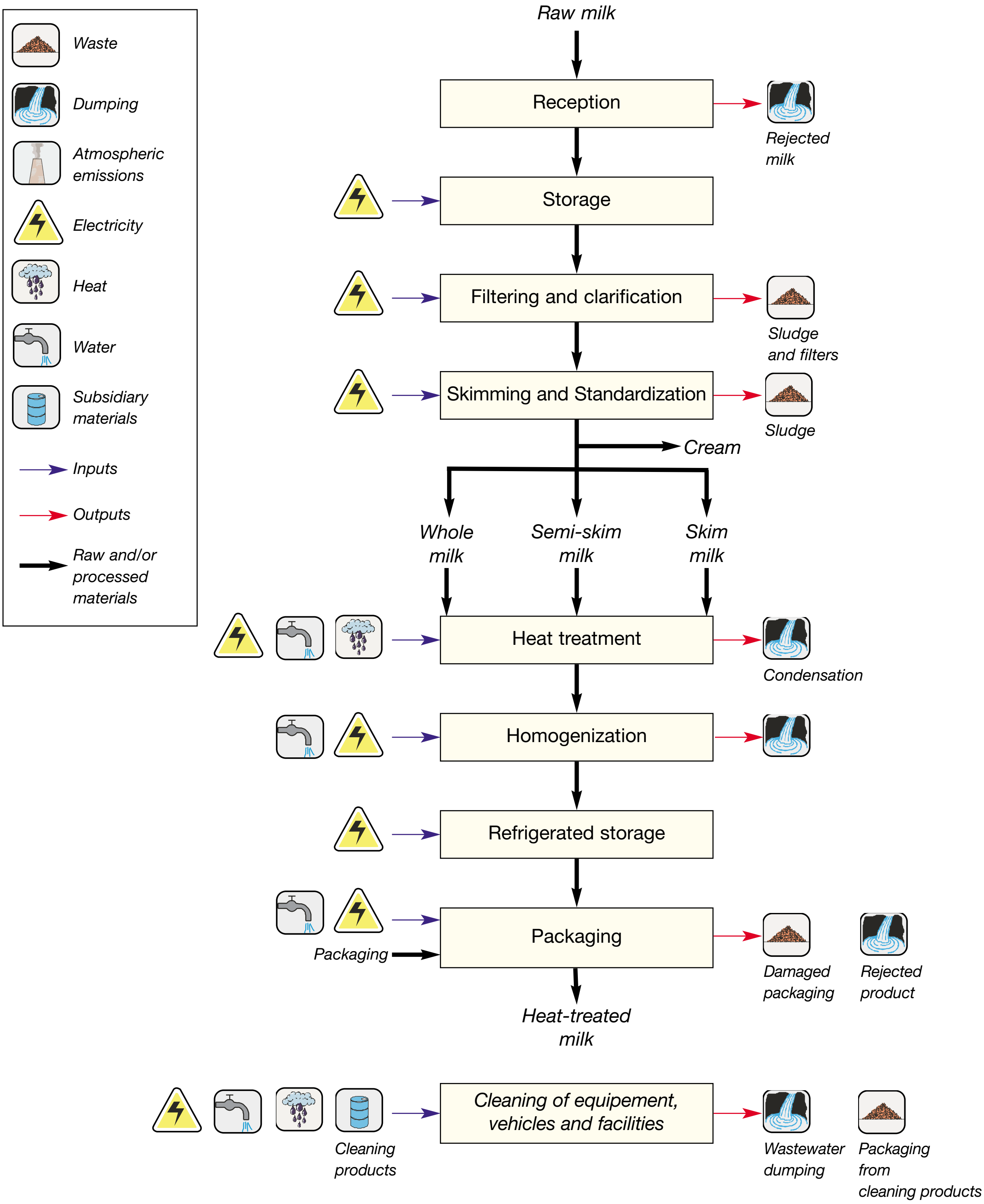


In the packaging process, machinery consumes large amounts of energy, and waste is generated because of manufacturing defects or problems during packaging.

3.1.3. Environmental effects of the processing of heat-treated milk

The main environmental effects derived from the production of heat-treated milk are the following.

Figure 26
ENVIRONMENTAL EFFECTS OF THE PROCESSING OF HEAT-TREATED MILK



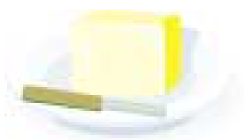
The following is a summary and ranking of the environmental effects of the heat treating of milk.

Table 4: Ranking of the environmental effects resulting from the processing of heat-treated milk

BASIC OPERATION	EFFECT	RANKING
Reception	Rejection of milk	Primary
Storage	Consumption of electricity	Secondary
Filtering/Clarification	Consumption of electricity Generation of sludge Waste used filters	Secondary Secondary Secondary
Skimming and standardization	Electricity Sludge	Secondary Secondary
Heat treatment	Consumption of heat Consumption of electricity Consumption of water* Condensation*	Primary Primary Secondary Secondary
Homogenization	Consumption of electricity Consumption of water Dumping of wastewater	Secondary Secondary Secondary
Storage	Consumption of electricity	Secondary
Packaging	Consumption of electricity Waste packaging Rejected product Consumption of water	Primary Primary Secondary Insignificant
Cleaning of tanks, equipment and installations	Consumption of heat Consumption of water Dumping of wastewater (amount of waste and pollution load) Consumption of chemicals Generation of waste (packaging of cleaning products) Consumption of electricity	Primary Primary Primary Primary Secondary Secondary

* In function of the heat-treatment system used, consumption of water and the generation of condensation will be more or less significant.

3.2. Dairy products obtained from milk fat: butter and cream



The main dairy products obtained from milk fat are butter and cream.
Cream is an emulsion of milk fat in water, while butter is a product obtained from cream after its curing and elimination of a large part of the water, which makes it in reality an emulsion of water in oil.

3.2.1. The processing of butter and cream

The raw material used in the industrial production of butter and cream for consumption is cream remaining from the operations of skimming and standardization during the processing of fresh milk.

Cream

Cream for consumption is obtained after deodorization and heat treatment of the cream base. It can be sold as fresh cream (pasteurized) or long life (UHT treatment) after being submitted to a process of microbiological stabilization through pasteurization or sterilization and final packaging.

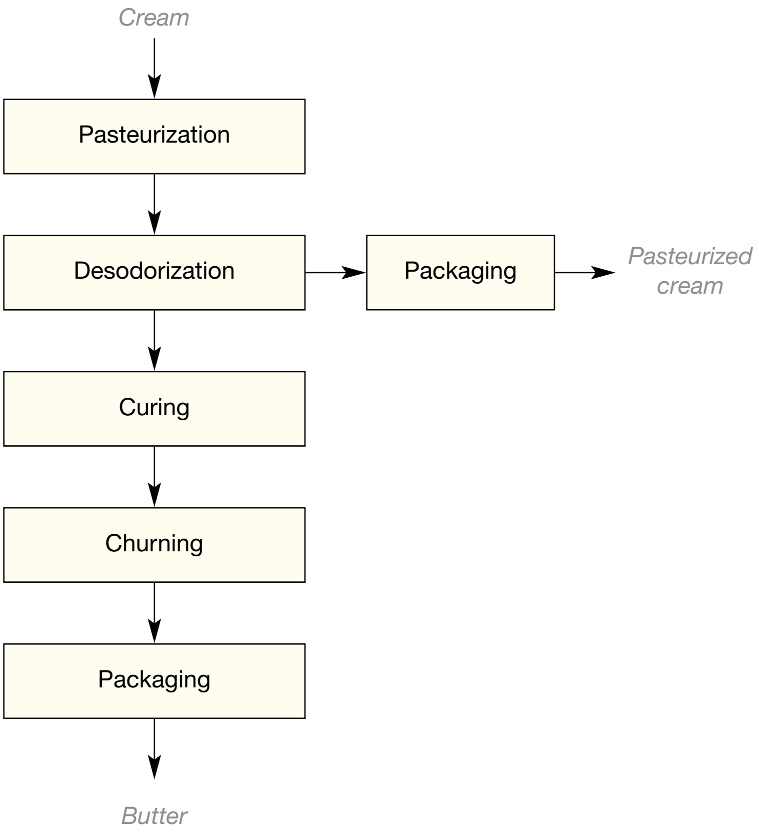
Butter

Butter is a product with a characteristic smell and taste obtained through the curing of cream, in which the cream undergoes a series of biochemical transformations. During churning, it looses a large part of its aqueous state and is transformed into an emulsion of water in oil.

There are several systems for making butter. The two most common systems are based on the agglomeration of fat globules and on refrigeration of a concentration of oil (used to obtain butter with a butter fat content of less than 50 per cent). The following description is for continuous preparation of butter based on the agglomeration of fat globules. It is the most widely used system.

The following figure presents the flow chart of the manufacture of cream and butter, which coincides in their first stages.

Figure 27
FLOW CHART OF THE PROCESS FOR PREPARING BUTTER AND CREAM



The preparation of butter begins with pre-treatment of cream (pasteurization and deodorization).

Later, it is submitted to a period of curing, after which the cream is churned to form lumps of butter.

The aqueous part (whey or buttermilk) is then separated from the grains of butter, which are then washed with cold water or its whey.

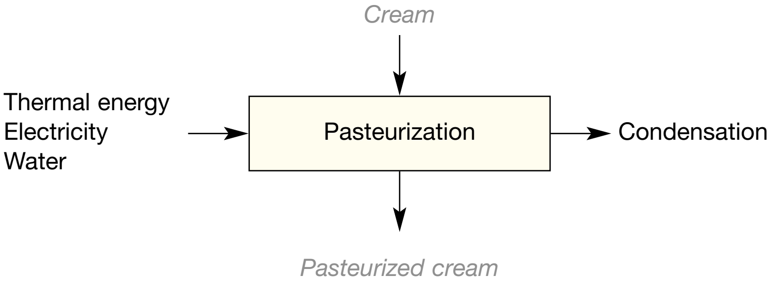
Finally, in order to obtain a compact and homogenous mass in which the water is uniformly distributed, the grains of butter are subjected to a kneading process. After that, the butter is packaged.

3.2.2. Production operations and environmental considerations

3.2.2.1. Pasteurization of cream

The temperatures for pasteurization of cream range between 95 and 110 °C. For cream with a high milk fat content, the pasteurization temperature must be higher. Especially designed and prepared plate exchangers are used for this operation, taking into account the high viscosity of cream. Before entering the curing phase, the cream must be cooled to a temperature of about 20 °C.

Figure 28
PASTEURIZATION OF CREAM



More information on pasteurization available on chapter 3.1.2.4.

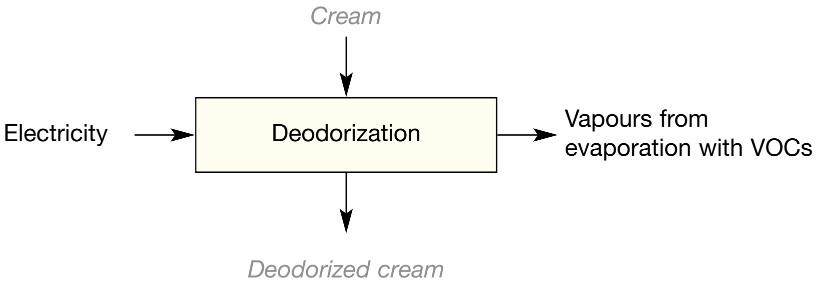
3.2.2.2. Deodorization of cream

Deodorization consists in the elimination of part of the aromatic substances from the fat that could later transmit foreign smells and tastes to final products. Deodorization also reduces oxidation of the fatty acids and growth of undesirable aerobic microorganisms. This can take place before or after pasteurization.

There are several systems for carrying out deodorization, the most important among which are:

- Open surface of corrugated plate, taking advantage of the temperature at which the cream arrives from the pasteurizer;
- Vacuum evaporators (80-85 kPa). The operation is carried out under heat in order to increase its effectiveness, using indirect heat interchangers (plates or tubes with a rough surface).

Figure 29
DEODORIZATION OF CREAM



The main environmental effects of this operation are consumption of energy and the generation of vapours that carry away the VOCs eliminated from the cream.

3.2.2.3. The curing of cream

The curing of cream is intended to crystallize the fat globules and develop aromas. A series of physical and biochemical changes are produced that depend on the system used for its fabrication. After a period of curing, the cream is cooled to below 10 °C.

Curing takes place in tanks equipped with a stirring rod and sometimes with an isolating external sleeve in order to maintain the temperature conditions required during this stage. The temperature varies in accordance with the stages of the curing. Therefore, temperature control is important at this stage.

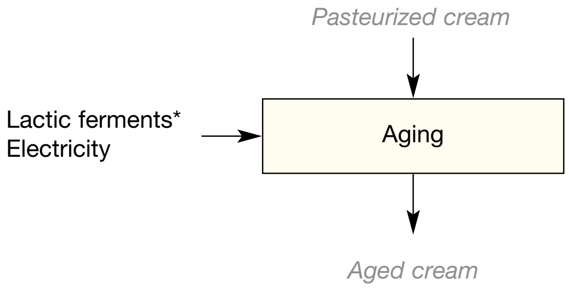
Depending on the kind of butter that is to be produced, the following systems of curing are used:

- *Curing without acidification*
  This method consists in maintaining the cream at a temperature of 6-12 °C during 4-15 hours, a period during which the cream goes through strictly physical transformations. The cream thus prepared is maintained at an approximate pH>6.2. This type of curing is used for the preparation of sweat cream butter.

- *Curing with acidification*
  In the curing with acidification, physical and biochemical processes occur. In this case, lactic yeasts are added to the cream that under certain conditions transform the lactose into lactic acid, acidifying the medium and causing physical-chemical changes that will later facilitate separation of the fat and whey during churning. Lactic ferments are added to the curing storage tank until obtaining the appropriate pH for carrying out the churning.

A combination of these methods consists in first carrying out the curing without acidification and later during the churning adding lactic ferments, obtaining butter from acidified cream.

Figure 30
CURING OF CREAM



* In the case of curing with acidification.

In order for curing to be effective, certain temperatures must be maintained, and as a result this stage consumes a large amount of energy.

3.2.2.4. Churning

Since the 1960s, there have been systems for continuous production based on a rotating cylindrical drum in which the churning and kneading occur consecutively.

In order to churn the cured cream, it must be heated to a temperature above that of curing. The churning produces a strong shearing force that breaks down the fat globules and allows them to join together, creating two states at the end of the operation: one state of fat composed of lumps of butter and an aqueous state composed of so-called buttermilk. The first is really an emulsion of water in fatty material.

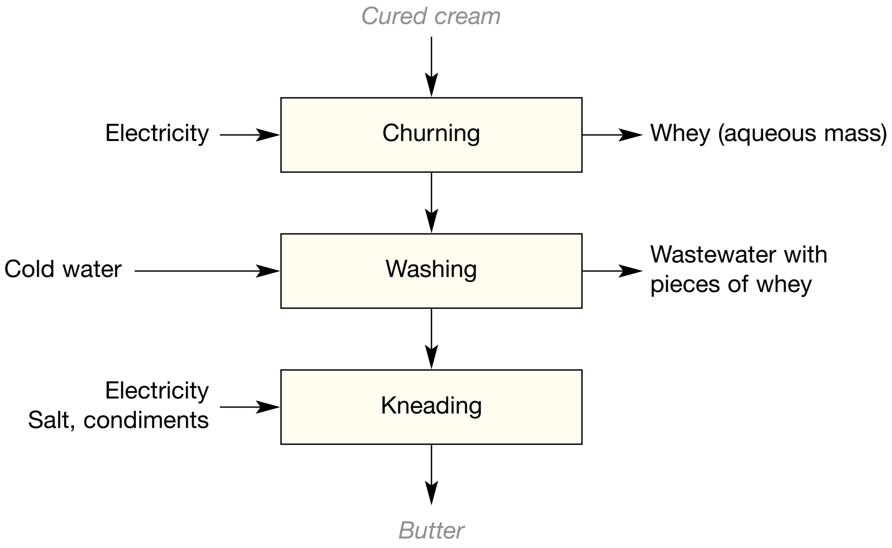
In some cases, the lumps of butter are washed with cold water in order to eliminate the remains of the buttermilk before the kneading process. The quality of the water used should guarantee that there is no contamination of the product.

The operation of kneading to which the grains of butter are subjected seeks to obtain a compact mass, adjust the content of water and mix it homogeneously with any additives used (salt, aromas).

The technique of continuous production consists in carrying out these operations without interruption and in less time, speeding up production per hour, raising the quality of the product and facilitating its packaging. The discontinuous system (batch system) is still used only in small installations.

From the point of view of economics and the environment, the continuous system of production makes it possible to reduce consumption of energy, decrease the loss of fat in the buttermilk, reduce consumption of water for washing and decrease the cleaning operations.

Figure 31
CHURNING OF CREAM



During the churning operation, buttermilk is produced from which most of the microorganisms present in the cream (lactic ferments and other microorganisms) are also eliminated. If the buttermilk is eliminated together with the wastewater generated by production, an increase in the pollution load of this water occurs, and that can damage the receiving medium.

In addition, washing consumes water that is later dumped with the rest of the buttermilk.

3.2.2.5. Packaging

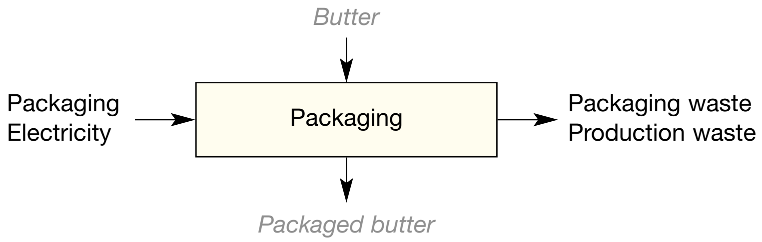
Butter must be packaged immediately after leaving the production machine in order to avoid microbiological contamination. Moulding, filling and sealing machines can be used for packaging.

The emulsion of the butter can oxidize fats, leading to its deterioration. Furthermore, butter rapidly absorbs odours. For this reason, packaging should protect the product from light, prevent oxidation and be resistant to water vapour in order to prevent the surface from drying out and producing changes in colour.

The most frequent materials used for packaging are paper or aluminium foil lined with film or fat-resistant paper, sheets of polythene, plastic tubs (thermoformed polypropylene, LDPE or PVC). For packaging for wholesale trade, cardboard boxes lined with LDPE or tins are used.

For the packaging of cream, plastic packaging (polystyrene), cardboard with plastic covers or aluminium sheets are used.

Figure 32
PACKAGING OF BUTTER AND CREAM

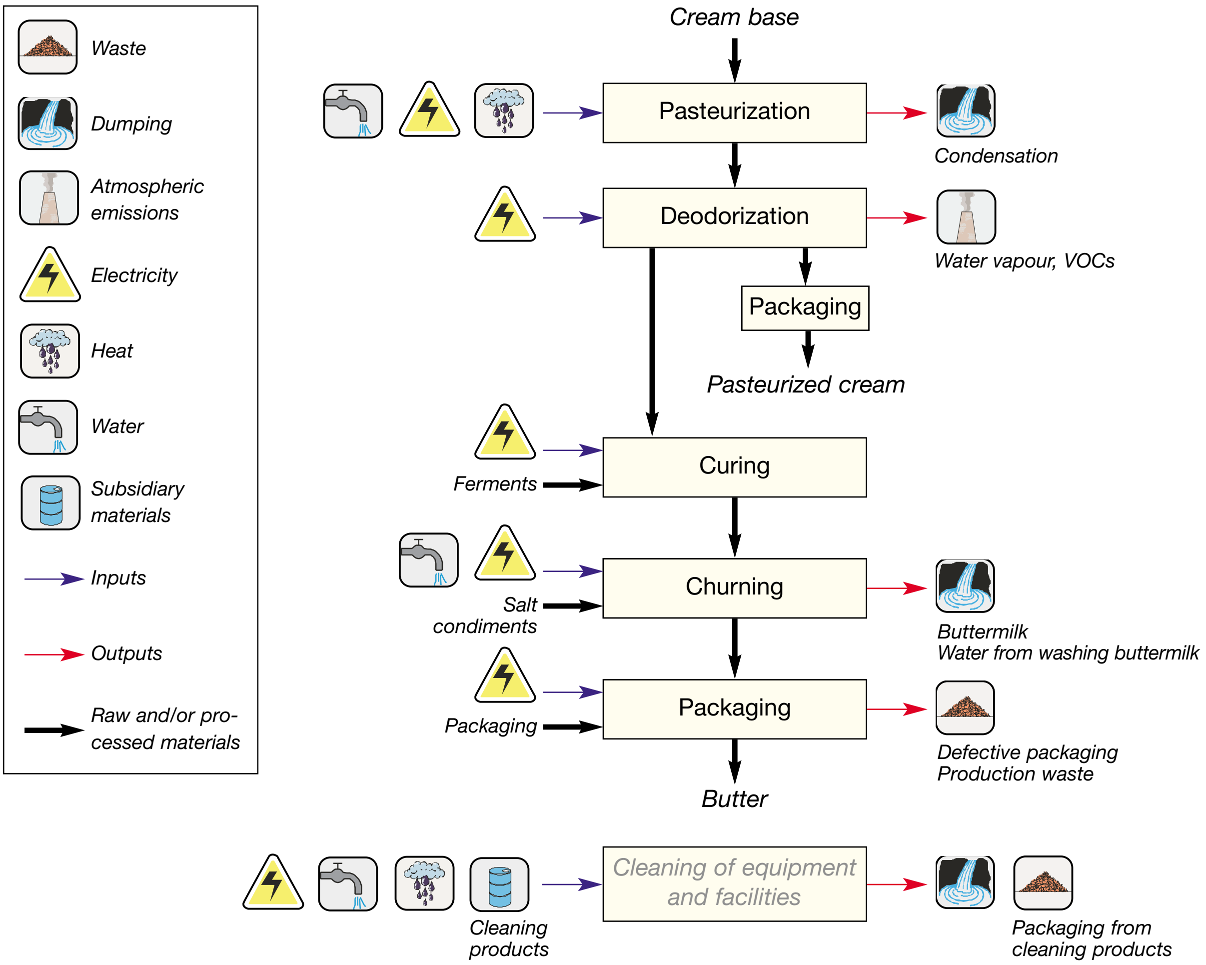


The main environmental effects of this operation are waste from production and defective packaging because of defects in the packaging, microbiological contamination and consumption of electricity by the packaging machines.

3.2.3. Environmental effects of the production of butter and cream

The main environmental effects resulting from the processing of butter and cream are the following.

Figure 33
ENVIRONMENTAL EFFECTS OF THE PROCESSING OF BUTTER AND CREAM



The following table summarizes and ranks the environmental effects that can be produced during the processing of butter and cream.

Table 5: Ranking of the environmental effects resulting from the processing of cream and butter

BASIC OPERATION	EFFECT	RANKING
Pasteurization	Consumption of heat Consumption of electricity Consumption of water Dumping of condensation	Primary Primary Secondary Secondary
Deodorization	Consumption of electricity Generation of steam with VOCs	Secondary Secondary
Curing	Consumption of electricity	Secondary
Churning	Dumping of buttermilk Consumption of electricity Dumping of water from washing buttermilk Consumption of water	Primary Secondary Secondary Secondary
Packaging of butter and cream	Waste from defective packaging Consumption of electricity Rejected products	Primary Secondary Secondary
Cleaning of equipment and installations (see chapter 3.5.1.)	Consumption of heat Consumption of water Dumping of wastewater (amount of dumping and pollution load) Consumption of chemicals Generation of waste (packaging of cleaning products) Consumption of electricity	Primary Primary Primary Primary Secondary Secondary

3.3. Production of fermented milks

Fermented milks are obtained by multiplication of lactic bacteria, sometimes mixed with other microorganisms, in a preparation of milk. Lactic acid produces coagulation and thickens the milk, giving it a rather pronounced acid taste.

The characteristics of the various fermented milks are due to a particular variation of certain factors, such as the composition of the milk, temperature of incubation and the lactic flora.

Fermentation of milk by lactic bacteria leads to modification of the normal components of milk, and lactose is partially transformed into lactic acid or, in some milk, into ethyl alcohol. The protides begin peptonization that improves their digestibility, and sometimes the milk takes on CO_2 and foams.

Yogurt is the best-known fermented milk, and as a result will be described in detail in this section.

There are a large variety of types of yogurt in function of their consistency (coagulates, liquids, mousse), composition (skim, low fat, normal, enriched) or flavour (natural, with sugar, flavours, or pieces of fruit, etc).

3.3.1. Production of yogurt

Yogurt is produced from coagulated milk obtained by lactic fermentation, produced by the action of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in pasteurized or concentrated milk, totally or partially skimmed with or without additions (pasteurized cream, powered milk, sugar…). Other species of lactic bacteria and even other genera, such as *Bifidobacterium,* are also used for the preparation of fermented milk. The acceptance of these products as yogurts depends on the legislation of each country.

Yogurt can be prepared from goat's milk, sheep's milk and donkey's milk, although the most widely used is that made from cow's milk.

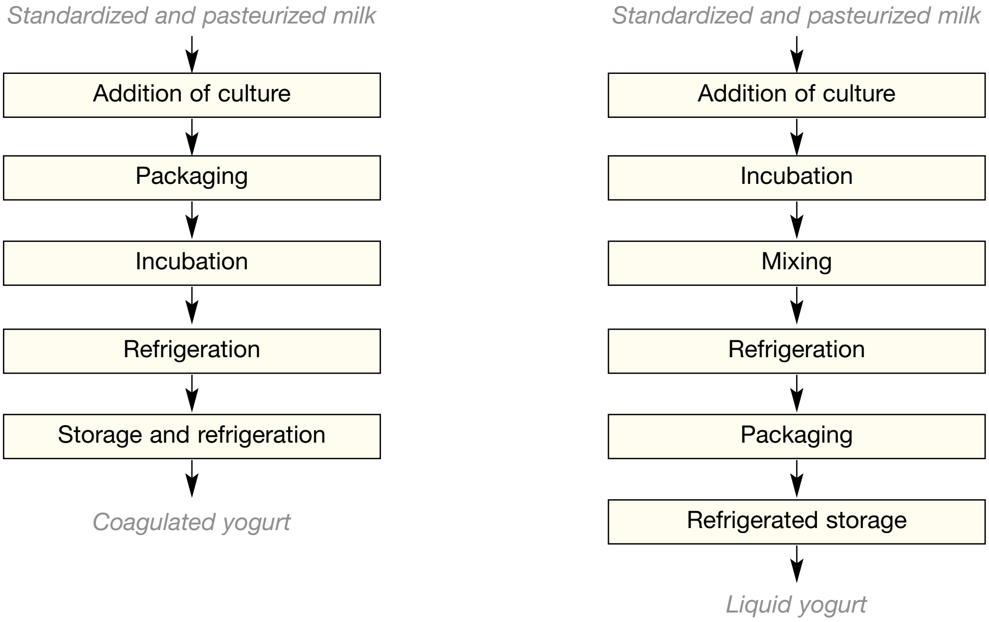
For the preparation of yogurt, standardized milk is used the fat content of which has been stabilized and pasteurized in order to avoid undesirable microbial contaminations.

First, the milk is fermented through inoculation with the bacterial culture and then incubated at an appropriate temperature. In function of the type of yogurt being prepared, incubation can be carried out in the final packaging in which it will be sold or in tanks for later packaging. Fermentation is halted through refrigeration.

The consistency of the yogurt depends on the proportion of lean dry extract (casein) of the milk. At times during preparation, thick yogurts must be adjusted by adding skim-powered milk or by concentration. The addition of sugar and other supplements (fruit syrups, jams, fruit pulp, etc.) can be carried out directly during the processing of the product before packaging using dosage equipment or during fermentation or storage in tanks.

The following flow chart describes the preparation of yogurt.

Figure 34
FLOW CHART OF THE PRODUCTION OF YOGURT



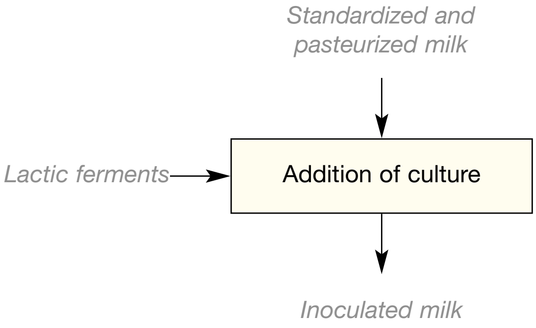
3.3.2. Production operations and environmental considerations

3.3.2.1. Addition of culture

Addition of culture consists in adding ferment to milk heated to the incubation temperature of that culture.

Depending on the type of yogurt, the culture can be added during continuous processing directly in doses into the flow of milk before packaging or in discontinuous processing it can be added in incubation tanks.

Figure 35
ADDITION OF CULTURE FOR THE PREPARATION OF YOGURT



3.3.2.2. Incubation

After the addition of ferments, the incubation stage begins. In this stage, the fermenting microorganisms metabolise the lactose, producing lactic acid. This phenomenon makes the pH drop, producing coagulation of the casein. This process takes place under specific conditions of temperature and time (42-45 °C during 2.5-3 hours), which vary depending on the type of ferment used.

Once coagulation has been produced the casein, the process stops, suddenly decreasing the temperature.

Formation of the casein gel is especially sensitive to mechanical forces, for which reason incubation should be carried out under completely calm conditions.

Depending on the type of product to be prepared and the type of installation available, incubation can be carried out in the following ways:

- *Fermentation in the packaging.* This is used to produce coagulated yogurt, carrying out fermentation in the individual packaging in which the product will be sold. The culture is added to the milk on-line before packaging and placing on pallets. The pallets with the packaged yogurt are placed in air-heated incubation chambers. This is the least efficient system from the point of view of energy use.

- *Discontinuous fermentation in tanks.* This is the most efficient technique from the point of view of production and energy. Incubation is carried out in fermentation tanks and once finalized the yogurt is cooled and packaged. It is used preferably for the production of whipped yogurts, although it can be used for coagulated yogurts if stabilizing agents are added to the milk.

- *Continuous fermentation.* This type of fermentation requires special fermenting agents that permit the formation of the yogurt with very little mixing. Expensive and advanced technology is needed for this, although there are clear advantages from the point of view of production and energy.

Figure 36
FERMENTATION IN PACKAGING

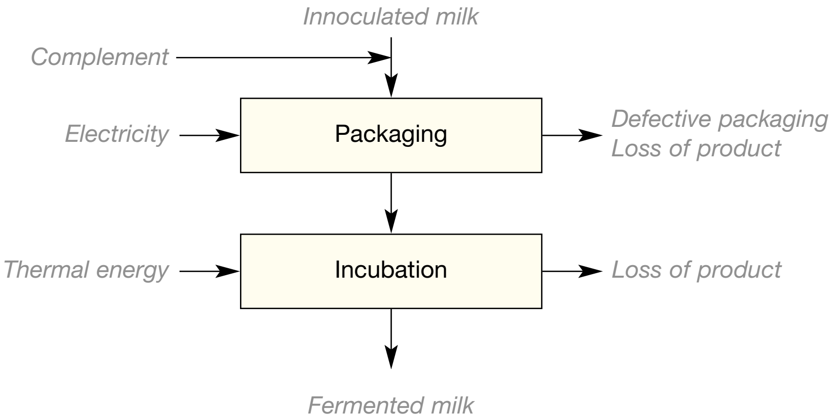
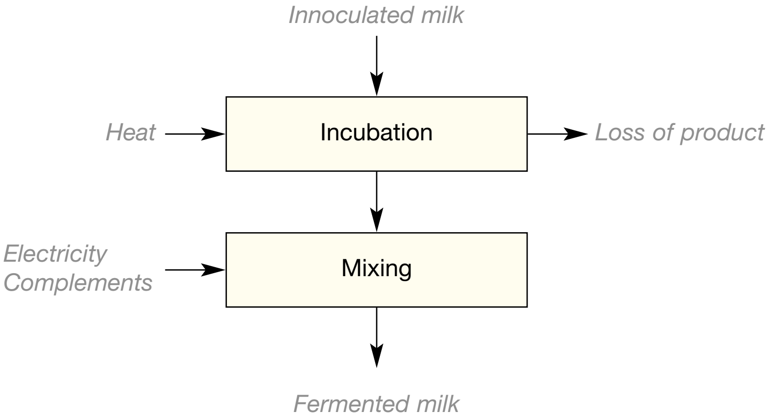


Figure 37
DISCONTINUOUS FERMENTATION IN TANKS



Incubation requires special conditions of temperature (42-45 °C) during periods that can vary between 2.5 and 3 hours. As a result, there is high consumption of energy during this stage in order to maintain the conditions for incubation.

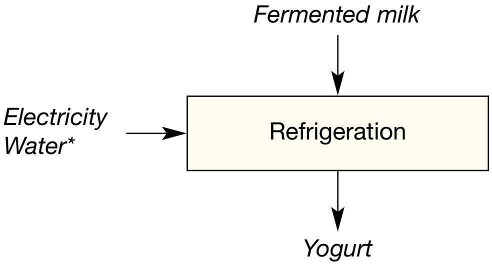
3.3.2.3. Refrigeration

Cooling of the yogurt paralyses the fermentation reactions, preventing the yogurt from continuing to acidify. Depending on the type of incubation system used (see previous section), there are two main refrigeration systems:

- *Dry-air cold tunnels.* When fermentation is carried out in the final packaging, pallets with the packaging are introduced in cooling tunnels with cold, dry air where the temperature of the product is dropped to 15 °C.

- *Plate exchangers.* When cooling is used between fermentation and packaging, the yogurt can be cooled quickly once it is incubated, using plate exchangers.

Figure 38
REFRIGERATION STAGE



* In the case of refrigeration by heat exchangers.

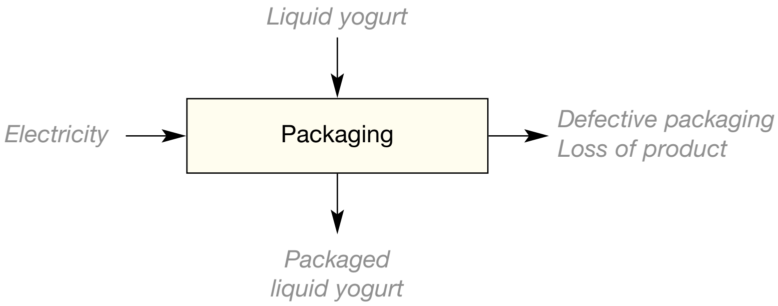
This stage consumes a great deal of energy. The use of plate exchangers for refrigeration is more profitable in terms of energy than cold tunnels.

3.3.2.4. Packaging

As mentioned earlier, packaging can be carried out before or after incubation.

Polystyrene packaging with aluminium foil tops covered with polyethylene that can be sealed with heat are almost always used for packaging yogurt. Other types of packaging, such as glass jars, are also used.

Figure 39
PACKAGING STAGE

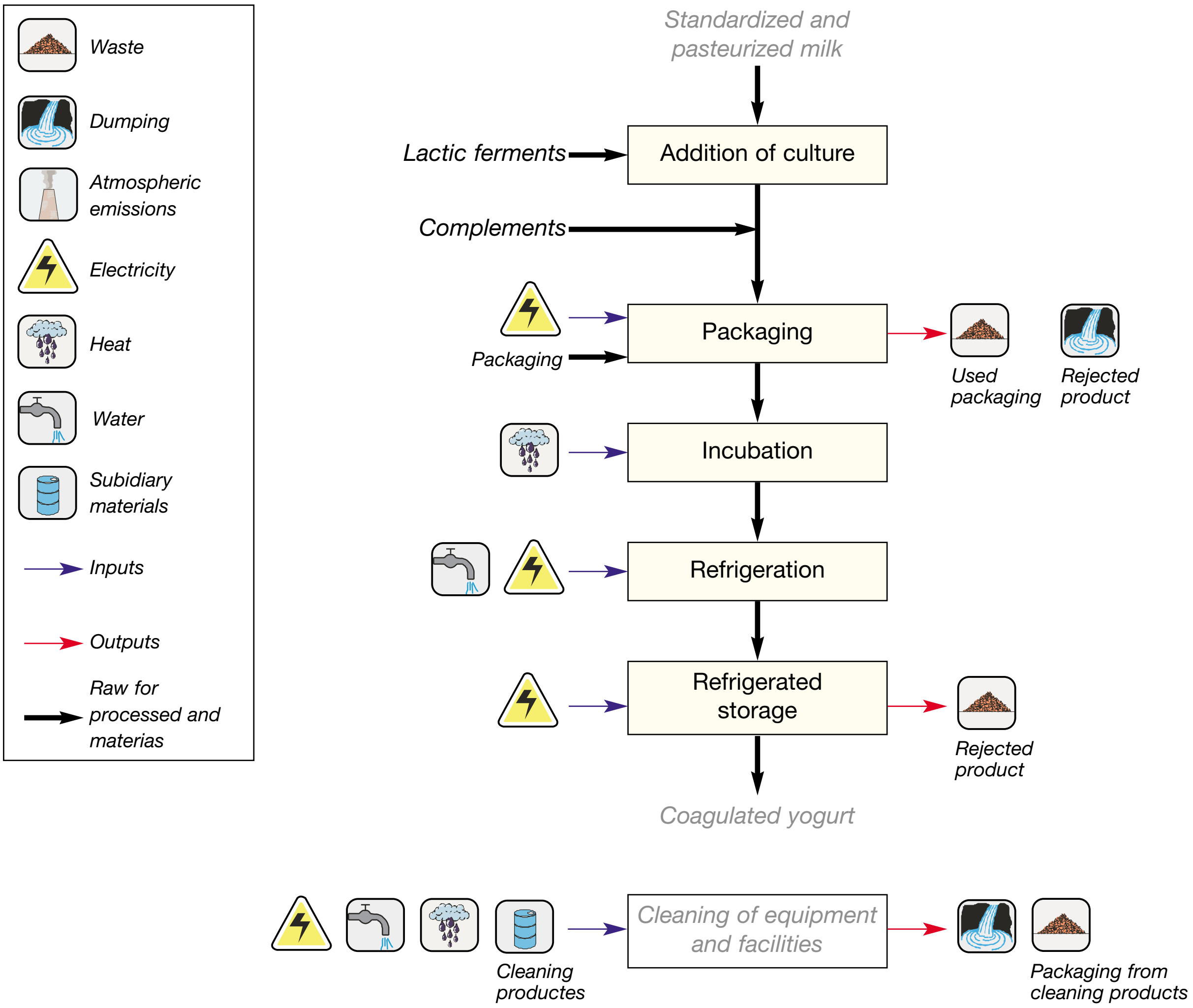


The generation of packaging waste is usually the main environmental effect generated during this stage. Occasionally, there can also be losses of the product that are washed away with the wastewater during cleaning operations.

3.3.3. Environmental effects of yogurt production

The main environmental effects caused by the production of yogurt are the following.

Figure 40
ENVIRONMENTAL EFFECTS OF THE PREPARATION OF YOGURT



The following table summarizes and evaluates the environmental effects that can be generated during yogurt production.

Table 6: Ranking of the environmental effects resulting from the production of yogurt

BASIC OPERATION	EFFECT	RANKING
Packaging	Packaging waste Consumption of electricity Loss of rejected products	Primary Secondary Secondary
Incubation	Consumption of heat	Secondary
Refrigeration	Consumption of electricity Consumption of water for refrigeration	Primary Secondary
Refrigerated storage	Loss of rejected products Consumption of electricity	Primary Secondary
Cleaning of equipment and installations	Consumption of heat Consumption of water Dumping of wastewater (amount of dumping and pollution load) Consumption of chemicals Generation of waste (packaging of cleaning products) Consumption of electricity	Primary Primary Primary Primary Secondary Secondary

3.4. Cheese production

The preparation of cheese is one of the oldest forms for processing milk, and it is carried out traditionally within each family, village or district.

Cheese is a product that is prepared from whole milk, cream, skim milk or buttermilk or with combinations of these products. In general, cheese is produced by the coagulation of milk proteins, using lactic ferments and/or rennet. The addition of enzymes, acidification or heat can accelerate this process. After coagulation, it is moulded, salted, pressed and, for some types of cheese, it is treated with fungi or bacterial cultures. In some cases, special colouring or other non-lactic ingredients are also added. It is consumed as soft cheese or as cheese with different degrees of curing.

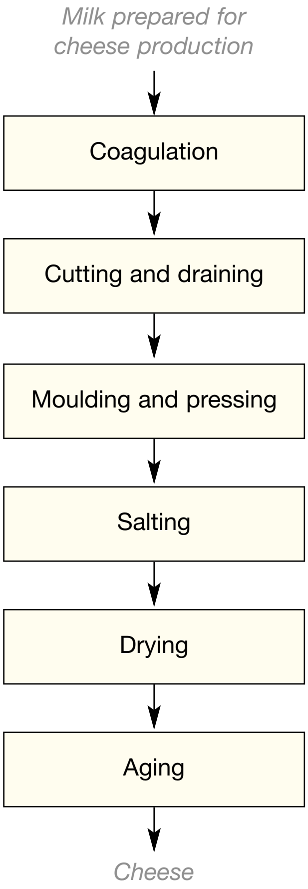
There are more than 2,000 different types of cheeses throughout the world with very distinct characteristics that require a series of more or less distinct procedures for preparation.

Several classification criteria can be used:
- In accordance with the origin of the milk with which it has been prepared (cow’s, goat’s or sheep’s milk);
- Depending on the characteristics of the final product (salted cheeses, melted cheeses, etc.);
- Depending the curing process (cured cheeses, soft cheeses).

3.4.1. Cheese production

Milk should be treated and prepared by conditioning its physical, chemical and biological characteristics (filtering, clarification, standardization) to the final product desired before being used in the operations for producing cheese (see chapter 3.1.2.4. concerning production of milk). Once ready for the stage of coagulation, the milk is raised to an appropriate temperature and ferments and enzymes are added that produce the formation of the gel or coagulate. After coagulation, the curds are cut into small cubes in order to promote the draining of the whey. After separation of the whey, the curds are placed in moulds and in some cases are pressed. Once the form of the cheese is stabilized, it is salted and curing begins. For some cheeses, the process ends with the draining of the whey and packaging without curing (fresh cheeses).

Figure 41
CHEESE PRODUCTION



3.4.2. Production operations and environmental considerations

3.4.2.1. Coagulation

Coagulation causes an alteration in the casein and its precipitation, creating a gelatinous mass that covers all the components of the milk. The nature of the gel that forms upon coagulation of the casein strongly influences the later processes for producing the cheese (rinsing, ripening, formation of "eyes").

Coagulation is carried out in vats where the curds are formed. These tubs must remain stationary and not be moved during the coagulation in order to avoid alteration of the coagulation processes with the resulting loss of casein with the wastewater.

There are three types of coagulation:
- Acidic coagulation.
- Enzymatic coagulation.
- Mixed coagulation.

Acidic coagulation is produced by acids, usually lactic bacterial action, transforming the lactose into lactic acid. The formation of lactic acid reduces the pH of the milk, producing changes in the casein-calcium compound, gradually releasing calcium from this compound. the pH reaches 4.6, the remaining casein is precipitated into a liquid state (whey), which contains the dissolved calcium from the casein. The gel resulting from this process is formed by more or less polymerised protein chains in a network without rigidity or compactness.

Enzymatic coagulation is the system of coagulation most widely used for the preparation of cheese and is produced by the addition of protein enzymes. The rennet obtained from the dry stomachs of lactating calves contains these enzymes and have traditionally been used in cheese production.

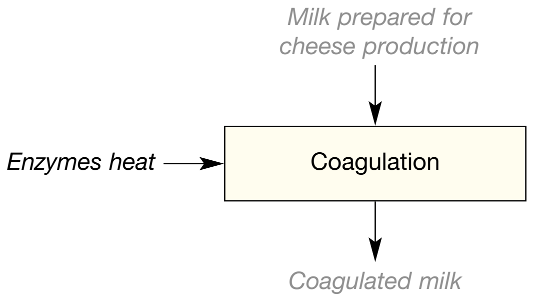
Enzymatic coagulation transforms the casein-calcium compound in colloidal dissolution into a network of casein calcium, forming the gel or coagulate that covers the rest of the cheese components. The minerals in the micelles of the coagulate thus formed give it rigidity and compactness. An important part of the liquid state (whey) is thus retained in this structure.

The amount of enzyme coagulant to add to the milk depends on its pH, the coagulating strength of the enzyme and the concentration and characteristics of the milk to be coagulated. Another important factor to take into account in coagulation is the temperature of the rennet or coagulant enzymes to be added.

The time required for coagulation depends on the temperature of the added rennet. Temperature also influences the capacity of the rennet to link with water, retraction of the curds and acidification. Normally, temperature is between 28 and 34 °C, except for cheeses that are not cured that are worked at lower temperatures.

Finally, *mixed coagulation* is the result of the joint action of rennet and lactic acidification. A mixed gel can be obtained by adding rennet to acidic milk or by acidifying an enzymatic gel.

Figure 42
COAGULATION OF MILK IN CHEESE PRODUCTION



During this stage, losses or spills of milk can occur through handling. Heat is consumed during this stage in order to raise temperature for formation of the curds.

3.4.2.2. Cutting and draining

The gel formed during coagulation, whichever method is used, is in an unstable physical state. Depending on the conditions, the liquid state or the whey that impregnates it separates more or less quickly. This phenomenon is known as draining of the whey.

The draining of the curds obtained by acidic coagulation is difficult and creates very moist rennet that is poorly drained. This is because dispersion of the casein agglomerates, the slight contraction of the curds and the absence of minerals from the casein that forms a pliable mass containing whey. Draining produces run-off from the mass of coagulate.

The coagulate obtained through enzymatic coagulation does not drain out the whey by leaving it at rest. To drain the whey, it is necessary to apply mechanical action. In order to promote the draining of the whey, the curds are cut in order to multiply the surface for draining.

The conditions under which the gel is cut up influence the final product and varies depending on the type of cheese sought.

There are two main methods for draining the whey. During the draining of the whey in vats, the coagulate is divided into cubes, which remain floating in the whey that they exude. During the draining of whey in moulds, the cut-up coagulate is maintained in a mass from which the whey is separated as it forms. For some types of very acidic and demineralised coagulates, the whey is separated by centrifugation.

Separation of the whey from curds left at rest is weak and slow and in most cases the cheese does not have the desired final composition.

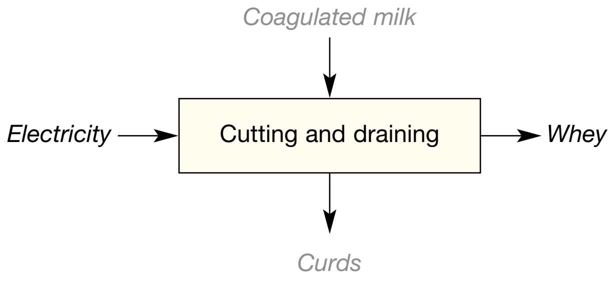
For this reason, other operations are carried out that facilitate the draining of the curds. There are two types of treatment: heat and mechanical.

For the preparation of certain types of cheeses with a very high dry extract, heat treatment is used during which a rise in temperature produces an increase in the degree of draining of the cheese.

Mechanical treatments applied to the curds can be cutting, agitation, moulding or pressing. Depending on the type of cheese, one or several of these treatments are used.

Agitation consists in moving the pieces of curd obtained by cutting the whey in order to avoid the tendency of the cut-up curds to precipitate.

Figure 43
CUTTING AND DRAINING



The main environmental effect produced by the preparation of cheese is whey. Depending on the type of coagulation used, various types of whey will be obtained:

- Sweet buttermilk. This is produced during the enzymatic coagulation of milk. It usually contains between 0.6-0.9 per cent of soluble protein, approximately 0.3 per cent fat and a large amount of lactose (more than 5 per cent). In this type of whey, the presence of lactic acid is practically nil.
- Acidic buttermilk. This is generated when acidic coagulation is used to coagulate the milk. This type of whey contains approximately the same proportion of soluble protein as the sweet whey but a lower proportion of fat and slightly less lactose (4.5 per cent), while there is up to 0.8 per cent lactic acid.

Generically, the liquid obtained during cheese production independent from the type of coagulation used is called whey.

The lactose and protein content of the whey causes an especially high increase in the degree of pollution of wastewater, (reaching more than 60,000 mg COD/litre of whey). For this reason, dumping the whey together with the rest of the wastewater should be avoided.

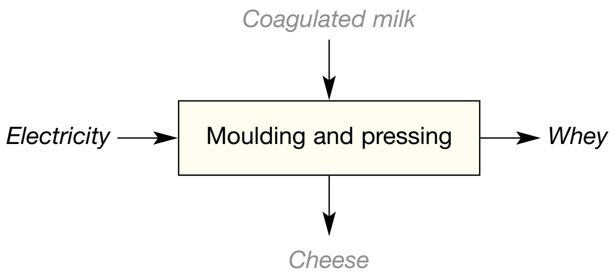
Consumption of electricity will be a function of the degree of automation of the process and the use of mechanical means for separation of the whey.

3.4.2.3. Moulding and pressing

Moulding consists in pouring pieces of curd into moulds prepared for this. The moulds are usually plastic (PVC), although sometimes metal or wooden moulds are used. The moulds give the finished cheese the required dimensions and weight.

Pressing is applied in order to promote expulsion of the inter-granular whey from the curds and give the cheese its final form. Pressing gives the final product a higher consistence. The intensity of the pressure exerted varies in function of the type of cheese being produced. Cheeses can be pressed by the weight of the cheese or by applying additional force.

Figure 44
MOULDING AND PRESSING OF CURED CHEESES



Like in the previous stage, consumption of electricity depends on the degree of automation of production.

During pressing, whey is also separated from the mass of the cheese, although the amount of whey produced during this stage is less than during the draining of the whey.

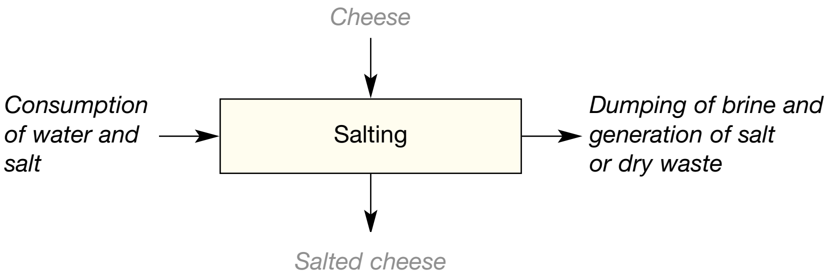
3.4.2.4. Salting

Each variety of cheese has a predetermined content of common table salt. As a general rule, salt content decreases in proportion to the dry extract.

Salting is one of the most determining factors and gives cheese the desired taste. Furthermore, it plays a role in the regulation of whey content and acidity. Salt makes the cheese mass spongy, ensures its conservation (together with the pH), inhibits germination of microorganisms that cause bloating and stimulates the development of flora for ripening the cheese. Salt content also influences the consistency of the cheese: the greater the salt content, the greater its consistency.

This operation can be carried out on the milk (in the vat) or on the cheese using brines (16-22 per cent salt) or dry salt. The time and amount or concentration of salt depends on the type of cheese and the method of salting used.

Figure 45
SALTING OF CHEESE



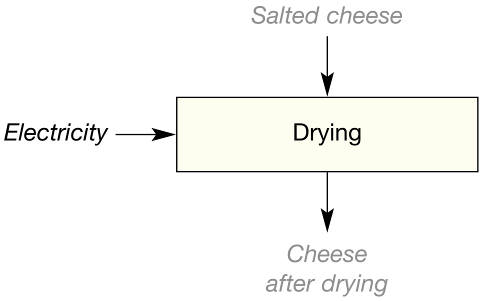
During the salting stage, water is consumed for formation of the brine and dumping of consequent wastewater once they are exhausted. When this operation is carried out by the application of dry salt on the surface of the cheese, there is salt waste that is removed with cleaning washes. This produces wastewater with high conductivity (similar to the brine waste) or a waste in cases where the salt is extracted dry.

3.4.2.5. Drying

Once the salting is finished, the cheese can be exposed to an air current in order to dry the surface. Surface drying has a special importance when the cheese is wrapped or is covered with wax for curing.

This operation is carried out in drying chambers conditioned for this, in which air is circulated under conditions of controlled temperature and humidity in order to cause the surface of the cheese to dry.

Figure 46
DRYING OF CHEESE



During this stage, electricity is consumed for generation of an air current at a determined temperature and humidity.

3.4.2.6. Curing

Cheeses, once salted and dried, are taken to storage rooms for aging, in which the temperature and humidity are controlled.

The curing of cheese includes physical, microbiological and enzymatic processes, creating a finished product with certain characteristics of aroma, taste and texture.

Organoleptic transformations

The most evident processes that occur are, usually:

- Formation of a more or less hard crust that, depending on the type of cheese, can be dry or covered with a layer of ferments or molds (external aspect);

- Formation of a homogeneous and smooth paste with a colour ranging from white to yellow (internal aspect);

- Formation of holes, “eyes” or cracks.

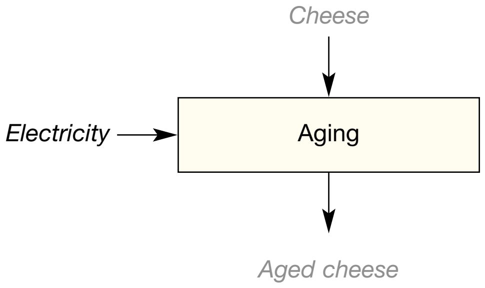
Chemical transformations

The casein goes through hydrolytic division (decomposition with the addition of water) that occurs staggered or parallel, sometimes affecting its most basic components, the amino acids. Also involved in these chemical transformations are fats, which go through division that produces aromatic substances that characterize the finished cheese.

Microbiological transformations

One of the indispensable conditions for the optimum aging of cheese is formation of a specific aging flora, which is a superficial flora. A frequent result is the formation of holes inside the cheese body.

Figure 47
AGING OF CURED CHEESES

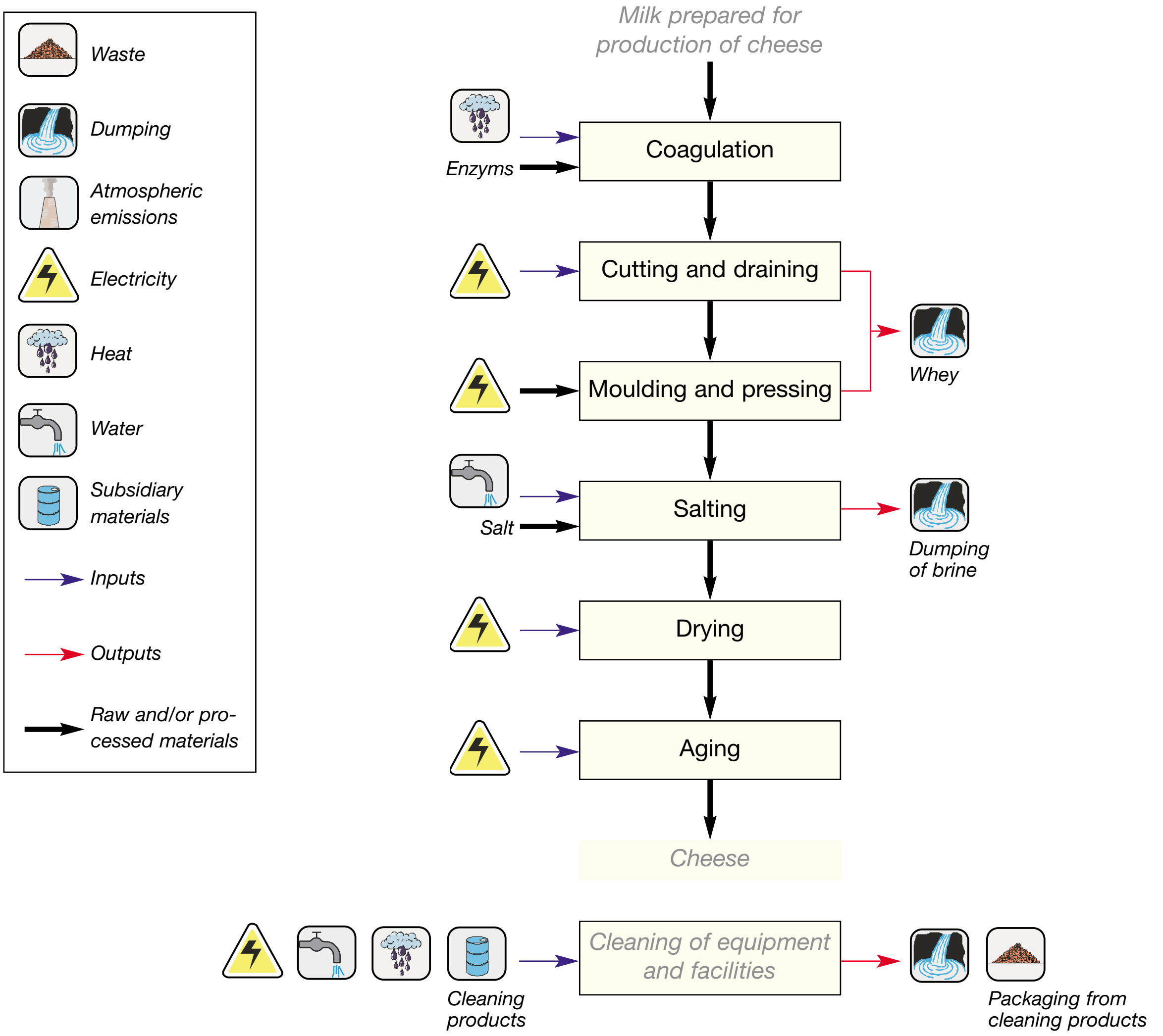


Like in the previous stage, electricity is consumed during the curing of cheese as a result of the use of aging chambers with controlled temperature and humidity.

3.4.3. Environmental effects of cheese production

The main environmental effects caused by cheese production are the following.

Figure 48
ENVIRONMENTAL EFFECTS OF CHEESE PRODUCTION



The following table summarizes and ranks the environmental effects that can be generated during the cheese production process.

Table 7: Ranking of the environmental effects resulting from the production of cheese

BASIC OPERATION	EFFECT	RANKING
Coagulation	Consumption of heat	Secondary
Cutting and draining	Dumping of whey Consumption of electricity	Primary Secondary
Moulding and pressing	Dumping of whey Consumption of electricity	Primary Secondary
Salting	Consumption of water Dumping of brine	Primary Primary
Drying	Consumption of electricity	Secondary
Curing	Consumption of electricity	Secondary
Cleaning	Consumption of heat Consumption of water Dumping of wastewater (amount of waste and pollutant load) Consumption of chemicals Generation of waste (packaging of cleaning products) Consumption of electricity	Primary Primary Primary Primary Primary Secondary

3.5. Secondary operations in the dairy industry

In this section are described the secondary operations common to all processes in the dairy industry. Environmental effects associated with these operations are evaluated at the end of this section.

3.5.1. Cleaning and disinfection operations

Because of the characteristics of the raw material used and the products produced, the hygienic conditions of the equipment and installations of the dairy firms should guarantee the quality of the products produced.

Maintenance of the hygienic conditions in a dairy firm require continuously carrying out cleaning operations and disinfection, up to one fourth of the total time worked. These operations use most of the water, energy and chemicals consumed by the plant and produce a considerable amount of wastewater.

Cleaning means total elimination of all traces of milk or its components and other visible impurities. Disinfection means eliminating all pathogenic microorganisms and most of those that are non-pathogenic that can affect the quality of the final product.

Cleaning and disinfection are two operations that are usually carried out one after the other over time; first, cleaning and then disinfection, using detergents and disinfectants separately.

Nonetheless, they can also be carried out simultaneously using products with a combined action.

In all cases, cleaning operations and disinfection require the following:

- Water, which fulfils several functions including softening and dissolving dirt that has adhered to surfaces, the formation of detergent solutions and the elimination of the remains of cleaning solutions;
- Heat for maintaining the optimum temperature for the process and electricity for circulating cleaning solutions through the equipment and pipes (CIP systems);
- Chemicals (detergents and disinfectants);
- Personnel for carrying out the cleaning operations.

Cleaning techniques can be classified into *mechanical* or *physical* (pressure, temperature, brushes, sponges and brooms) and chemical (acidic and alkaline products). Normally, they are used together for the cleaning of equipment and installations.

Physical means are used to remove dirt mechanically. The use of brushes and sponges is a cheaper method, although this has the inconvenience of requiring additional cleaning in order not to convert the means of cleaning into a source of pollution. The use of pressurized water has several advantages over systems without pressure, namely that of increasing the energy of impact in order to increase the power to carry away solids and consuming less water.

Chemical methods are based on the use of chemical products, which in most cases are applied in the form of acidic or alkaline aqueous solutions. Alkaline detergents cause fat to emulsify, which makes them easy to remove, while acidic products dissolve and eliminate incrustations formed by accumulation of salts from milk and water.

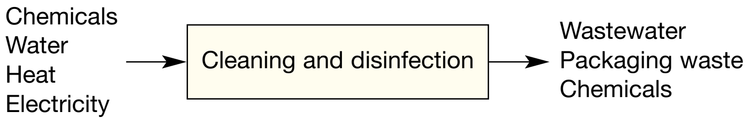
As in the case of cleaning, the **means for disinfecting** can be *physical* (such as temperature) or *chemical* (disinfecting products). The action of the temperature consists in applying heat, through hot water, steam or hot air, to the surfaces that require disinfection. Most chemical disinfectants contain compounds of germicide substances containing alkalis, chlorine and oxygen. Disinfectants also contain acids or alkalis, inhibitors of corrosion and substances that form compounds in order to improve their industrial application.

Depending on the type of dirt existing on the equipment, surface or installation, the appropriate cleaning and disinfection protocol should be applied. In the dairy industry, dirt is due primarily to the components of milk, mostly fats and proteins that are deposited on pipes and equipment.

3

It should be pointed out that the efficiency of cleaning depends on multiple factors, among which are the training of personnel, the existence of procedures and written instructions, available equipment, the chemical products used, the design of the installations, etc.

Figure 49
CLEANING AND DISINFECTION



As a result of the cleaning operations, the wastewater from cleaning and the chemical products used are dumped, plus the organic load from the washing away or dissolution of the remains of the production.

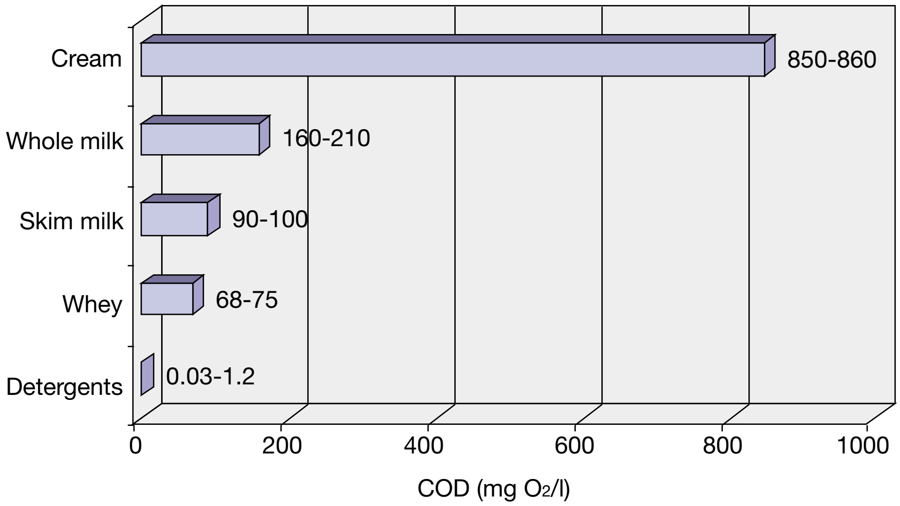
Cleaning removes particles of sand and dust, which reach the industry from many sources, but the most common waste that is eliminated is the remains of organic components of milk (fat, proteins, mineral salts).

In general, the use of cleaning systems based on physical means implies savings in the consumption of water and less generation of waste. On the contrary, the use of cleaning products applied in most cases as aqueous solutions produces a greater amount of water to be treated.

As has already been commented, wastewater from the dairy industry can have very high levels of COD, primarily because of the milk components, and the contribution of the detergents from the cleaning operations is minor in relation to that of dirt.

In general, there is a wide range in the contribution of the organic load of each detergent (30-1,200 mg O_2/litre) owing to the various chemical compositions of these products. Thus, we can find alkaline products without surfactants in the low range and surfactant products with foam-forming detergents in the upper range of the values indicated (F. Arnau, 1995).

Figure 50
COD OF VARIOUS DAIRY PRODUCTS AND DETERGENTS (F. Arnau, 1995)



Another important aspect of the use of detergent products is their phosphate and nitrate content, which makes an important contribution to eutrophication of water. Traditional detergents based on phosphoric acid that are used in cleaning operations contain 10 to 20 per cent phosphorous, and their contribution to the wastewater should, therefore, be kept in mind.

3.5.2. Steam generation

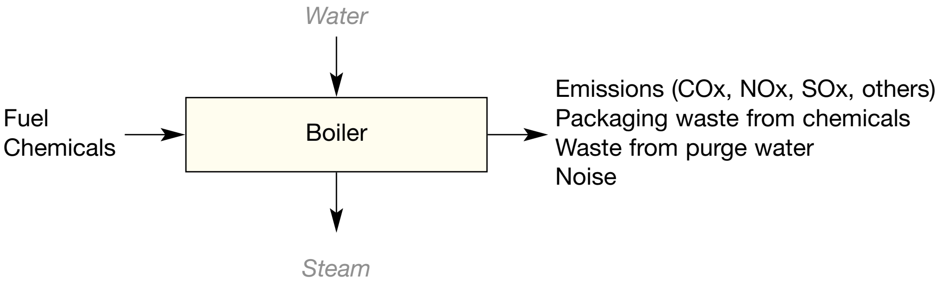
The heat needed by dairy firms is produced primarily steam or hot water depending on the needs of the operation and the process being used.

Steam is produced in boilers and is then distributed through pipes to where it is used in the plant.

This system requires an additional installation of pipes where heat can be loss and must, therefore, be adequately insulated in order to avoid losses. The water used for supplying the boilers does not require special hygienic conditions but it should have a low content in carbonates and sulphates otherwise incrustations of salts are formed in the boilers and distribution pipes, rendering difficult the exchange of heat. As a result, chemicals are frequently used in order to avoid incrustations and salt deposits.

Condensation that is produced a result of condensation of the steam during distribution can be reused to supply the boilers or as heating water in the process, resulting in savings in water consumption.

Figure 51
STEAM GENERATION



Combustion in boilers produces atmospheric emissions of gases whose composition and quantity vary primarily in function of the type of fuel used and the conditions under which the boiler operates. The combustion of fuel oil (which is the fuel most frequently used in the dairy industry) produces and emits primarily carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NOx). Depending on the functioning of the boiler, unburned elements are emitted in the form of solid particles.

Water consumption can be optimized by repairing leaks in the equipment and pipes and reusing condensation that is generated.

The generation of chemical packaging wastes is significant since it is a dangerous waste that should be properly managed.

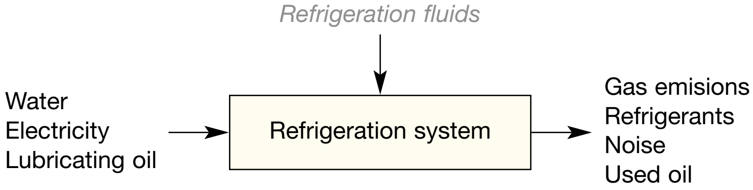
3.5.3. Refrigeration

In dairy firms, refrigeration is produced primarily for two uses: for refrigeration of storage rooms or for the cooling of liquids.

The refrigeration equipment most frequently used in the dairy industry is compression refrigeration machines with ammoniac or compounds based on chlorofluorocarbons (CFCs) as refrigerant.

This refrigerating agent can be used for directly cooling rooms or products or can be used to cool a second fluid refrigerant, usually brine or glycol water, which will do the refrigeration operation (system of indirect refrigeration).

Figure 52
REFRIGERATION



The consumption of electricity and water for the generation of cold is the main environmental effect of this operation.

However, refrigerant gases can be emitted to the atmosphere as a result of leaks in the cold circuits.

In the case of the use of CFCs (prohibited in many countries), it is recommended that they be substituted by other refrigerant fluids, in light of the CFC's contribution to the destruction of the ozone layer.

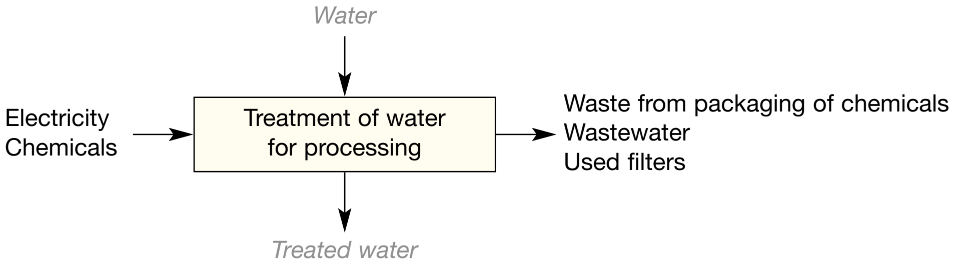
3.5.4. Water supply

The quality of water used in the dairy firm should be that of water for domestic use, especially if the water enters into direct contact with the product, such as water used in heat treating milk, in the rinsing of the buttermilk of butter or in the brines used in salting cheese.

When the quality of the water entering the dairy firm is inadequate, it should be treated in order to eliminate possible causes of contamination of the final product.

Treatment can consist in eliminating suspended solids, dissolved substances and microorganisms.

Figure 53
WATER TREATMENT



The consumption of electricity is the main environmental effect produced by this operation. Electricity is used both for pumping water and for treating water.

In function of the type of treatment used, wastewater with high conductivity or extreme levels of pH is created.

Other environmental effects are consumption of chemicals, for example when chlorine is added to the water and the generation of waste packaging of these products.

3.5.5. Environmental effects of secondary operations

The following table summarizes and ranks environmental effects that can be generated by secondary operations in the dairy industry.

Table 8: Ranking of environmental effects resulting from secondary operations in the dairy industry

BASIC OPERATION	EFFECT	RANKING
Cleaning and disinfection	See tables ranking the environmental effects of various production processes	
Steam generation	Emissions of gases and particles Consumption of fuel Wastewater with a high conductivity (purges) Consumption of chemicals (additives) Waste chemical packaging	Primary Primary Secondary Insignificant Insignificant
Refrigeration	Emission of refrigerant gases (CFCs and ammoniac) Consumption of electricity Noise Products from equipment maintenance Wastes from the packaging of chemicals	Primary Primary Secondary Insignificant Insignificant
Water supply*	Consumption of electricity Dumping of waste used for treatment Consumption of chemicals and filters Packaging waste	Secondary Secondary Secondary Insignificant

* The ranking of this operation depends in large part on the characteristics of the initial water and the treatment necessary for its preparation.

4. ENVIRONMENTAL EFFECTS OF THE DAIRY INDUSTRY

The main environmental effects of the dairy industry are related to the high consumption of water and energy, generation of wastewater with a high organic content, and the production and management of waste. Of minor importance are emissions of gases and particles into the atmosphere and noise.

It is important to point out that quantification of these aspects can vary from one installation to another in function of factors such as the size and age of the installation, equipment, use, cleaning programmes, awareness of the employees, etc.

4.1. Water consumption

Like most of the other firms in the food and agriculture sector, dairy industries consume daily large quantities of water in their processes, especially in order to maintain the required hygienic and sanitary conditions.

Table 9: Water consumption in the dairy industry

PRODUCTIVE PROCESSES	LEVEL OF CONSUMPT.	OPERATIONS WITH HIGHEST WATER CONSUMPTION	OBSERVATIONS	PPO*
Milk	Low	Heat treatment Packaging		1-29
Cream and butter	Low	Pasteurization of cream Churning	Rinsing of buttermilk before churning	1-29
Yogurt	Low	—	Mainly in secondary operations	1-29
Cheese	Medium	Salting	Salting using brine	1-10-11-29
Secondary operations	High	Cleaning and disinfection Generation of steam Refrigeration	Consumption of water is the greatest during these operations	12-13-14-15-16-17-18-19-21

* Pollution prevention opportunity (see chapter 5).

Depending on the type of installation and the cleaning system and its management, the total quantity of water consumed in the process can reach several times the volume of milk processed. Consumption is usually 1.3-3.2 litres of water/kilo of milk received, but can reach as much as 10 litres of water/kilo of milk received. Nonetheless, it is possible to optimize this consumption at 0.8-1.0 litre of water/kilo milk received using advanced equipment and proper management (UNEP, 2000).

As indicated in table 9, the greatest consumption of water occurs during secondary operations, particularly in the cleaning and disinfection where 25-40 per cent of the total is consumed.

4.2. Energy consumption

Energy is consumed to ensure the quality of dairy products, especially those submitted to heat treatment, refrigeration and storage.

Table 10: Most frequent uses of energy by dairy firms

ENERGY	MOST FREQUENT USES	EQUIPMENT
Heat	Generation of steam and hot water, cleaning	Pasteurizers/sterilizers, CIP cleaning systems
Electricity	Refrigeration, lighting, ventilation, operation of equipment	Electrical equipment (pumps, mixers, etc.), lights

Approximately 80 per cent of total energy consumption in a dairy firm is heat obtained from the combustion of fossil fuel (fuel oil, gas, etc.) and the remaining 20 per cent is electricity.

Table 11: Energy consumption in the dairy industry

PRODUCTIVE PROCESSES	LEVEL OF CONSUMP.	OPERATIONS WITH HIGH CONSUMPTION OF ENERGY	OBSERVATIONS	PPO
Milk	High	Filtration/Clarification Skimming/Standardization Heat treatment Homogenization Packaging	Mainly consumption of heat for treatment of milk	1-4-5-30
Cream and butter	Medium	Pasteurization Deodorization Aging Churning Packaging	Mainly consumption of electricity for operation of machines	1-4-5-30
Yogurt	Low	Incubation Packaging	Electricity for the operation of machines and heat for incubation	1-4-5-30
Cheese	Medium	Coagulation Cutting - draining Moulding - Pressing Drying Aging		1-4-5-30
Secondary operations	High	Cleaning and disinfection Refrigeration	Heat is consumed in the cleaning operations while electricity is more greatly consumed in refrigeration	18-22

Operations with a greater consumption of heat such as pasteurization/sterilization of milk and CIP cleaning can consume up to 80 per cent of the total heat used in the plant. Use of systems with lower consumption of energy and adoption of means of saving energy can contribute to an important reduction in total consumption.

As for consumption of electricity, refrigeration can use 30-40 per cent of the total of the consumption of the installation (López and Hernández, 1995). Other services, such as ventilation, lighting or generation of compressed air also have a high consumption.

The following table shows average values of the consumption of energy in some dairy industries.

Table 12: Specific consumption of energy for several dairy products (UNEP, 2000)

	CONSUMPTION OF ENERGY (kWh/litre of product)		
	Electricity*	Fuel	Total
Fresh milk	0.05	0.12	0.17
Cheese	0.21	1.20	1.41
Butter	0.19	0.98	1.17

* In function of the degree of automation of the process, consumption of electricity can vary.

As in the case of water consumption, consumption of energy depends on the type of product prepared and other factors such as the age and size of the installation, the degree of automation, the technology used, the management of cleaning, the design of the installation, energy saving measures adopted or the carrying out at that plant of other operations such as the concentration of whey.

Table 13: Consumption of energy in function of the plant characteristics (UNEP, 2000)

MILK PLANT	TOTAL CONSUMPTION OF ENERGY (kWh/litre of milk processed)
Modern plant with highly efficient pasteurizer and modern boiler	0.09
Modern plant using hot water for processing	0.13
Old plant using steam	0.27
Range of most of the plants	0.14 - 0.33

Inadequate consumption of energy leads to reduction of limited natural resources such as fossil fuel and an increase in atmospheric pollution due to the emission of gases produced by the generation of energy. The emission of these gases contributes to the greenhouse effect.

4.3. Wastewater

The most important environmental problem of the dairy industry is the generation of wastewater, because of its volume and its pollutant load (primarily organic). A dairy firm generates a volume of wastewater between 2 and 6 litres/litre of milk processed.

Table 14: Volume of wastewater created by different processes

MAIN ACTIVITY	VOLUME OF WASTEWATER*
Production of butter	1 - 3
Production of cheese	2 - 4
Processing of fresh milk (pasteurization and sterilization)	2.5 - 9

* Litres of wastewater/litre of milk.

The wastewater generated by a dairy firm can be classified in terms of their source: processes and cleaning or refrigeration.

Table 15: Wastewater created by a dairy firm

ORIGIN	DESCRIPTION	CHARACTERISTICS	VOLUME*
Cleaning and processing	Cleaning of surfaces, pipes, tanks and equipment. Loss of product, whey, brine, ferments, etc.	Extreme pH, high organic content (BOD and COD), oils and fats, suspended solids	0.8 - 1.5
Refrigeration	Water from cooling towers, condensation, etc.	Variations in temperature, conductivity	2 - 4

* Volume expressed in litres of wastewater/litres of processed milk (Source: E. Spreer, 1991).

Table 16: Wastewater in the dairy industry

PRODUCTIVE PROCESSES	LEVEL OF WASTE	OPERATIONS PRODUCING HIGH AMOUNTS OF WASTEWATER	OBSERVATIONS	PPO
Milk	Medium	Heat treatment Packaging	Waste decreases if water used for heat treatment is re-circulated	2-3
Cream and butter	Medium	Pasteurization Churning Packaging	Water used for cleaning the buttermilk has a high fat content	2-3-6
Yogurt	Low	—	Mainly secondary operations	2-3
Cheese	High	Cutting - Draining Moulding - Pressing Salting	Dumping of whey leads to a high high amount of pollution. Regeneration of brine produces periodic dumping of highly conductive waste	2-3-7-8-10-11
Secondary operations	High	Cleaning and disinfection Refrigeration	The amounts and pollutant load of cleaning water depend on their management by the firm. Wastewater from refrigeration depends on the degree of their re-use	12-13-14-15-16-17-18

It is estimated that 90 per cent of the COD of wastewater from a dairy industry is attributable to milk components and only 10 per cent to outside dirt.

In the composition of milk in addition to water there are fats, proteins (in solution and suspended), sugars and mineral salts. In addition to milk components, dairy products can contain sugar, salt, colorants, stabilizers, etc., depending on the type of product and the production technology used. All these components appear in wastewater to a greater or lesser degree, either through dissolution or their being carried away with cleaning water.

In general, liquid waste in the dairy industry present the following characteristics:

- A *high organic content,* due to the presence of milk components. The average COD of wastewater from a dairy firm is between 1,000-6,000 mg BOD/litre;
- *Oils and fats,* due to the milk fat and other dairy products, such as in the water used for rinsing the buttermilk;
- High levels of *nitrogen and phosphorous,* mainly because of the use of cleaning and disinfection;
- *Large variations in pH,* waste of acidic and alkaline solutions, primarily from cleaning operations, with a pH of 2-11;
- *High conductivity* (especially for cheese producers because of sodium chloride waste from the salting of the cheese);
- *Variations in temperature* (caused by water used for refrigeration).

Loss of milk, which can reach be between 0.5-2.5 per cent of the amount of milk received or in the most unfavourable cases up to 3-4 per cent, is an important contribution to pollutant load of the final effluent (UNEP, 2000). A litre of whole milk is the approximate equivalent of a BOD_5 of 110,000 mg O_2/litre and a COD of 210,000 mg O_2/litre.

Table 17: Losses of milk to wastewater

PROCESS	SOURCE OF LOST MILK
Production of milk for direct consumption	- Spills from storage tanks. - Overflowing of tanks. - Spills and leaks in pipes and hoses. - Deposits on the surface of equipment. - Elimination of sludge from filtering/clarification. - Spills because of damaged packaging. - Defects in the packaging process. - Cleaning operations.
Production of butter and cream	- Spills during storage. - Spills and leaks in pipes and hoses. - Overflowing of tanks. - Cleaning operations.
Production of yogurt	- Leaks and spills from storage tanks. - Spills from incubation tanks. - Defects in the packaging process. - Cleaning operations.
Production of cheese	- Leaks and spills from storage tanks. - Losses in the curd vats. - Spilling from moulds. - Incorrect separation of the whey from the cheese. - Cleaning operations.

In the process of preparing cheese, a great deal of whey is generated. The amount of whey generated by the production of cheese is approximately nine times the amount of milk treated, with a very high organic content (COD of approximately 60,000 mg/litre) and as a result the dumping of it together with wastewater considerably increases pollution of final waste.

4.4. Waste

Most of the waste generated by a dairy firm is inorganic: primarily packaging waste from both raw and secondary materials as well as the final product. Other wastes related to the maintenance activities, cleaning or laboratory and repair work are also produced.

Table 18: Main waste produced by a dairy firm

GROUP		WASTE	PLACE OF GENERATION	CUSTOMARY USES
Organic wastes		Rejected product (raw material, semi-finished product, final product)	Process	Recycling (animal feed)
Similar to domestic waste		Bits of food, paper	Offices	Composting or storage at a dumping site
Packaging and packing	Empty	Removable film, wooden pallets heavy paper bags, Plastic, glass, cardboard, paper packaging	Reception	Reuse or recycling
	Full	Plastic, glass, cardboard, paper packaging	Packaging Storage Returns	Dumping or separation of the packaging from the product and separate management
Waste from maintenance operations		Electric cables, scrap iron	Workshops Maintenance areas	Recycling or storage at dumps
Hazardous waste		Used oils, batteries, packaging from hazardous waste	Laboratory Storage Workshop Cleaning areas	Transport, treatment and elimination or storage at hazardous dump sites

The recycling and treatment of waste generated in a dairy firm begins with separation, which avoids their being discarded with liquid waste and mixing together that would prevent adequate treatment of each type of waste.

Table 19: Waste in the dairy industry

PRODUCTIVE PROCESS	LEVEL OF GENERATION	MOST SIGNIFICANT OPERATIONS	OBSERVATIONS	PPO
Milk	High	Filtering/Clarification Skimming/Homogenization Packaging	Used filters and sludge from filtering organic material Waste from packages and packaging	25
Cream and butter	High	Packaging	Waste from packages and packaging	25
Yogurt	High	Packaging	Waste from packages and packaging	25
Cheese	Low	—	Mainly from secondary operations	25
Secondary operations	Medium	Cleaning and disinfection Maintenance of installations Laboratories	Waste from packaging from cleaning and disinfection. Waste from maintenance operations. Laboratory wastes	24-26-32

4.5. Atmospheric emissions

The main emissions of gases from the dairy industry are produced in boilers for producing steam or hot water required for production and cleaning operations.

The pollutants in the combustion gases are CO, SO_2, NOx and particles. The level of emission of these pollutants varies in function of the type and quality of the fuel used, the state of the installations and the efficiency and control of the combustion process.

The fuels most frequently used in the boilers are solid fuel (coal or wood), liquid (fuel or gas oil) or gas (natural gas).

Table 20: Average properties of several fuels
(Source: Brennan, J.G., 1998)

TYPE OF FUEL	CALORIES (MJ/kg)	SULPHUR (per cent)	ASH (per cent)
Coal	29	2	8
Firewood	14	-	4 - 5
Gas oil 34 sec.*	45.5	0.75 max.	0.01 max.
Fuel 220 sec.*	43.5	3.2 max.	0.05 max.
Natural gas	37.2 MJ/m^3	Neg.	Neg.

* Viscosity in Redwood seconds at 38 °C.

Solid fuels are characterized by a high content of sulphur and ash. In addition, they usually have traces of volatile and toxic products, such as lead and arsenic. Their content varies in function of the quality and source of the fuel.

Like solid fuels, liquid fuels have a high sulphur content and the possibility of producing soot and particles through incomplete combustion. Furthermore, they should have fuel storage facilities with proper security arrangements in order to avoid the risk of possible leaks and explosions.

Natural gas, in spite of representing only 10 per cent of the world's energy reserves, represents a fuel that is more and more widely used given its advantages. Natural gas is free from sulphur and other impurities and does not emit these pollutants. It is also unnecessary to store it in the plants, although its use also presents risks of fire and explosion.

Preventive measures against emission of polluting gases are based on adequate maintenance and cleaning of burners, self-control of emissions and, wherever necessary, implementation of corrective measures.

Another source of pollution to be considered in atmospheric emissions is emission of refrigerant gases used in refrigeration systems. Losses or leaks of these gases have an important environmental impact given their repercussion on the destruction of the ozone layer.

4.6. Noise

In function of the closeness of urban centres, problems can occur because of noise from the machinery used in the industrial activities, primarily in packaging and refrigeration equipment. Another effect is the noise caused by the traffic of lorries, both in reception of milk as well as at the time of delivery of the finished product. The constant traffic of lorries can produce high levels of acoustic contamination.

Noise is a significant effect in dairy plants located in inhabited areas. Preventive measures include isolating noisy machines acoustically and as a source of vibrations. Another preventive measure is the monitoring of noise levels, thus allowing reduction of the impact before it is produced.

5. OPPORTUNITIES TO PREVENT AND REDUCE POLLUTION AT THE SOURCE

In general, the processes used by the dairy industry require high consumption of water and energy and produce large amounts of wastewater with a high organic content.

These characteristics depend on the technology used and the operation and management of each installation. For this reason, the following specific Pollution Prevention Opportunities (PPO) are described in order to reduce consumption and final waste without affecting production.

The Pollution Prevention Opportunities have been classified in function of the following considerations.

- *Reduction at the source* is considered to be any modification of process, installation, procedure, composition of the product or substitution of raw materials that leads to a decrease in the generation of waste (in quantity and potential danger), both in the production process and during later stages of production.

- *Recycling* is considered to be the option that returns waste to use, either in the same process or in another. When this is done at the same production plant where the waste has been created, it is considered as recycling at the source.

- *Recovery* is procedures that permit the use of resources contained in waste.

Each Pollution Prevention Opportunity is recorded on a card with the following information.

<table>
<tr><td colspan="2">PPO-X: Name of the Pollution Prevention Opportunity</td></tr>
<tr><td>Type of Opportunity: This gives the classification of the PPO: reduction, recycling or recovery.</td><td>Possibilities of reduction are classified in function of the PPO affecting the products or processes.</td></tr>
<tr><td>Process: Productive process in which the PPO takes place.</td><td>Stage / Operation: Operation on which the PPO will act.</td></tr>
<tr><td colspan="2">Environmental considerations:
The environmental situation that needs to be improved.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
A short description of the PPO.</td></tr>
<tr><td rowspan="2">Implementation:
In this section, the actions or operations to be taken to prevent the pollution are listed.</td><td>Economic balance:
👍 This symbol indicates that the result of the PPO produces an economic benefit.
This symbol indicates that implementation of the PPO has an economic cost.</td></tr>
<tr><td>Environmental balance:
☺ This symbol indicates that the result of the PPO produces a positive environmental effect.
☹ This symbol indicates that the result of the PPO produces a negative environmental effect.</td></tr>
</table>

Table 21: Pollution Prevention Opportunities

POLLUTION PREVENTION OPPORTUNITIES	
PPO-1	Control in the reception of raw materials
PPO-2	Reduction in the loss of milk
PPO-3	Separation of sludge produced by clarification
PPO-4	Use of continuous systems for pasteurization of milk
PPO-5	Recovery of energy from heat treatment of milk
PPO-6	Use of buttermilk
PPO-7	Avoid the dumping of whey
PPO-8	Uses of whey
PPO-9	Dry elimination of salt from cheese after salting
PPO-10	Physical-chemical and microbiological control of brines used for salting cheese
PPO-11	Recovery of brine
PPO-12	Control of water consumption
PPO-13	Cleaning of surfaces without water
PPO-14	Installation of systems for automatic closing of water hoses
PPO-15	Use of pressurized water for cleaning surfaces
PPO-16	Use of foam systems for cleaning surfaces
PPO-17	Use of CIP cleaning systems
PPO-18	Use of non-recoverable detergents
PPO-19	Recovery of cleaning products
PPO-20	Periodical control of emissions from boilers
PPO-21	Recovery of condensation
PPO-22	Avoiding leaks of refrigerants
PPO-23	Substitution of refrigerants with others that do not contain CFCs
PPO-24	Storage of hazardous products under adequate conditions
PPO-25	Minimization of packaging waste
PPO-26	Adequate separation of solid waste
PPO-27	Neutralization of acidic and alkaline waste before dumping
PPO-28	Optimisation of energy efficiency through cogeneration
PPO-29	Good Practices for reduction of water consumption
PPO-30	Good Practices for reduction of energy consumption
PPO-31	Good Practices for reduction of gas emissions
PPO-32	Good Practices to facilitate the management of waste

<table>
<tr><th colspan="2">PPO-1: Control of raw materials</th></tr>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Reception of materials.</td></tr>
<tr><td colspan="2">Environmental considerations:
Accepted raw materials that result from the low quality or are microbiologically altered can be converted into their own waste or later the waste generated by rejected products.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Establishment of quality specifications for raw materials and carrying out tests upon reception using microbiological and physical-chemical tests.</td></tr>
<tr><td rowspan="2">Implementation:
- Creation of specifications for acceptance of raw materials.
- Laboratory and/or kits for quick testing.
- Control of the storage conditions for raw materials.
- Trained personnel.
- Operational procedures.
- Implementation of an HACCP system (Hazard Analysis and Critical Control Points). This system includes approved suppliers.
- Work in an integrated system from farms to industry.</td><td>Economic balance:
👍 Reduction in the cost of raw materials.
👍 Savings in the cost of eliminating waste and/or treatment costs.
👍 Adjustment in the price of the quality of milk.
👍 Savings in the cost of processing rejected products.
Personnel costs.
Costs of testing equipment.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in the amount of waste produced.
☺ Lower consumption of resources (energy, water, etc.).</td></tr>
</table>

Comments

Implantation of a quality control system for raw materials and secondary materials (such as ferments, sugar, fruits, etc.) implies knowledge of the specifications of the product that are acceptable to the dairy firm.

Once the specifications of the product that are required are known, opportune controls and analysis are carried out to verify that those specifications are being met. This control requires trained personnel for carrying out analytical tests and operational procedures that guarantee systematic and correct application.

Under the notion of quality of raw milk are grouped several aspects, although in general the following are taken into account:

- Content in nutrients;
- Fat content;
- Total content of microorganisms;
- Presence or absence of pathogenic germs;
- Presence or absence of certain substances (for example solids, pus, antibiotics);
- Organoleptic characteristics (aroma and flavour).

PPO-2: Reduction in the loss of milk

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** Throughout the process.

Environmental considerations:
Spills and loss of milk that are evacuated together with wastewater increase the amount and pollution load (especially the organic content, 90 per cent of which is estimated to come from the milk components) of the waste.

Pollution Prevention Opportunity:
Creation of control mechanisms to reduce milk losses at reception and in the tanks, pipes, pumps and equipment.

Implementation: - Establish operational procedures for operations with greater risk of spills and loss of milk. - Carry out preventive maintenance on the equipment and installations. - Separate spilt milk from the rest of the wastewater. - Create controls and alarms.	**Economic balance:** 👍 Less loss of raw material. 👍 Reduction in the cost of treating the final waste. Cost of valves and control mechanisms. **Environmental balance:** ☺ Reduction in the amount of final waste. ☺ Reduction in pollutant load of waste. ☺ Decrease in organic content (decrease in COD and BOD and fats).

Comments

In order to reduce milk waste, the following measures can be taken.

Operational procedures	- Check the correct connection of hoses before opening the milk valve. - Avoid spills of milk when connecting hoses and pipes. - During the preparation of cheese, avoid milk losses when filling the cheese moulds.
Maintenance of equipment and installations	- Install air-tight faucets and avoid leaks at the faucets and from equipment and pipes. - Repair defects that produce dripping and loss of milk as soon as possible. - Carry out preventive maintenance in order to avoid dripping and loss.
Segregation of flows	- Install trays to catch drops and spills of milk. - Install a system for gathering spilt milk independent from wastewater.
Control of losses	- Install alarm systems of automatic disconnection in order to avoid spills on tanks and storage. - Establish indicators, for example, the amount of milk received/amount of milk processed.

Example of application

For a firm with the following daily production.

Production	50 tons
Amount of waste	175 m³
Loss of milk (4 per cent)	2 tons
COD of the waste (from milk loss)	2,400 mg/litre
Cost of the milk lost (*)	590.19 €

* Assuming an average price of milk of 0.30 €/kg.

In function of the measures implemented, the following percentages of reduction in the loss of milk can be obtained. The following estimate gives the variation of COD of waste in function of the percentage of milk that is lost with wastewater and the cost of the lost milk.

Loss of milk	4 per cent	3.5 per cent	3 per cent	2.5 per cent	2 per cent	1.5 per cent	1 per cent
COD (mg/litre)*	2,400	2,100	1,800	1,500	1,200	900	600
Cost of the loss of milk** (€/day)	590.19	516.42	442.65	368.87	295.10	221.32	147.55

(*) COD from only the milk, approximately 90 per cent of the organic load of the wastewater.
(**) Based on an average milk price of 49.1 €/kg.

PPO-3: Separation of sludge produced by clarification

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Filtering/Clarification.</td></tr>
<tr><td colspan="2">Environmental considerations:
Sludge from clarification is semi-soft waste that contains dirt particles, blood components, germs and other substances from proteins which when mixed with wastewater produce an increase in the organic load of the final waste.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Separation of clarification sludge from the rest of the waste of the firm, gathering it before it is mixed with other waste. This option makes it possible to use the waste later.</td></tr>
<tr><td rowspan="2">Implementation:
- Separate storage of sludge produced by clarification.
- Conditioning and treatment of sludge for use.</td><td>Economic balance:
👍 Reduction in the cost of treating wastewater.
👍 Reduction in the cost of waste management (in the event of its use).
👍 Benefits obtained from use of sludge.
Cost of the storage tanks for sludge.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in the load of pollutants in the waste, especially organic material (COD and BOD$_5$) and suspended solids.
☺ Reduction of the amount of final waste.
☺ Use of a waste.</td></tr>
</table>

Comments

The use of centrifuges for clarification of milk facilitates the segregation of sludge and its later use. In self-cleaning centrifuges, this sludge is separated automatically, however, in centrifuges requiring manual cleaning have to be separated during cleaning operations.

In centrifuges requiring manual cleaning, sludge is separated as a relatively thick mass, which facilitates its later management, however, in self-cleaning centrifuges the sludge is obtained as a liquid.

Sometimes, the sludge can be used as cattle feed, because of its high content in nutritive substances. In these cases, pathogenic germs must be eliminated in order to avoid the possibility of creating a source of infection. When the sludge is gathered for later use, the cost of treating it should be taken into consideration.

Example of application

In a firm that processes 50 tons of milk daily, clarification of milk will produce a waste flow of some 17 m^3/day with a COD of 1,176 mg/litre and 117.6 mg/litre of fats. By separating this sludge, the following amount of pollution to the wastewater can be avoided.

	WASTE	COD	MILK FAT
Milk plant	0.30 - 0.34 l/litres milk	100 - 400 mg O$_2$/litres milk	10 - 40 mg/litres milk

(Source: Danish EPA, 1991).

PPO-4: Use of continuous systems for pasteurization of milk

Type of Opportunity: Reduction at the source.	Redesign of processes: Substitution of technologies.
Process: Preparation of dairy products.	**Stage / Operation:** Heat treatment.
Environmental considerations: Heat treatment requires high consumption of energy, which is aggravated in the case of discontinuous pasteurizers because of the difficulty of recovering heat.	
Pollution Prevention Opportunity: Substitution of discontinuous milk pasteurization equipment with continuous pasteurizers with provision for heat recovery.	
Implementation: - Substitution of discontinuous pasteurization equipment with continuous functioning equipment. - Adaptation to a continuous production process.	**Economic balance:** 👍 Lower energy costs. 👍 Reduction in the cost and number of personnel. Cost of a continuous pasteurizer. Cost of adapting the production process.
	Environmental balance: ☺ Lower consumption of energy. ☺ With these systems it is possible to recover between 65–80 per cent of heat.

Comments

Discontinuous pasteurizers (batch type) heat milk to relatively low temperatures (about 64 ºC) during long periods of time (25-30 minutes). Continuous pasteurizers heat milk to higher temperatures during shorter periods of time.

The first use energy inefficiently, require more frequent cleaning (often manual cleaning) and do not permit recovery of heat.

Continuous pasteurizers can have either plates or pipes and are constructed so that all sections can be mounted together in order to facilitate the recovery of heat and reduce losses. In addition, the rest of the installation can be integrated into the CIP cleaning system.

The continuous systems consists of a tank from which milk is pumped to a section of the pasteurizer where it is pre-heated by the exchange of heat with milk that exits the pasteurizer. Next, the milk is heated using hot water or steam to the temperature required. Then, the milk passes to a storage section where the temperature is maintained during a certain period of time, in function of the heat treatment that it is going to receive.

Finally, the milk is returned to the first sections, where it is cooled by the milk that is entering, which permits greater energy efficiency in the process.

PPO-5: Recovery of energy from heat-treatment of milk

Type of Opportunity: Reduction at the source.	Redesign of processes: Substitution of equipment.
Process: Preparation of dairy products.	**Stage / Operation:** Heat treatment of milk.

Environmental considerations:
High consumption of energy in the heat treatment of milk.

Pollution Prevention Opportunity:
Optimize the recovery of energy during heat treatment of milk, using heat exchangers that make it possible to recover a maximum of heat from the milk at the exit of the pasteurizer/sterilizer in order to pre-heat the refrigerated milk at the entrance and from the circulating milk from the circuits for pre-heating and refrigeration. As much as 90 per cent of energy can be recovered.

Implementation: - Plate and tubular exchangers. - Pumps. - Changes in the system of milk pipes, hot water and cold water.	**Economic balance:** 👍 Consumption of energy. 👍 Cleaning requirements. Installation costs.
	Environmental balance: ☺ Lower consumption of energy.

<table>
<tr><td colspan="2">PPO-6: Use of buttermilk</td></tr>
<tr><td>Type of Opportunity: Recycling.</td><td>Recycling at the source or externally.</td></tr>
<tr><td>Process: Butter production.</td><td>Stage / Operation: Churning.</td></tr>
<tr><td colspan="2">Environmental considerations:
Buttermilk has a composition similar to skim milk with a larger content of phospholipids. Its dumping with the wastewater leads to an increase in pollutant load, especially the organic content.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Use of the buttermilk for preparation of other products for human consumption or animal feed.</td></tr>
<tr><td rowspan="2">Implementation:
- Separation of the buttermilk.
- Conservation of the buttermilk for later use.
- Elaboration of other products using the buttermilk (use at the source of outside).</td><td>Economic balance:
👍 Reduction in the cost of treatment.
👍 Economic benefits from the use of the buttermilk.
Cost of conditioning the buttermilk for use.
Cost of preparing a new product.</td></tr>
<tr><td>Environmental balance:
☺ Decrease in pollutant load of the final waste.
☺ Reduction of the organic load (BOD, COD, oils and fats).
☺ Use of the buttermilk.</td></tr>
</table>

Comments

The use of the buttermilk for later use requires that it be kept under proper conditions during gathering and refrigerated storage in order to inhibit the development of microorganisms. It is important to prevent air from mixing during pumping and storage because this causes alterations in taste and appearance. Later, it is packaged and stored under refrigeration like other fermented products.

The buttermilk can be used as fermented milk for human consumption or other uses:

- Cattle feed.
- Obtaining powdered buttermilk through dehydration processes. Powered buttermilk is used in the food industry for pastries, baking, preparation of deserts and ice creams, etc., primarily because of its emulsifying properties.
- Use in the preparation of certain cheeses or added to milk used for the preparation of cheese.

PPO-7: Avoid the dumping of whey

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Cheese production.	**Stage / Operation:** Draining.

Environmental considerations:
The whey generated in the preparation of cheese is some nine times the volume of cheese, with a COD of 60,000 mg/litre. These characteristics make the whey into a very difficult waste if it is dumped into the environment.

Pollution Prevention Opportunity:
Implement control measures in order to prevent loss of whey and prevent it from reaching the final waste. Avoid spilling the whey.

Implementation:
- Placing of collection trays in order to avoid dripping and spills at the whey exit points.
- Completely remove the whey and the remains of curds from moulds before cleaning.
- Collect the whey in a storage container specifically for that.
- Establishment of operational procedures.
- Training of personnel.

Economic balance:
👍 Reduction in the costs of treating final waste.
Cost of the storage containers for storage of the whey.
Training costs.
Cost of eliminating the whey.

Environmental balance:
☺ Reduction in the volume of waste.
☺ Reduction in the pollutant load of the effluent, especially the organic load (decrease of COD and BOD) and conductivity.

PPO-8: Use of whey

Type of Opportunity: Use and external recycling.

Process: Cheese production.

Stage / Operation: Draining.

Environmental considerations:
The whey recovered during processing should be used in order to cause as little impact on the environment as possible. Other activities associated with its use, such as transportation to place of use or its concentration in situ in order to decrease its volume and reduce transportation costs should also be taken into account in the overall approach to dealing with whey.

Pollution Prevention Opportunity:
Use of whey for preparing other products, animal feed or obtaining increments of value added, such as lactose or proteins.

Implementation:
- Identification of alternative uses.
- Evaluation of alternatives (technical and economic evaluation).
- Selection of alternatives.
- Implementation of the option chosen.

Economic balance:
👍 Reduction in the cost of treating final waste.
👍 Economic benefits derived from use of the whey.
Cost of the study of alternatives and their implementation.
Cost of equipment.
Personnel costs.

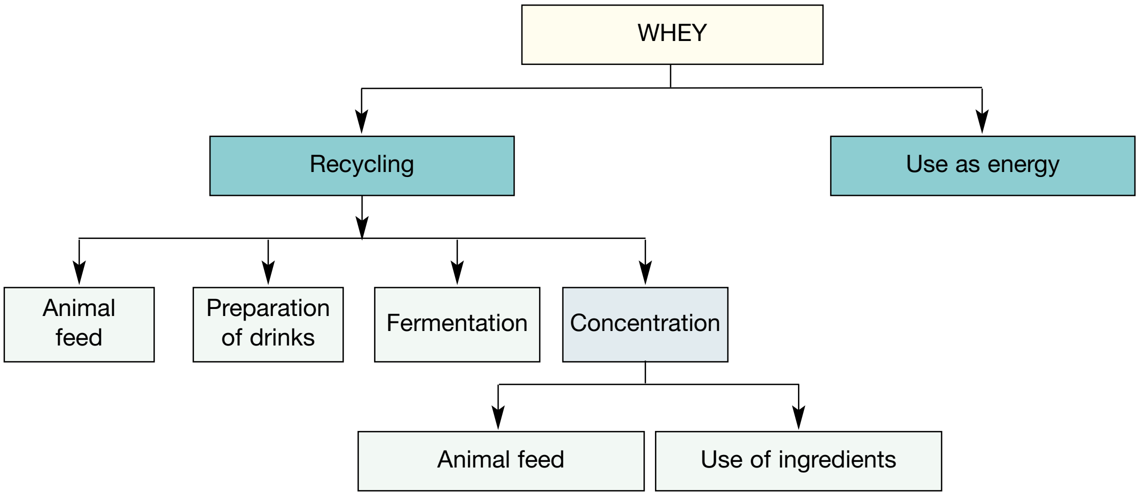
Environmental balance:
☺ Reduction of volume of final waste.
☺ Reduction of pollutant load in the effluent, especially the organic content (decrease of COD and BOD) and conductivity.
☺ Use of waste.

Comments

Given that the production of whey can reach some nine times the amount of cheese produced, its contribution to total wastewater is of great importance, both in terms of its volume and high concentration of organic material, reaches more than 60,000 mg COD/litre (F. Omil and F. Morales, 1996).

In the following figure alternatives to the dumping of whey are shown:

Figure 54
ALTERNATIVE USES OF WHEY



The following aspects should be kept in mind before choosing any option:

- Separation of the whey;
- Analysis;
- Study of possible alternatives to dumping;
- Technical and economic ranking of the alternatives;
- Selection of alternatives;
- Implementation of the chosen alternative.

Animal feed

Traditionally, whey has been used for directly feeding animals, primarily pigs; with 12 kilos of whey being the equivalent of approximately one kilo of barley (A. Fernández and M. Díaz, 1995). Nonetheless, the high content in lactose of the whey can cause digestive problems in certain animals because of a lack of lactase (the enzyme that hydrolyses lactose). This is the case of young calves, in which this problem occurs if they have an excess of lactose in their diet. Furthermore, the whey has a low content of nitrogenous substances; as a result its use in excessive amounts in animal feed can cause nutritional imbalances.

For this reason, it is recommended that a study be carried out on the diet with a supplement in cereal ration of correctors and concentrated feed in order to counteract these deficiencies.

If this possibility is adopted, the following considerations should be taken into account:

- Separation of the whey;
- Analysis of the whey;
- Selection of potential users (cattle centres) for the whey;
- Adaptation of the animals' diet;
- Cost of transporting the whey;
- Requirements and cost of conditioning the whey for its transportation and use (whenever necessary).

Depending on the cost of transportation, concentration of the whey at the dairy firm can be profitable.

Preparation of drinks from whey

Another possibility for use of whey is the preparation of drinks from buttermilk.

The main inconvenience in using whey to prepare drinks is its high lactose content, which is difficult to digest, and gives it a characteristic taste that is unacceptable to consumers. In order to avoid these problems, drinks made from whey are prepared with a low lactose content and with the addition of fruit aromas that improve taste. These products should be sterilized and packaged aseptically in order to guarantee proper conservation.

Concentration of whey

Given the high percentage of water in whey, it may be convenient to remove it or reduce it through concentration in order to decrease transportation costs and facilitate obtaining elements of the whey.

Concentration can be carried out in evaporators with various effects of low pressure or inverse osmosis. This operation takes place in the plant of the dairy enterprise, in attempting to reduce the volume of whey in order to minimize transportation expenses to places of final use.

Obtaining parts of the whey

Traditionally, industrial use of the whey has been based on the recovery of the parts of greatest use from the industrial point of view, principally proteins and lactose.

The installation of a plant to recover parts of the whey is a viable alternative in the case of large industries with high volumes of whey, because for small industries there is a high economic cost.

Demineralisation of the whey is unattractive, but does make it possible to increase the possibilities for use of certain elements of the whey.

a.1) Obtaining protein

Whey contains an average of 0.8 per cent proteins, representing between 15 and 22 per cent of total proteins in milk. It also contains a waste variable of casein agglomerates that enter the whey during the process of separating the curds and whey from the milk.

The recovered proteins can be incorporated back into the cheese-making process or be used in other industrial processes (bread baking, pastries, preparation of diet foods or in the preparation of pharmaceutical products).

A third option for use of the proteins is their separation and purification. Pure proteins of higher commercial value can thus be obtained.

a.2) Obtaining lactose

Lactose is the most abundant component of whey. Its characteristics permit its use in pharmaceutical products (as an excipient) and diet products (as a sweetener). In addition, the lactose can serve as a substratum for a large variety of microorganisms, so it is used for example in the production of penicillin and other antibiotics.

Fermentation of whey

Lactose represents a source of energy for the fermentation processes of many microorganisms. Through fermentation of the whey, the lactose content is lowered and as a result the BOD_5 is lowered.

Fermentation of the microorganisms produces CO_2 and ethanol. In addition, it is possible to obtain lactic acid from the lactose, which can be used as a food additive, and in function of the degree of purity it can have other applications in the pharmaceutical industry and in the fabrication of polymers.

Use of energy

Anaerobic treatment of whey produces good results by eliminating a large amount of organic material, with the advantage that it is unnecessary to supply ventilation. In addition, methane is produced that can be recovered as fuel.

In function of the flow and degree of concentration of organic material of the waste, energy can be obtained through combustion of the biogas produced, which can be more than the energy needs of the digester, thus obtaining excess gas that can be used as a fuel in the plant.

Example of application

A dairy firm with a production of cheese of about 850 tons/year produces 5 tons of whey and 1 ton of cheese for every 6 tons of milk processed.

The residual whey obtained has the following characteristics.

CHARACTERISTICS	WHEY
Volume (m^3/year)	4,200
COD (mg/litre)	90,400
Oils and fats (mg/litre)	14,000

Separation of whey for use, leads to elimination of this element from the final waste, producing important reductions in the parameters of the organic load of the final waste.

<table>
<tr><th colspan="2">PPO-9: Dry elimination of salt from cheese after salting</th></tr>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Good Practices.</td></tr>
<tr><td>Process: Cheese production.</td><td>Stage / Operation: Salting.</td></tr>
<tr><td colspan="2">Environmental considerations:
The salt used in salting cheese makes the wastewater highly conductive.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Initial elimination of dry salt from the surface of the cheese or in place of the use of water.</td></tr>
<tr><td rowspan="2">Implementation:
- Use of machines (brushes or brushes and aspiration of the salt) for dry elimination of the salt.
- Establishment of operational procedures.
- Training of personnel.</td><td>Economic balance:
👍 Reduction of wastewater treatment costs.
👍 Reduction in the cost of salting.
👍 Lower cost of materials (salt).
Personnel costs.
Cost of eliminating solid waste.</td></tr>
<tr><td>Environmental balance:
☺ Reduction of pollutant load in the wastewater, especially conductivity.
☺ Reduction in the consumption of resources.</td></tr>
</table>

Comments

There are several ways to carry out the salting operation. This is one of the factors that most influences the characteristics of the final product.

In the case of dry application of the salt, it is rubbed or spread evenly over the surface of the cheese to which it adheres. With this procedure for salting, there is heavy use of salt, in some cases as much as 7 kilos of salt for every 100 kilos of cheese and a longer period is required for salting.

Dry removal of the salt has no effect on the final product but presents important advantages for the environment and for the dairy firm because the salt can be reused as long as proper hygienic conditions are maintained.

Manual removal of the salt does not efficiently remove the salt stuck to the surface of the cheese. In these cases, automatic systems for dry elimination of the salt from the surface of the cheese can considerably improve the efficiency of the removal.

PPO-10: Physical-chemical and microbiological control of brines used for salting cheese

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Good Practices.</td></tr>
<tr><td>Process: Cheese production.</td><td>Stage / Operation: Salting.</td></tr>
<tr><td colspan="2">Environmental considerations:
The brines used to salt cheese have a high conductivity, a characteristic that they transmit to the wastewater when they are dumped together. In addition, any deteriorated brine generates waste in the form of rejected products.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Creation of a system for controlling the physical, chemical and microbiological parameters of brines, making it possible to determine the degree of aging of the brines and obtain optimum salting of the cheese.</td></tr>
<tr><td rowspan="2">Implementation:
- Establishment of specifications for use of brines for salting cheese.
- Operational procedures.
- Equipment for control and analysis.
- Trained personnel.</td><td>Economic balance:
👍 Reduction in the cost of elimination of waste and treatment costs.
👍 Savings in the cost of elaborating rejected final products.
👍 Reduction of the cost of raw materials (optimisation of the consumption of brine).
Cost of the equipment for control and/or analysis.
Personnel costs.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in the consumption of water.
☺ Reduction of the final amount of waste.
☺ Decrease of waste from rejected products.</td></tr>
</table>

Comments

Immersion in brine is one of the methods most used in the salting of cheese because it permits even salting, reduces labour and can be easily integrated into very mechanized systems de production. The use of salt is lower than when it is applied dry, between 3 and 4 kilos for each 100 kilos of cheese.

The brine is composed of water and sodium chloride, but during the salting, there is an exchange between the brine and the cheese. As a result of this exchange, the brine takes on soluble substances from the cheese (soluble proteins, mineral salts, lactose, lactic acid, etc.). Microbiological contamination of the brine can also occur. The microorganisms can come from the natural flora of the cheese, in which case there are no problems, or from other sources (personnel, materials, water, etc.) causing changes in the cheese during aging that prevent the cheese from acquiring the desired characteristics.

In order to ensure optimum conditions for salting, it is necessary that the brine be adequate requiring the creation of controls that guarantee the physical, chemical and microbiological conditions of the brine. This control should take into account the following considerations:

- The water and salt used for the brine should be free from any pollution because it enters into direct contact with the cheese;
- Control of the pH, temperature and duration of salting in function of the type of cheese that is being prepared;
- Maintaining an adequate concentration of salt in order to obtain optimum salting;

- Adequate calcium content of the brine in order to promote drying of the rind;
- Elimination of cheese particles;
- Maintaining the presence of microorganisms as low as possible;
- Elimination or treatment of brine contaminated with undesirable microorganisms.

For carrying out these controls, both simple methods of sampling and laboratory analysis as well as the installation of automatic equipment for measuring the parameters of the brine and automatic dosage can be used.

PPO-11: Recovery of brine

Type of Opportunity: Reduction at the source.	Redesign of processes: New technologies.
Process: Cheese production.	**Stage / Operation:** Salting.
Environmental considerations: For the preparation of brine, large quantities of salt and water are used. Dumping it into the environment causes heavy environmental impact.	
Pollution Prevention Opportunity: Use of filtering techniques for the recovery of brine.	
Implementation: - Selection of a filtering system. - Operational procedures. - Trained personnel.	**Economic balance:** 👍 Reduction in the use of water. 👍 Reduction in the use of salt. Cost of the filtering equipment. Cost of the energy for running the equipment. Maintenance costs. Personnel costs.
	Environmental balance: ☺ Reduction in the consumption of water. ☺ Reduction of the final volume of waste. ☹ Consumption of energy.

Comments

The elimination of large quantities of brine together with final effluent generates environmental problems because these brines are rich in suspended particles, microorganisms, calcium salts, magnesium, lactose, lactic acid, etc. This leads to an increase in the amount of organic load and conductivity of the final waste.

Separation of the brines from the rest of the waste of the plant makes it possible to treat it for possible reuse at the source or its recycling in other processes.

Filtering techniques using membranes make it possible to eliminate the microorganisms present in the brine and separate other parts such as suspended particles and salts.

Once the brine is treated with these techniques, it is possible to reuse them in the same process compensating for loss of salts that are produced during recovery.

PPO-12: Control of water consumption

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Operations that consume water.</td></tr>
<tr><td colspan="2">Environmental considerations:
The high consumption of water by firms in the dairy sector.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Periodic control of water consumption permits detecting leaks, open faucets, differences between shifts, products and processes, etc. It permits adjustment of water consumption to that which is strictly necessary. Reductions of more than 5 per cent can be obtained simply because of the fact of establishing a system of control of water consumption.</td></tr>
<tr><td rowspan="2">Implementation:
- Installation of water meters in the main areas of consumption.
- Reading of the meters regularly.</td><td>Economic balance:
👍 Reduction of the cost of water consumption.
Cost of the meters.
Personnel costs during the reading of the meters.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in water consumption.
☺ Decrease in the dumping of wastewater.</td></tr>
</table>

Example of application

A firm that produces 45 tons/day of sterilized milk and consumes a monthly average of 3,895 cubic metres of water installed water meters in several areas of the firm (water supply, water treatment, outside area and reception, production, laboratories and steam production) and monitored the reading of the meters daily. The simple daily control of consumption permitted the detection of leaks in the internal supply network and unnecessary consumption of water in several areas, such as laboratories, vacuum equipment and refrigeration area. Control of consumption during the day made it possible to detect variations in consumption between the work shifts, especially during cleaning. At the end of the process, reductions of water consumption by 15 per cent were obtained.

PPO-13: Cleaning of surfaces without water

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** Cleaning of surfaces.

Environmental considerations:
Cleaning operations require high consumption of water and the dumping of a high volume of wastewater. In addition, cleaning of the installations and surfaces carries away solids that are finally eliminated with the final effluent, increasing the pollution load of the waste.

Pollution Prevention Opportunity:
Reduction of water consumption in the cleaning operations and the amount of solid waste that reaches the final effluent through the use of systems for removing that waste without water.

Implementation:
- Dry removal of solid waste using brushes, brooms or systems of compressed air.
- Install traps in drains in order to prevent the solid waste from entering into the wastewater drainage system.
- Training of personnel.
- Establishing operational procedures for cleaning operations.

Economic balance:
👍 Reduction in water costs.
👍 Reduction in the cost of treatment of final sewage.
👍 Reduction in the costs of management of solid waste.
Personnel costs.

Environmental balance:
☺ Reduction in water consumption.
☺ Reduction of the final amount of waste.
☺ Reduction of the pollutant load of the waste, especially suspended solids.
☹ Greater volume of solid waste.

Comments

ESometimes a hose with water is used to wash away solid waste before beginning cleaning operations. This practice leads to the consumption of a large amount of water and increases the pollutant load in the wastewater. This waste can include incrustations of elements of milk, remains of curds, packaging and other materials.

The removal of solid waste without using water reduces the amount of solids present in the wastewater and decreases water consumption. This method also permits reductions of 25 per cent of water consumption in the cleaning.

The management of solid waste obtained without water is easier and more economical, similar to that of packaging waste that can be reused and/or recycled.

Example of application

In function of the degree of implementation of this option, various percentages of reduction of the consumption of water are obtained. For a firm that processes 50 tons of milk daily with a consumption of water estimated to be 160 cubic metres/day, the following reduction in the daily consumption of water in the cleaning operations can be obtained.

Reduction in the consumption of water for cleaning	5 per cent	10 per cent	15 per cent	20 per cent	25 per cent
Reduction in the consumption of water in cleaning operations (m^3)	2.4	4.8	7.2	9.6	12
Consumption of water (m^3)	157.6	155.2	152.8	150.4	148

PPO-14: Installation of systems for automatic closing of water hoses

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** Cleaning of installations.
Environmental considerations: Cleaning operations consume 25-40 per cent of the water consumed in dairy firms.	
Pollution Prevention Opportunity: Installation of nozzles or automatic valves on the water hoses used for cleaning.	
Implementation: - Installation of systems of automatic cut-off on water hoses.	**Economic balance:** 👍 Reduction of expenditures for water. Cost of the automatic cut-off devices.
	Environmental balance: ☺ Lower water consumption. ☺ Reduction in the final volume of wastewater.

Comments

Water reaches the cleaning areas through hoses that make it possible to reach a greater number of surfaces to be cleaned. The opening and closing of the water depends directly on the workers.

During changes in activities or when moving from one area to another, the hoses can remain open with the resulting loss of water. This situation can be avoided by installing automatic mechanisms at the end of the hoses for cutting off water when the worker is not holding down the handle.

Lower consumption of water decreases the generation of wastewater. With these systems, it is estimated that reductions of up to 15 per cent of the volume of water consumed in the cleaning operations can be made.

Example of application

In a dairy firm that processes 7,025 tons/year of milk for the production of yogurt and other dairy products with an annual consumption of approximately 15,000 m^3 of water, it was estimated that the consumption of water for cleaning was about 60 per cent of the total consumption of the plant and as a result, several steps were taken to reduce the consumption of water for cleaning surfaces, with the following results (estimates for one year).

ACTIONS	REDUCTION	REDUCTION OF WATER CONSUMPTION (m^3)
Cleaning without water of floors and other surfaces before cleaning with water	4 per cent	360
Installation of systems of automatic cut-off of water on the hoses	11 per cent	990
Use of pressurized water for cleaning outside areas	8 per cent	720
Total	23 per cent	2,070

PPO-15: Use of pressurized water for cleaning surfaces

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Cleaning of installations.</td></tr>
<tr><td colspan="2">Environmental considerations:
Cleaning operations consume 25-40 per cent of the water consumed in a dairy firm.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Use of pressurized water for cleaning surfaces, installing nozzles on hoses and using portable sources of pressurized water.</td></tr>
<tr><td rowspan="2">Implementation:
- Install nozzles on the hoses.
- Install portable units for providing pressurized water.</td><td>Economic balance:
👍 Reduction of water costs.
Equipment costs.</td></tr>
<tr><td>Environmental balance:
☺ Lower water consumption.
☺ Reduction of the final volume of waste.</td></tr>
</table>

Comments

The use of pressurized water increases the efficiency of cleaning because the water exerts a mechanical action to eliminate dirt.

Implementation of this option can be easily done by installation of nozzles on existing hoses including those with systems of automatic cut-off. With this system, water is obtained at medium to low pressures.

For high-pressure water, there is equipment available that provides pressurized water.

High-pressure systems can be used for cleaning surfaces outside installations although there is the inconvenience that the force of impact pulverizes dirt particles and spreads them in all directions. They are later deposited again on surfaces already clean and can contaminate the surfaces.

PPO-16: Use of foam systems for cleaning surfaces

Type of Opportunity: Reduction at the source.	Redesign of processes: Substitution of equipment.
Process: Preparation of dairy products.	**Stage / Operation:** Cleaning of installations.
Environmental considerations: Cleaning operations consume 25-40 per cent of the water consumed in dairy firms.	
Pollution Prevention Opportunity: Substitution of traditional surface cleaning systems with cleaning systems using foam and rinsing with pressurized water.	
Implementation: - Establishment of operational procedures. - Equipment for application of cleaning products using foam. - Training of cleaning personnel.	**Economic balance:** 👍 Reduction in the consumption of water. 👍 Reduction of the consumption cleaning products. Cost of equipment. Training costs.
	Environmental balance: ☺ Lower water consumption. ☺ Reduction in the volume of final waste. ☺ Reduction of pollutant load in the final waste. ☺ Lower consumption of cleaning products.

Comments

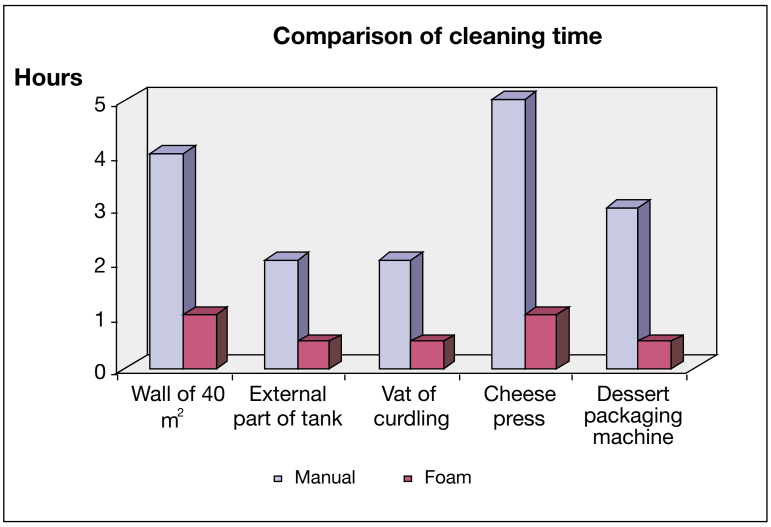
Traditionally, installations are cleaned manually without adequate technology. These practices are usually carried out with an excessive consumption of water and cleaning products and generate high volumes of wastewater from cleaning.

Cleaning systems using foam apply detergents in the form of foam onto the surface to be cleaned and, after the time required for contact in order to soften or make the dirt soluble, they are removed by rinsing with water at medium or high pressure. Next, the surface is disinfected and rinsed.

For the application of foam products, it is necessary to have adequate equipment for mixing the detergent with air. The systems can consist of a central unit that feed satellite stations from which the cleaning is done or portable stations capable of reaching all areas to be cleaned.

Because the system provides previously determined amounts necessary for each cleaning stage, the dosage of cleaning product is optimised and better results are obtained from cleaning and disinfection.

Figure 55
COMPARISON OF CLEANING TIME USING MANUAL METHODS OR FOAM
(Source: Esteban Andueza, 1997)



PPO-17: Use of CIP cleaning systems

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Substitution of technology.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Cleaning of installations.</td></tr>
<tr><td colspan="2">Environmental considerations:
Cleaning operations consume between 25 and 40 per cent of the water consumed by a dairy firm.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Substitution of traditional cleaning methods by equipment with CIP cleaning systems with closed circuit circulation.</td></tr>
<tr><td rowspan="2">Implementation:
- Installation of CIP cleaning equipment.
- Training of personnel.
- Operational procedures.
- Possibility to re-use rinsing water and other solutions.</td><td>Economic balance:
👍 Reduction in the consumption of water.
Reduction in personnel costs.
Cost of energy.</td></tr>
<tr><td>Environmental balance:
☺ Lower water consumption.
☺ Reduction in the volume of wastewater.
☺ Less packaging of cleaning products.
☹ Greater consumption of energy.</td></tr>
</table>

Comments

Traditional cleaning methods for equipment and pipes consist in dismounting and manual cleaning of parts. These systems are characterized by their low efficiency, high labour cost and the long periods during which production is stopped.

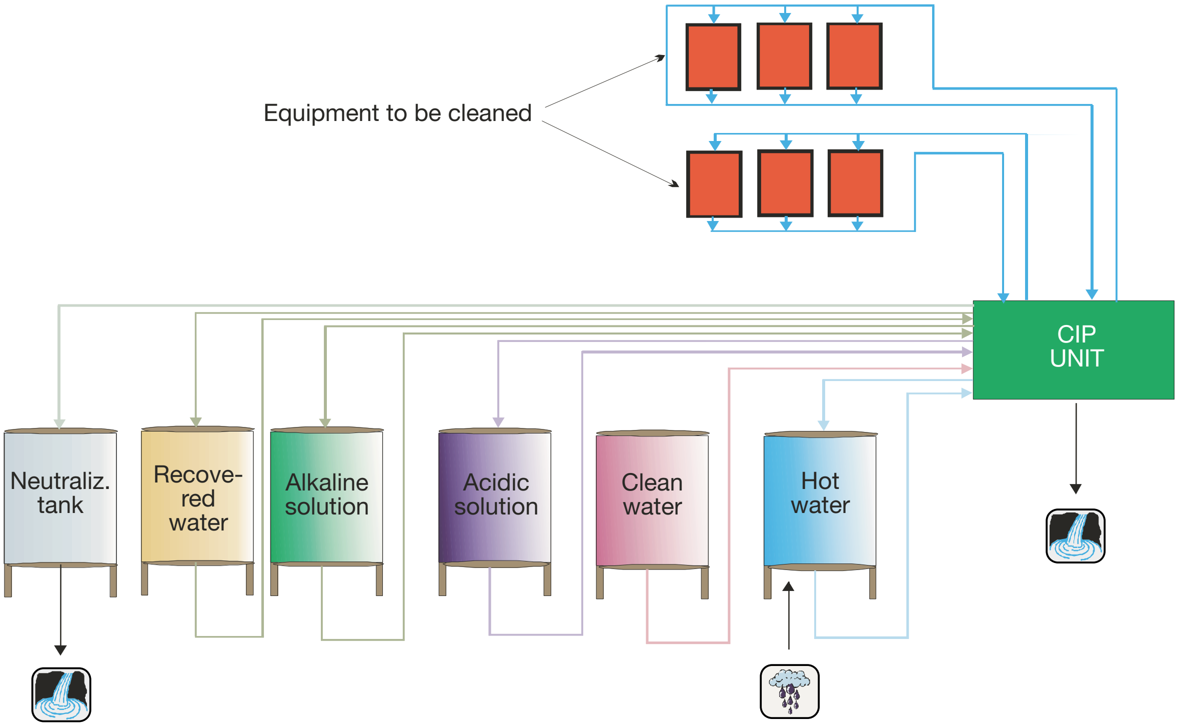
CIP systems (cleaning in place) consist in sequentially passing cleaning products, disinfection and rinsing through pipes and inside the machines. These systems permit greater efficiency in cleaning, decrease the time used and minimize environmental impact.

Complete CIP cleaning in a dairy industry is usually composed of the following stages:

- Initial rinsing;
- Detergent phase with a caustic agent to remove organic residues;
- Intermediate rinsing;
- Scrubbing phase with an acidic agent for elimination of calcareous deposits;
- Intermediate rinsing;
- Disinfection of installations;
- Final rinsing.

The main unit of a CIP system consists of storage tanks for concentrated detergents, reservoirs of clean water, re-circulation pumps, tanks for recovering the water used for washing (if it is recovered) and other systems for the preparation of cleaning solutions.

Figure 56
CIP CLEANING



One of the big advantages of this equipment is that it permits extensive automation, which in turn lowers water and chemical consumption and produces less wastewater. Control of the cleaning parameters (temperature, pH, concentration) in the equipment being cleaned makes it possible to optimise consumption even more.

Given that the water and cleaning solutions are re-circulated from the corresponding storage tanks, implementation of CIP systems permits introducing systems for re-using washing solutions and regeneration of detergent solutions.

In the case of recovery of water from the final washing and its re-use for initial washing in the following cycle, decreases of up to 50 per cent of the consumption of water in the operation are obtained. Another advantage is a decrease in the generation of waste from packaging of cleaning products because with this system the products are stored in refillable deposits.

Example of application

The following table presents an estimate of the reductions obtained in a cheese factory that processes 100,000 litres of milk per day (Source: Esteban Andueza, 1998).

	TRADITIONAL CLEANING WITHOUT RECOVERY OF PRODUCTS (m^3/day)	CLEANING USING CIP SYSTEMS (m^3/day)
Water for washing	50	15
Water with a pH of 11-12	12	2
Water with a pH of 1-2	8	1

PPO-18: Use of non-recoverable detergents

Type of Opportunity: Reduction at the source.	Redesign of processes: Substitution of secondary materials.
Process: Preparation of dairy products.	**Stage / Operation:** Cleaning of equipment.
Environmental considerations: Cleaning operations consume between 25 and 40 per cent of the water consumed in a dairy firm. When this water is dumped, there is a high volume of wastewater with a high pollutant load caused by residual dairy products, detergents and disinfectants.	
Pollution Prevention Opportunity: Substitution of traditional detergents by detergents that are used only once, obtaining the same results but with lower consumption of water and detergents.	
Implementation: - Establishment of a cleaning and disinfection programme. - Creation of operational procedures. - CIP cleaning equipment. .	**Economic balance:** 👍 Lower cost of labour. 👍 Reduction of the consumption of resources (water and energy. 👍 Reduction of the consumption of resources (water and energy. 👍 Reduction in the cost of treatment.
	Environmental balance: ☺ Reduction in the consumption of water. ☺ Reduction in the consumption of energy (electricity and steam). ☺ Reduction in the consumption of cleaning products. ☺ Reduction in the amount of final waste. ☺ Reduction of pollutant load in the waste (reduction of phosphorous and nitrogen waste).

Comments

For CIP cleaning systems, the study focused on development of new detergents capable of obtaining the same results with a single treatment as with the double treatment with alkali and acid. This led to the development of single-use products. In some cases, a disinfectant can be added, carrying out disinfection at the same time as the cleaning.

In traditional systems with two phases, alkaline products eliminate proteins, fats and lactose but an acidic product is necessary to eliminate inorganic salts. Nonetheless, single-use detergents are capable of eliminating with a single product both proteins, fats and lactose as well as salts.

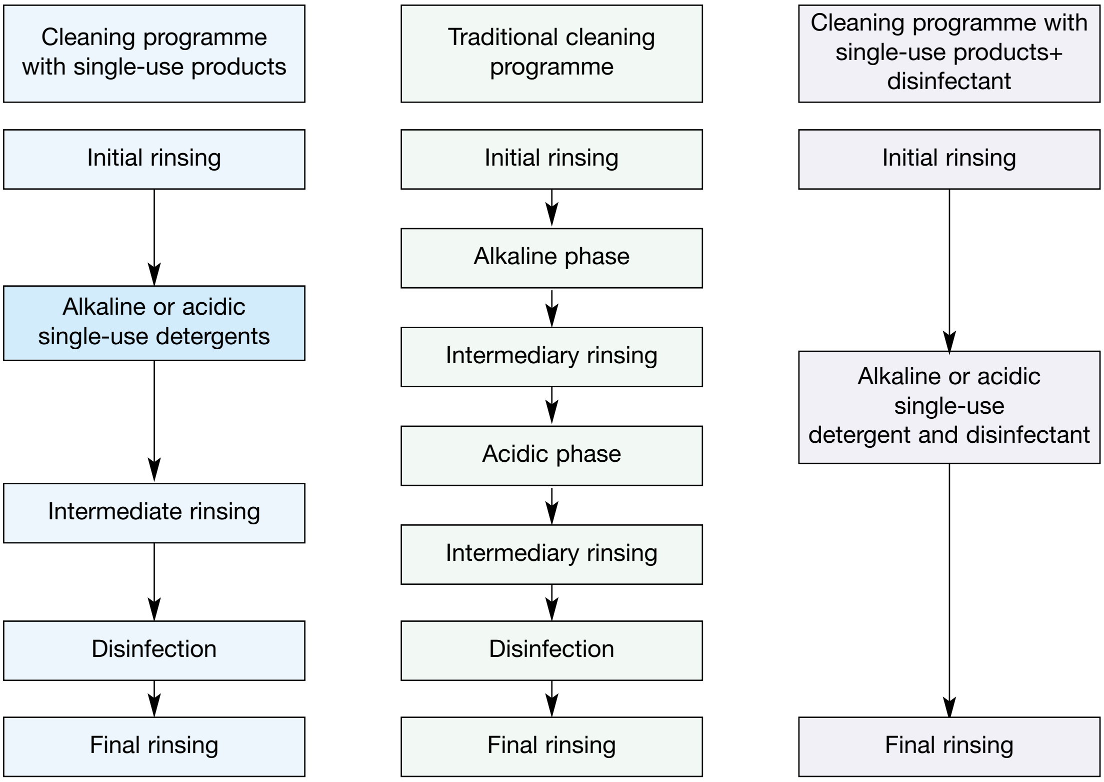
In order to meet industrial cleaning requirements, two types of single-use products were developed: products with an acid base and products with an alkaline base.

- The *acid-based products* use an acid and a large amount of surfactant to act on residues of grease and protein, thus removing with a single use the organic and inorganic dirt.

- Alkaline products and a high concentration of moisturizers and emulsions (to facilitate the breaking-down of fat and protein residues) and capturing agents that impede the deposit of alkaline salts present in the cleaning solution and eliminate incrustations produced by the production process.

The following figure shows differences compared to a traditional CIP cleaning programme.

Figure 57
CIP CLEANING PROGRAMMES WITH VARIOUS CLEANING PRODUCTS



The following table presents several examples of the application of this type of cleaning for different areas of the dairy industry.

Table 22: . Examples of CIP cleaning applications
(Source: Arnau Calduc, F., 1995)

AREA	CLEANING
Area of cold milk: collection tanks, pipes, filling installations	One-phase cleaning (acid or alkaline). Depending on the hardness of the cleaning water, acid can be more economical
Coagulation of cheese, cheese moulds	Cleaning with an acid phase
Area of cold milk: tanks and fillers for curd, yogurt, etc.	Cleaning with an alkaline phase
Pasteurizers	Cleaning with an alkaline phase with additives
UHT equipment, evaporators	Inadequate cleaning during a phase

The environmental advantages are quite evident because the cleaning programme with a single-application detergent requires fewer washing stages and less application of product.

Table 23: Reductions obtained with single application detergents compared to traditional CIP cleaning systems (Esteban Andueza, 1998)

	CLEANING PROGRAMME WITH SINGLE-ACTION PRODUCTS	CLEANING PROGRAMME WITH ACID-DISINFECTANT SINGLE-APPLICATION PRODUCTS
Reduction of waste	50 per cent	62 per cent
Reduction of time and energy	60 per cent	74 per cent

(Percentage of reduction compared to a traditional cleaning programme).

A reduction of the time spent cleaning can result in a large increase in production time. In some cases, a reduction of the cleaning time by 25 per cent can lead to an increase of production time of 1.5 hours per day (UNEP, 2000).

Another environmental advantage of these systems is the lower content of phosphorous and nitrogen of the products that are one of the main aspects of cleaning products contributing to water pollution. While traditional detergents contain between 10 and 20 per cent phosphorous, acidic detergents using a single phase contain between 0.1 and 0.2 per cent and alkaline detergents between 0.2 and 0.3 per cent phosphorous (F. Arnau, 1995).

Example of application

For the cleaning of a pasteurizer of 15,000 litres/hour, a circulation of 250 litres and a pump flow of 20,000 litres/hour.

TRADITIONAL CIP CLEANING			CLEANING WITH A SINGLE USE DETERGENT		
PHASE	TIME	CONSUMPTION	PHASE	TIME	CONSUMPTION
Rinsing	10’	3.3 m^3 water	Rinsing	10’	3.3 m^3 water
Alkaline treatment	40’	5 kg soda	Treatment with a single use detergent	20’	7.5 kilos
Rinsing	15’	5 m^3 water			
Acidic treatment	20’	4 kg nitric acid			
Rinsing	15’	5 m^3 water	Rinsing	10’	3.3 m^3 water

	TRADITIONAL CIP CLEANING	CLEANING WITH A SINGLE USE DETERGENT
Total consumption of water	13.3 m^3 water	6.6 m^3 water
Total time spent	100’	40’
Consumption of cleaning products	9 kilos	7.5 kilos

PPO-19: Recovery of cleaning products

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td></td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Cleaning of equipment.</td></tr>
<tr><td colspan="2">Environmental considerations:
Occasional dumping of cleaning solutions (acidic, alkaline, disinfectants) with a high concentration of pollution.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
The use of one system for recovery of cleaning solutions in order to avoid the dumping of chemicals that can be re-used.</td></tr>
<tr><td rowspan="2">Implementation:
- Equipment for recovering solutions (filtering systems).
- Trained personnel.
- Operational procedures.</td><td>Economic balance:
👍 Reduction in the consumption of cleaning products.
👍 Reduction in the cost of treatment of final waste.
👍 Reduction in the consumption of water.
Increase in energy consumption.
Equipment costs.
Cost of maintenance of equipment for filtering solutions.
Training costs.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in the volume of final waste.
☺ Reduction in the consumption of water.
☺ Reduction in pollutant load of the waste.
☹ Increase in the consumption of energy.</td></tr>
</table>

Comments

The amount of cleaning products used by the dairy industry is high. It is estimated that for each ton of milk processed, between one and four kilos of cleaning solutions are used that are dumped once they are exhausted (Alejandro Held, 1995).

The use of techniques for recovering these solutions makes it possible to re-use them and decrease their consumption.

The regeneration of acid cleaning solutions is based primarily on systems for decanting organic components because they do not dissolve in the acidic solutions and remain in suspension. Eliminating sediment from the bottom and floating fat, the solution can be re-used without additional treatment, compensating for losses through the addition of concentrated product (G. Wildbrett, 2000).

Regeneration of alkaline cleaning solutions requires rather more complex treatment because the organic components of the dirt are mainly dissolved in solution. In the presence of surfactants, emulsions can also be produced. Conventional sedimentation techniques or centrifugation do not produce good efficiency results. Tangential filtering techniques, in which the solution to be cleaned strikes a membrane tangentially permits good efficiency results.

Savings in cleaning products by recycling cleaning solutions after ultra or micro filtration can be more than 90 per cent (Alejandro Held, 1995). The concentration of organic material resulting from regeneration has been used in some cases as animal feed or fertilizer (Alejandro Held, 1995).

Example of application

For a firm with the following values:

CHARACTERISTICS	
Milk production (tons/day)	50
Consumption of chemicals (kilos/ton of milk produced)	100

Recovery of cleaning solutions through tangential filtration techniques leads to a savings in cleaning products of about 60 per cent. Quantification of the benefits obtained is presented in the next table.

	BEFORE IMPLEMENTATION OF PPO	AFTER IMPLEMENTATION OF PPO
Total consumption of cleaning products (tons/year)	30	12

PPO-20 Periodic control of emissions from boilers

Type of Opportunity: Reduction at the source.	Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** : Generation of hot water or steam.

Environmental considerations:
Emissions of combustion gases into the atmosphere.

Pollution Prevention Opportunity:
Establishment of a programme of periodical maintenance of boilers and monitoring and control of emissions of combustion gases. This ensures proper functioning of the system and optimisation of combustion.

Implementation:
- Preventive maintenance of boilers.
- Periodic measurement of gas emissions.
- Operational procedures.
- Visual control of smoke emissions.
- Skilled labour.

Economic balance:
👍 Reduction in the consumption of fuel.
Cost of measurements and analysis of emissions.
Personnel costs.

Environmental balance:
☺ Reduction in the emission of pollution gases.
☺ Reduction in the consumption of fuel.

Example of application

For a boiler producing steam with a thermal power of 528,000 kcal/hour and 800 kilo/hour of maximum production that uses propane as fuel, the following measurements were made before and after adjustment of the boiler.

	BEFORE	AFTER
per cent O_2	1.81	5.79
per cent CO_2	12.52	9.93
ppm CO	8,919.38	1.63
ppm NOx	70.75	72.00
ppm SO_2	0.00	0.00
per cent efficiency	83.82	90.56

In light of these results, the tuning of the boiler led to improvement in the excess oxygen during combustion, which in turn increased the efficiency of the boiler and considerably decreased the emission of carbon monoxide and CO_2.

PPO-21: Recovery of condensation

Type of Opportunity: Recycling at the source.	
Process: Preparation of dairy products.	**Stage / Operation:** Secondary operations.
Environmental considerations: The high consumption of water (between 1.3 and 3.2 litres of water/kilo of processed milk) by dairy firms.	
Pollution Prevention Opportunity: Recovery of condensation water generated during heat treatment and refrigeration. If of proper quality, this water can be used to feed the boilers.	
Implementation: - Determine the water quality required for each operation. - Installation of systems for recovering condensation. - Re-circulation of condensation water. - Use of condensation for supplying the boilers. - It may be necessary to use additives (fungicides, anti-calcium, anti-incrustant, algaecides, disinfectants, etc.).	**Economic balance:** 👍 Reduction in the consumption of water. Adjustment of the equipment and installation of systems for collection and re-circulation of condensation
	Environmental balance: ☺ Reduction in the amount of final waste. ☺ Reduction in the consumption of water.

PPO-22: Avoiding leaks of refrigerants

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Refrigeration equipment.</td></tr>
<tr><td colspan="2">Environmental considerations:
The emission of refrigerants containing CFCs into the atmosphere.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Establishment of a procedure for controlling emissions of refrigerants in order to avoid leaks and optimise the output of equipment.</td></tr>
<tr><td rowspan="2">Implementation:
- Periodically check the status of the installations, especially if there is loss of pressure in the circuit or decreases in output.
- Check the joints between pipes, accessories and equipment.
- Installation of control devices in the installation.
- Substitution of equipment.
- Trained personnel for replacing and repairing refrigerants and refrigeration equipment.</td><td>Economic balance:
👍 Reduction in expenditure for leaks of refrigerants.
👍 Reduction in energy consumption.
Personnel costs for maintenance.
Cost of equipment.</td></tr>
<tr><td>Environmental balance:
☺ Reduction in the emission of refrigerant gases.
☺ Lower energy consumption.</td></tr>
</table>

PPO-23: Substitution of refrigerants with others that do not contain CFCs

Type of Opportunity: Reduction at the source.	Substitution of materials.
Process: Preparation of dairy products.	**Stage / Operation:** Refrigeration equipment.

Environmental considerations:
The release of refrigerants with CFCs into the atmosphere.

Pollution Prevention Opportunity:
Elimination of refrigerating fluids that contain CFCs, whether by substitution of refrigerants if the installation allows it or by changing cold refrigeration equipment.

Implementation: - Use of authorized refrigerants. - Substitution of equipment.	**Economic balance:** Equipment costs. **Environmental balance:** ☺ Reduction in the emission of CFCs into the atmosphere.

PPO-24: Storage of hazardous products under adequate conditions

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Good Practices.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Secondary operations.</td></tr>
<tr><td colspan="2">Environmental considerations:
Hazardous products can pollute large areas of ground and water in the event of dumping or accidental spills.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Provide a storage area appropriate for hazardous goods. This area should be protected from passing vehicles, have access restricted to responsible personnel and have measures for collecting leachate that might be produced.</td></tr>
<tr><td rowspan="2">Implementation:
- Provide a specific storage area for these products with security measures.
- Make the soil impermeable on which these products are stored.
- Provide a system of collection independent from wastewater for spills of hazardous products.
- Training of personnel in the management of these products.
- Establishment of a contingency system in the event of an accident (both with regard to the environment and workers).
- Provide adequate symbols and labelling to hazardous products.</td><td>Economic balance:
👍 Reduction in the cost of treatment.
Cost of preparation of storage areas.
Cost of training personnel.</td></tr>
<tr><td>Environmental balance:
☺ Prevention of accidents with environmental effects.</td></tr>
</table>

PPO-25: Minimization of packaging waste

<table>
<tr><td>Type of Opportunity: Reduction at the source.</td><td>Redesign of processes: Packaging.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Packaging.</td></tr>
<tr><td colspan="2">Environmental considerations:
The dairy industry puts on the market a large amount of packaging. Because of defects in the packaging line or defects in the final product, much used packaging is often generated that becomes waste for the firm.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Implementation of a minimization plan for waste packaging after completion of a study permits considerable reduction in the amount of packaging material placed on the market without substantial reduction in its qualities (mechanical resistance, preservation of the product, ...).</td></tr>
<tr><td rowspan="2">Implementation:
- Study of minimization possibilities and market study
- Modifications in equipment for production of packaging (if this is carried out at the plant).
- Possible change in the supplier of packaging.
- Re-design of packaging of dairy products.</td><td>Economic balance:
👍 Lower consumption of packaging material.
👍 Lower costs for the management of waste packaging produced by the firm.
Cost of the minimization study.
Modifications in the packaging operation and storage.</td></tr>
<tr><td>Environmental balance:
☺ Decrease in the amount of waste of packaging put on the market.</td></tr>
</table>

Comments

The dairy industries are characterized by the production of very perishable products that must be protected with packaging in order to market them. Optimisation of the ratio of weight of packaging to weight of product permits reducing unnecessary consumption of resources and/or energy for their production and reduces the amount of packaging waste that will remain on the market once the product is consumed.

In order to implement a minimization plan for packaging in a dairy firm, the following steps are usually taken:

- Carrying out of an inventory of all packaging used by the firm regarding formats, type of materials, volumes, specifications, etc.
- Study of possibilities for minimization of packaging (changes in material, characteristics of the material, packaging design, volume of packaging, transportation, storage) taking into account among other things the product's needs and the conditioning factors of the transportation system and storage used.
- Application of the measures;
- Quantification of the results.

Example of application

Case 1

A firm that uses 2,000 single-use pallets per year for transportation of its products considered the possibility of using recyclable pallets of better quality with a useful life of 12 reuses. The improvements achieved are described below.

	BEFORE OPTIMISATION	AFTER OPTIMISATION
Number of pallets	2,000	50
Unit weight (kilos/pallet)	17	23.5
Number of times used	1	40
Waste pallets (tons/year)	**34**	**0.78**

Case 2

A firm that produces 50,000 litres of UTH milk uses cardboard boxes of 124 gr/m^2 to pack brick type packaging in groups of six units. Two options for minimization of the use of cardboard were considered: a) use of lighter cardboard (110 gr/cm^2) or b) a change in design in order to use less area of cardboard, which would reduce the area of cardboard from 4,140 cm^2 to 3,515 cm^2. The following table describes the results obtained.

	CURRENT	OPTION A	OPTION B
Number of packages	8,333	8,333	8,333
Unit weight per box (g/m^2)	124	119	124
Area (cm^2)	4,140	4,140	3,515
Total weight of cardboard (tons/year)	**427.8**	**410.5**	**363.2**

PPO-26: Adequate separation of solid waste

<table>
<tr><td>Type of Opportunity: Recovery.</td><td>External recycling.</td></tr>
<tr><td>Process: Preparation of dairy products.</td><td>Stage / Operation: Packaging.</td></tr>
<tr><td colspan="2">Environmental considerations:
The volume of solid waste produced is high, especially from waste packaging and packing. This waste can be recycled for preparing new products.</td></tr>
<tr><td colspan="2">Pollution Prevention Opportunity:
Creation of the infrastructure necessary to permit adequate separation of the main types of solid waste generated by the firm (packaging, paper/cardboard, plastics, glass), in order that it can be adequately managed later.</td></tr>
<tr><td rowspan="2">Implementation:
- Provide containers for each type of waste.
- Identify the different containers in function of the waste to be deposited there.
- Place containers near areas of greatest generation of waste packaging and packing in order to facilitate its separation.
- Provide a storage area.
- Compact the packaging waste in order to save storage space and transportation costs.
- Training of personnel.</td><td>Economic balance:
👍 Reduction in the cost of waste management.
Cost of containers.
Cost of the conditioning equipment (compactors, packaging machines, ...).
Cost of training personnel.</td></tr>
<tr><td>Environmental balance:
☺ Recovery of waste.</td></tr>
</table>

PPO-27: Neutralization of acidic and alkaline waste before dumping

Type of Opportunity: Reduction at the source.

Process: Preparation of dairy products.

Stage / Operation: Treatment of wastewater.

Environmental considerations:
Occasional dumping of wastewater from cleaning with extreme pHs when emptying tanks used for acid or alkaline cleaning solutions. They cause a heavy environmental impact on the receiving medium and can be very harmful for wastewater treatment systems (especially if they are biological).

Pollution Prevention Opportunity:
Neutralize sources with extreme pH before dumping, mixing acid and basic sources or dosing reagent to reach a pH near neutral at the point of dumping.

Implementation:
- Construction of a tank for homogenization/neutralization of acid and basic sources.
- Dosing of reagents.

Economic balance:
👍 Reduction in the cost of treatment.
Cost of the construction of the homogenization tank.
Cost of the system for dosing reagents.

Environmental balance:
☺ Reduction in the hazardous content of waste.

PPO-28: Optimisation of energy efficiency through cogeneration

Type of Opportunity: Reduction at the source.

Process: Preparation of dairy products.

Stage / Operation: Generation of energy.

Environmental considerations:
The high demand for energy (heat and electricity) of dairy firms.

Pollution Prevention Opportunity:
In large industrial plants or in plants with a high consumption of heat (for example those that have operations for concentrating whey), the production of electricity using residual heat for production of thermal energy can be economically viable. The viability of this option depends at all times on the price of fossil fuels, electricity and governmental support in each country participating in the cogeneration.

Implementation:
Development of a project for cogeneration:
- Feasibility study.
- Basic project.
- Optimisation of design.
- Construction and start-up.
- Legalization and administrative procedures.
- Relations with the electric company and the source of fuel.
- Maintenance and use.

Economic balance:
👍 Decrease in the cost of energy.
👍 Energy independence.
Cost of project development.
Investment in the system.
Cost of maintenance and use.

Environmental balance:
☺ Savings in primary energy.
☺ Reduction of emissions into the atmosphere (less fuel is burned to generate the same energy).
☺ Use of less polluting fuel (natural gas) or use of residual fuels (biogas, biomass, industrial waste, etc.).

PPO-29: Good Practices for reduction of water consumption

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** All.

Environmental considerations:
High consumption of water in dairy firms, with values between 1.3 and 3.2 litres/litre of milk processed.

Pollution Prevention Opportunity:
Implementation of Good Practices for the reduction of water consumption in all parts of the firm.

Implementation:
- Adjustment of the flow of water to the needs for each operation.
- Creation of optimum operating conditions, posting them in writing and providing them to the workers.
- Installation of valves that make it possible to regulate water flow.
- Installation of systems for cutting off parts of the water network, making it possible to cut off water supply to an area in the event of leakage.
- Use of the amount of water suitable for each operation, permitting re-use of water in less critical stages and savings in pre-treatment of water for each process.
- Carry out periodical inspections of the installation and/or consumption in order to detect leaks, breaks or losses as soon as possible.
- Use of closed circuit refrigeration.
- Automatic systems for closing off water outlets (hoses, taps, services, etc.).
- Use of wastewater after being treated, as long as they reach an acceptable level of quality, for operations such as watering of landscaped areas of the firm or cleaning of outside areas.

PPO-30: Good Practices for reduction of energy consumption

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** All.

Environmental considerations:
In most dairy firms, a high level of energy is consumed (electricity and heat), in many cases more than 0.14 kWh/litre of milk processed.

Pollution Prevention Opportunity:
Implementation of Good Practices for the reduction of the consumption of energy in the plant of the dairy firm.

Implementation:
- Installation of systems of automatic control for turning off lights and equipment when they are not being used.
- Creation of optimum operating conditions, posting them in writing and informing the workers.
- Preventing doors of refrigerated areas from remaining open for a long time.
- Installation of automatic mechanisms for turning off lights and equipment when not in use.
- Prevention of steam leaks.
- Avoid heat losses in the pipes and installations using insulation.
- Carry out adequate maintenance of the insulation and heat sealing.
- Installation of mechanisms for monitoring operations in order to avoid the functioning of empty equipment.
- Installation of a system of information technology for monitoring temperature in the refrigerating chambers and alarm.

PPO-31: Good Practices for reduction of gas emissions

Type of Opportunity: Reduction at the source.

Redesign of processes: Good Practices.

Process: Preparation of dairy products.

Stage / Operation: Generation of heat and refrigeration.

Environmental considerations:
The emission of combustion gases (CO, SO_2 or NOx, and particles) by the boilers used to produce steam and hot water and refrigeration fluids of the refrigeration equipment.

Pollution Prevention Opportunity:
Carrying out Good Practices as a simple form for the reduction of gas emissions.

Implementation:

- Make a visual check of the emission of fumes.
- Carry out periodic measurement of gas emissions.
- Check the correct functioning of boilers.
- Carry out periodic maintenance of boilers and burners.
- Check periodically the refrigeration installations in order to detect possible leaks.
- Use of cleaner fuels, such as natural gas.

PPO-32: Good Practices to facilitate the management of waste

Type of Opportunity: Reduction at the source.	Redesign of processes: Good Practices.
Process: Preparation of dairy products.	**Stage / Operation:** All.

Environmental considerations:
The generation of waste resulting from the activities of the dairy industry (processing, maintenance, cleaning, office work, laboratory).

Pollution Prevention Opportunity:
Carry out measurements to decrease the amount of waste generated or facilitate its transport and management.

Implementation:
- Prevent the dumping of used lubricating oils and other hazardous wastes into the drainage system.
- Prevent fuel leaks from reaching the system for evacuating wastewater.
- Install a system for collecting possible leaked fuel.
- Completely empty containers with cleaning products, additives, chemicals, etc.
- Carefully check the products available in warehouse.
- Use refillable tanks for products used in large quantities.
- Use of larger packaging for products of greatest consumption in order to decrease packaging waste.
- Avoid dumping laboratory waste into the general system for evacuating wastewater.
- Gather separately waste that can be recycled.
- Avoid mixing hazardous waste with non-recyclable waste.
- Identify the storage area for hazardous waste in order to avoid their mixing with non-hazardous waste.
- Dry-separate solid waste in order to facilitate its transportation and later management.

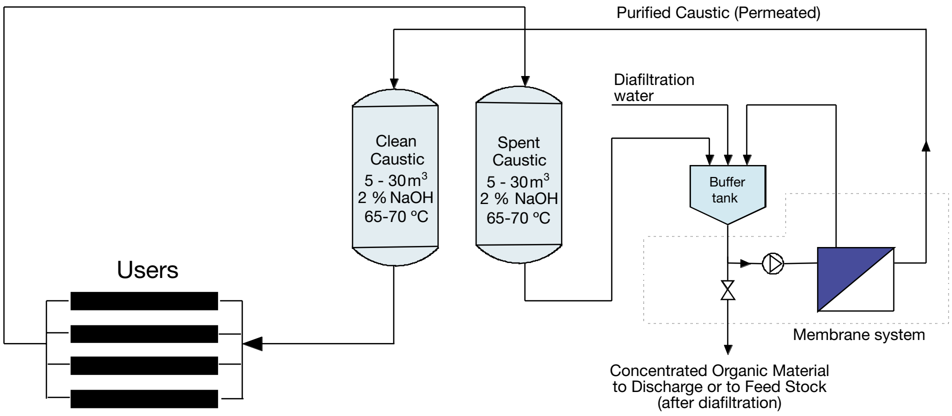
6. CASE STUDIES

<table>
<tr><th colspan="2">CASE STUDY 1/5</th></tr>
<tr><td>Company background</td><td>MISR. COMPANY FOR MILK AND FOOD is one of the largest public firms in the dairy sector in Egypt with more than 512 workers. It processes 8,250 tons of raw milk per year to produce 1,250 tons/year of soft cheese and 850 tons/year of hard cheese in addition to other dairy products.</td></tr>
<tr><td>Industrial sector</td><td>Food industry. Production of dairy products.</td></tr>
<tr><td>Environmental considerations</td><td>The plant produces significant amounts of two types of whey with different characteristics:
• *Permeated* whey obtained from ultra filtration for preparation of soft cheese (1.5 tons of whey/ton of soft cheese).
• *Sweet* whey from the preparation of aged cheese (5.0 tons of whey/ton of hard cheese produced).
Whey incorporated into the wastewater considerably raises the degree of pollution. The firm dumps 183,000 m^3/year into the municipal sewage system without pre-treatment with a BOD_5 of 2,300 ppm and a COD of 4,050 ppm.</td></tr>
<tr><td>Background</td><td>In addition to the environmental problems caused, the dumping of whey leads to not taking advantage of a source of carbohydrates, high-quality proteins and minerals.
<table>
<tr><th>COMPOSITION OF THE WHEY (% OF DRY MATERIAL)</th><th>SWEET</th><th>PERMEATED</th></tr>
<tr><td>Total nitrogen (%)</td><td>1.30</td><td>0.26</td></tr>
<tr><td>Non-protein nitrogen (%)</td><td>0.30</td><td>0.24</td></tr>
<tr><td>Calcium (%)</td><td>0.058</td><td>0.055</td></tr>
<tr><td>Phosphorous (%)</td><td>0.052</td><td>0.045</td></tr>
</table>
In Egypt, sugar cane and sugar beet molasses have been used for many years as a liquid feed for ruminants. For this reason, the opportunity to use whey as a new high-quality liquid feed at low cost awoke interest in the livestock sector near the plant.
In order to demonstrate to the farmers the viability of this alternative, a pilot study was carried out with 30 sheep during eight weeks substituting the liquid (water) in the usual diet with various combinations of permeated whey, molasses and urea.
The results show that the relation kilo of liquid feed/kilo of weight gained by the live animal is more efficient when the whey is 100 per cent (7.51) compared to molasses at 100 per cent (9.16) or la combination of molasses, whey and urea (9.66).
19 litres of permeated whey replace the same energy and protein provided by 2.4 kilos of cereal/hay with 88 per cent of raw protein.
Note: Ultra-filtrated permeated whey is used because of its greater conservation compared to sweet whey. Nonetheless, in order to avoid acidification, preserving agents were added in order to maintain pH above 6 even at high temperatures.</td></tr>
</table>

<table>
<tr>
<td>Summary of actions</td>
<td>Based on the results of the study, it was estimated that the real value of the whey was 18.49 €/ton. In order to make this alternative more attractive to the farmers, the plant first sold it to the farmers for only 0.26 €/ton.
A training programme for five persons from the firm and two workers from a dairy farm (cows) was carried out, which explained the control procedures and the handling of the whey, cleaning activities, maintenance records and measurements for monitoring the whey and the reaction of the animals.
A practical system for distributing the whey was established with an installation of pipes, pumps and tanks for collecting the whey up to the loading into lorries for distribution. The whey is off loaded at the farms directly at the places where the water for the cows is supplied.
The firm also acquired portable metres for measuring pH and thermometers in order to monitor continuously the whey at four key points: at the exit of the plant, during transportation to the farm, at the entrance to the farm and where it is consumed.</td>
</tr>
<tr>
<td>Balances</td>
<td>By eliminating or reducing waste whey in the plant, pollution of wastewater was significantly reduced: 415 tons fewer of BOD_5, 522 tons fewer of COD, 58 tons fewer of suspended solids, 218 tons fewer of dissolved solids and 62 tons fewer of oils and fats. The volume of waste was also reduced by 5,970 m^3/year.
The cost of treating wastewater has been reduced by about 25 per cent.
The costs associated with feeding with whey were primarily separation at the source and operation of the storage and distribution system from the plant to the farm.
The economic benefits come from reduction of the costs of treatment of wastewater and the sale of whey. For the farm, there are significant savings in the direct costs of feeding cattle and an increase in productivity. The following table summarizes the cash flow during the first year of feeding 412 cows with whey.
<table>
<tr><th>CASH FLOW</th><th>PLANT €/YEAR</th><th>FARM €/YEAR</th></tr>
<tr><td>Transportation of whey and construction of storage</td><td>(13,164)</td><td>—</td></tr>
<tr><td>Probes and monitoring equipment</td><td>(1,122)</td><td>(1,122)</td></tr>
<tr><td>Distribution costs</td><td>(320)</td><td>—</td></tr>
<tr><td>Investment in treatment plant</td><td>26,407</td><td>—</td></tr>
<tr><td>Sale of 6,000 m^3 of whey at 0.26 €/ton</td><td>1,584</td><td>(1,584)</td></tr>
<tr><td>100% of savings in water consumption (40 kilos/head/day)</td><td>—</td><td>1,584</td></tr>
<tr><td>75 per cent of savings in hay and grain (2 kilos/head/day)</td><td>—</td><td>36,521</td></tr>
<tr><td>Net savings</td><td>12,385</td><td>35,399</td></tr>
<tr><td>Payback period (months)</td><td><10</td><td><1</td></tr>
</table>
(The amounts in parenthesis indicate an increase in cost).
Savings achieved during the first year result mainly from savings on the investment in treatment plant. During the second and third years, the net savings for the plant were 10,563 and 22,447 € respectively, increasing the sales price of the whey to 1.98 and 3.96 €/ton.</td>
</tr>
</table>

Recommendations	The plants can use the routes established for gathering milk for delivery of the whey to the farms. Special attention should be given to quality control during handling of the whey to prevent it from contamination and increase its conservation. It is recommended that materials resistant to corrosion, such as stainless steel or fibreglass, be used in the pipes and storage tanks. The pipes should be cleaned at least once a week in order to avoid microbiological contamination and unpleasant smells. Introduction of the whey in the animal diet should be gradual in order to avoid digestive troubles, diarrhoea, lack of appetite or reduction of production. A mixture of water and 20 per cent whey can be used at the beginning and the proportion of whey increased by 20 per cent each week during three weeks until arriving at 100 per cent. The amount of whey offered to the animals should be properly monitored in order to prevent excessive consumption over a short period of time, which can produce problems of bloating.
Conclusions	Thanks to this action, the firm MISR. COMPANY FOR MILK AND FOOD was able to reduce the degree of pollution of its wastewater and obtain significant savings, especially in relation to the investment in water treatment. In addition, this reduction made it possible for the firm to comply with Law 93 on dumping of industrial wastewater.

<table>
<tr><th colspan="2">CASE STUDY 2/5</th></tr>
<tr><td>Company background</td><td>DAIRY ISRAEL Ltd. is a modern enterprise used to produce fresh milk and other dairy products. In its installations, 150 tons of raw milk are processed daily. There is a CIP (cleaning in place) cleaning system.</td></tr>
<tr><td>Industrial sector</td><td>Food industry. Production of dairy products.</td></tr>
<tr><td>Environmental considerations</td><td>The cleaning and disinfection operations carried out represent the most important environmental effect of DAIRY ISRAEL Ltd. and require the largest consumption of water and the dumping of large amounts of wastewater (about 120 m^3 of waste per day).
One of the main characteristics of this water is its high alkalinity produced by the use of NaOH as a cleaning agent.
In order to correct the pollution of the wastewater, the firm installed a treatment system, in which the stage of neutralization was the key element. It uses a large amount of acid in order to reduce the pH.
In addition, DAIRY ISRAEL Ltd. has a high consumption of energy caused by the heating of cleaning water and operation of the treatment plant.</td></tr>
<tr><td>Background</td><td>Cleaning and disinfection of DAIRY ISRAEL Ltd. results in a high economic cost including the cost of the cleaning agents, water, energy and treatment. The following table shows the most important unit costs.
<table>
<tr><th colspan="2">INITIAL HYPOTHESIS</th></tr>
<tr><td>Cost of NaOH</td><td>336,470 €/ton</td></tr>
<tr><td>Cost of hot water</td><td>1.12 €/m^3</td></tr>
<tr><td>Cost of energy</td><td>0.05608 €/kWh</td></tr>
<tr><td>Cost of waste treatment</td><td>0.33647 €/m^3</td></tr>
<tr><td>Cost of acid (for neutralization)</td><td>112,157 €/ton</td></tr>
</table>
</td></tr>
<tr><td>Summary of actions</td><td>The high economic cost mentioned earlier led to adoption of corrective measures. After analysis of possible solutions, it was decided to install a system for recovering and reuse of the cleaning and disinfection solutions through filtering with AlkaSaveTM organic membranes.
The use of membrane techniques makes it possible to separate the wastewater from the CIP system into two flows. From one, a permeate with high concentration of NaOH is obtained that is reintroduced into the CIP system as regenerated cleaning solution. From the other, a concentrate in which most of the organic load is concentrated is obtained.
By reusing the cleaning solutions, consumption of water, energy and chemicals is reduced and at the same time the amount of waste is reduced. The following sketch shows the functioning of the implemented system.</td></tr>
</table>



HYPOTHETICAL OPERATION		
System capacity	120	m^3/day
Concentration (NaOH) of the solution to be treated	2	%
Recovery	90	%
Days in operation	300	days/year
Hours of operation	22	hours/day
Amount of soda recovered (100%)	2.16	tons/day
Amount of soda recovered	648	tons/year

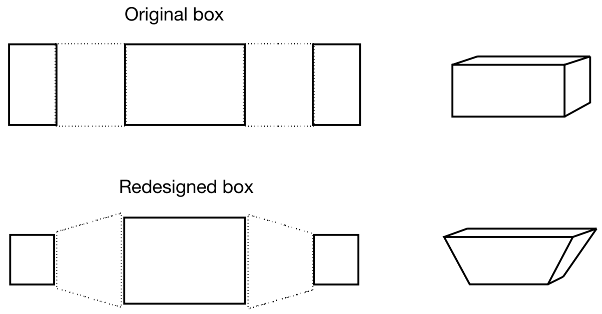
Balances

As a result of the installation of a membrane filter for separation and reuse of the caustic part of the wastewater of the CIP, the following results have been obtained.

ECONOMIC CONSIDERATIONS	
Recovery of NaOH	218,033.0 €/year
Consumption of hot water	36,338.8 €/year
Direct savings	**254,371.8 €/year**
Neutralization (including savings in acid)	72,677.5 €/year
Charges and taxes/other treatments	10,901.6 €/year
Indirect savings	**83,579.1 €/year**
Total savings	**337,950.9 €/year**
Cost of the system (including membranes)	392,549.0 €
Secondary costs	78,509.7 €
Initial investment	**471,058.7 €**
Substitution of membranes	43,673.9 €/year
Consumption of energy	10,280.3 €/year
Cleaning reagent	1,009.4 €/year
Labour	8,411.8 €/year
Total cost of the operation	**63,375.4 €/year**

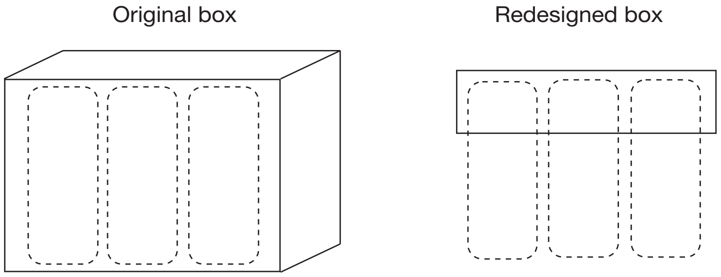
Payback period: 1.5-3 years.

Conclusions	Although the cost of the initial investment is high, the large volume of cleaning solution (120 m^3/day) used by DAIRY ISRAEL Ltd. permits recovery of the investment in about two years because of large savings in chemicals, water and energy. This action is advisable primarily in large firms with a high volume of production.

<table>
<tr><th colspan="2">CASE STUDY 3/5</th></tr>
<tr><td>Company background</td><td>LEYMA (Spain) is a dairy product firm that annually processes 10,000 tons of milk for the production of solid and liquid yogurt as well as other dairy products.</td></tr>
<tr><td>Industrial sector</td><td>Food industry. Production of dairy products.</td></tr>
<tr><td>Environmental considerations</td><td>Waste from packaging and packing creates a large volume of waste for the dairy firm and the final consumer because of commercialisation and marketing of packaging and packing. Consumption of resources and packaging materials and management of existing packaging create greater and greater problems given the high volume of generation.</td></tr>
<tr><td>Background</td><td>In Spain, Law 11/97 seeks to prevent and reduce the impact of packaging on the environment and the management of packaging waste throughout its life cycle. In order to fulfil these objectives, measures are established to promote reduction of packaging waste and its reuse, recycling and use of this waste.
In order to meet these objectives, Law 11/97 and its regulation (RD 782/98) provide for preparation of an Enterprise Programme for Prevention in order to reduce, minimize and prevent at the source the production and harmfulness of packaging waste generated.</td></tr>
<tr><td>Summary of actions</td><td>The firm made a study of its packaging and packing with the aim of minimizing at the source the waste generated without affecting conservation of the product.
1. Design of bulk packing for solid and whipped yogurt was changed, decreasing the surface of the cardboard used.
Action 1.1: Packing of solid yogurt.


<table>
<tr><th>ACTION 1.1.</th><th>BEFORE THE ACTION</th><th>AFTER THE ACTION</th></tr>
<tr><td>Number of packs per year</td><td>12 x 10^6</td><td>12 x 10^6</td></tr>
<tr><td>Weight (gr/cm^2)</td><td>0.027</td><td>0.027</td></tr>
<tr><td>Area (cm^2)</td><td>481.25</td><td>439.00</td></tr>
<tr><td>Cardboard waste (tons/year)</td><td>156.0</td><td>141.6</td></tr>
</table></td></tr>
</table>

Action 1.2: Packing of whipped yogurt.



ACTION 1.2.	**BEFORE THE CHANGE**	**AFTER THE CHANGE**
Number of packs per year	4.16 x 10^6	4.16 x 10^6
Weight (gr/cm^2)	0.035	0.035
Area (cm^2)	497	330
Cardboard waste (tons/year)	72.36	48.00

2. Substitution of non-reusable wooden pallets (of a single use), with reusable pallets with a longer useful life that can be used at least 12 times.

	BEFORE THE CHANGE	**AFTER THE CHANGE**
Number of pallets	2,000	50
Unit weight (kilos/pallet)	17	23.5
Number of uses	1	40
Wood waste (tons/year)	34	0.78

Balances

Annual balance

ACTION	**ENVIRONMENTAL BENEFITS**	**SAVINGS**
Action 1.1.	Reduction of 14.4 tons of paper/ cardboard waste	8,654.88 €
Action 1.2.	Reduction of 24.36 tons of paper/ cardboard waste	14,641.18 €
Action 2.	Reduction of 33 tons of wood waste	9,015.50 €
TOTAL	38.76 tons of cardboard and 33 tons of wood	32,311.56 €*

* Savings obtained only from the reduction of consumption of materials.

Conclusions

The new design used for the packs of yogurt provides for grouping jars of yogurt with less material consumption and decrease cardboard waste (in the second case, there was a reduction of 30 per cent of the unit weight of the bulk packaging). Furthermore, the use of reusable pallets permitted reduction of the amount of wood waste generated by the firm (by approximately 95 per cent).

As a result of the minimization steps, a savings of 32,311.56 € was obtained resulting from reduction in the consumption of materials.

CASE STUDY 4/5	
Company background	MISR. COMPANY FOR DAIRY AND FOOD (Egypt) is one of the largest producers of dairy products in Egypt. The factory processes annually an average of 7,200 tons of milk, producing mainly pasteurised milk, white cheese, blue cheese and mish. Yoghurt, sour cream, ghee and processed cheese are also produced. An industrial audit was conducted in this company in order to identify pollution prevention opportunities.
Industrial sector	Food industry sector. Production of dairy products.
Environmental considerations	The audit identified a series of environmental considerations to take into account, mainly due to the following reasons: – Different solid wastes were stored haphazardly in open areas and roads, constituting a fire risk and impairing the general appearance of the premises. – Considerable amounts of milk were wasted due to overflow during the filling of storage and service tanks. – Milk leakages occurred in the milk packaging and refrigeration units. – Oil used in the car and truck maintenance facilities was drained to factory sewers, encouraging drain blockage and consequent development of foul odours. – Excessive consumption of mazot in the boiler house, due to poorly turned boilers. This also resulted in excessive air emissions being discharged form the boiler stacks.
Background	During the audit stage, particular attention was paid to those improvements which could be carried out at low or no cost to the factory, focusing on the following options: 1) Good housekeeping: improvement of factory units and buildings, maintenance and upgrading of factory drainage, sewers, and manholes to eliminate blockage and overflow problems, collection of garage oil for resale, and segregation of solid wastes generated to be afterwards disposed or sold. 2) Water and energy conservation: optimisation of the ratio of air to mazot to increase the efficiency of the boilers and restoration of the softening unit to prevent the scaling of the boiler by chemical treatment of the feedwater. 3) Reuse and recycling: upgrading of raw milk storage units and the refrigeration room of the packaged milk products to prevent spoilage and loss, reuse of 50% of the permeate with a high lactose concentration in the cheese packaging stage in place of fresh water, and installation of level controls in storage tanks and control valves throughout the factory.
Summary of actions	The following actions and achievements were put into practice: 1) With low cost, improvement of the cleanliness of the factory premises was achieved, a monthly accumulation of 0.75 tons of used garage oil was sold at 81.4 € per ton, thereby reducing the strength of wastwater, and preventing blockage of sewers and overflow, and an efficient removal of solid wastes from the site was achieved with additional economic benefits due to selling of the same. 2) By means of the boiler tune-up and upgrade, mazot consumption was reduced by 60 tons/year and, in addtition, energy consumption reduction was also achieved. With the restoration of the softening unit, a 16% increase in boiler efficiency was achieved. 3) By means of the installation of a refrigeration system which permitted temperature to be fully controlled and the relocation of the packaging unit from a restricted area to be adjacent to the refrigeration facility thus preventing handling losses, production capacity, process efficiency and quality control were improved, and a reduction of 3.3 tons/month of milk losses was achieved. By reusing permeate in the cheese packaging stage, a 50% drop in the organic load generated from the white cheese unit was achieved, and 2,200 m^3 of water were saved on an manual basis. By installing level controls and control valves, daily savings of 350 kg of milk were obtained and pollution loads were reduced, thus improving cleanliness and hygiene.

Balances	**Options**	**Environmental benefits**	**Investments**	**Annual savings**	**Payback period**
	Good housekeeping	- Prevention of blockage of sewers and overflow - Overall improvement of the factory's image and cleanliness	3,997 €	36,245 €	1.3 months
	Boiler upgrade and softening unit restoration	- Increase in boiler efficiency - Reduction of mazot consumption and gas emissions	592 €	10,924 €	<1 month
	Increase in milk refrigeration efficiency	- Increase in production capacity, process efficiency and quality control - Reduction of reject rates of the final product	7,861 €	11,741 €	8 months
	Permeate reuse	- 50% drop in organic load generated from the white cheese unit - Water savings	None	612 €	Inmediate
	Installation of milk tank level controls and food quality valves	- Milk savings - Pollution loads reduction - Improvement of hygiene and safety	21,951 €	37,266 €	7 months
Conclusions	By means of the carrying out of an environmental audit, the company producing dairy products identified several opportunities to prevent pollution, increase the efficiency of processes and obtain economic benefits. These opportunities were focused on good housekeeping, recovery solutions, better quality of milk products and by-products and reduction in water and energy consumption, and could be carried at low or no cost, therefore having very short payback periods.				

<table>
<tr><th colspan="3">CASE STUDY 5/5</th></tr>
<tr><td>Company background</td><td colspan="2">LURA is the biggest producer of milk and dairy products in Croatia. In LURA’s factory Zagreb-Dukat, approximately 166,000 litres of milk are processed per year, obtaining the following main products: fresh and UHT milk, fermented products, cream, spreads, desserts and juices.</td></tr>
<tr><td>Industrial sector</td><td colspan="2">Agro-food industry. Dairy Industry.</td></tr>
<tr><td>Environmental considerations</td><td colspan="2">In the factory, fresh, drinking water was used for washing vehicles, production lines and machinery, heat exchange in technological processes and sanitary requirements.
Wastewater obtained from cleaning the machinery, containing both washing liquids and raw material remains, was drained into the sewer without previous treatment.
In addition to this, losses of hot water, condensate and “soft-demi” water were detected and attributed to technical reasons and inadequate habits of the employees.</td></tr>
<tr><td>Background</td><td colspan="2">Given the environmental situation of the factory, the main aspects to improve were the reduction in drinking water consumption and wastewater generation, the reduction of the pollution load of the wastewater and the reduction of energy consumption.</td></tr>
<tr><td>Summary of actions</td><td colspan="2">The factory implemented the following measures to achieve its pollution prevention and water and energy saving objectives:
– Carried out employee education concerning water consumption reduction and optimal concentrations of washing liquids.
– Used hoses with a samller diameter (12 mm) for washing the process lines and machinery.
– Used hot condensate as an additional energy source for warm water preparation.
– Applied warm water circulation and replaced the steam with warm water in the mixer.</td></tr>
<tr><td rowspan="6">Balances</td><td>OPTIONS</td><td>BENEFITS OBTAINED</td></tr>
<tr><td>Water saving and pollution load reduction options</td><td>Reduction of waste water amount by 286,000 m^3/year (27%)
Reduction of waste water pollution load (COD) by 25%
Savings of fresh (drinking) water by 280,000 m^3/year
Saving of washing liquids by 183 t/year (12%)</td></tr>
<tr><td>Energy-saving options</td><td>Savings of steam by 904 t/year (2%)
Heat energy savings of 500,000 kWh/year</td></tr>
<tr><td>Total investment</td><td>31,051 €</td></tr>
<tr><td>Savings</td><td>328,008 €/year</td></tr>
<tr><td>Payback period</td><td>1 month</td></tr>
<tr><td>Conclusions</td><td colspan="2">Thanks to the implementation of simple and low-cost measures, the factory achieved significant savings of water and energy and reduced the pollution load of its wastewater with a payback period of only one-month. By involving the employees in the environmental improvement measures, not only technical solutions, but also environmental awareness was promoted in the company.</td></tr>
</table>

7. CONCLUSIONS

The meaning of the symbols used to evaluate the status of dairy firms in the Mediterranean countries is explained as set out below.

COUNTRY	BASIC DATA FROM THE DAIRY INDUSTRY	% Production		
	Level	☺	😐	☹
WATER consumption				>75
ENERGY consumption		<25	25-75	<25
Pollution of WASTEWATER				25-75
Management of WASTE and WHEY		>75	<25	

The numbers indicate percentage of milk and dairy products which occurs at levels of:

- Water and energy consumption: low ☺, medium 😐, high ☹ level
- Degree of wastewater pollution generated: low ☺, medium 😐, high ☹ level, and
- Management of waste and whey in an appropriate ☺, intermediate 😐 or inadequate ☹ manner.

The information presented in this section has been obtained from the data included in questionnaires filled in by the countries. This information does not seek to make any value judgement on the environmental performance of industries but to point out, based on the stated data, several possible initiatives in order to implement measures aimed at prevention of pollution at the source.

<table>
<tr><td>
ALBANIA</td><td>No. of dairy firms: 330
Production (tons/year)
- Fresh milk: 10,242
- Yogurt: 5,310
- Cheese: 8,403
- Butter: 440
- Cream: 1</td><td colspan="3">% Production</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td></td><td></td><td>>75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td></td><td></td><td>>75</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td></td><td></td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td></td><td></td><td>>75</td></tr>
</table>

RECOMMENDATIONS

1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).
6. Replace batch pasteurization systems with continuous systems in the larger firms.
7. Establish a system for the collective gathering of whey from small firms for centralized recovery.

In Albania, the dairy industry is poorly developped (only 25% of total milk is pasteurized; the rest is sold directly on farms). Furthermore, production is rather traditional. At a legislative level, the standards concerning dumping limits of industrial effluents are still in preparation. Thus, cleaner production in the dairy industry in Albania still has to be defined.

Because of that, it is recommended to start with promotion of environmental awareness as well as introducing Good Housekeeping Practices.

<table>
<tr><td>**ALGERIA**</td><td>No. of dairy firms: 19
Production (tons/year)
- Fresh milk: 72,730
- Yogurt:
- Cheese: 37,024
- Butter: 10,000
- Cream: 5,000</td><td colspan="3">**% Production**</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>—</td><td>—</td><td>25-75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>—</td><td>—</td><td>25-75</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td>25-75</td><td>—</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td>—</td><td>>75</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
</table>

1. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-15, 16 and 18).
2. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
3. Recover whey for animal feeds or for use in advanced systems of recovery (see OPC-7 and 8).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Replace batch pasteurization systems with continuous systems in the larger firms (see OPC-4).
6. Progressively replace manual cleaning systems with CIP systems (see OPC-17). Standardize cleaning procedures.
7. Organize internal environmental awareness promotion and training programmes in all 19 firms.
8. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).

Water and energy consumption are generally high. In order to solve this problem, Good Housekeeping Practices should as a first step be introduced, along with minimization programmes. The Algerian government has foreseen creating a fund consisting of financial aid to enterprises aiming at reducing pollution.

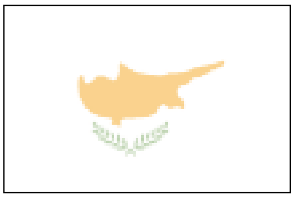
<table>
<tr><td>BOSNIA-HERZEGOVINA</td><td>No. of dairy firms: 16
Production (tons/year)
- Fresh milk: 24,802
- Yogurt:
- Cheese: 4,311
- Butter: 1,179
- Cream: 897</td><td colspan="3">% Production</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>—</td><td>25-75</td><td>25-75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>—</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td>—</td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td>—</td><td>>75</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
<tr><td colspan="5">1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).
6. Replace batch pasteurization systems with continuous systems in the larger firms.
As a first step, interest in cleaner production should be fostered by means of promoting environmental awareness and training programmes, as well as introducing Good Housekeeping Practices.</td></tr>
</table>

<table>
<tr><td>CROATIA</td><td>No. of dairy firms: 34
Production (tons/year)
- Fresh milk: 271,116
- Yogurt: 54,178
- Cheese: 15,282
- Butter: 1,743
- Cream: 1,147</td><td colspan="3">% Production</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td><25</td><td>25-75</td><td><25</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td><25</td><td>25-75</td><td><25</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td><25</td><td>25-75</td><td><25</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td><25</td><td>25-75</td><td><25</td></tr>
</table>

RECOMMENDATIONS

1. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-13, 15, 16 and 18).
2. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with final effluent (see OPC-2).
3. Recover whey and use it as animal feed (see OPC-7 and 8).
4. Provide for the proper management of waste through sorting at the source (see OPC-26).
5. Recover energy in the used condensation in the heating of milk (see OPC-5).
6. Use cleaner fuels; for example, natural gas.
7. Initiate training programmes for environmental specialists.

The use of cleaner technologies, Good Housekeeping Practices and projects for recovering whey should be promoted.

<table>
<tr><td>
CYPRUS</td><td>No. of dairy firms: 133
Production (tons/year)
- Fresh milk: 61,664
- Yogurt: 6,820
- Cheese: 7,956
- Butter: 440
- Cream: 792</td><td colspan="3">**% Production**</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>—</td><td>>75</td><td>—</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td>—</td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td>>75</td><td><25</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
<tr><td colspan="5">1. Provide for the proper management of waste through sorting at the source (see OPC-26).
2. Minimize packing waste, reduction of defective bottling and introduce recovery or recycling systems for used packaging (see OPC-25).
3. Avoid the loss of milk during processing (see OPC-2).
4. Use leftover production; for example, for feeding animals.
5. Reduce pollutant load in wastewater produced by the processing of cheese (see OPC-9 and 11).
Correct management of waste generated should be given special attention, by promoting projects aiming at recovering whey for animal use.</td></tr>
</table>

 **EGYPT**	No. of dairy firms: 3,334 Production (tons/year) - Fresh milk: 30,000 - Yogurt: 2,500 - Cheese: 310,000 - Butter: 130,000 - Cream:	**% Production**		
	Level	☺	😐	☹
WATER consumption		<25	<25	>75
ENERGY consumption		—	—	—
Pollution of WASTEWATER		<25	<25	>75
Management of WASTE and WHEY		<25	25-75	25-75

RECOMMENDATIONS

1. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32).
2. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
3. Provide for the sorting of waste at the source for later management (see OPC-26).
4. Continue the trend of introducing CIP cleaning systems, reusing cleaning products where new systems are introduced (see OPC-17 and 19).
5. Where manual cleaning systems are used, introduce measures to reduce water consumption (see OPC-14, 15, 16 and 18).
6. Avoid the loss of milk in processing and reduce the quantity of milk incorporated into the final effluent.
7. Use continuous processes instead of batch processes (see OPC-4).
8. Use milk residues in other products or using it in animal feed.
9. Introduce measures for recovering energy (see OPC-5).
10. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).

In Egypt, there are initiatives related to cleaner production in the dairy industry. A project for use of whey in animal feed has been successfully developed. Following this trend is recommended, by promoting these kind of projects not only in most advanced firms but also in the small ones.

ISRAEL	No. of dairy firms: 15 Production (tons/year) - Fresh milk: 872,927 - Yogurt: 56,152 - Cheese: 100,000 - Butter: 5,235 - Cream: 77,686	**% Production**		
	Level	☺	😐	☹
WATER consumption		<25	25-75	25-75
ENERGY consumption		<25	25-75	25-75
Pollution of WASTEWATER		<25	25-75	25-75
Management of WASTE and WHEY		<25	25-75	25-75

RECOMMENDATIONS

1. Introduce minimization plans, beginning with avoiding loss of product during production and incorporation of that waste into the final effluent (see OPC-2).
2. Use whey; for example in animal feed (see OPC-8).
3. Reduce pollutant load in effluents generated by cheese production (see OPC-9 and 11).
4. Recover cleaning products where CIP systems are being introduced (see OPC-19).
5. Reduce packaging waste and defects in the packaging process.
6. Replace fuel oil with cleaner fuels; for example, natural gas.
7. Sort waste at the source (see OPC-26).

In Israel there is regulations concerning dumping from dairy firms, particularly significant restrictions related to brine. In order to achieve compliance with the law, several environmental projects are set about.

<table>
<tr><td>ITALY</td><td colspan="3">No. of dairy firms: 2,133
Production (tons/year)
- Fresh milk: 3,100,000
- Yogurt: 190,000
- Cheese: 958,062
- Butter: 105,000
- Cream: —</td><td colspan="3">% Production</td></tr>
<tr><td colspan="4">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="4">WATER consumption</td><td><25</td><td><25</td><td>25-75</td></tr>
<tr><td colspan="4">ENERGY consumption</td><td><25</td><td>25-75</td><td>25-75</td></tr>
<tr><td colspan="4">Pollution of WASTEWATER</td><td><25</td><td>25-75</td><td>25-75</td></tr>
<tr><td colspan="4">Management of WASTE and WHEY</td><td>25-75</td><td>25-75</td><td>—</td></tr>
<tr><td colspan="7">RECOMMENDATIONS</td></tr>
<tr><td colspan="7">1. Promote environmental awareness and organize environmental training programmes for workers and technicians in dairy firms.
2. Reduce pollution load in wastewater generated by the production of cheese; for example, through the recovery of brine (see OPC-11).
3. Reduce water consumption through techniques for eliminating salt from cheese, using dry processes (see OPC-9).
4. Optimize energy consumption; for example, through the recovery of energy in the treating of milk with heat (see OPC-5).
5. Recover cleaning products where CIP systems are used (see OPC-19).
6. Improve the maintenance of boilers, refrigeration systems and other systems (see OPC-20, 21 and 22).
In Italy, milk production is considerably high and the dairy enterprises have advanced technologies. Special attention should be given to projects aiming at reusing effluents.</td></tr>
</table>

<table>
<tr><td>LEBANON</td><td>No. of dairy firms: —
Production (tons/year)
- Fresh milk: 4,042
- Yogurt: —
- Cheese: 21,091
- Butter: —
- Cream: —</td><td colspan="3">% Production</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td><25</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td><25</td><td>25-75</td><td>25-75</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td><25</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td><25</td><td><25</td><td>25-75</td></tr>
</table>

RECOMMENDATIONS

1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Establish a system for the collective gathering of whey from small firms for centralized recovery.

Concern in dairy firms is focused more largely on milk production and improvement of both hygiene and quality, rather than on cleaner production or pollution prevention.

On the other hand, waste reuse, cleaner technologies and rational consumption of energy are still new concepts in Lebanon.

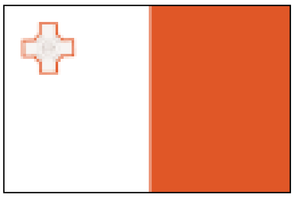
Because of the previously mentioned, Good Housekeeping Practices should be introduced, since this does not require considerable economical efforts.

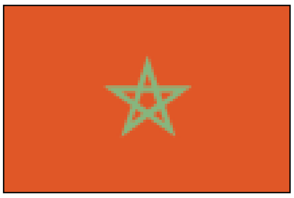
<table>
<tr><td>LYBIA</td><td>No. of dairy firms: 12
Production (tons/year)
- Fresh milk: 57,000
- Yogurt: 14,000
- Cheese: 100
- Butter: —
- Cream: —</td><td colspan="3">% Production</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>>75</td><td>—</td><td><25</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>>75</td><td>—</td><td>—</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td>>75</td><td>—</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td>—</td><td>>75</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
</table>

1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices, especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Manage the use of water in processing (see OPC-12).
4. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
5. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
6. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).
7. Replace batch pasteurisation systems with continuous systems in the larger firms.
8. Establish a system for the collective gathering of whey from small firms for centralized processing.
9. Recover cleaning products in order to reuse chemicals (see OPC-19).

In Libya, small dairy firms are mainly owned by the government, except from small traditional enterprises.

There are already some firms having means of treating wastewater.

<table>
<tr><td>
MALTA</td><td>No. of dairy firms: 1
Production (tons/year)
- Fresh milk: 30,200
- Yogurt: 1,510
- Cheese: 2,300
- Butter: —
- Cream: 360</td><td colspan="3">**% Production**</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td><25</td><td>>75</td><td>25-75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>25-75</td><td>25-75</td><td><25</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td><25</td><td>—</td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td><25</td><td>—</td><td>>75</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
<tr><td colspan="5">1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices, especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).
6. Replace batch pasteurisation systems with continuous systems in the larger firms.
7. Establish a system for the collective gathering of whey from small firms for centralized recovery.
There are many possibilities of environmental improve, especially concerning use of whey.</td></tr>
</table>

<table>
<tr><td>
MOROCCO</td><td>No. of dairy firms: 38
Production (tons/year)
- Fresh milk: 860,000
- Yogurt: 390,000
- Cheese: 10,686
- Butter: 10,000
- Cream: 66</td><td colspan="3">**% Production**</td></tr>
<tr><td colspan="2">Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>—</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td><25</td><td>25-75</td><td><25</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td><25</td><td>25-75</td></tr>
<tr><td colspan="5">RECOMMENDATIONS</td></tr>
<tr><td colspan="5">1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32), especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Establish a system for the collective gathering of whey from small firms for centralized recovery.
Due to current status of environmental management, introduction of Good Housekeeping Practices would be very useful, contributing to significantly improve it.</td></tr>
</table>

SPAIN	No. of dairy firms: 1,511 Production (tons/year) - Fresh milk: 3,645,400 - Yogurt: 581,600 - Cheese: 293,800 - Butter: 36,200 - Cream: 86,000	**% Production**		
	Level	☺	😐	☹
WATER consumption		<25	25-75	<25
ENERGY consumption		<25	25-75	—
Pollution of WASTEWATER		<25	25-75	<25
Management of WASTE and WHEY		—	25-75	25-75

RECOMMENDATIONS

1. Introduce Good Housekeeping Practices (see OPC-29, 30, 31 and 32).
2. Use whey (see OPC-4).
3. Reduce pollutant load in wastewater generated by cheese production; for example, through the recovery of brine (see OPC-10 and 11).
4. Reduce the consumption of water through techniques for eliminating salt from cheese, using dry processes (see OPC-9).
5. Optimize energy consumption; for example, through the recovery of energy in the treating of milk with heat (see OPC-5).
6. Recover cleaning products where they are used in a CIP cleaning systems (see OPC-19).
7. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20, 21 and 22).
8. Introduce cogeneration systems in order to optimise energy use (see OPC-28).

Programmes financing projects for preventing pollution and promoting cleaner technologies should encourage Spanish firms launch advanced projects regarding use of whey and zero dumping.

<table>
<tr><td rowspan="2">SYRIA</td><td>No. of dairy firms: 31
Production (tons/year)
- Fresh milk: 14,111
- Yogurt: 7,030
- Cheese: 82,170
- Butter: 3,356
- Cream: —</td><td colspan="3">% Production</td></tr>
<tr><td>Level</td><td>☺</td><td>😐</td><td>☹</td></tr>
<tr><td colspan="2">WATER consumption</td><td>—</td><td><25</td><td>>75</td></tr>
<tr><td colspan="2">ENERGY consumption</td><td>—</td><td>>75</td><td><25</td></tr>
<tr><td colspan="2">Pollution of WASTEWATER</td><td>—</td><td>>75</td><td><25</td></tr>
<tr><td colspan="2">Management of WASTE and WHEY</td><td>—</td><td><25</td><td>>75</td></tr>
</table>

RECOMMENDATIONS

1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices, especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Avoid the dumping of whey and establish a system for gathering and use of whey (see OPC-7 and 8).
6. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Introduce measures to reduce water consumption (see OPC-12).

Most unattended environmental aspects are water consumption and management of waste and whey. There is an initiative regarding reuse of whey that will be shortly developed. Water consumption could be significantly reduced by introducing Good Housekeeping Practices. This solution is perfectly feasible both for large enterprises and small-sized traditional firms (which represent 70% of total number of firms), since they are generally simple operations with low cost.

TURKEY	No. of dairy firms: 4,320 Production (tons/year) - Fresh milk: 251,632 - Yogurt: 204,961 - Cheese: 201,260 - Butter: 15,771 - Cream: 1,383	**% Production**		
	Level	☺	😐	☹
WATER consumption		<25	<25	>75
ENERGY consumption		<25	<25	>75
Pollution of WASTEWATER		<25	<25	>75
Management of WASTE and WHEY		<25	<25	>75

RECOMMENDATIONS

1. Promote environmental awareness and organize environmental training programmes for workers. Publish information material and distribute it to all firms.
2. Introduce Good Housekeeping Practices, especially those related to cleaning operations (see OPC-15, 16 and 18).
3. Avoid loss of milk during processing and, above all, prevent the mixing of milk residues with wastewater (see OPC-1 and 2).
4. Establish at least a pre-treatment system for wastewater consisting of homogenization and sterilization processes before dumping (see OPC-27).
5. Improve the maintenance of boilers, circuits and refrigeration systems (see OPC-20 and 21).
6. Replace batch pasteurization systems with continuous systems in the larger firms.
7. Establish a system for the collective gathering of whey from small firms for centralized recovery.

In Turkey, milk production is considerably high although the enterprises are primarily traditional, and only 0.5% of the total number of firms have advanced technologies. Introducing Good Housekeeping Practices for these firms would be the most suitable.

8. BIBLIOGRAPHY

8.1. Reference material

AINIA, 1998: *Manual de buenas prácticas medioambientales.*

AINIA: *Guías Tecnológicas. Directiva 96/61 relativa a la prevención y control integrados de la contaminación. Sector Agroalimentario.*

AJKA *Information Memorandum 2000.*

Brennan J.G., Butters J.R., Cowell N.D., Lilley A. E.V., 1998. *Las operaciones de la ingeniería de los alimentos.* Editorial Acribia.

CEAS Consultants (Wye) Ltd, Centre for European Agricultural Studies, The European Forum on Nature Conservation and Pastoralism, 2000: *The environmental impact of dairy production in the EU: practical options for the improvement of the environmental impact.* Final report for European Commision (DGXI).

Confederación Española de Organizaciones Empresariales. Agencia Española de Cooperación Internacional, 1999: *Proyecto CEOE TT PYMEs en Egipto. Sector Lácteo.*

Haidar, J., 2001: *Agriculture in Lebanon.* Lebanese American University.

Hyginov C., 2001. *Guía para la elaboración de un plan de limpieza y desinfección.* Editorial AranAcribia

Instituto Nacional de Estadística (INE): *Encuesta Anual de Empresas.*

Kiermeier F., Wildbrett G., 2000. Principios básicos de la limpieza. En *Limpieza y desinfección en la industria agroalimentaria.* Editorial Acribia. P. 67-84.

Klopcic, M., Habe, F.: *Extension Service and Quality of Milk in Slovenia.* University of Ljubljana.

López A. y Hernández A., 1995. *Eficiencia energética de las industrias catalanas de procesado de leche líquida.* Alimentación. Equipos y Tecnología. Julio/agosto: pág.: 35-42.

Luquet F.M., 1991: *Leche y Productos Lácteos.* Editorial Acribia.

Omil F. y Morales F. J., 1996: *Alternativas de tratamiento y recuperación de compuestos proteicos de los efluentes residuales del sector lácteo.* Alimentación, Equipos, Tecnología.

Paine F. y Paine H., 1994. *Manual de envasado de alimentos.* Ediciones A. Madrid Vicente.

PUIG-DURÁN FRESCO J., 1999. *Ingeniería, Autocontrol y Auditoría de la Higiene en la Industria Alimentaria.* Editorial Mundi-Prensa.

Rapporto Assolatte Industria Lattiero-Casearia Italiana, 2000.

Secretaría General Técnica. Ministerio de Agricultura, Pesca y Alimentación, 2000: *Hechos y cifras del Sector Agroalimentario Español.*

SPREER E., 1991. *Lactología Industrial.* Editorial Acribia.

Statistic of food association (Syria), 2001.

Statistics Year Book Egypt, 2000.

Syrian Standard, 1995.

Turkish National Water Pollution Control Act., 1988.

UNEP, 2000: *Cleaner production assessment in dairy processing.* United Nations Publications. 95 pp.

USDA Foreign Agricultural Service: *GAIN Reports* (Global Agriculture Information Network).

VEISSEYRE R., 1988. *Lactología Técnica. Composición, recogida, tratamiento y transformación de la leche.* Editorial Acribia.

8.2. Other sources of information:

AECI (Spain).

Arab Federation for Food Industries.

Central Administration for Statistics of Lebanon.

Central Agency for Public Mobilization and Statistics of Egypt.

Central Bureau of Statistics of Israel.

Centre Marocain de Production Propre.

Croatian Central Bureau of Statiscs.

Cyprus Organisation of Dairy Products.

Danish Environmental Protection Agency.

Departamento Español de Aduanas.

Israel Embassy.

EPAP, EEAA (Egypt).

Faculty of Agriculture by University of Zabreg.

FENIL (Federación Nacional de Industrias Lácteas).

Food Research Institute.

General Dairy Product (Lybia).

Greek Ministry of Agriculture.

Household Consumption Survey of Croatia.

IGEME. Turquía.

Industrial Statistics.

INSTAT.

Institut National de la Statistique. Republique Tunisienne.

Institute of Statistics of Albania.

Instituto Nacional de Estadística Español.

ISTAT (Italy).

MA (France).

MAI (Israel).

Manufacturers Association of Israel.

Ministère de l'Agriculture, du Développement Rural et des Eaux et Forêts.

Ministerio de Agricultura, Pesca y Alimentación. FIAB (Spain).

Ministry of Agriculture and Rural affairs of Turkey.

Ministry of Commerce, Industry and Tourism of Cyprus.

Ministry of Industry of Algeria.

Ministry of Industry of Syria.

Ministry of Public Economy and Privatisation of the Republic of Albania. National Agency of Privatisation.

National Institute of Statistics and Economic Studies France.

National Office of Statistics of Algeria.

National Statistical Institute of Italy.

National Statistical Service of Greece.

National Statistics Office of Malta.

SEAM/Entec (Support for Environmental Assessment and Management).

State Institute of Statistics Turkey.

Statistical Office Slovenia.

Statistical Service of Cyprus.

Statistics Directorate Morocco.

UNEP.

8.3. On-line resources:

Corporate Information: http://www.corporateinformation.com

Euromilk. European Dairy Industry Figures: http://www.eda.euromilk.org

FAOSTAT Database: http://www.fao.org

Tradeport Food Market Reports: http://www.tradeport.org

TABLES

FIGURES