MEDITERRANEAN

Pollution Prevention in
Food Canning Processes

CLEANER production

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

UNEP

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 if you could notify it to us.

Study finished on November 2000
Study published on March 2001

Additional copies or information could be requested to:

Regional Activity Centre for Cleaner Production (RAC/CP)

C/ París, 184 – 3ª planta
08036 Barcelona (Spain)
Tf. +34 93 415 11 12 - Fax. +34 93 237 02 86
e-mail: cleanpro@cema-sa.org
Web page: http://www.cema-sa.org

TABLE OF CONTENTS

CHAPTER IV

CHAPTER I

BACKGROUND AND INTRODUCTION

1.1 Context

1.1.1 Objective

The Regional Activity Centre for Cleaner Production (RAC/CP) of the Mediterranean Action Plan (MAP) has made this study on *Pollution Prevention in Food Canning Processes in the Mediterranean Region*. Its object is to gather relevant data to provide information on the environmental impact of food canning activities in the Mediterranean region and mainly to present opportunities that can be applied for preventing pollution in this sector.

The aim is to provide a reference tool and food for thought for experts and manufacturers in the Mediterranean that help them at the decision-making level to incorporate environmental criteria into company management.

1.1.2 Scope

This is a survey on industrial activities that specialise in the production of canned animal (fish and meat) and vegetable foodstuffs.

There are substantial differences between what is conventionally known as canned food (a foodstuff preserved in a can or glass jar) and what preserved food is in technical terms. The criterion used to choose the different product families is not precise but based mainly on environmental considerations with the intention of dealing with processes that would be difficult in specific studies. In this respect, the scope of the survey has been reduced in order for its perspective to be as minimally abstract as possible.

For the reasons explained in the previous paragraph, consideration within the scope of this survey is not given to preserved milk (sterilised and UHT milk), slaughterhouse activities or cured meat products for it is considered that these deserve specific attention.

1.2 Survey methodology

The strategy used in developing this survey can be summarised under the following points:

- Prioritise in the survey the most significant products in each area and in general in the entire Mediterranean region.
- Establish organised levels of data on the region that are more in-depth on each level in order to arrive at opportunities for preventing pollution.
- Maintain all levels of data open during the project and to sequentially close them as the deadline for it to be submitted approaches until the report is consolidated.
- Base the survey on documentary sources, the Internet and on-line enquiries. In cases where there is a lack of information, to search directly by means of field work.

The project is structured around the search for the following seven levels:

N1. Types of food and containers (type of product, the format and material of the container).

N2. Canning technologies (prior processing of the food, preservation treatment and canning or bottling itself).

N3. Canning technology auxiliary operations (steam, cleaning, water purification, materials logistics).

N4. Characteristics of the environmental aspects that derive from canning technologies and the corresponding auxiliary operations.

N5. Environmental impact of the waste flows and problems in the context of the environmental situation of the countries in the Mediterranean region.

N6. Opportunities for pollution prevention at source offered by the technologies that are identified through the consideration of their contribution to reducing environmental impact.

In order for the information to be compiled efficiently, the search process has been divided into two main stages:

General compilation of information. In this process, information has been compiled on all levels from the following sources:

- Libraries and documentary sources
- Official bodies and manufacturers' associations
- Documentary information from manufacturers on equipment for carrying out the operations studied

Specific compilation. Gaps in the information have been identified through analysis of the information obtained. Points of inquiry have also been identified. In order to cover gaps in the information, questionnaires that cover the identified points have been drawn up. The points of inquiry have been:

- Manufacturers
- Manufacturers' associations
- Consumer associations
- Expert consultants, National Focal Points of RAC/CP
- Technology and canning equipment suppliers
- Organisations and agencies connected with environmental quality

This survey has been drawn up from the data that have been compiled.

1.3 Structure of the survey report

The survey is structured around the following points:

1.3.1 The main canned foodstuffs in the mediterranean region

An overview is given of the primary production of foodstuffs that are canned in the Mediterranean region, together with the most important aspects in each country.

The different products are then classified in families that form the basis of the survey in the following chapters.

1.3.2 Food canning processes and environmental aspects and impacts

The main canning processes in each of the families are reviewed, the main environmental aspects are enumerated and quantified and environmental impacts in this sector are assessed in different scenarios. Auxiliary operations are also analysed in the same way.

This point is structured according to a particular outline that is given in the introduction to the chapter in order to be able to describe as accurately as possible those aspects that are common as well as specific to the sector.

1.3.3 Opportunities for preventing pollution at source

The most significant opportunities for preventing pollution for the sector have been selected on an intuitive basis, with details of the processes for those that are most significant.

Opportunities that have been detected and that enable the canning industry in general to minimise its impact on the environment are described as follows:

- Introduction
- Technical aspects
- Determining factors
- Improvements
- Application example

1.3.4 Proposals and final conclusions

The main proposals for minimising impacts on the environment are compiled and an analysis made of the principal challenges and trends in the prevention of pollution in this sector.

1.4 Food and the food canning industry in the Mediterranean region

Eating is a basic activity of the human species. The type of food is strongly connected with the natural resources of each region. With the passing of time, food type has come to form part of the culture of the different nations and is one of the most influential cultural elements in the individuals of a given culture.

The so-called “Mediterranean diet” has gained great prestige in recent years. Numerous studies point out that people in the Mediterranean region have a lower tendency to suffer from certain illnesses and that the cause of this outstanding phenomenon lies in certain foodstuffs that the diet in this region is composed of or, to be more precise perhaps, in the appropriate combination of these in the diet.

The preserved foodstuffs that are considered within the scope of this survey are relatively modern types of food. Right from the beginnings of his evolution, man has always looked for ways to preserve food resources that nature offers in superabundance during certain periods and denies in others. Salting, curing, smoking and dehydration were all discovered in time but all of these processes slightly modified the characteristics of the original fresh food. It wasn‘t until the discoveries made by Appert (a combination of heat treatment and hermetic sealing of the food) that it became possible to preserve foodstuffs in a state that is relatively similar to its fresh state. These results were improved some years later with the introduction of freezing techniques.

Canned foods are the great contribution of the eighteenth century to the world of food. They completely modify the range of food that is available. All of a sudden, meat, fish and vegetables can be preserved for weeks and months in a state that is very similar to its original form. Canned food symbolised a revolution for those in charge of provisioning an army or a crew on board ship during long voyages.

As a result of new technologies that have appeared, canned food no longer has this basic function of feeding certain populations in advanced societies and today they are just one more type of food in the wide range of foodstuffs that are available.

There is an endless number of types of food in the Mediterranean area that are commercialised as canned food. As preserved food appeared in time as an answer to society‘s need for food, the traditional foodstuffs of the region were converted into preserved food. There was an important boom and development in the canning industry in the Mediterranean area during the nineteenth century and the first half of the twentieth century that has been maintained up until the present day.

While the basic technology for producing canned food has evolved very little during recent years, the equipment and installations designed for this function have undergone variations, together with the types and materials of the containers used.

The canning industry in the Mediterranean has a rich diversity of products just like the Mediterranean culture itself, irregular in terms of its location, with strong roots in the tradition of the characteristic flavours of the preserved food and in the process of a profound transformation to face new challenges in the future.

The new challenges in the future that the food industry must face and resolve quickly lie in taking old systems of food production that are based on the former way that the environment was perceived and transforming them into systems that are less aggressive on the environment. The main axes of this transformation are:

- The use of renewable forms of energy that do not reduce the planet‘s limited energy reserves.
- The use of resources and raw materials that are renewable or subjected to safe recovery processes.
- No emission or disposal of any substance that modifies or deteriorates the natural environment and the life forms that develop in it.
- To not produce any product whose consumption may cause a decrease in natural reserves, or cause the deterioration or modification of the natural environment.

This survey seeks to make a step forward in this direction by presenting a series of strategies and opportunities for preventing pollution and facilitating management and decision-making in companies that specialise in food canning processes in the Mediterranean region.

CHAPTER II

THE MAIN CANNED FOODSTUFFS IN THE MEDITERRANEAN REGION

Canned foodstuffs are very diverse in the Mediterranean region and they are adapted to the nature of the product and the dietary habits of the market that they are assigned to.

In order to establish the environmental problems facing the food canning industry as a whole, the diversity of preserved foodstuffs has been grouped into so-called families with products that use basically similar raw materials and processes of preparation and preservation. The families that have been established appear in table 2.1 on the following page.

A brief description is given in the following sections of the main characteristics of the various types (or families) of processing.

2.1 Description of the different types of canned food processing

2.1.1 Canned fish

2.1.1.1 Family 1. Canned tuna

Canned tuna is a product that is obtained from the corresponding species, with practically no scales, blood, skin or bones.

For products to be considered as canned, they are packed in hermetic metal tins and appropriately sterilised and stabilised by heat means. Canned tuna is presented in vinegar, oil or different types of sauce.

The processing industries of this type of canned food are generally located on the coast although some are to be found inland. The ones on the coast have the possibility of using duly treated seawater in some of the stages of the production process.

2.1.1.2 Family 2. Canned clupeids, mackerel and garfish

Products obtained from species like *Sardina pilchardus* (sardine)*, Scomber scombrus* (mackeral) and *Belone belone* (garfish) with the head and viscera removed.

Canning is done using olive oil, other edible oils and also appropriate sauces. The containers are made of metal and are hermetically sealed and appropriately sterilised by way of thermal treatment.

The presentation of these canned foods is similar to those for tuna.

Most factories that pack tuna also pack this family so that they can take advantage of the seasonal nature of the fishing of different species and also process the different products according to the season.

2.1.1.3 Family 3. Canned cephalopods

These are canned foods prepared from species that are also very diverse such as *Octopus sp.* or *Eledone sp.* (octopus), *Loligo sp.* (squid), *Sepia officinalis* (cuttlefish) and other similar varieties and hybrids.

These are canned in brine, edible oils or appropriate sauces, with or without their ink, spices, condiments and other edible ingredients in hermetic tins and sterilised by a thermal treatment technique.

2.1.1.4 Family 4. Canned molluscs

Examples of mollusc species used for canning are *Mytilus edulis* (mussel), *Venerupis sp., Spisula sp. o Ruditapes sp.* (clam), *Ensis ensis* (razor shell), *Pecten maximus* (scallop), *Cerastoderma edule* (cockle) and other similar varieties and hybrids.

They packed in hermetic tins, a covering liquid is added and then they are conveniently sterilised by thermal treatment.

2.1.1.5 Family 5. Semi-cured anchovy and clupeid products

The production of these preserved foodstuffs can in the majority of cases be considered to be a craft industry because the establishments that produce them are often small and are hardly mechanised.

The production process for semi-cured fish products must be done very carefully in order to achieve a high level of quality and raw materials must be used that are fresh and that have technologically homogeneous characteristics. As they are semi-cured, these products are not subjected to heat treatment so they must be kept preferably under refrigeration until they are consumed.

2.1.1.6 Family 6. Other preserved fish products

Products included in this family are difficult to classify in the previous families although they must be given consideration due to their importance both industrially and in terms of consumption.

One of these preserved foodstuffs is caviar. It is made from the roe of different species of fish, including the sturgeon that is one of the most highly valued. It is considered to be a luxury product that not everybody can afford, although there is a wide range of varieties according to both the source species and the quality that make caviar more readily available.

The characteristics of fish pâté vary according to the area where it is produced and even between the various processing factories in a particular region. The basis is always the same: fish paste that is either emulsified or not, together with different ingredients, condiments and additives that are added to give it its organoleptic characteristics. It is a highly processed product that that can go off very easy and for this reason it is preserved in metal tins or glass jars and put through a heat treatment to stabilise and preserve it.

2.1.2 Canned fruit

Fruit plays a very important role in the human food supply in the Mediterranean region for it provides essential minerals and vitamins and makes for a more varied diet.

2.1.2.1 Family 7. Fruit juice and nectars

Fruit juice is made by mechanically liquidising the fruit so that the resulting product has the characteristic colour, aroma and taste of the fruit from which it is made.

Fruit nectar is made by adding water and/or sugar to fruit juice.

2.1.2.2 Family 8. Fruit jams and marmalades

Jam is the product made by cooking whole, cut or minced fruit that is strained or not and to which sugar is added to achieve a semi-liquid or thick product.

Marmalade is the product obtained by mixing sugar and the pulp or purée of one or more species of fruit. The product must have an appropriately gelled consistency.

2.1.2.3 Family 9. Fruit in syrup

These are products obtained by sterilising fruit with the addition of syrup as a covering liquid. They come as whole fruit, halves or regularly sliced.

2.1.3 Canned vegetables

The case of vegetables is equivalent to that of fruit because they are also very important in the human food supply in the Mediterranean region for they provide essential minerals and vitamins and also make for a more varied diet.

2.1.3.1 Family 10. Vegetables preserved in their own juice

These are preserves obtained by sterilising vegetables with or without a covering liquid. They come as whole vegetables or sliced.

A very widespread product is preserved cooked pulses that maintain all of their nutritional properties as well as providing the important added value of saving time and work in preparation.

Sauces include preserved foods that are made of vegetables that have been crushed and often have condiments and other ingredients added. The most common example of this type of canned foodstuff is crushed tomato that is very extensively used in the Mediterranean region.

2.1.3.2 Family 11. Vegetable pickles (in brine)

Vegetables conserved in brine and in appropriate containers. Heat treatment or any other procedure that ensures their preservation is used.

Special mention must be made of olives for this is a deep-rooted product in the whole of the Mediterranean region. Processing (pickling) is very similar in different countries, with variations in the use of aromatic herbs and other condiments that are added before and after fermentation. Olive quality depends on many factors, although one of the most determinant ones is the period of time between the harvesting of the fruit and the beginning of the preparation process.

2.1.4 Canned mushrooms

2.1.4.1 Family 12. Mushrooms preserved in their own juice

The preparation and method of preservation are analogous to those of vegetables in their own juice.

Mushroom cultivation is not very frequent in agriculture and the products are few and highly specialised. Moreover, mushrooms are traditionally consumed fresh which means that the volume of preserved mushrooms is relatively low.

2.1.5 Meat products

2.1.5.1 Family 13. Canned meat

Surpluses of livestock and of the meat obtained from them, especially in countries in the southern hemisphere, increased the need to process meat in order to optimise its use and reduce waste generation.

The preserved products from this family are obtained by the combining or condimenting of meat from cattle, pigs and fowl, with or without the addition of other authorised substances, contained in appropriate containers, hermetically sealed and available to be consumed directly.

One product that stands out in this family are pâtés, the basis of which is liver paste and/or meat in the form of a *mousse* to which an infinite number of ingredients and condiments can be added that give them their final organoleptic characteristics.

Other products to be considered are certain types of cooked sausage that are preserved. A summary is also given of the case of salted and cooked meat products due to their importance as regards waste and pollution.

2.1.6 Others

2.1.6.1 Family 14. Preserved ready-to-serve meals

The rapid change in lifestyle caused by urbanisation in all of the countries in the Mediterranean region leads to the need for foodstuffs that are easy, quick to prepare and of a controlled quality. The development of preserved ready-to-serve dishes also follows this trend.

These products are obtained by combining or condimenting foods of animal and/or vegetable origin, with or without the addition of other authorised substances, contained in appropriate containers, hermetically sealed and available to be consumed directly on being heated or given an additional domestic treatment.

Preserved ready-to-serve dishes are understood to be only those that are prepared and packaged as has been described and that are also heat treated so they have a long expiry date.

The nutritional quality of preserved ready-to-serve dishes is enhanced because the oxidation of nutrients that occurs during the refrigeration of a product is prevented. On the other hand, the end heat treatment to these dishes may affect the integrity of some nutrients.

Primary matters	Family number	Family description	Examples of products	Presentation	Conservation method	Type of packaging
Fishing products	1	Canned tuna	Tuna, bonito, sardine	In oil, vinegar or different types of sauces	Thermal treatment	Metallic
	2	Canned clupeids, mackerel and garfish	Sardine, herring, mackerel, pipefish	In oil, vinegar or different types of sauces	Thermal treatment	Metallic
	3	Canned cephalopods	Squid, cuttlefish, small squid, octopus	In oil, vinegar, in their ink, or different types of sauces	Thermal treatment	Metallic
	4	Canned molluscs	Mussels, cockle, pipefish, scallop, and cockle	In their own juice, in oil, Vinegar, in their ink or different types of sauces	Thermal treatment	Metallic
	5	Semi-cured anchovy and clupeid products	Anchovy, sardine, herring	In oil, vinegar, Salting	Salting, macerated	Metallic, glass, plastic
	6	Other products	Fish pâté	At natural, in oil, brine	Thermal treatment	Metallic, glass, plastic
Fruit	7	Fruit juice and nectars	Fruit Juice and nectars, fruit jam and marmalades	Squeezed, fruit in syrup, concentrated	Thermal treatment	Glass, plastic, tetra-brick
	8	Fruit jams and marmalades				
	9	Fruit in syrup				
Vegetables	10	Vegetables preserved in their own juice	Pea, artichoke, green bean, asparagus, pepper, beet, tomato, potato, onion, leek, pumpkin, carrot, corn, Soya, vegetable, mixed vegetables, crushed/ sauces	In their own juice	Thermal treatment	Metallic, glass, plastic, tetra-brick
	11	Vegetable pickles (in brine)	Olive, pickles, cabbage, caper bush	In brine	brine	Metallic, plastic, glass
Mushrooms	12	Mushrooms preserved in their own juice	Mushroom, other mushroom	In their own juice	Thermal treatment	Metallic, glass
Meat	13	Canned meat	Stew meat, meat pate, , pudding, meatball, and cooked sausage	According to product	Thermal treatment	Metallic
Various	14	Preserved ready-to-serve meals	Various	According to product	Thermal treatment	Metallic, plastic, glass, tetra-brick

Source: See bibliography

Table 2.1 Families of canned food processes

2.2 Main areas of production and characteristics

2.2.1 The general situation of the food industry sector in the Mediterranean region

Table 2.2 gives the general economic indicators of the countries included in this study. These data clearly show a division between countries that economically depend on the primary sector and those with economies that are based on industry.

A country with a low GNP and with a high percentage of this GNP devoted to agriculture and fishing indicates that production in the country basically goes on self-consumption subsistence. There will therefore be no developed industrial structure for these products in such countries.

Country	Year	GNP (milliards Euro, 1998)	Agriculture and fishing (% GNP)	Industry (% GNP)
Albania	1998	2.60	54.4	24.5
Algeria	1998	39.73	13.4	52.4
Bosnia-Her.	1998	1.85	—	—
Cyprus	1998	7.56	—	—
Croatia	1998	17.56	8.9	32.4
Egypt	1998	69.47	17.5	32.3
Slovenia	1998	16.38	4.0	38.6
Spain	1995	470.06	3.0	—
France	1995	1,058.40	2.4	26.6
Greece	1995	97.44	10.6	17.7
Israel	1998	105.00	—	—
Italy	1995	924.00	2.9	31.5
Lebanon	1998	14.44	12.4	26.5
Libya	—	—	—	—
Malta	1995	2.94	—	—
Morocco	1998	13.94	32.0	—
Monaco	—	—	—	—
Syria	1998	14.62	—	—
Tunisia	1998	16.80	12.4	28.4
Turkey	1998	166.99	17.6	25.4

Table 2.2. General economic indicators of MAP countries

On the other hand, there are countries with a high GNP, a low percentage of the GNP in the primary sector and a high industrial potential. In absolute terms, they are the main producers of food raw materials and a large proportion of their production goes to the processing sector as canned foods.

In conclusion, there are two distinct groups of countries, one with an abundant food processing industry, lead by France, Spain, Italy, Turkey and Egypt, and a second group in which agri-foodstuffs do not play a relevant role in the country’s economy. The first countries in the first group stand out for their production of canned foodstuffs.
Out of regard for other considerations, it is important to point out that the food industry in general and the canning industry in particular have had to restructure in order to be able to respond to social changes occurring in most of the Mediterranean region. Two of the most especially important of these social changes have been the concentration of most of the population in cities and the involvement of women in the labour market. These changes have without doubt lead to changes in agri-foodstuffs.

Table 2.3 on the following page gives a balance of production of the raw materials considered to be important for the production of preserved foodstuffs. This production is represented in the form of relative importance in the map given in Diagram 2.1. The following considerations are clear from these data:

- With regard to fishing, there are historical and traditional reasons why countries like France, Spain and Morocco have the largest catches in the Mediterranean region. However, these countries concentrate their large fleets in the Atlantic and even areas that are much further afield like the Pacific through the use of large factory ships. Morocco is a special case for it has a low-level industrial structure, yet it dominates very rich fishing areas, which give rise to large catches.

- Countries like Italy, Turkey and Egypt take appreciable catches of fish from the Mediterranean because of the fact that they have well-prepared fleets. Catches in the Mediterranean Sea are based on coastal fishing, shellfish and molluscs. The fishing boats are not large and problems of over-fishing and pollution do not allow large catches to be made in their waters. Italy also has large ships that fish a long way away from the Mediterranean.

- With regard to vegetables and fruit, production is very much determined by climatic conditions and the availability of water in the area. A big distinction can thus be made between the countries in the northern area of the Mediterranean that have few problems in this respect, and those in the southern Mediterranean area and the Near East where the availability of water does not permit the large scale production of vegetables and fruit.

- Farm structure is also important for vegetables and fruit. In the northern area (Spain, France, Italy, Greece, and Turkey fundamentally), farms in general are large and give high yields as a result of the terrain and climatic conditions, together with a high degree of mechanisation. In the south and in the Near East, the case is the opposite with small, mostly family-run and low-yield farms. The exception is in Egypt where there is an abundant production of vegetables and fruit along the whole of the River Nile.

- Meat production is concentrated in the more developed countries where intensive livestock production is more established, especially France, Spain and Italy. These countries also have the longest tradition of preserved meat products, which are produced above all from pork. Meat production in African countries with an Islamic tradition is based on sheep and goat livestock.

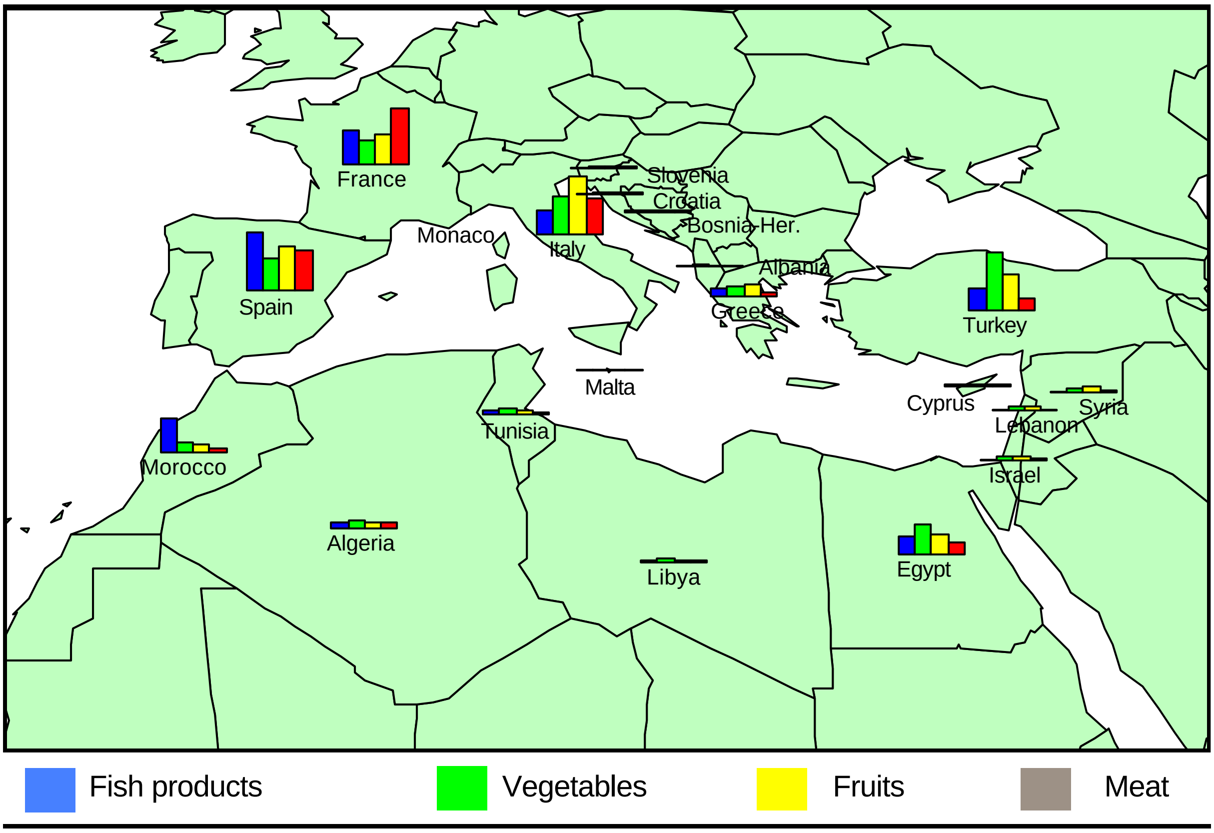


Figure 2.1 Map of raw materials production. 1998

Unit: 1000 Tm metrics

PRODUCT	FISHING PRODUCTS				FRUITS				VEGETABLES				MEAT			
COUNTRY	PRODUCTION	%	IMPORT	EXPORT	PRODUCTION	%	IMPORT	EXPORT	PRODUCTION	%	IMPORT	EXPORT	PRODUCTION	%	IMPORT	EXPORT
Albania	1	0.02	7	2	168	0.19	69	0	1096	0.77	35	10	60	0.29	18	0
Algeria	99	2.01	5	1	1588	1.84	15	10	4096	2.9	67	4	512	2.45	11	0
Bosnia-Her.	3	0.06	6	0	121	0.14	53	22	1143	0.81	44	16	24	0.11	56	1
Cyprus	3	0.06	51	0	298	0.35	26	81	259	0.18	16	29	96	0.46	5	4
Croatia	20	0.41	105	23	776	0.9	164	28	826	0.58	139	19	169	0.81	19	15
Egypt	419	8.5	272	1	7051	8.17	101	286	17577	12.43	12	354	1244	5.96	137	1
Slovenia	1341	27.19	1790	827	16045	18.6	1146	6607	19070	13.48	677	7165	4600	22.02	304	496
Spain	830	16.83	1889	549	11291	13.09	6555	2849	14972	10.58	4056	2949	6522	31.22	1123	1809
France	214	4.34	322	73	4336	5.03	364	1880	6168	4.36	188	1116	508	2.43	402	15
Greece	23	0.47	238	1	1601	1.86	169	683	2836	2	75	398	328	1.57	67	5
Israel	562	11.39	1413	223	21059	24.41	2514	5287	23255	16.44	1691	4964	4044	19.36	1359	362
Italy	4	0.08	39	0	1756	2.04	37	197	2266	1.6	223	55	109	0.52	20	0
Lebanon	33	0.67	29	6	458	0.53	41	1	1314	0.93	390	35	202	0.97	5	0
Libya	3	0.06	26	2	27	0.03	61	0	84	0.06	16	0	18	0.09	16	0
Malta	786	15.94	49	267	3088	3.58	24	583	5656	4	13	387	522	2.5	6	7
Morocco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monaco	3	0.06	32	3	269	0.31	152	38	175	0.12	129	12	183	0.88	32	31
Syria	0	0	0	0	2269	2.63	70	174	3107	2.2	0	337	310	1.48	0	0
Tunisia	89	1.8	11	16	1171	1.36	23	52	2867	2.03	84	84	193	0.92	4	2
Turkey	499	10.12	276	61	12887	14.94	188	2373	34680	24.52	39	1426	1244	5.96	0	10
TOTALES	4932	100			86259	100			141447	100			20888	100		

Source : FAO

Table 2.3. Primary matters balance 1998

2.2.2 Areas of production and their characteristics

The twenty countries that form the Mediterranean coastline and that are included in this study are:

Albania	Egypt	Israel	Morocco
Algeria	Slovenia	Italy	Monaco
Bosnia-Herzegovina	Spain	Lebanon	Syria
Cyprus	France	Libya	Tunisia
Croatia	Greece	Malta	Turkey

Below are details for each of the twenty countries on the characteristics of primary production, agri-foodstuffs in general and the canning industry in particular.

2.2.2.1 Albania

60% of the population is employed in agriculture, which shows the importance of the sector. The main crops are citrus fruit, grapes, olives, potatoes, sugar beet, corn and vegetables in general. Use is frequently made of surpluses from the fresh market as raw material for practically no crops are given over to this type of industry.

Factories processing preserved fruit and vegetables, together with those that produce canned fish and molluscs are scattered over the whole country although production as a whole is not abundant.

The main areas of preserved fruit and vegetable production are Vlora, Fier, Shijak, Elbasan and Shkoder.

The industries that specialise in canned fish and molluscs are equipped with machinery that is fairly old and that mostly originated from Eastern Europe. This will have an enormous influence when considering waste by these industries. The main areas of production of these types of preserved foodstuffs are Vlora, Durres, Lezha, Saranda and Korca.

The production of other types of preserved foodstuffs that have been mentioned is not very important, and there is the same problem of most factories that preserve foodstuffs being equipped with old machinery. A point of note is that Albania has been an important exporter of preserved foodstuffs to Eastern Europe up until the present time.

2.2.2.2 Algeria

The main crops from Algeria that are used to produce preserved foodstuffs are citrus fruit, olives, dates and vegetables in general. A large proportion of the date crop is exported, although dates cannot be considered a preserved foodstuff in the strict sense of the definition used here.

There has been a marked increase in the production of crushed tomato and tomato juice in this country, which has led to the recent increase in the planting and harvesting of this vegetable.

The fish canning industry in Algeria is underdeveloped despite the large maritime territory that the country controls. Alliances have been formed with industry in countries like Mauritania and Senegal to exploit their rich fishing grounds. Attempts are also being made to modernise the ports in order to increase their efficiency although the results have not been totally successful.

2.2.2.3 Bosnia-Herzegovina

The food industry is considered the most important sector in the country. Since the war, this has been the sector that has developed most and it is though to cover 65% of internal needs at the present time.

According to data from 1999, 58 food industries dedicated to food preservation are currently in operation in this country. These industries are centred especially near large cities such as Sarajevo, Mostar, Tuzla or Zenica.

2.2.2.4 Cyprus

Around 47% of the surface area of Cyprus is cultivated and agriculture and stockbreeding provide subsistence for most of the population. Despite investments in rural areas, however, agricultural production is insufficient to satisfy national demand so food products are, thus, one of the leading imports.

The main crops are potatoes, grapes, citrus fruit, barley, wheat, carob and olives. Livestock breeding is important, especially sheep and goats, although pigs, cattle and other animals are also bred. Milk products such as cheese and yoghurt are made from sheep and goat's milk. Fishing is not a significant source of wealth.

Although it is a small country, Cyprus also has an industrial structure that produces canned foodstuffs. Production is aimed almost exclusively at internal consumption and so exports of these products are therefore small.

There has been a decrease in the production of preserved foods since 1995. The total dropped from 9.5 tons produced in 1995 to approximately half of that figure (4.7 tons) in 1998.

2.2.2.5 Croatia

The pacification of the area of the former Yugoslavia in 1995 led to a great advance and permitted the inflow of foreign capital, the recovery of consumption and the increase in industrial production in Croatia.

With regard to cultivated products, the importance of agriculture in Croatia is limited and this situation has become more marked in recent years. The main crops are wheat, corn, sugar beet, barley and sunflower.

Fishing is a very important activity, with catches of around 20,000 tons per year (see the balance of raw materials table); fish farm production is also being developed.

Industry and mining account for 20% of the GNP, although the food industry is not one of the leading sectors: Croatia is clearly an importer of manufactured food products. 80% of industry is concentrated in the central region of Zagreb-Sisak-Karlovak.

2.2.2.6 Egypt

Agri-foodstuffs is an advancing sector in Egypt as a result of enormous efforts being made to reduce surpluses in fresh product markets.

The main products that are preserved are fruit, fruit juice and concentrates, vegetables (especially pulses and tomato products), canned fish and semi-cured herring (smoked).

A wide range of fruit is processed as juice, concentrate, jam, preserves and fruit in syrup. Production is seasonal as in other countries in the Mediterranean region. Vegetables also follow the same pattern of production.

The food processing industries are located particularly in the area of Sharkia, Cairo and Guiza and the volume of production is small/medium.

The gradual increase in food industry production in Egypt at the present time is being brought about by production capacity that was not totally taken advantage of in the past.

2.2.2.7 Slovenia

Slovenia is a predominantly agricultural country that has little industrial structure. Dairy production and livestock breeding dominate the farming sector. The main crops are corn, potatoes and wheat.

Industry in Slovenia accounts for 38.89% of GNP. The main industries in the Republic are electronics, electrical machinery, metallurgy and motor vehicles, and the food industry is thus not one of the main sectors in this country.

With regard to preserved food, the main products in this category are fruit and vegetable juice, followed by processed meat products.

2.2.2.8 Spain

Spain is one of the largest producers of preserved foodstuffs in the Mediterranean region, along with countries like France, Italy, Morocco and Turkey.

Spain has traditionally been an agricultural country and it is still one of the largest producers in Western Europe. The main cultivated products are wheat, barley, sugar beet, corn, potatoes, rye, oats, rice, tomatoes and onions. Large areas are also given over to vineyards, citrus fruit and olives.

The canning industry in Spain ranges from small cottage industries to large multinational food companies with a large capacity for production and development. The potential is in two sectors, fish products, and vegetables and fruit. These industries are located especially in areas like Murcia, Navarra, Galicia and Catalonia.

The fishing industry is important for the Spanish economy. Tuna, squid, octopus, hake, sardines, anchovies, mackerel, whiting and mussels make up the main catches. The canning industry that specialises in this sector has been affected by the progressive decrease in catches over recent years. This had been compensated with increased imports of raw materials. Nevertheless, production of these products is expected to continue to increase in the same way up until now.

2.2.2.9 France

The study of food preservation using heat treatment and sealed containers began in France during the eighteenth century. Nicolás Appert is considered to have been the first to use and to research this method.

35.4% of the total surface area of the country is cultivable and 5% of the working population is employed in agriculture, forestry and fishing.

The main crops are cereals, wheat, sugar beet, corn, barley and potatoes. Other important products are rye, oats, root vegetables, artichoke, flax, hemp and tobacco. Fruit cultivation totalled 11 million tons in 1998 and is a leading sector of the rural economy in France with large quantities of apples, pears, plums, peaches, apricots, cherries, olives, citrus fruits and nuts being produced.

The French fishing fleet is important and large catches are taken, mainly of oysters and shellfish. The most important commercial fish are cod, whiting and tuna.

France can be considered to be the main producer of preserved foodstuffs in the Mediterranean region. It is a country with a long industrial tradition of food preservation and it has a wide variety of products. Many of the techniques for preparing processed foodstuffs originate from France and have been adapted to the characteristics of products in each area.

Preserved meat products clearly predominate and there are an infinite variety of raw materials and processing methods used. These products are widely accepted in this country and abroad (the most obvious example being pâtés).

2.2.2.10 <u>Greece</u>

Greece is a market with strong contrasts. As it is a member of the European Union, business is not subject to any restrictions; the country’s geographical position and other factors, however, mean that sectors like agri-foodstuffs are mid-way between those of southern EU countries like Italy or Spain and those on the southern Mediterranean coastline or in the Near East.

Agriculture accounts for an important part of the GNP but productivity is lower than that expected for this sector of the economy. Drought and soil erosion have an enormous influence in this matter. The most important crops are tobacco, wheat, fruit (especially oranges and grapes), vegetables, corn, oil seed, potatoes and cotton.
Fishing is limited, with sponges being the main sea product that is exported. The fish canning industry is very limited.

The food industry is not an important part of the manufacturing sector. Canning industries are not therefore very extensive. Most of the industry is concentrated in the Athens area.

2.2.2.11 Israel

Agriculture has traditionally been very important in the economy of Israel although the primary sector only accounts for 2.6% of the GNP at present and 20% of agricultural production is exported. The main products are citrus fruit, followed by vegetables, fruit and seeds.

Agriculture covers approximately 75% of the country's needs, and some products are exported, especially citrus fruit and eggs. The main crops are fruit (oranges, apples, melons, avocados and grapes), potatoes and wheat.

Large catches of fish are taken, with approximately half of all of the catch coming from freshwater fish raised on fish farms.

The whole of the industrial sector accounts for 34.1% of the economy, although the food industry is of very low importance. While electronics, chemical products and telecommunications are sectors undergoing important developments, the situation in the food industry is the opposite. Israel is therefore a net importer of manufactured food products, including canned food.

2.2.2.12 Italy

Italy is one of the world's leading producers of olives and olive oil. Other important agricultural products include vegetables, sugar beet, corn, wheat, potatoes and rice. Barley, rye, artichokes, chilli peppers and watermelons are also produced. The most important cultivated products are olives, apples, oranges, figs, dates and walnuts.

With regard to the fishing industry, mussels and other molluscs, shrimp, prawns, sardines, trout, red mullet, squid and anchovies are the main species captured.

The canning of practically all of the different families described in this study is carried out. The structure of the canning industry ranges from small cottage industry establishments to large-scale food industries.
Alliances and agreements between different companies are typical and many companies that specialise in producing preserved meat, fish and vegetable products resort to doing business in this way.

The canning industries are found particularly in the areas of Lombardy, Emiliar, Sicily and Campania, amongst others. There is more of a canning tradition in the south, where preserved meat products are important, as is the case in France.

2.2.2.13 Lebanon

The coastal plain is intensively cultivated and produces tobacco and fruit and vegetable products, especially oranges, bananas, grapes, figs and melons. Cereals and vegetables are cultivated in the partially irrigated Bekaa valley. More temperate areas produce apples, cherries, plums, potatoes, wheat and barley.

Lebanon does not stand out as a canning production area because it is hardly industrialised and the economy is based on agriculture and livestock, with the small amount of agri-foodstuffs that exists is predominantly small, family and of a cottage-type industry. A so-called "light" industrial structure does exist but the most important products are silk, cotton textiles, footwear, matches and soap. The food industry is not significant.

Lebanon used to export a large part of its production of preserved products (from 50 to 70%), but the fraction exported has decreased a lot recently due to the competitiveness of other producer areas like Saudi Arabia, the Arab Emirates and Syria.

2.2.2.14 Libya

The important area for agriculture in Libya is Tripolitania, although the sector is being revitalised in the eastern provinces. In general, production is difficult as a result of the shortage of water and there is a strong dependence on rain. The leading products are cereals, fruit, vegetables and oil seed.

Libya is considered to be self-sufficient in terms of food products. Most agricultural production is for domestic consumption, for the food industry is very limited.

Small quantities of tuna and sardines are caught in the Libyan coastal waters and sponges are harvested along the coast. The canned fish products industry is of little importance with fish being consumed mostly fresh with some semi-cured, cottage industry-type products (dried/ salted fish).

2.2.2.15 Malta

Agriculture plays an important role in Malta's economy.

As in the case of Cyprus, Malta is a small country as far as area and population are concerned, which means it has little influence on the food preservation industry. Sixteen percent of the working population work in the food and drink sector.

Existing food industries are small with few workers, which implies a low level of technology due to difficulties of modernisation.

The fish canning industries stand out amongst the few canning industries that do exist. Nevertheless, this sector faces the serious problem that the waters around Malta are highly contaminated due to the impact of different industries, which consequently has a negative impact on the quality of the fish and other products.

2.2.2.16 Morocco

The main crops in Morocco are cereals, potatoes, grapes, sugar cane and sugar beet. Other fruit and vegetables are also cultivated.

The food industry is concentrated above all in the Casablanca area. There are mostly small and middle-sized companies

The canning industry produces fish products from the enormous catches taken in territorial waters in the Atlantic and are very important. The most abundant species in these waters are sardine, tuna, mackerel, anchovy and shellfish. This is the country's main food industry.

The fruit and vegetable canning industries are also important, together with companies that produce meat products.

2.2.2.17 Monaco

The economy here depends to a great extent on the service industries, especially tourism and the banking and financial sectors.

The manufacture of pharmaceutical and chemical products, electronic equipment, cosmetics, paper, textiles and clothing are the basis of the industrial economy of this small country. The food sector is insignificant as an industry.

2.2.2.18 Syria

Despite disadvantageous climatic conditions, Syria grows a wide variety of crops, such of which are produced in sufficient quantities to be exported. The main ones are cereals, cotton, tobacco, grapes, olives, citrus fruit and vegetables.

The only large manufacturing industry is textiles, although sectors such as processed foodstuffs are growing.

Many of the companies that process preserved foods are in public ownership, although the private sector is emerging more and more. Most food product exports are sent to Jordan and the Lebanon.

Vegetables and fruit are not processed too much for they are mostly consumed fresh. Syria is also a large producer of citrus fruit, and part of its production goes to making juice. There are six plants specialising in this activity in Syria.

2.2.2.19 Tunisia

The primary sector accounts for approximately 15% of the GNP in Tunisia so it does play an important role in the country's economy. The annual harvest indices fluctuate as a result of frequent droughts and the lack of extensive irrigation resources. The main crops are cereals, fruit, vegetables and oil seed. The most productive area is in the fertile plains in the north, with the cultivation of oranges being particularly important in the Cape Bon peninsula. Mostly olives are grown in the semi-arid central regions and dates are grown in the oases in the Sahara region. Tunisia is one of the largest producers and exporters of olive oil.

The most important fish catches are sardine, horse mackerel, tuna and various species of white fish. The fishing industry is turning more to developing the processing industry such as canning, and factories of this type are to be found concentrated in the Sfax area.

2.2.2.20 Turkey

The climatic diversity in Turkey permits specialised types of crop, such as tea. Wheat, barley, corn, sugar beet, tomatoes, melons, grapes, apples, onions, aubergines, walnuts, cabbage, potatoes, rye, oats, cotton, tobacco, olives and citrus fruit are all important.

Large catches of fish are taken and anchovies account for over half of the total. The fishing grounds are the Mediterranean, the Aegean and the Black Sea. Other important species are mackerel, sardine, red mullet and carp.

The food processing industry in Turkey is characterised by sustained growth and highly diversified production. This development is possible due to the increase in competitiveness and foreign investment in the country. As in other countries that have experienced changes in the population's eating habits, products that are preserved, easy and quick to prepare have become increasingly necessary.

The structure of the canning industry in Turkey ranges from small companies formed of just one single person (handicraft) to large multinational food companies with a large production and development capacity.

The most important canning industry in the country handles fish canning, especially crustaceans and molluscs. Canned fish products make up the most important export commodity of the Turkish fishing industry.

The fruit and vegetables sector is also very important in terms of food preservation. Given the characteristics of its climate and soils, Turkey is a leading producer of a very wide variety of processed fruit and vegetables that are harvested in the country itself. This has led to the development of a preserved fruit and vegetable industrial structure that covers the whole country and is highly efficient.

One of the most important preserved products is crushed tomato. Tomato cultivation is centred in the Bursa and Marmara areas. Most factories also specialise in other products like other vegetables and fruit, ready-to-serve dishes and jams and fruit preserves. Seasonal variations in the harvests are thus taken advantage of.

CHAPTER III

FOOD CANNING PROCESSES AND ENVIRONMENTAL ASPECTS

The following chapter describes the different production processes in the food canning industry as a whole and gives the technology used, together with the environmental aspects and impacts that derive from these.

In the preparation of canned food from vegetables, fish and meat, there are main operations that are common to all (for example, heat treatment for preservation) and other main operations that are characteristic of the type of raw material being processed (gutting, peeling/shelling/skinning, mincing). These three types of industry also have auxiliary operations in common that service the installations and equipment of the main process (steam production).

In order to avoid needless repetition, the chapter is structured according to the following outline:

SECTIONS	Process	Unit operations	Enviromental aspects and impacts
3.1 General unit operations	✓	✓	
3.2 Canned fish processing	✓	✓	✓
3.3 Canned fruit and vegetable processing	✓	✓	
3.4 Cannedmeat processing and ready-to-serve meals	✓	✓	
3.5 General auxiliary operations		✓	

The content of the different possible sections for each field described is as follows:

- **Process:** Description of the production process. This includes a process diagram. Details of the production processes for all of the families described in chapter 2 are given in sections 3.2, 3.3 and 3.4.

- **Unit operations:** Details are given of the technology used for each of the main unit operations that make up the processes, together with the environmental aspects.
- **Environmental aspects and impacts of the process:** The main possible environmental aspects for different processes are analysed and quantified. According to the quantified aspects, an assessment is made of their possible impacts.

3.1 General unit operations

Production processes in the food industry normally consist of the following stages: washing of the raw material, elimination of the non-edible part, preparation of the food product and canning.

These process stages are applicable to any canning industry and what makes them characteristic in relation to the rest of the food industries is the heat treatment, sterilisation or pasteurisation process that is applied after canning to destroy microbes.

The preparation of canned food starts with a raw material, either fruit, vegetables, fish or meat, which is prepared by applying different treatments such as washing, peeling or skinning and chopping. Once it is prepared, the product is packed in metal or glass containers together with a control juice in most cases that optimises and protects the foodstuff from any subsequent treatment.

Given that the harvest periods for vegetables and fruit and the seasonal variations of fish products are short, many factories are set up to process more than one product. This gives rise to big differences in the quantities of waste that are generated throughout the year and makes treatment problematic.

The basic characteristics of a food-canning industry are:

- A straightforward activity that is independent of the refrigeration chain. No longer dependent on the refrigeration chain with preserving, the life of the product is increased and costs are reduced.

- High efficiency in terms of energy

- They serve to overcome the limitations of the seasonal nature of production.

- They reduce product loss when there are no means to adequately preserve the product.

3.1.1. The general process in the canning industry

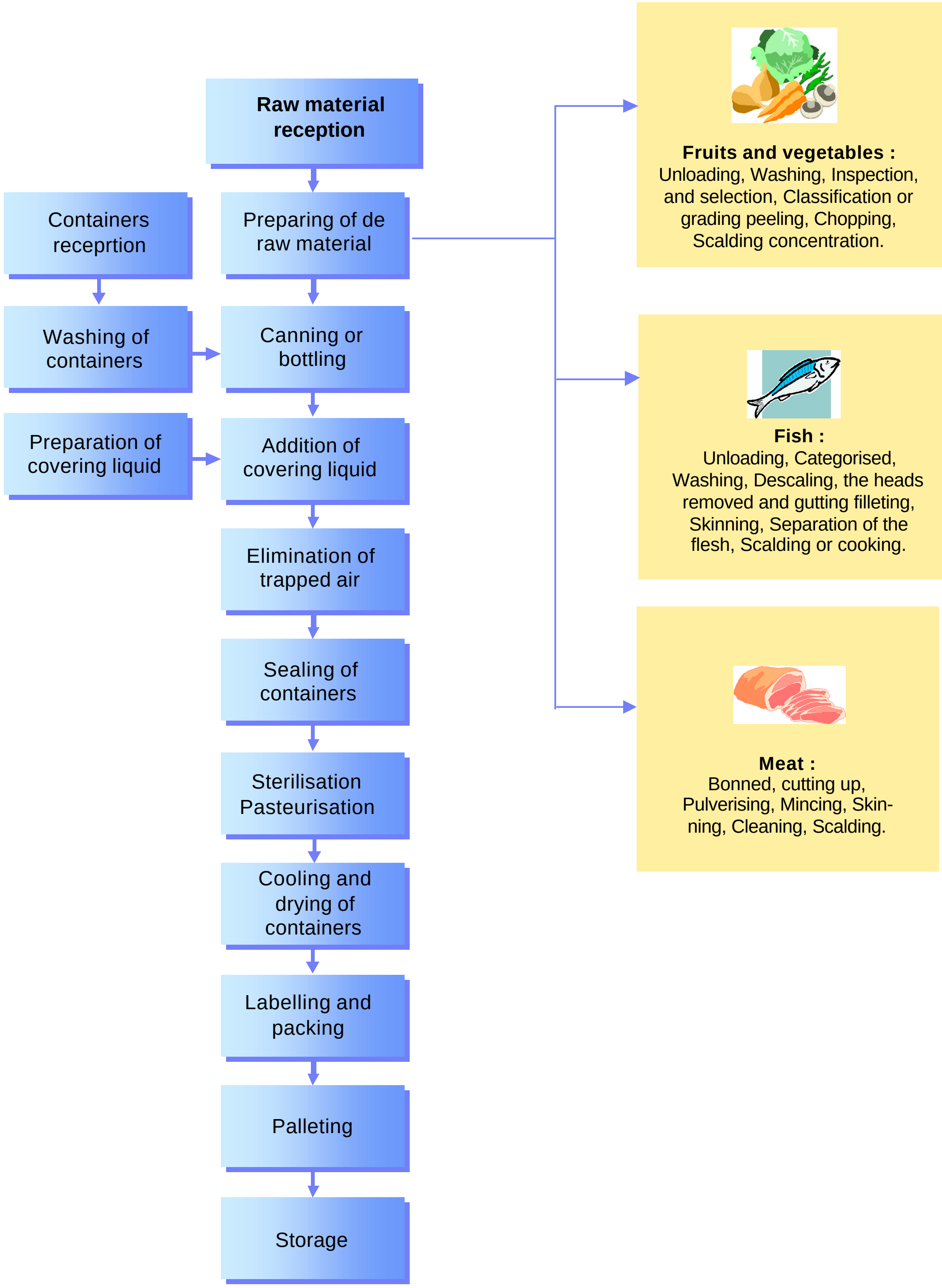


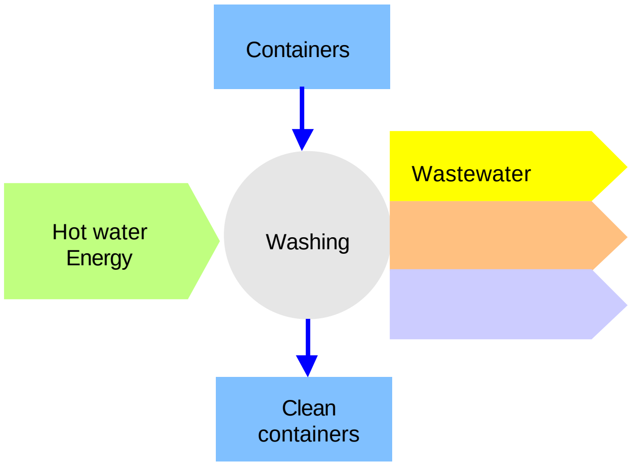
Figure 3.1. Process in the canning industry

3.1.2 Unit operations and environmental aspects

3.1.2.1 Washing of the containers

It is usually necessary to wash the containers before they are filled, even though they are normally supplied clean. For washing to be effective, it must be done using hot water sprinklers with the container upside-down because a jet of steam is insufficient for correct cleaning.

It is important for the container to be clean because it plays the fundamental role of accompanying the product throughout its whole shelf life. Its contribution is therefore very significant.



Input		Output	
Product	Quantity	Product	Quantity
Containers	1000 Kg	Containers	1000 Kg
Water	0.1- 0.5 m3	Wastewater	0.1- 0.5 m3
Energy	30-50 Kw/h		

Table 3.1. The balance of materials and energy used in the washing of containers

3.1.2.2 Preparation of the covering liquid

Most canned products are filled with hot sweet syrup solutions, brines (salt with a small amount of sugar) or sauces, that must be at the highest possible temperature at the time that the container is being filled. This helps to optimise the sterilisation process because the container starts at an initially high temperature, and at the same time it helps to eliminate air from the headroom in the container.

In the case of vegetables, a 2% brine solution with a small quantity of sugar to enhance the flavour is used.

Most fruit is preserved in syrup. This sweetens the fruit and at the same time helps to keep the texture firms and prevents the loss of colour that could occur due to the degradation of anthocyanic pigments.

This process only generates wastewater from cleaning.

3.1.2.3 Filling of the containers and elimination of any trapped air

Once the containers have been washed, they are uniformly filled with the appropriate quantity of the product in order to expel any unwanted gases, especially oxygen. Here a covering liquid is added that can be brine, a sauce, juice or syrup, according to the type of preserved food.

Different types of canning equipment exist on the market, ranging from semi-automatic to automatic ones, although for products like asparagus, filling has to be done by hand.

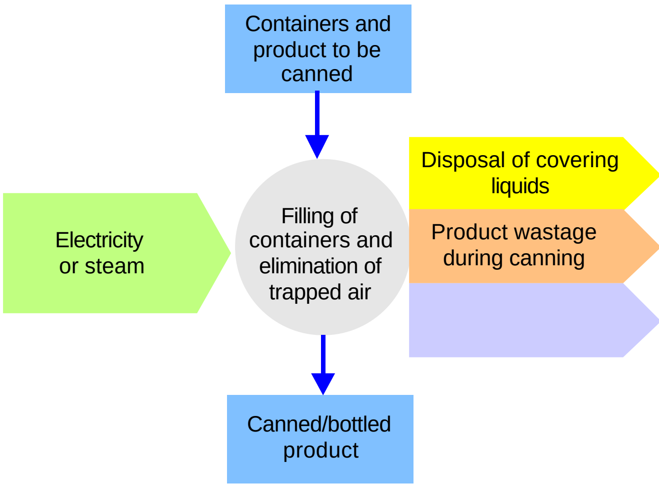
Solid/liquid fillers are normally used for products that come in pieces, such as runner beans and broad beans that are covered with a juice. The containers are put into the machine on a small conveyor belt and transferred directly to the solids' filler head by a synchronised feeder. The container is filled with the pre-set amount of product while it moves and then goes to the liquids' filler head, with the containers positioned on lifting platforms in the filling position. Here they are gravity filled and space left for a predetermined headroom gap.

Piston or plunger fillers consist of a cylindrical tank with external measuring rollers where the product is drained as the tank revolves.

Once the containers are filled and before they are sealed, they are preheated to eliminate any air trapped inside of the containers so that there is a partial vacuum that prevents alterations occurring during storage and to reduce the sterilisation time, at the same time that the pressure inside the container is reduced during the period of sterilisation.

In the case of some acid foodstuffs, such as tinned fruit, hydrogen gets produced in the can as a result of acid attacking the steel base of the tin plate. Once enough hydrogen is produced, the container can burst unless sufficient space has been left.

Another possibility is for the filling of the product or control juice to be hot packed, which is the case especially with small sized containers. The application of jets of steam is necessary here during sealing.



Input		Output	
Product	Quantity	Product	Quantity
Product	1000 Kg	Canned product	1145-1190 Kg
Control juice	100-750 Kg	Disposal of the control juice	0-25 Kg
Containers	100-250 Kg	Wastage canned product	10-30 Kg
Steam	0-25 Kg		

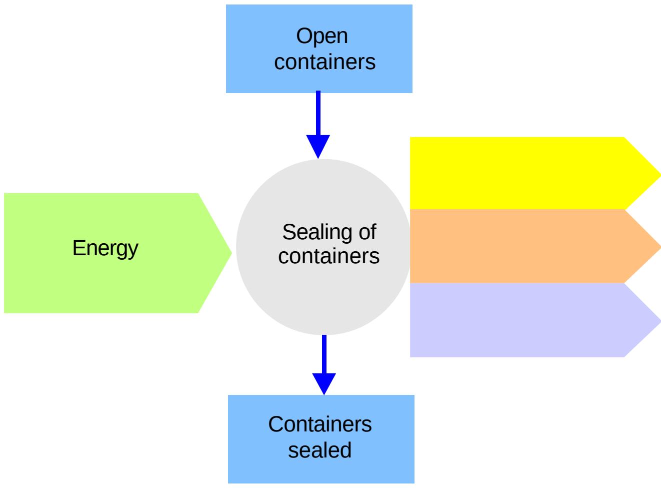
Table 3.2. The balance of materials and energy used in the filling of containers

3.1.2.4 Sealing the containers

Sealing the containers is an essential part of the canning process because incorrect sealing would lead to recontamination of the foodstuff once it has been sterilised.

There are various sealing alternatives according to the type of container. Glass jars are normally vacuum sealed while tins are closed with a double seam on the seal side and they can also be vacuum sealed.

Sealing can be done with either manual equipment or very modern, efficient machinery than can seal over a thousand cans a minute.



Input		Output	
Product	Quantity	Product	Quantité
Product container closed	1000 Kg	Product container open	1 000 Kg
Energy	5-6 kWh		

Table 3.3. The balance of materials and energy used in the sealing of containers

3.1.2.5 <u>Sterilisation</u>

Heat treatment is the most important operation in the process of manufacturing canned products. It is an operation in which the foodstuff is heated to a sufficiently high temperature and during a sufficiently long period of time to destroy all microbial and enzymatic activity in the food and it also lengthens the life of the product.

Nicolás Appert was the first person to try out the sterilisation process in 1809 by preparing stable preserved foodstuffs in sealed glass jars. The system has evolved since then with equipment that is more efficient and that enables the application of much more homogeneous and suitable treatments.

Nowadays, the different sterilisation techniques are classified into two systems, in batches and continuously. The difference between these is that the first system works with discontinuous system autoclaves (steam-driven sterilizers) that make automation of the production line difficult, whereas the second system uses continuous sterilizers where the product is sent through different areas at different temperatures that are maintained constant the whole time that the sterilizer is being undergone. This second system represents:

- A saving of energy.
- The uniform treatment of the product.

The disadvantage of the first system (batches) can be avoided by setting up various parallel autoclaves and a mechanised feeding system that puts the containers in racks, transports them to the autoclave that is ready to begin the operation, puts them into it and, once the processing time has finished, takes them out of the autoclave and removes them from the racks.

The selection criteria for the system to be used according to the product and the production of the industry are as follows:

3.1.2.6 Batch system

In batches: when the factory produces a considerable number of different foodstuffs, in different containers and in different sizes. This gives sufficient flexibility to respond efficiently to variations in time and process temperature that are required by this type of production.

1. Wet steam heating
   Principle*:* The product is sterilised inside of autoclaves by airless wet steam as a convector fluid. This type of round section autoclave that can either be in a vertical or horizontal position is widely used in the canning industry.

   The containers can either be cooled inside or outside of the autoclaves. If it is done inside the autoclave when cooling begins, the pressure of the chamber goes down suddenly while the pressure inside of the container remains high due to the heat treatment. This difference in pressure means that the containers need to be highly resistant mechanically, and only metal cans comply with this.

2. Heating with a steam-air mixture

   Principle: This is based on the same principle as wet steam heating except that the equipment has a compressed air supply, which means that the pressure in the chamber can be maintained higher than that inside the container during the whole process.

   Under these conditions, the sterilisation of products in any type of container is possible without its mechanical resistance being a limiting factor.

   Diagram:

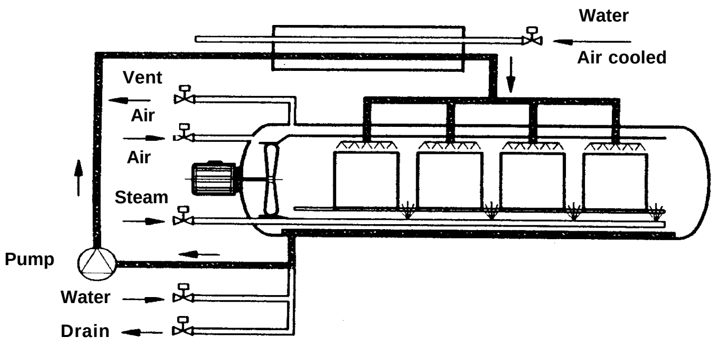


Figure 3.2. Diagram of the workings of a horizontal autoclave, heated with a mixture of steam and air (Source: see Ref. 78)

3. Superheated water heating

   Principle: The product is sterilised by superheated water in the autoclave that is kept at a pressure higher than that of saturated steam at the working temperature. The product is heated as the result of the sensitive heat exchange that has a thermal transfer coefficient that is lower than steam condensation.

   The water loses temperature as it flows over the surface being heated which leads to density layering. The water must thus be constantly moving and with a flow speed that is always constant.

4. Immersion heating

   Principle: Sterilisation is done by immersing the containers in superheated water. In order to prevent the natural layering of the water in the autoclave, due to temperature, from affecting the homogenous treatment of the product, either the product is shaken or the water is recycled.

Diagram:

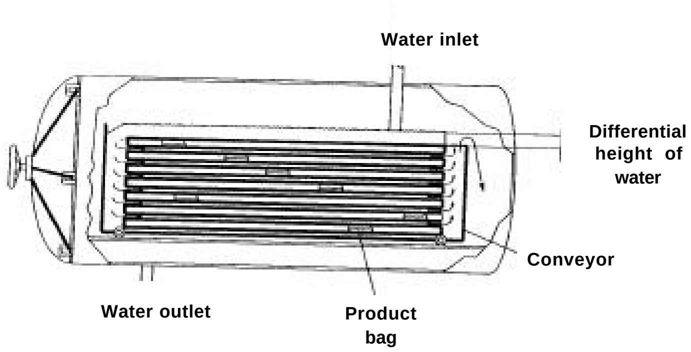


Figure 3.3. Convenience Food Sterilizer (F.M.C.) (Source: see Ref. 78)

5. Drop heating
   Principle*:* The heating here is done by means of a flow of superheated water that sprays over racks that are full of containers. The total volume of water is much less compared to that used in the aforementioned systems and it is heated directly by steam or indirectly in an appropriate heat exchanger.

3.1.2.7 Continuous system

Continuous: used where large series of the same product are being processed in the same container.

1. Hydrostatic sterilizers
   Principle*:* These consist of a steam chamber that is partially full of water that is kept under pressure by two 12 to 18 metres high hydrostatic columns and to which it is connected. Under these conditions, the temperature of the steam chamber is that of the saturated steam according to the pressure at which it is at, and this corresponds to the difference between the height of the water in the steam chamber and that of the two hydrostatic columns.

   Due to the fact that the pressure inside the container is higher than that of the chamber when cooling begins, this system of sterilisation is not appropriate for products that are canned with materials or types of seal that cannot withstand this type of internal pressure.

Diagram:

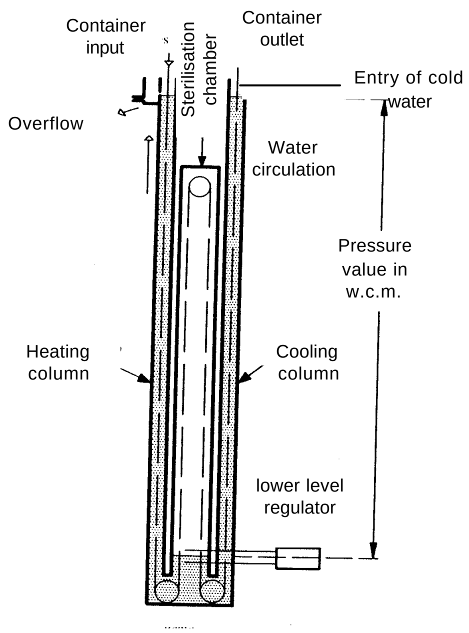


Figure 3.4. Diagram of the hydrostatic sterilizer (source: see Ref. 78)

2. Pneumohydrostatic sterilizers

   Principle: This system of sterilisation was developed to offset the void created by the previous system in that it did not permit the hydrostatic sterilisation of semi-rigid or deformable containers.

   The principle is the same as the previous one with the sole variation that it uses superheated water instead of steam.

3. Continuous sterilizers

   Principle: made up of two or more horizontal cylindrical casings joined in a series, where heating and cooling is produced successively for all of the containers.

   Sterilisation is done in the first casing by steam, with cooling in the following one/s being done by overpressure cooling or cooling at atmospheric pressure by partial immersion in water. A lock is used to transfer the containers and to move them from one casing to another.

Diagram:

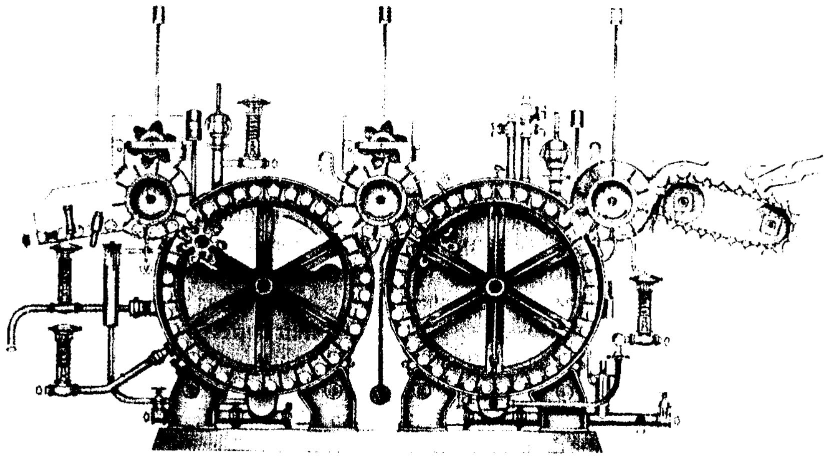
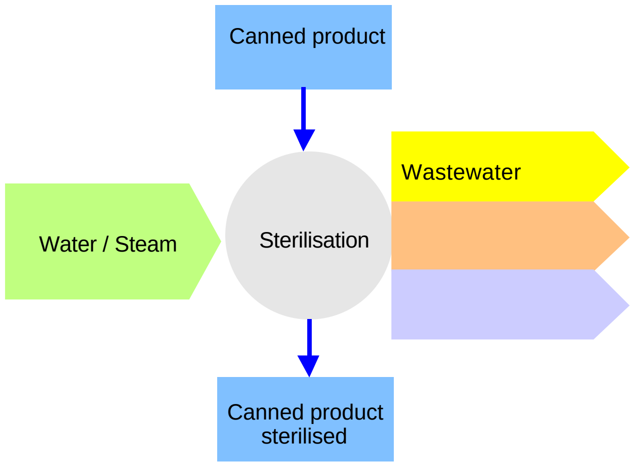


Figure 3.5. Section of the Sterilmatic sterilizer (F.M.C.) (Source: see Ref. 78)

4. Direct flame sterilizers

   Principle: These are based on the principle that the speed of heat penetration is directly proportional to the difference in temperature between the product and the medium used for heating.

   The containers are preheated with live-steam and intensely heated by contact with gas burner flames to 1,100 ºC and then more mildly heated by flame during the necessary time to sterilise the product. The cooling of the containers is done subsequently with cold water sprinklers.



Input		Output	
Product	Quantity	Product	Quantity
The canned product	1000 Kg	Canned product sterilised	1000 Kg
Steam	300-750 Kg		
Water	3-7 m3	Wastewater	3-7 m3

Table 3.4. Balance of materials and energy used in sterilisation

3.1.2.8 Pasteurisation

This treatment involves the application of temperatures that are lower than in sterilisation (lower than 100 ºC) and of a low intensity to stabilise the product in a way that respects its organoleptic qualities.

In the case of fruit juice (a type of preserved foodstuff that uses this treatment), treatment with a higher temperature is not necessary, as is the case with sterilisation, because the growth of sporulated bacteria is not possible in acid foodstuffs.

There are two systems of pasteurisation:

- **Low temperature during a long period of time** (**LTLT**: low temperature-long time). This system can work with batches or continuously, for all types of product presentation (liquid or solid, bulk, packaged).
- **High temperature during a short period of time** (**HTST**: high temperature-short time). In this case, the system is only applied to liquid products in continuous processes.

3.1.2.9 LTLT system in canned products

In the first system (**LTLT**), in the case of packaged products, the product is heated by immersion or hot water spraying.

1. Water bath immersion
   Characteristic*:* Used for the pasteurisation of meat products, the pasteuriser consists of two sections, one for heating and the other for cooling, both of which are made up of

rectangular vessels full of water at the appropriate temperature. Conveyors run through these vessels and transport the products through the bath. On coming out of the second cooling bath, there is sometimes an air cooling section that dries the surface of the container at the same time.

2. Drop cooling
   Characteristic*:* Used for foodstuffs preserved in glass jars, it consists of a heat-isolated tunnel through which the containers move. Inside of the pasteuriser there is a preheating area, a pasteurising area and a cooling area.

   This type of equipment consists of heat recovery systems for the water used for cooling the product is collected and used for preheating.

3.1.2.10 <u>HSTT system</u>

The central core of the equipment necessary for carrying out pasteurisation in the **HTST** system is made up of an heat exchanger, which is where the thermal exchange occurs. The necessary heat is supplied by hot water because the working temperature does not require the use of steam.

The end cooling of the product is also carried out with cold or freezing water, depending on the temperature that is required for the product at the end of the process.

The are two options with heat exchangers, counter-current flow and parallel flow. In the case of the first, the liquid to be pasteurised and the convector fluid circulate in opposite directions, and in the case of the latter they circulate in the same direction.

In the first case, the product can be heated to a temperature that is just below that of the input threshold of the convector fluid, whereas in the second case it is impossible to heat the product more than would be obtained if it was physically mixed with the heat conducting fluid.

There are different kinds of heat exchangers:

1. Tubular heat exchangers
   Characteristic*:* The exchange surface is made up of tubes. Low, medium and even high viscosity liquids and, depending on the diameter of the tubes, solid particles can be treated up to a certain size.

Diagram:

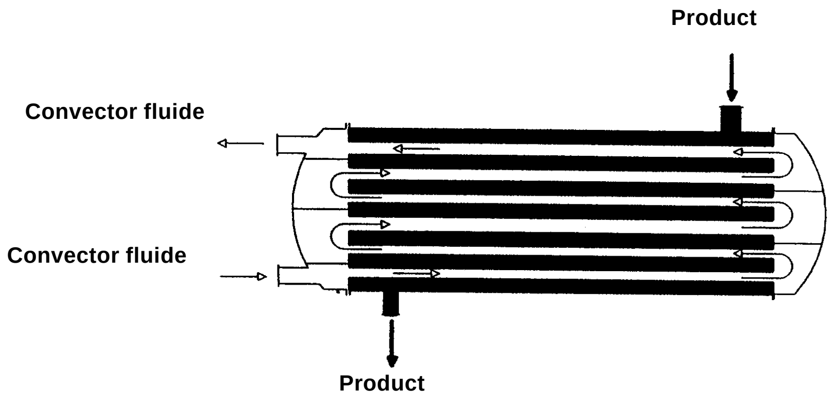


Figure 3.6. Multitubular rectilinear tube economiser (Source: see Ref. 78)

2. Panel heat exchangers

   Characteristic*:* Equipment composed of one or various stainless steel panels used for pasteurising low viscosity liquid products.

   Each pair of adjacent panels forms a channel and the two fluids (the product and the convector fluid) circulate through alternate channels. Each panel will therefore be in contact with the two fluids, each one on either side.

Diagram*:*

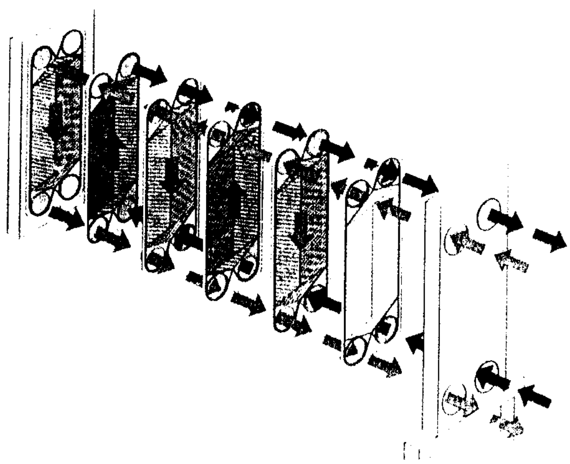
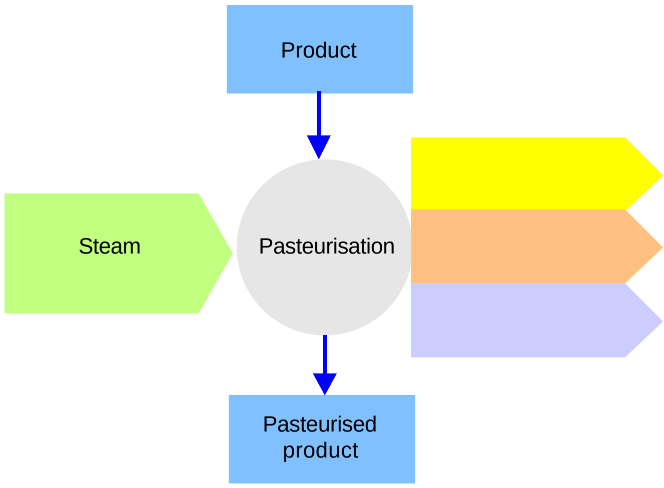


Figure 3.7. Fluid circulation through a panel economiser (Alfa-Laval) (Source: see Ref. 78)



Input		Output	
Product	**Quantity**	**Product**	**Quantity**
Product	1000 Kg	Pasteurised product	1000 Kg
Steam	60-150 Kg		

Table 3.5. Balance of materials and energy used in pasteurising

3.1.2.11. Final preparation (cooling, labelling, packing, palletising)

Once it has been given the heat treatment, the product is cooled. The object of this operation is to avoid the harmful effects of overbaking which softens the foodstuff excessively and produces negative changes in the flavour and colour.

Many of the heat treatment systems explained in the previous section include the cooling phase of the product in the same system.

The water used to carry out this cooling is chlorinated and does not pollute microbiologically. The container reaches 38-40 ºC and retains sufficient heat to dry because a wet container is dangerous.

Once they are dry, the containers are labelled, packed and put on pallets.

3. 2 Preserved fish processing

3.2.1 Processes

3.2.1.1 Tuna

The processing factories either receive the fish refrigerated or frozen. The long periods of time that voyages last make it essential for fishing boats to have brine refrigeration tanks or freezing systems to preserve the properties of fresh fish as much as possible. The unloading and reception operation can either be done manually or automatically.

With frozen fish, the process starts with a thawing out stage. The tuna is put into tanks with water at room temperature until it reaches the appropriate temperature. Once it is unfrozen, the characteristics of the fish are equivalent to those of the original refrigerated fish.

The following operation consists of eliminating most of the unwanted parts of the end product (the head and viscera). There is a wide range of machinery on the market for carrying out this operation either manually or automatically. Inspection to eliminate spoilt fish is often done at this stage as well.

Fish with the head and viscera removed are washed with water under pressure and then left to bleed in water tanks for a period of time.
In order to reduce the existing wetness coefficient in the fish to approximately 65% to avoid the dilution of the sauce or oil by the water released during sterilisation as a result of the heat, the fish are put through a heat treatment using steam until the final temperature of the spine reaches 71 ºC (344K).

This process is done in baking ovens where the fish are put on shelves. Once the baking process is complete, the trays are taken out of the oven and cooled. The fish are taken off of the shelves and the skin, tail, fins and dark meat removed. Lastly, the meat is separated from the bones in the form of “sides’” and different cuts.

Before being canned, the cans and jars are rinsed with water under pressure or steam before being filled. This eliminates any micro-organisms that would otherwise increase the initial bacterial load of the product.

Most canned tuna is canned mechanically. The sides of tuna are preserved in containers as “trunks” or compact filled. Smaller pieces and meat scraps are generally canned as flakes after being pressed into moulds.

The remaining filler is then added; this can be water, brine, vegetable oil, tomato, mustard or different types of sauce. The weight is checked at this point to prevent excessive filling that could lead to the foodstuff not being processed appropriately, swelling of the tin or even bursting of the seams. Immediately afterwards, the headroom air is eliminated by steam or vacuum injection and the can is sealed. The sealed cans are cleaned to eliminate any remains of filler and they are prepared for sterilisation.

Sterilisation is done in optimum temperature conditions to ensure an adequate level of commercial sterility and to preserve the nutritional properties of the product. This operation can be done according to the quantity and diversity of the product being processed in batches or continuously.

Batch sterilisation is done in an autoclave or steam-driven sterilizer. This is a chamber with generally a vertical or horizontal cylindrical form that is capable of withstanding an internal pressure that is higher than atmospheric pressure and where the containers being treated are put (generally on racks or cages). The autoclave has appropriate heating, cooling and process control systems.

Lastly, the cans are labelled and put into convenient boxes according to the distribution system that is to be used.

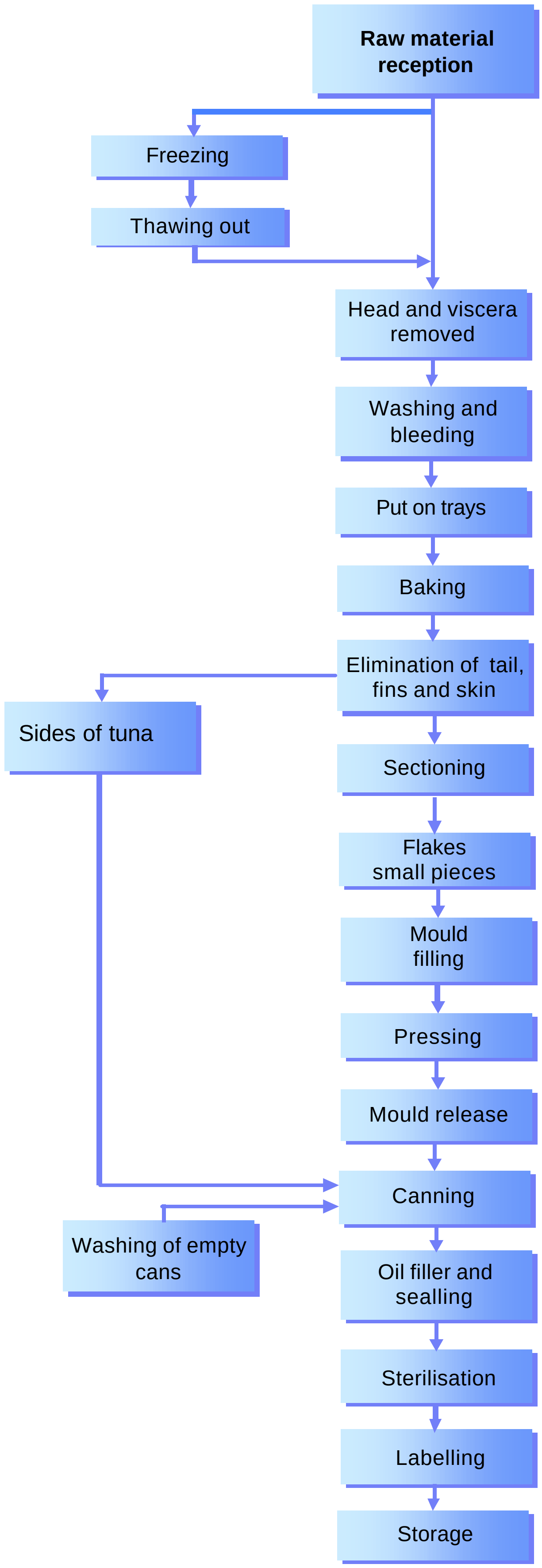


Figure 3.8. The process of preparing canned tuna fish in oil

3.2.1.2 Clupeids, mackerel and garfish

3.2.1.2.1 Mackerel processing

The best quality canned products of this species are obtained from fish that are rich in oil and over 25 cm long.

Once it is unloaded, the fish enters the production process and the head, tail, fins and viscera are removed. These operations can be done by hand or machine according to the volume of production.

The abdomen is then carefully washed and the meat cut crosswise into slices. The pieces are then submerged in brine at a temperature close to –3ºC (270K). The immersion time depends on the salt concentration that is used. This operation eliminates any remains of blood and prevents the formation of turbid liquids and mass during the processing of the flesh.

After being soaked, the meat is rinsed with clean water and put into cans that have been washed previously.

With pickled mackerel, the brine is added immediately and the tin vacuum sealed. If the mackerel is to be canned in oil or sauce, the filled can is first cooked for 10-20 minutes, the liquid drained and the sauce or vegetable oil then added. In general, the cans are vacuum-sealed and processed in boilers in idle mode.

Once the thermal treatment has come to an end, the cans are cooled, dried and then labelled and stored.

Plant operations of this type are very irregular throughout the year as a result mainly of the availability of raw materials.

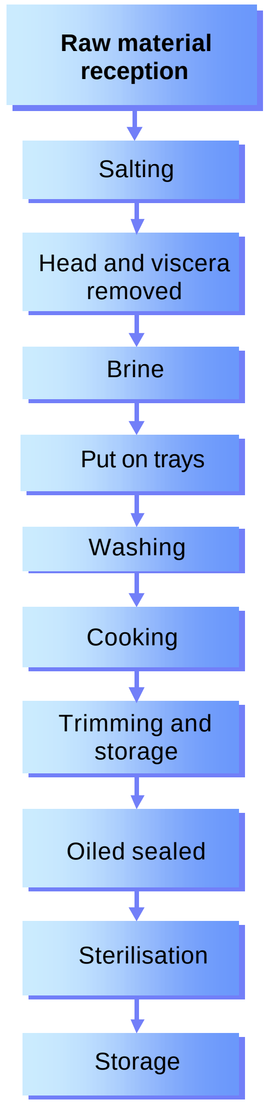


Figure 3.9. The process of preparing canned mackerel

3.2.1.3 Cephalopods

Preserved squid can be made either from the fresh or frozen product. In the case of frozen squid, it is first unfrozen before going on to processing.

Once it is unfrozen, the viscera are removed and the squid is then washed and rinsed. There are different ways that squid is presented, according to the way that cutting is done. It can be sliced, filleted or presented as squid legs.

The product is then cooked and dehydrated to avoid the exuding of water during sterilisation that would negatively affect the market presentation of the product. The texture is improved as a result and it also conditions the meat.

Once the product has been cooked, it must be cooled quickly to avoid excessive softening of the product. Any remains of skin are eliminated and it is then canned. Oil is used as the covering liquid for the product and is either added hot or the containers are heated once it has been added. This operation eliminates any air that is trapped inside of the container.

The containers are sealed hermetically and then sterilised to ensure that any germs that produce toxins or cause alterations to the processed food are destroyed or inactivated. Once this is completed, the containers are cooled to prevent the product from overcooking by residual heat and to reduce breakage or alterations in the texture due to brusque handling when the product is still hot

The containers are labelled and packaged and then stored at room temperature.

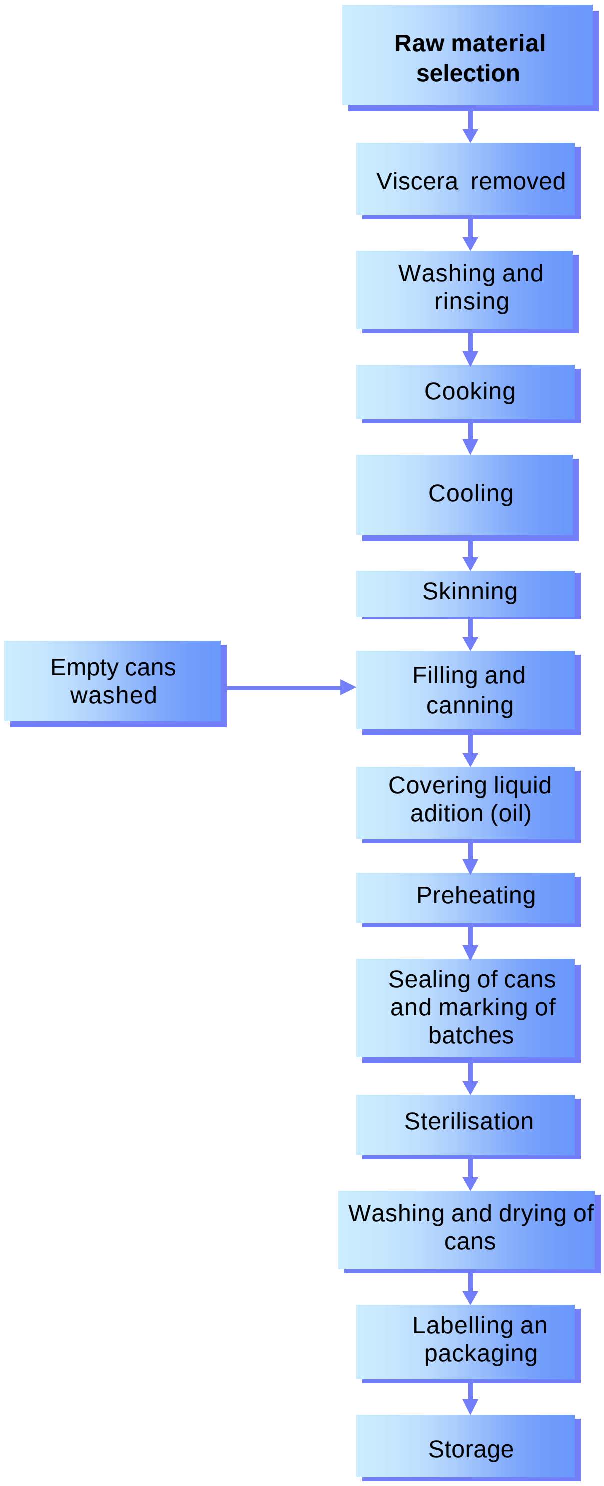


Figure 3.10. The process of preparing canned squid in oil

3.2.1.4 Molluscs

Once the product reaches the factory, it is washed to eliminate any remains of mud or sand. Water consumption is high for this operation and results in a high content of solids in suspension.

Once the mussels have been cleaned, they are cooked. This operation is done by reheated steam injection in chambers with a capacity of 250kgs of mussels and a cooking cycle of two minutes. The resulting flow volume is around 0.5 litres per kilogram of processed mussel.

The mussels are then shelled manually, leaving just the meat of the mussel. This is fried in vegetable oil and then dehydrated before being canned. The purpose of frying the mussel is that it modifies the flavour and aroma of the foodstuff.

The product is canned, usually by hand, and then the sauce or oil is added to the container. Once the containers have been sealed, these are then heat treated and sterilised to ensure that any germs that produce toxins or cause alterations to the processed food are destroyed or inactivated.

After being heat treated, the containers are cooled to prevent the product from being overcooked by residual heat, and to reduce breakage or alterations in the texture due to handling of the container. The product is then labelled and packaged and stored at room temperature.

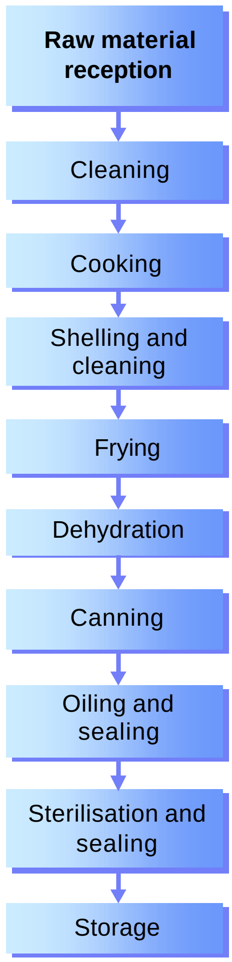


Figure 3.11. The process of preparing canned molluscs

3.2.1.5 <u>Semi-cured anchovies and other clupeids</u>

At the industrial level, the first stage in processing once the raw material has been acquired is removing the head and viscera, spine and other lateral bones.

The fish are then filleted. Salting is then done by putting the fresh anchovy fillets in maturing trays and adding different mixtures of salt to them.

It is important for there to be no physical contact between the different pieces of fish for this can considerably affect the salting of the anchovy.

The maturation process takes three days and enzymatic hydrolysis of the muscular proteins takes place during this time. Bacterial growth is inhibited due to the reduced activity of water (around 0.80-0.75).

During this period of time, the product goes through both physical, chemical and biological changes. When the maturation process comes to end, the salt is cleaned off and the product bottled or canned.

The product is usually bottled in glass jars and olive oil is added as a control juice. The oil is heated beforehand to a temperature of 65 ºC.

The jar is then sealed, labelled and finally stored.

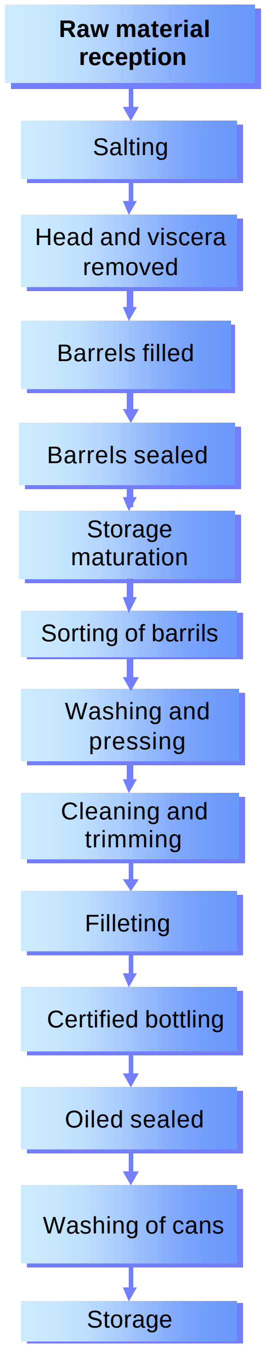


Figure 3.12. The process of preparing bottled anchovies

3.2.1.6 Caviar

Caviar is produced from the roes of different species, the most popular being sturgeon while it is still alive. The fish ovaries and the ovary membranes pass through special kinds of mesh to separate the roes from the connective tissue.

Once they have been separated, they are washed in clean, cold water and put in a sieve so that the water can pass through them and finish the cleaning process.

Once they have been well washed, the roes are salted with a mixture of fine, dry salt and an antiseptic. The quantity of salt is between 3-5% of the weight of the roe. The brine that forms during salting is eliminated once the salt is added to the roes, which are put in sieves again and washed to remove this.

The roes are potted in glass jars or metal tins and vacuum-sealed. Caviar is heated to a temperature of around 60 ºC so that it pasteurises. This process takes 3 hours.

At the end, the container is cooled in cold water until the temperature drops to 20-30 ºC, and then it is rinsed, dried and kept at 0-2 ºC during 24 hours. The cooled tins are packed in cardboard boxes and stored.

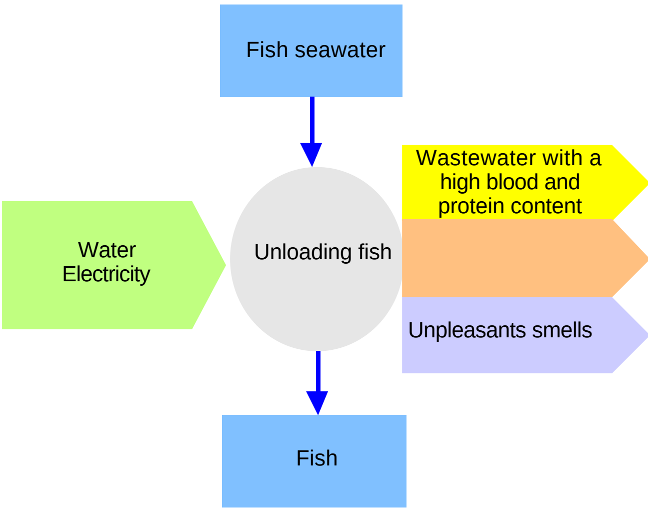
Soft, pasteurised caviar that comes in small tins is the most valuable article of those produced from fish roe. Common salt is the main preserving substance. The antiseptics are additional preservatives that are permitted by health regulations.

3.2.2 Unit operations and environmental aspects

3.2.2.1 Unloading

Fish are kept in water tanks on the fishing boats. The most common method for unloading the fish from the hold is to pump and/or gravity feed seawater to the processing plant. At the plant, the water runs away and the fish is weighed and stored in water tanks again inside of the processing plant. Seawater is also used to transport the fish in some processes inside the processing plant.

The main waste flow of this operation is the water used for this transportation together with the water used on the ships for preservation. The wastewater from this stage contains fish blood, stones and sand from the tanks on the fishing ships. Depending on the kind of fish and the conditions when unloading is done, the wastewater containing blood may amount to 20-25% of the total organic load that the fish canning industry generates.



Input		**Output**	
Product	Quantity	Product	Quantity
Fish and seawater	1000 Kg.	Fish	980 Kg
Water	2-5 m3	Wastewater	2-5 m3
Electricity	3 kWh	COD	27-34 Kg.

Table 3.6. The balance of materials and energy used in cooking tuna fish

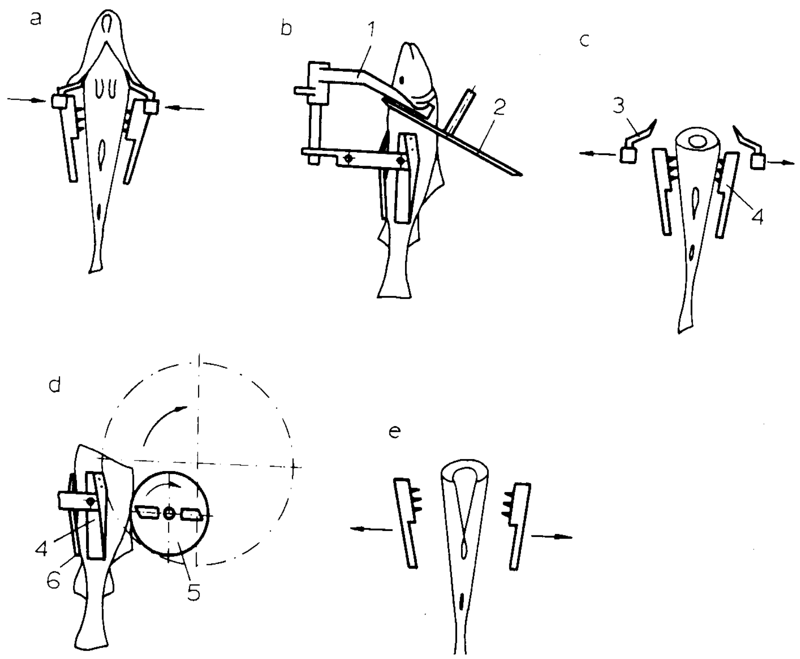
3.2.2.2 Elimination of the unwanted parts of the fish

The elimination of unwanted parts of the fish is not in itself a unit operation but a group of them that has the object of preparing the parts of the fish that are of value as food. Whether just one or more of the operations described below are carried out depends mainly on the type of fish.

The head of the fish is not used for human consumption so it is removed and eliminated. The head represents a large proportion of a fish's total weight and it is cut off by hand or mechanically. Given their size, most fish canning factories usually do this operation manually.

The main requisite is for the removing of the head to cause the minimum loss of muscular tissue.

The most commonly used head trimming machines make a crosswise or oblique cut. Determining the most profitable cutting plane is not gauged automatically but depends on the experience and skill of the person handling the machine. In more automated installations, the fish are held on slide tracks by the gills or pectoral fins and decapitated by rotary knives that make a V-shaped incision.



1) Hanging, 2) Knife, 3) Arm of the feather, 4) Feather, 5) Eviscerator knife, 6) Fish holder

Figure 3.13. Diagram of how a head trimming and eviscerator machine works (Source: see Ref. 63)

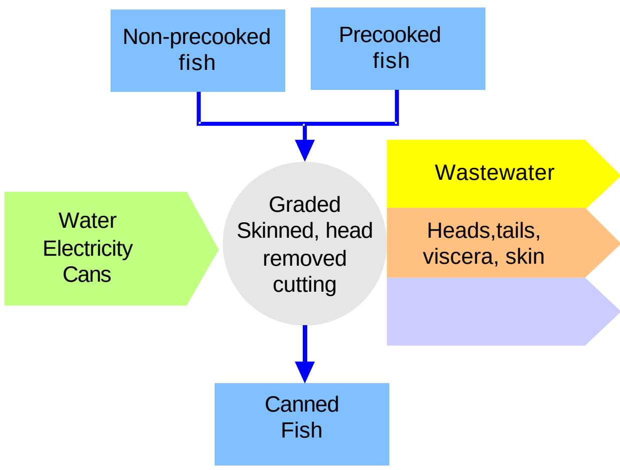
The head sometimes separates without having to cut the viscera connected to it. This type of cut makes the extraction of the viscera easier as they can be pressed out after the head is cut. This operation is known as nobbing and is done when preparing herring for salting.

The most common type of machine-eviscerating consists of opening the abdominal cavity through an incision that is made before or after the head is removed and the viscera extracted mechanically. There are also techniques that extract the viscera by suction after the head is removed.

Scaling can be done manually or automatically. The machines used for mechanical scaling must not damage the skin nor impair the texture of the muscular tissue. In the fish processing industry, three types of scaling machines are used:

- Drum type, where the fish is scaled as it chafes against the rough walls of the tumbler; and
- Mechanical, where the fish crosses a system of static or moving (scanner) scrapers
- Electrical; here the scaling is done by a revolving scraper that repeatedly passes over the surface of the fish from the tail to the head.

The main waste flows of this operation are the remains of the fish parts that are unusable as food, together with the wastewater used by the machine itself to clean the fish once the head and viscera have been removed.



Input		Output	
Product	Quantity	Product	Quantity
Fish	1000 Kg	Classified fish	970-1000 Kg
Water	0.2 m3	Wastewater	0.2 m3
Electricity	0.15 Kw/h	COD	0.35-1.7 Kg
		Solid waste	0-30 Kg

Table 3.7. The balance of materials and energy used in classifying the fish

Input		Output	
Product	Quantity	Product	Quantity
Fish	1000 Kg	Fish	750-760 Kg
Water	0.2-0.9 m3	Wastewater	0.2-0.9 m3
Electricity	0.4-1.5 Kw/h	COD	7-15 Kg
		Heads and viscera	150 Kg
		Spine and meat	100-150 Kg

Table 3.8. The balance of materials and energy used in removing the head, viscera and spine

Input		Output	
Product	Quantity	Product	Quantity
Skinned fish	1000 Kg	Skinned fish	940 Kg
Water	17 m3	Wastewater	17 m3
Electricity	NA	COD	3-5 Kg
Chemical products	NaOH (8%)	Skin waste	55 Kg

Table 3.9. The balance of materials and energy used in skinning the fish

3.2.2.3 Filleting

The presentation of preserved fish in the form of fillets occurs with products like anchovies and mackerel. Filleting in the case of the first species is often done manually which is hard work because the workers need to be skilful and experienced to reach a high level of efficiency. A certain quantity of meat is eliminated with the appendages in this operation, which reduces the yield by up to 25%.

Filleting of mackerel and herring can be done by machines. The basic operations of the filleting machine are:

- Trimming of the upper and lower appendages along the body of the fish
- Cutting of the ribs along the spine

As these species are bilaterally symmetrical, each operation is done by a pair of symmetrical cutters (Figure).

3.2.2.4 Separating the meat

Flaked fish has become very popular in recent years as a raw material in the processing industry. This is obtained from the remains of ordinary filleting, fish with the head and viscera removed, and portions of the spine. This type of product has been promoted as a way of economising expensive raw materials and has been stimulated by the manufacture of machines that are capable of separating the meat from the non-edible parts, such as bones, fins and skin.

The use of separator machines enables from 15 to 30% more meat to be obtained in the form of flaked fish than in the form of boned fillets.

3.2.2.5 Washing the fish

The following washing operations are important during the processing of the fish:

- The fish is washed on arrival.
- Washing and bleeding of the fish after the viscera are removed.

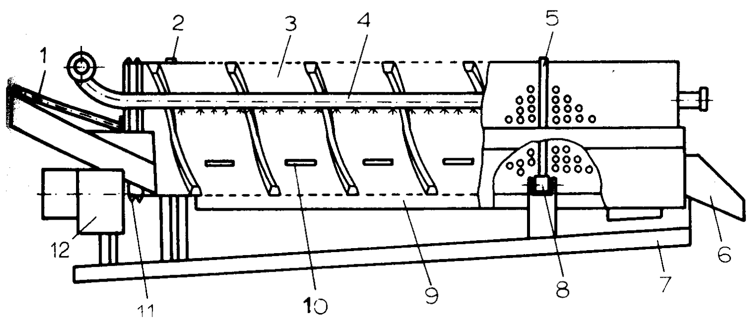
The fish is washed to reduce the bacterial contamination of the fish. Efficient washing depends on two factors, the kinetic energy of the water that does the washing and the water/fish proportion. To ensure that the washing is adequate, this proportion must be at least 1:1 but in practice, however, a double quantity of water is used. In various models of washer, the washing action of the water is reinforced by mechanical friction on the surface of the fish.

In processing plants located on land, tap water is used for washing; on board ship, clean seawater is used that must be collected from the bow of the ship.

There are different models of washer:

- Horizontal axis tumbler washers (Figure 3.14)
- Vertical axis tumbler washers (scanner), (Figure 3.15)
- Washer-conveyors

The vertical axis tumbler washer is frequently used on board ships because of its small size. The horizontal axis tumbler washer is the type that is most used**.** The main element of the machine is a drum with holes of around 10mm in diameter. Inside the tumbler, raised fixed metal or rubber ribs ensure the adequate tossing of the fish and the tumbler is inclined so that the contents move towards the exit as it turns. The washing operation is continuous under a current of water that enters through a perforated pipe inside the tumbler drum. Dirty water flows out to a waste tank. This type of washer is normally used to wash fish that is round or fish with fragile tissue that has had the head and viscera removed, for it does not cause any damage.

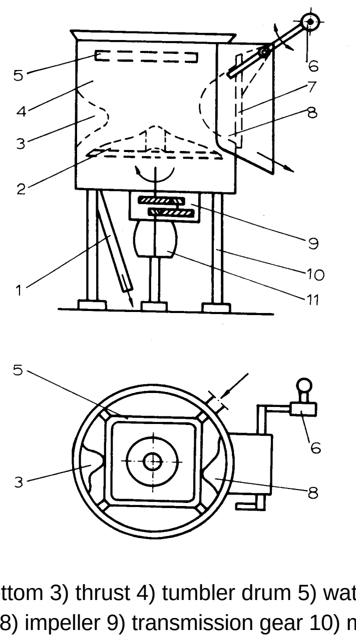


1) Water inlet 2 and 5) tumbler guides 3) perforated drum 4) main water pipe 6) exit for cleaned fish 7) mounting 8 and 11) rollers 9) wastewater tank 10) impeller 12) electric engine with transmission

Figure 3.14. Horizontal axis tumbler washer (Source: see Ref. 63)

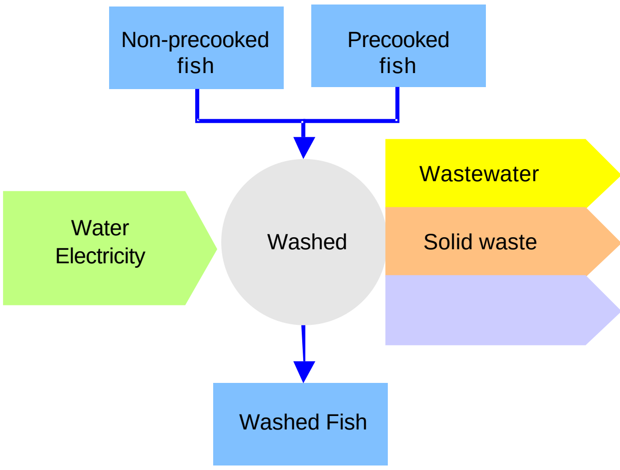
Washer-conveyors are the last type and they can also serve to remove ice. As ice has a lower density than fish, it immediately floats and can be mechanically eliminated. The fish falls onto a conveyor grid that removes it from the tank. Although it has a complementary water jet, this type of washer is not as efficient as the other two models.

The main environmental aspect of this operation is the wastewater from washing. This water mainly contains juices, blood, oil, scales, tissue remains, and salt from the fish. The main characteristic of the waste flows of the wash water is that is has a low level of contamination in relation to other flows; nevertheless, wash water makes up an important volume in relation to the plant total.



1) drain 2) revolving bottom 3) thrust 4) tumbler drum 5) water input 6) counterweight 7) cleaned fish comes out 8) impeller 9) transmission gear 10) mountings 11) electric engine.

Figure 3.15. Vertical axis tumbler washers (Source: see Ref. 63)



Input		Output	
Product	Quantity	Product	Quantity
Fish	1000 Kg.	Washed fish	970-1000 Kg.
Water	3-6 m3	Wastewater	3-6 m3
Electricity	0.15 kW/h	COD	0.35-1.7 Kg.
		Solid waste	0-30kg.

Table 3.10. Balance of the materials and energy used in washing

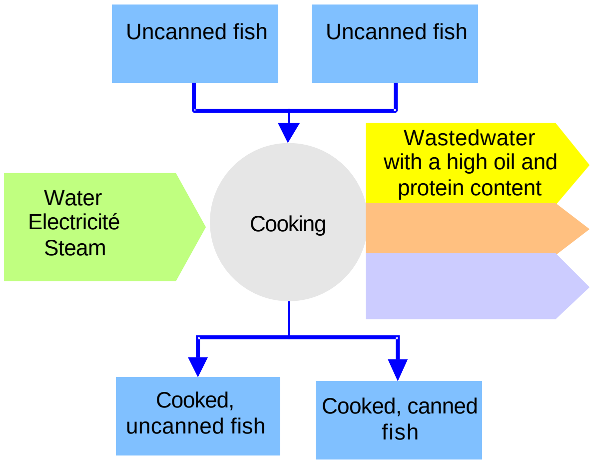
3.2.2.6 Cooking

The cooking and subsequent cooling of the fish, together with the separating of the skin and bones, are operations that are done with the fish held in grids that are washed daily with a caustic soda solution.

Cooking the fish is done by direct contact with steam inside cookers during approximately 2 hours. After this period of time, the water that is produced is drained away and the fish cooled using sprinklers. There are two parts to the water generated by this process, one that derives from the cooking itself that has a very high concentration of organic material and another from the wash and cooling water (generally seawater) that is not so loaded but has a high salinity. An especially significant point is that while the volume of this water is 1% of the total, it contains 7.4% of the organic load and its average temperature is 45 ºC.

Cooking broth is the most important flow in terms of organic load and nutrients, and it is also rich in chlorides. Its pH is slightly acid and it is poured away at a temperature close to 90 ºC.

Large quantities of energy are consumed to produce steam during the cooking process. Table 3.11 shows the balance of materials and energy for this operation.



Input		Output	
Product	Quantity	Product	Quantity
Raw fish	1000 Kg	Pre-cooked fish	850 Kg
Steam	560 Kg	Wastewater	0.07-0.27 m3
Electricity	0.3 -1.1 KW/h	Solid waste	150 Kg

Table 3.11. The balance of materials and energy used in cooking the fish

3.2.3 Environmental aspects and impacts

3.2.3.1 General Considerations

The main environmental aspects that derive from the processing of canned fish are:

- Water consumption
- Energy consumption
- Wastewater
- Solid waste

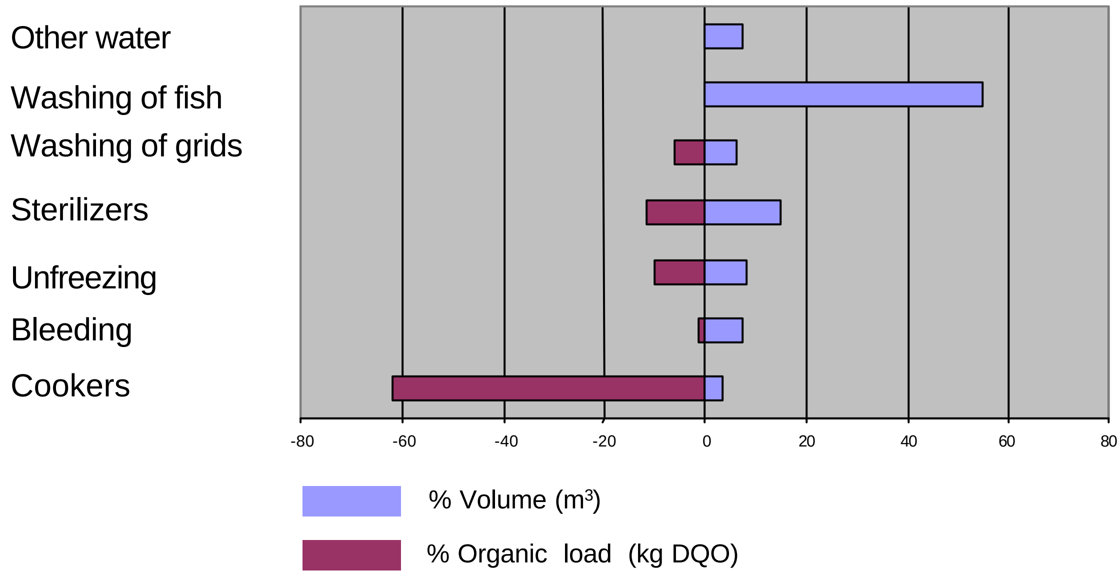


Figure 3.16. Percentage distribution of the volume flow and pollution in different wastewater

Fish processing plants are in general large in size and are concentrated in specific areas near to the sea. Direct discharge using ocean outfalls produces a negative impact on the environment caused by high contamination levels. Some industries use end treatments although the biological treatment of these waters presents very specific problems due to the high salinity.

In terms of waste, this consists in general of organic fish remains that have traditionally been processed to obtain fish meal and fish oil that are used for animal (dried food) and human (margarine and shortening) food respectively.

One of the main impacts at the local scale of this type of industry are unpleasant smells due to the rapid decomposition of the fish and made worse where plants have installations for producing fish meal and fish oil.

Environmental aspect	Main characteristics	Operations
Water consumption	In some cases seawater is used	Unloading Elimination of unwanted parts Washing of fish Cooking or scalding Sterilisation Washing of containers
Energy consumption	Thermal or electric	Unloading Elimination of unwanted parts Washing of fish Cooking or scalding Sterilisation Washing of containers
Wastewater	High organic load	Unloading Elimination of unwanted parts Washing of fish Cooking or scalding Sterilisation Washing of containers

3.2.3.2 Water consumption

Water is used in large quantities in the unfreezing, cleaning (product, containers and installations) and bleeding operations.

Figure 3.16 shows the distribution of water consumption in a tuna canning plant. It can be seen that there is a predominance of certain operations in terms of consumption and of other operations with regard to contamination.

Water consumption in fish canning factories is very high and because they are concentrated in very small areas this can sometimes represent a critical factor. The factories are located in areas that are near the sea because they need fresh raw materials and they often use seawater for certain processes. This depends on the level of seawater contamination and it can not be used.

The main impact caused by the excessive harnessing of aquifers is the inversion of flow and the entry of seawater into phreatic areas which renders harnessing useless.

3.2.3.3 Energy consumption

Energy is consumed mainly to operate machinery, to make ice, and for heating, refrigeration and cooking. Given the large size of this type of factory, plus:

- The need for industrial cold storage to preserve the product,
- The high degree of automation and
- The sequence of thermal differences that occur in the process

Means that consumption is high. The approximate fuel consumption per ton of product amounts to 100-Kg fuel/metric ton.

The sources of energy that are used are:

- Electrical energy supplied by utility companies
- Electrical energy produced by cogeneration
- Fossil fuels for operating boilers (fuel oil, natural gas, etc.)

The repercussion of energy on the total costs of the sector is 1.8% and the distribution of the energy used is between 40-60% for both.

This balance between both sources of energy is due to the fact that plants in this sector are very large in general and highly automated.

3.2.3.4 Air pollution

Air pollution produced by the fish canning industry is due mainly to:

- Accidental gas leaks in refrigeration circuits (ammonia and CFCs). CFC emissions destroy the ozone layer.
- Direct emissions due to combustion in boilers or indirect emissions caused by the use of electrical energy.

The environmental impact due to combustion is given in the following table:

Consumption		**Fuel oil** 100 Kg.fuel oil/m.ton	**Diesel oil** 101 Kg.diesel oil/m.ton	**Coal** 209 Kg. coal/m.ton	**Gas** 277 GJ PCS/m.ton
Emissions					
SO2	g/m.ton cons.	5,406	601	1,402	0
NOX	g/ m.ton cons.	642	268	448	14
CO	g/ m.ton cons.	57	65	327	2
CO2	Kg./ m.ton cons.	288	298	298	6
COV	g/ m.ton cons.	3	3	5	1
CH4	g/ m.ton cons.	12	1	5	0
PART	g/ m.ton cons.	330	27	851	0
N20	g/ m.ton cons.	1	1	42	0

The estimated energy consumption per ton of product that has been taken into account is the total consumption, given that the sources for both electrical and thermal energy are usually fossil fuels with the exception of nuclear energy.

The enormous difference between the air pollution produced by gas and other fossil fuels can be seen from this table.

The main environmental problems that derive from this are:

- Contribution to the greenhouse effect with important quantities of CO_2.
- Contribution to acid rain in the case of fuel consumption and with possibilities of cross-border problems due to the location of these industries
- Contribution to problems at the local scale due to the presence of toxic pollutants

In order to be able to somehow see the local impact of this need for energy on the region, an assessment is made below of the immission levels starting from a working hypothesis.

Working hypothesis:

- A working area for canning fish that produces 100 metric tons per week.
- Stable meteorological conditions during a week with a temperature inversion at an average of 500 m and a wind regime that permits dispersion within a radius of 100 km2.
- The situation prior to the weeklong episode means that the existing immission levels tend towards zero.
- Dispersion at the end of the week is homogenous in the whole of the region and in all layers below the top layer.

According to this hypothesis and starting with the data from the previous table, the following table has been compiled:

	Fuel oil	Diesel oil	Coal	Gas
SO2	54	6	14	0
NOX	6	3	4	0
CO	1	1	3	0
CO2	3	3	3	0
COV	0	0	0	0
CH4	0	0	0	0
PART	3	0	9	0
N20	0	0	0	0

Data in mg/m3 except for CO2 that is in mg/ m3

It can be observed from the table that the concentration of SO2 in this area would be above the average limit established by the EU for protecting ecosystems (20 mg/m3) and approximately half of the immission levels for people's health. Although parameters such as particles and nitrogen oxides do not in themselves exceed the limits laid down, they would however have an important effect.

3.2.3.5 Wastewater

In the sea products processing industry and specifically in the fish canning industry, enormous amounts of wastewater are produced in the processing of raw materials. The waste flows are connected with various processes such as cleaning, cooking and canning of the product. The main characteristic of these effluents is their high organic load because a significant part of the raw material (fish and shellfish) is eliminated in these flows, either as soluble substances or as solids in suspension.

In the majority of cases, the general waste flow of the factory is made up of all the factory's wastewaters. In general, its main characteristics are low organic load and high salinity. Table 3.12 shows the main characteristics of the effluents from a tuna-canning factory. The low organic load is due to the large contribution made by the volume of wash water and water from hosing down, together with the high load in water originating from cooking. Figure 3.13 gives the level of pollution expressed in DOC together with the volume of different waste flows.

TUNA CANNING FACTORY	
Parameter	Value
COD (mg/l)	4 300
BOD5 (mg/l)	2 970
Conductivity (mS/cm)	20 500
pH	6.1
Soluble solids (mg/l)	480
Nitrogen total Kjeldahl (mg/l)	720
Ammonia (mg/l)	140
Sulphate (mg/l)	270
Phosphate (mg/l)	210
Chlorides (mg/l)	6 900
Oil (mg/l)	400
Surfactants (mg/l)	6

Table 3.12. The characteristics of end effluent from a tuna canning factory

The volume and the characteristics of the waste flows vary slightly over time for they are produced by discontinuous discharges. Table 3.13 shows the variations observed in a plant during the testing of a pilot plant.

Operation day	Time	pH	COD (mg/l)	Chloride (mg/l)
85	11:15	9	4 270	19 460
451	11:15	10,3	2 190	16 640
673	18:15	9,8	2 330	16 690
673	19:30	8,4	950	17 030
723	13:15	9,9	940	13 260

Table 3.13. Variations over time of the end effluent from a tuna canning factory

Below is a more in-depth analysis of the operations that contribute to the most important waste flows in the process. Table 3.14 gives the corresponding data for the pollution of different flows inside of the plant and from this it can be derived, that most pollution derives from cooking.

Waste flows	pH	COD total (mg/l)	Solids in Suspension (mg /l)	Chloride (mg /l)
Unfreezing	6,6	2 090	490	3 670
Washing of the fish	6,6	3 420	1 980	130
Bleeding	6,4	3 710	1 180	400
Cooking	5,7	50 500	2 700	5 600
Washing of the grids	11,9	870	290	-

Table 3.14. The characteristics of different waste flows from a tuna canning factory

90% of the organic load is concentrated in 26% of the factory's waste flow volume, which groups together flows from cooking, bleeding and unfreezing. Given the characteristics of pH, salinity and average concentrations (8-10 kg COD/l), anaerobic means are the ideal form of treatment.

Another perspective of the problem appears in the table that gives emission levels for different canning industries. The table highlights the differences in discharge quantity and quality for different types of canned food, and that range from 20,000 COD for processing mussels to 500 COD for processing octopus.

	Flow	Volume m³/week	pH g/L	SST g/L	SSV g/L	CODt g/L	Cl⁻ g/L	T°C	Kg COD/week
Octopus	Unfreezing	100	6,70	0,68	0,28	1,11	18,11	4	110
	Cooking	20	6,30	1,92	1,24	14,50	17,15	100	290
	Washing	60	6,94	0,47	0,19	1,40	17,15	amb	80
	Total	**180**	**6,74**	**0,75**	**0,36**	**2,69**	**17,68**	**-**	**480**
Mussel	Trimming	8 000	7,97	1,59	0,69	1,20	19,21	amb	9 600
	Washing	8 000	8,06	0,34	0,15	0,23	19,32	amb	1 800
	Cookers	480	6,95	1,30	1,06	16,90	13,66	100	8 100
	Dehydrated	60	6,47	1,32	1,02	27,13	17,79	100	1 600
	Transportation	1 600	8,11	0,21	0,06	0,15	19,21	amb	240
	Total	**18 140**	**7,99**	**0,91**	**0,41**	**1,18**	**19,11**	**-**	**21 340**
Tuna	Unfreezing	140	6,48	0,53	0,39	2,55	19,72	4	360
	Skinning with caustic soda	105	10,39	5,04	3,76	8,37	18,34	amb	880
	Postskinning	220	8,86	0,33	0,20	0,75	19,12	amb	160
	Washing	240	7,99	0,52	0,33	1,70	19,34	amb	410
	Cookers	255	6,18	1,93	1,74	12,36	16,79	45	3 150
	Grid washing	15	12,40	3,38	2,09	16,78	0,30	70	250
	Total	**975**	**7,82**	**1,38**	**1,09**	**5,74**	**18,28**	**-**	**5 210**
Sardine	Scaling	20	6,70	1,03	0,65	3,12	18,23	amb	60
	Transportation	1 500	7,89	0,18	0,08	0,20	19,94	amb	300
	Cutting	320	6,75	1,61	1,47	4,10	19,57	amb	1 310
	Grid washing	10	12,44	2,29	1,43	17,15	6,86	amb	170
	Grid rinsing	340	9,05	0,40	0,18	0,33	19,23	amb	110
	Total	**2 190**	**7,91**	**0,44**	**0,31**	**0,89**	**19,70**	**-**	**1 950**

Table 3.15. Characteristics of the different waste flows of different food canning industries

The main environmental impacts caused by the emission of pollutants by this industry are based on the high COD and the high salt concentration. Other pollutants that produce lower quantities but contribute to degradation are nitrates (3 Kg/m.ton) and phosphates (0.4 Kg/m.ton).

In terms of the consequences for the environment, the degree to which ecosystems are affected will depend on the system used for discharge.

- Direct discharge into rivers is not very likely because the industry locates near to the sea. In such a case, the relatively limited flow in rivers in the Mediterranean basin (except for the Nile and others) would make an important contribution to the eutrophication of rivers and limit certain species due to the high salt content.

- Discharge into rivers and the low level of fluvial circulation would lead to accumulation in very specific areas that would cause serious degradation in those areas.
- Discharge into the sea by way of ocean outfalls is the optimum solution, although this can cause problems for fishing in certain areas if the level of pollution is too high. Salinity does not entail any problem.

3.2.3.6 Solid organic waste

The solid waste that is generated in fish canning processes originates from operations that prepare the product for canning. 20 to 50% of total fish weight can be wasted in these operations, which include removing the heads and viscera, filleting and scaling. This waste often ends up in plants that produce fishmeal for animal consumption or that extract the oil.

Fishmeal production began at the beginning of the last century in northern Europe and North America as a method for manufacturing herring oil.

The preparation of fishmeal involves high levels of energy consumption (50l of fuel oil/m.ton and 32 kWh/m.ton), wastewater flows of 21 m3/Tm and COD emissions of 42 Kg. This industry also produces unpleasant smells.

An important kind of waste in the case of the preparation of canned bivalves is the shells, as is the case with mussels. At the present time, there is no specific treatment for using this waste which means that the large producer companies are faced with the problem of not knowing what to do with this waste. One result is that they opt to import shelled mussels from countries like Peru where there is a large production and they save themselves the problem of having to treat the waste.

3.3 Fruit and vegetable processing

3.3.1 Processes

3.3.1.1 Fruit juices and nectars

Fruit juice was originally developed as a result of the surplus production of fruit. Although this still occurs in some areas, 60% of all commercial fruit juice today is made from fruit grown specifically for this purpose.

There are many varieties of juice including:

- Clarified clear juices (grape, apple, and blackcurrant).
- Slightly cloudy juices like pineapple.
- Cloudy juices that contain cellular material in suspension (orange, grapefruit, etc.)
- Pulpy juices like tomato.
- Fruit nectars made with all of the pulp, for example, peach.

The production process begins after the fruit is received at the plant. The fruit is washed to eliminate any organic impurities that it may contain and is then prepared for the juice extraction stage, with prior stages of pitting and peeling for certain types of products. The fruit is then crushed with or without being heated beforehand and the juice extracted by pressing or seiving. Pressing is often a seasonal operation depending on the season of the different kinds of fruit. In some cases (citrus fruit), very specific systems of extraction exist that do not require the fruit to be crushed beforehand.

Once a crush is obtained, the juice is then refined by decanting, clarifying and/or filtration. Filtration is normally done to give it lustre and clarity and to eliminate yeast. All methods use filtration adjutants, usually diatomaceous earth, all of which are retained by the filter. The main kinds of filter are plate and frame filters, rotary drum vacuum filters and candle filters. Fibre pad filters are used less and less.

Operations using desertion and pasteurisation are then carried out on the product to preserve it.

Desaeration is an obvious step given fruit juice's general susceptibility to oxygen and the corrosive effects of oxygen on tin.

Desaeration normally takes place by creating a flow of juice towards a column where the liquid is dispersed onto a surface at the same time that a vacuum of approximately 950 mbars is applied. The juice may be preheated to a maximum temperature. This stage must be preceded by pasteurisation or some other heat treatment because oxygen can cause the rapid deterioration of the heated juice and adequate precautions must be taken to prevent air from re-entering.

The temperature of the juice is increased to around 70 ºC during pasteurisation by means of a plate or tubular heat exchanger. The heated juice is maintained at this temperature for a short period of time following which it is cooled before filling. Quick pasteurisation uses temperatures of up to 80 ºC during 15 seconds for very short periods. As fruit juices have a low pH, commercial sterility is to all extents and purposes secured.

Finally, the juice is sent to cold storage to be later canned or bottled or it may go on to be concentrated.

The order and number of operations can vary considerably according to the raw material and the type of product.

The technology used by companies for each operation depends to a great extent on the type of raw material that is being worked with and the type of product that is required.

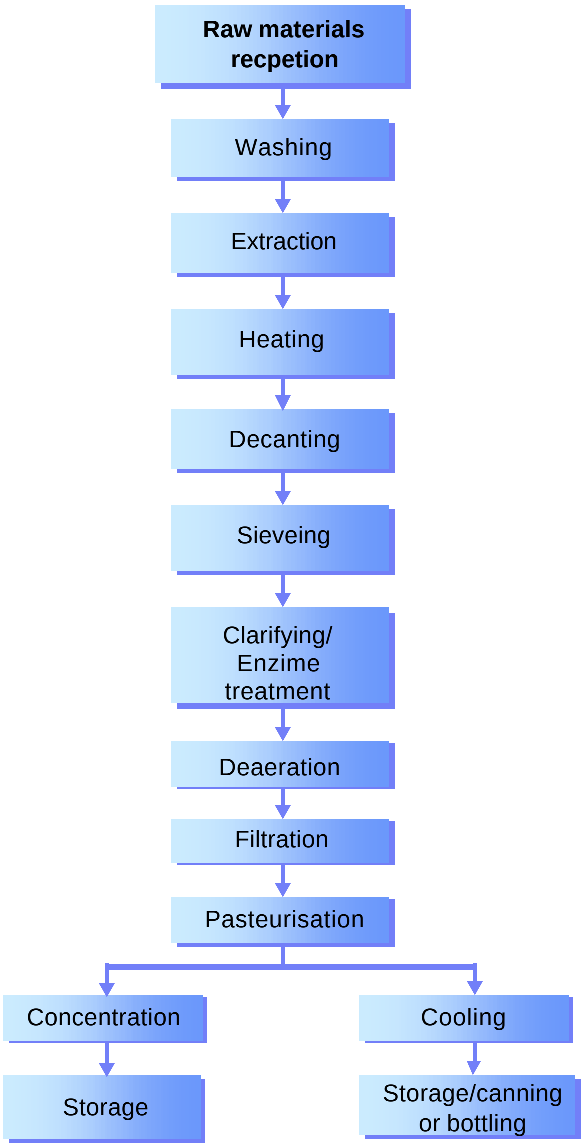


Figure 3.17. The juice canning process

3.3.1.2 Fruit jams and marmalades

Jams and marmalades consist of fruit, pectin, sugar, acid, water, colouring and flavourings. Fruit is the main determinant component of the quality of jam and of marmalade. It is not necessary to just use fresh fruit; frozen, refrigerated, tinned or canned fruit treated with sulphur dioxide may also be used.

The process is similar for preparing jams and marmalades although jams need more agitation during cooking to distribute the pieces of fruit more homogeneously.

The fruit is subjected to preliminary cleaning operations prior to being used. These include the inspection and elimination of fruit that is either in poor condition, mouldy or insect-ridden, the elimination of stalks, stems and stones in the case of fruit with a hard stone such as peach and plum, and washing and slicing into pieces.

Once all of the different ingredients are ready, they are mixed together and cooked. In this process, the water is evaporated until the required solid content is achieved. A series of phenomena take place during cooking, including:

- The fruit softens
- Elimination of excess water and SO2
- The partial inversion of sucrose
- The product becomes more concentrated, which enhances the characteristic taste and texture
- Mould and yeast are destroyed
- The drawing out of pectins and the elimination of hydrolytic enzymes that degrade them

Cooking can be done in two ways, either at atmospheric pressure or by vacuum cooking. In the first, cooking is done in open boilers (or 'evaporators', cooking pots or pans) that are heated by steam and that normally contain batches of between 75-100 Kg. of prepared fruit mixed with water, sugar, pectin and corn syrup.

The boilers are set up in sets of 4 to 8, and loaded in rotation so that jam production is continuous. Once they are loaded, the steam is turned on and the mixture boils until the precise level of solidity is reached. Once this has finished, the product is cooled until it reaches the optimum filling temperature.

In the case of the second method (vacuum cooking), larger quantities of product can be cooked and cooling is not necessary after discharge. The drawbacks are that it is more difficult to control the cooking process, and changes in the type of fruit to be processed involve a complicated cleaning system.

There are two alternatives in this system, discontinuous or batch boiling, and continuous boiling. Here the temperature of the product has to be increased when the vacuum is released to destroy mould and yeast.

Once the cooking is completed, the product must be potted at temperatures between 85 and 90 ºC. the fact that it is done at this temperature guarantees a series of aspects such as:

- Correct gelling and solidification
- Uniform distribution in the whole container
- It minimises variations in weight during filling due to changes in density
- It lessens temperature shock and contributes to cooling
- It sterilises the product.

Glass jars are normally used for bottling and automatic and continuous rotary multi-piston machines with a large filling capacity are used.

Once the jars are filled and sealed, they are cooled to 35 ºC by strip refrigerators with water sprayers. In principle, spraying is done at 60 ºC to avoid temperature shock and to make sure that initial cooling does not occur too fast and thus avoid boiling in the centre of the product. After being cooled, any moisture is eliminated from the surface of the jars with an air jet. A vacuum detector checks the hermetic seal by automatically verifying the concavity of the lid.

The jars then go to a visual inspection area where any defects such as foreign matter, floating fruit or bubble formation are observed, and any such jars being rejected. They are then left to settle for at least 24 hours for this is beneficial to gelling. Then they are labelled, packed into boxes, stored in areas that should be cool, dark, and ventilated.

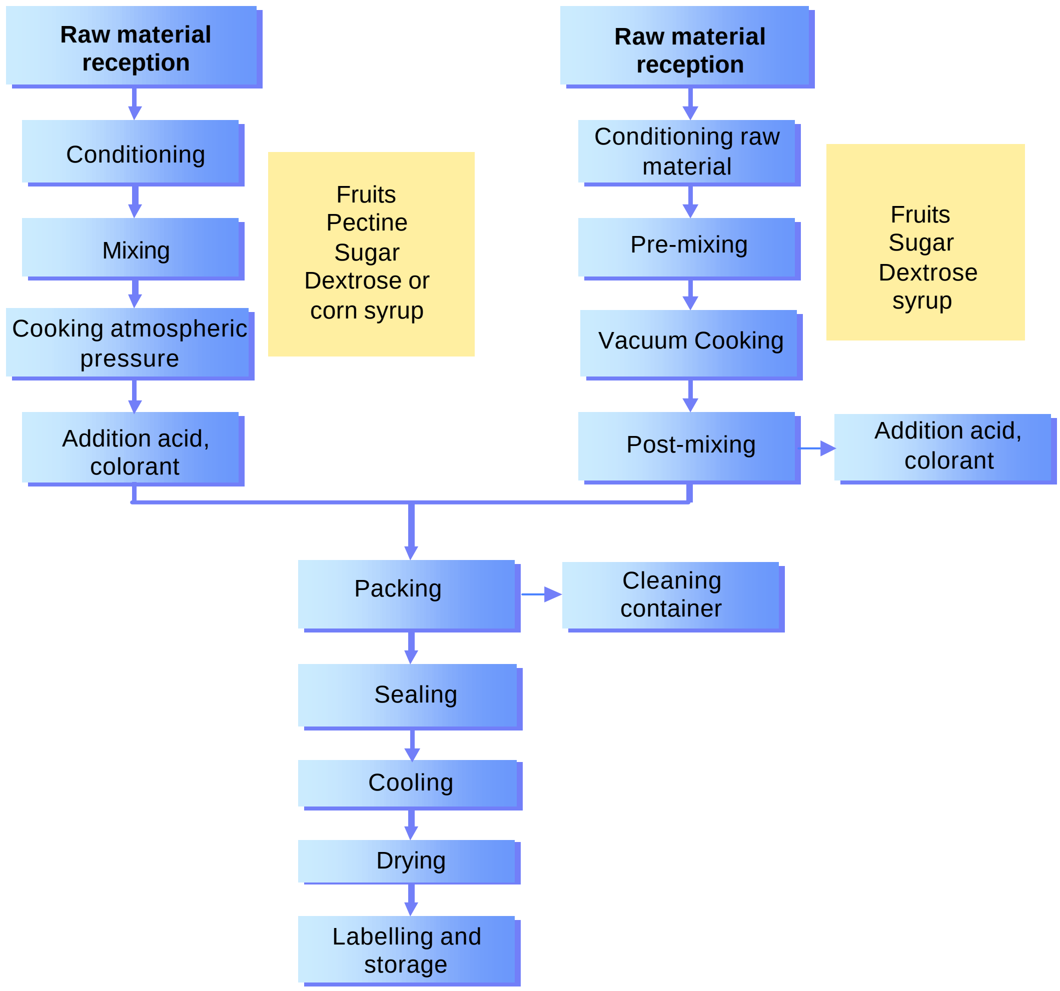


Figure 3.18. The marmalades process

3.3.1.3 Fruit preserved in syrup

After the fruit is received and weighed, damaged and sub-standard fruit are removed. The criteria for this are usually that the fruit is of good quality and that it has the correct structure for it to be heat-treated without deteriorating. Once the fruit is sorted, the Brix degrees and acidity are measured.

The fruit is washed with drinking water and then peeled and cut. The peeling operation is generally done chemically although in some cases, such as with pears and apples, mechanical peeling is still used.

The machines used for this are designed exclusively for each kind of fruit. The fruit is manually put into rotating hoppers and moveable, adjustable pressure cutters do the peeling. As well as doing the peeling, these machines also core and cut the fruit into halves, quarters, etc.

The way it is cut (cubes, slices, segments, and chunks) will depend on the type of fruit. The pieces must not be too small or thin in order for it to keep its structure once it comes into contact with the syrup and is heat-treated.

The pieces are put into clean sieves or mantels and submerged in hot syrup for a minute or less. This operation scalds the fruit. The fruit is then taken out of the syrup bath and is left to drain.

Once they have drained, the pieces of fruit are put into preserving jars or containers that have been duly washed and sterilised with hot water together with the lids.

The hot syrup is added afterwards (at boiling temperature) and distributed homogeneously in the jar so that the fruit is totally covered. Any trapped air is eliminated and the jars are sealed.

The syrup, which in this type of preserve serves as the covering liquid, is a sugar water in solution, with a sufficient quantity of sugar for it to be a liquid medium and the required sweet flavour based on the Brix degrees of the fruit and the final product.

This covering liquid has the following functions:

- It transfers the necessary heat to sterilise the product, for the heat cannot be applied directly from the jar to the fruit because it would get scorched.
- It keeps the pieces of fruit soft and appetising, and maintains their structure.
- It prevents the oxidation of the fruit by protecting it from contact with the oxygen in the air, and prevents the fruit from changing colour and the loss of its organoleptic characteristics.

Before being sterilised, the jars are washed by pressure water spraying to eliminate any remains of fruit or syrup on the surface of the jar.

Once they have been sterilised, the jars are dried, labelled and then put into storage.

3.3.1.4 Bottled vegetables in natural juice

3.3.1.4.1 Processing asparagus

Fresh asparagus is transported from the field to the processing plant in refrigerator lorries to facilitate reception, weighing and washing, and special care is given to the shoots to ensure that they are handled correctly.

The raw material is inspected and any product in bad condition is rejected. The raw material is then cut to the dimensions required for the different containers, which can either be of tin or glass. It is then washed using chlorinated water that helps to eliminate the bacterial load.

The following operations of scalding, peeling and grading are done in different orders according to the type of peeling.

White asparagus can be peeled in three different ways: the fresh asparagus can either be mechanically or manually peeled, or mechanical peeling can be done once the asparagus has been scalded.

There are two models of mechanical blade peeling equipment on the market, one circular and the other rectangular. The first system consists of a revolving carrousel where there are twenty pneumatic headstocks or tubes that hold the asparagus and twenty pairs of pincer blades that mechanically peel them. The asparagus are manually put into the headstocks and they hang suspended by the bud. The pincer blades ascend in the open position and, on closing, seize the stalk. They then descend, peeling either side of the asparagus and as the carrousel and headstocks come to the end of the turn, the peeled stalks fall into a compartment and are transported to the scalding section.

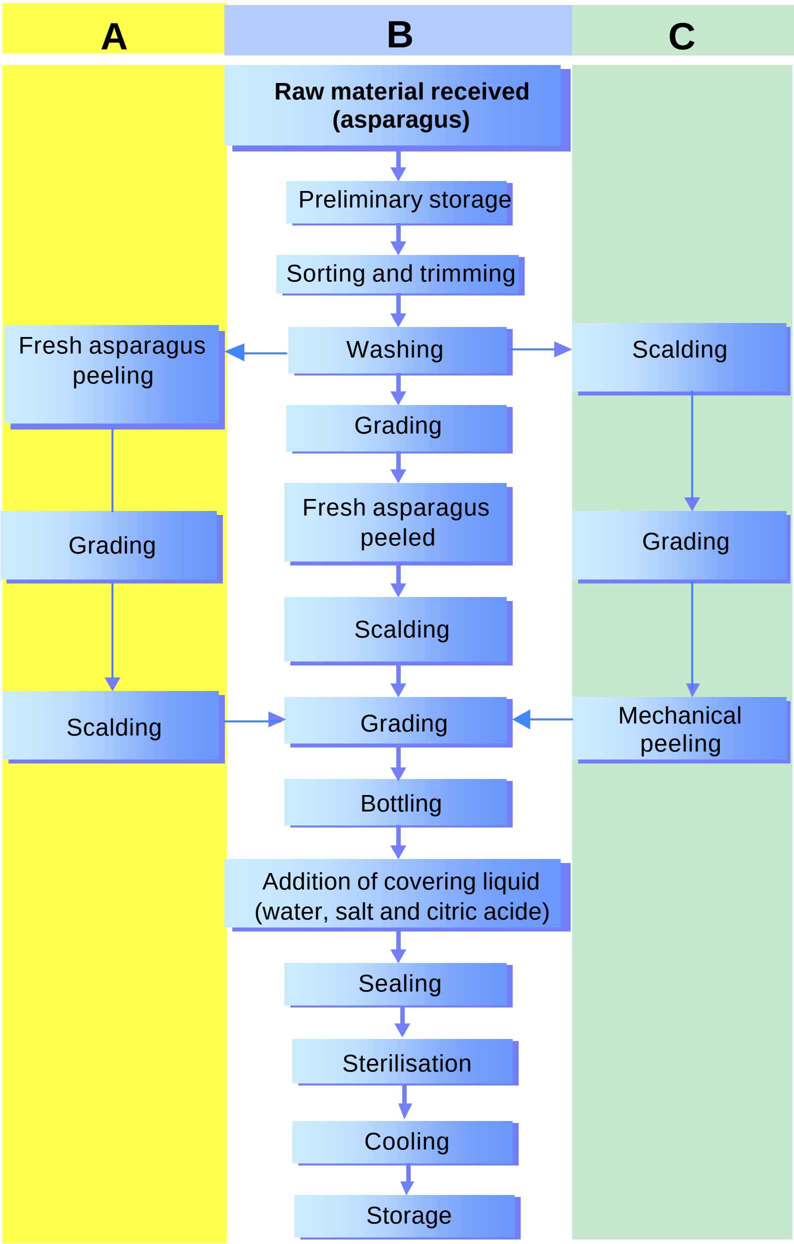
Scalding pre-cooks the product by contact with hot water and is done to deactivate the enzymes that cause oxidation and degradation of the asparagus‘ taste. This operation is also known as blanching. Cold is then applied immediately to avoid overcooking of the product.

Grading of the asparagus is done according to the diameter and the quality of the tips. Once the grading has been done, the scalded asparagus are transported to the bottling and weighing tables. The product can be bottled or canned either mechanically or manually.

It is important for the weight to be controlled during the filling process to ensure the minimum dry weight established by the regulations. The asparagus is constantly in contact with water during this filler process to avoid dehydration.

Once the product is inside the containers, these are filled with the covering liquid that has been heated to boiling point in stainless steel pots. The air content in the container is then eliminated using steam jets and they are hermetically sealed. Chlorinated water sprinklers then remove any remains of product or cover on the outside of the containers.

The containers are then sterilised. Once they have been sterilised, the containers are carefully checked during labelling and packaging, and are then stored.



A) Mechanucal peeled and scalding B) Manual peeled and scalding C) Scalding and mechanical peeled

Figure 3.19. The asparagus canning process

3.3.1.4.2 Processing sweet peppers

Once the raw material is received, a preliminary inspection is made where unripe, damaged or defective peppers are separated out. Peeling is then done and there are various alternative processes for this. Peeling can be done by flame or chemically.

In the case of peeling by flame, the peppers are baked in revolving ovens, which are inclined cylinders covered on the inside by a layer of refractory material. The flame, which is produced by a centrifugal or atomiser-type burner, is injected through the lower part of the cylinder and almost pierces the whole length of it. The peppers, which are conveyed on a hoist, enter through the upper part and roll towards the exit under the action of gravity and the movement of the revolving cylinder. This rotation exposes the whole of the surface of the pepper to the direct action of the flame.

The burnt skin is then eliminated by a revolving wire sieve drum and this is followed by washing with water sprinklers. Scalding is not necessary afterwards as the peppers have been baked during these operations.

In the case of chemical peeling, the selected peppers are submerged in a solution of NaOH (18-20%) at 95-97 C for 40-50 seconds. After this period, the skin can be eliminated by pressurised water. The peppers are transported through the revolving rod drum or rough surface drum where there are pressurised sprinklers along the central axis.

In order to eliminate the action of any remains of NaOH, the product is washed in a bath with an acid solution. In this case, the pepper must be scalded.

Once they are skinned, the product is checked and sorted, and graded by colour and size. The peppers are then canned and a covering liquid is added that consists of a solution of citric acid with a pH lower than 4.4.

Before the containers are sealed, they are preheated to eliminate any air that remains trapped inside. Once they are sealed, they are washed and heat-treated to sterilise them.

The containers are then dried, labelled and stored.

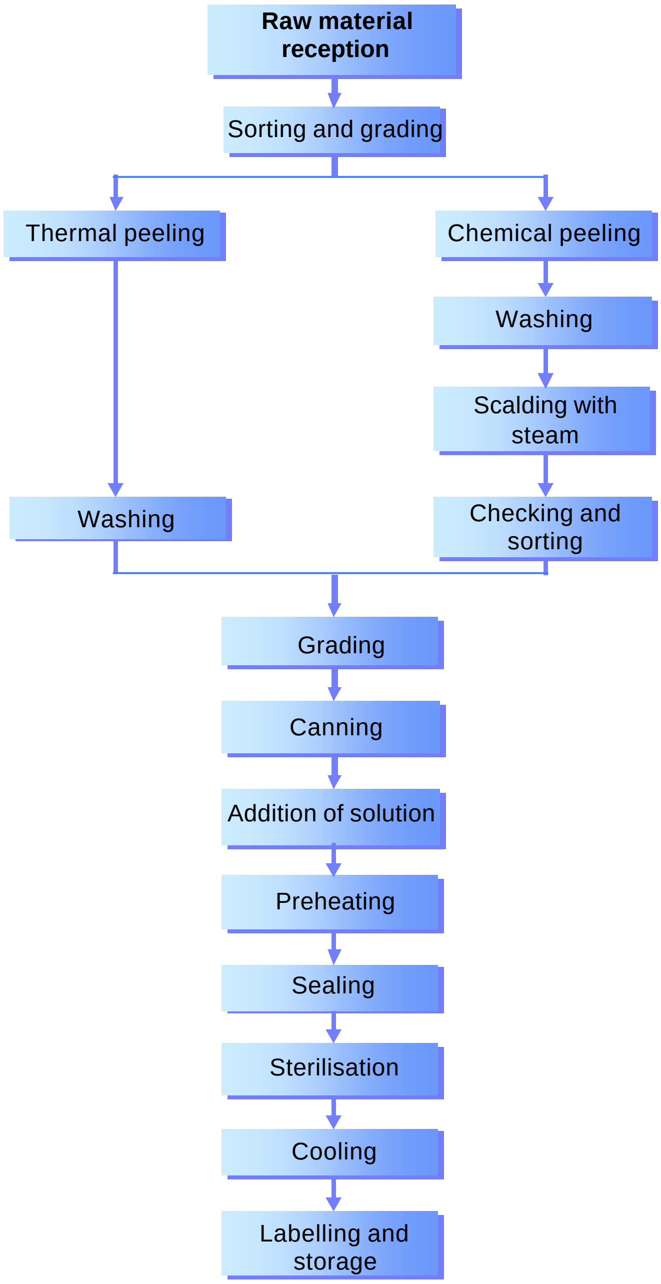


Figure 3.20. The sweet pepper canning process

3.3.1.4.3 Processing artichoke hearts

After the raw material is received, it is inspected and sorted. This operation, which is normally done manually, separates out any artichokes in bad condition and grading, is then done according to size.

They are then washed to eliminate any remains of earth, stones or other contaminating substance on the surface. Once they have been washed, the stalks of the artichokes are cut to a length less than three centimetres. The product is then scalded by immersion in water at a temperature of 96-98 C for 10-20 minutes, depending on the size and consistency of the fruit.

Once they have been scalded, the fibrous ends of the leaves are cut off. The equipment for doing this operation consists of a cup conveyor that takes the artichokes to the peeling section that does the operation in two stages:

First the leaves are removed and then the base of the artichoke is turned and shaved so that the outer leaves fall away from the base of the holder. The artichoke then passes through a revolving rod drum, where the friction of the artichokes rubbing against each other and the rods eliminates the leaves.

Another line version consists of two machines. The first cuts the stalk and the leaves without scalding. The artichokes are then scalded and a second machine then extracts the base using a special cutter activated by pressurised air that automatically adapts to the form of the fruit.

The artichoke hearts are checked and sorted before being canned. Once they are in the containers, a covering liquid consisting of brine with citric acid with a pH lower that 4.4 is added. Before the containers are sealed, they are preheated and once sealed they are then washed.

The containers are sterilised, cooled, dried, and then stored.

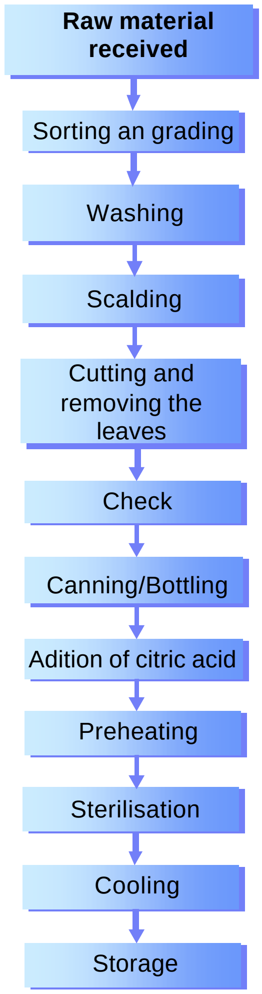


Figure 3.21. Processing artichoke hearts'

3.3.1.4.4 Processing green beans

When the green beans are received, they are first sorted by a system of drum sifters that are made of mesh or perforated metal sheet cylinders that revolve in an almost horizontal position.

Once the product has been sorted, the beans are then topped and tailed or cropped and a second sorting is done.

Special green bean cutters exist on the market. The first step is to eliminate the tips in a cropper that essentially consists of a slightly inclined perforated cylinder with fixed blades on the outside that turns. The tips of the beans pass through the holes and are cut by the blade. The bean is then cut crosswise or lengthways in strips.

The product is then checked to make sure that all of the beans have been cropped and it is then washed.

To cook the beans, they are scalded by immersion in water at 78-80 C. If the product is not to be canned immediately; it is cooled with water to prevent deterioration.

The beans are generally canned in metal tins to which hot brine is added as covering liquid. Once the cans are sealed, they are heat-treated and sterilised.

The sterilised product is cooled and dried for labelling and then stored.

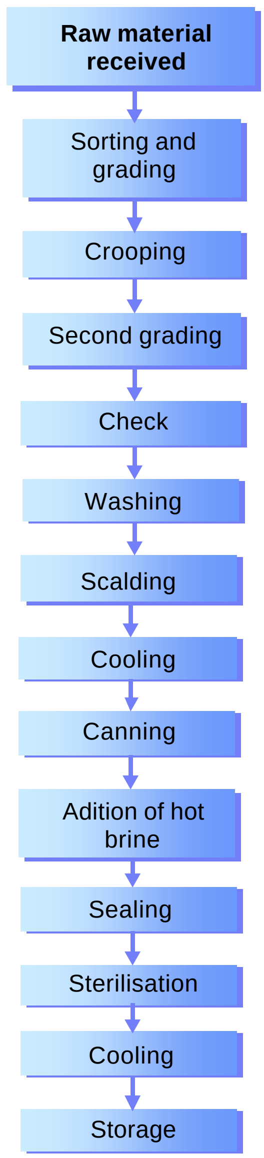


Figure 3.22. Processing green bean

3.3.1.5 Vegetable pickles (in brine)

Olives must be harvested when they are of an optimum size but before they are completely ripe.

Once they have arrived at the factory, they are sorted and graded. They are then put in bleach baths (a sodium hydroxide solution with a concentration of between 1.25-2.5%). The olives are left in the bath for sufficient time for most of the bitterness to be removed. Bleach penetration must be between two thirds and three quarters of the distance to the stone.

The olives are then totally washed in a process that lasts for one or two days until they are free of bleach. If they are washed for too long, the carbohydrates that are necessary for fermentation are lost and if there is any residue of bleach, fermentation does not occur due to the loss of bacteria.

The olives are then immediately put into brine barrels or tanks that contain 11% salt and this concentration is maintained by adding salt whenever necessary.

Fermentation is much slower than with gherkins and they often need to be incubated at 25 ºC to accelerate the process. Glucose is frequently added to maintain the fermentation.

Once the fermentation has come to an end, the containers are filled. These can be either of glass, metal or bags. A 7% brine concentration is added that can also contain lactic acid.

The brine can be hot packed to avoid the presence of oxygen in the container. If the brine is not hot when it is added, the air that is trapped in the full containers is eliminated using steam jets.

Olives can be pasteurised and this is sufficient heat treatment for preservation because their pH (values of around 3.5) drops during fermentation due to the action of lactic bacteria that develop and the activity of the water due to the penetration of NaCl into the olives. The action of all of these factors means that olives are stable at room temperature for long periods of time.

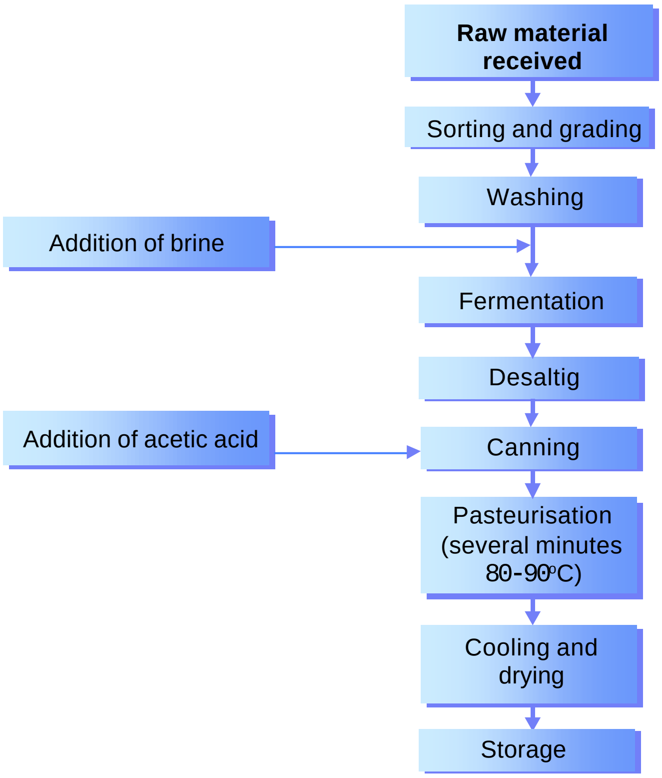


Figure 3.23. The olive canning process

3.3.1.6 Canned mushrooms

Once the raw material arrives at the canning factory, it is given a prior inspection and is graded. They are checked for remains of earth adhering to the mushrooms, the colour and consistency and the presence of any defects (breakage, insects, and surface moisture).

The product is then prepared which includes the manual or mechanical cutting of the stem to a length that is less than or equal to the diameter of the cap.

Once the product is ready, it is carried and washed by water to the blanching stage that consists of the scalding of the product. This operation is either done with water or steam for 5-7 minutes depending on the freshness, size and state of maturity of the mushroom.

Once they have been blanched, the mushrooms are cooled to below 30 ºC in order for the product to be of the best quality. Cooling is done in tanks full of clean, fresh water where they are transported rapidly due to the fact that exposure to the air for periods longer than 30 seconds can cause important discolouring and stains on the surface of the mushrooms.

The product is then put into cans, taking care to fill the containers with more product quantity than that which is desired at the end, due to the fact that the mushrooms undergo an important reduction in size.

Headspace is left when the brine is added, and this should not be more than 10% of the height of the can. The brine is heated to a temperature of around 72 ºC before being added.

Once this has been added the cans are sealed very shortly afterwards to avoid cooling of the solution which would mean having to create a vacuum by mechanical methods, such as steam jets.

The closed cans are washed to eliminate any remains of the product or brine and are then sterilised. After this treatment, they are immediately cooled to around 38 ºC. the cans must be dry when they are packed. Once they have been labelled and put into boxes, the product is then stored.

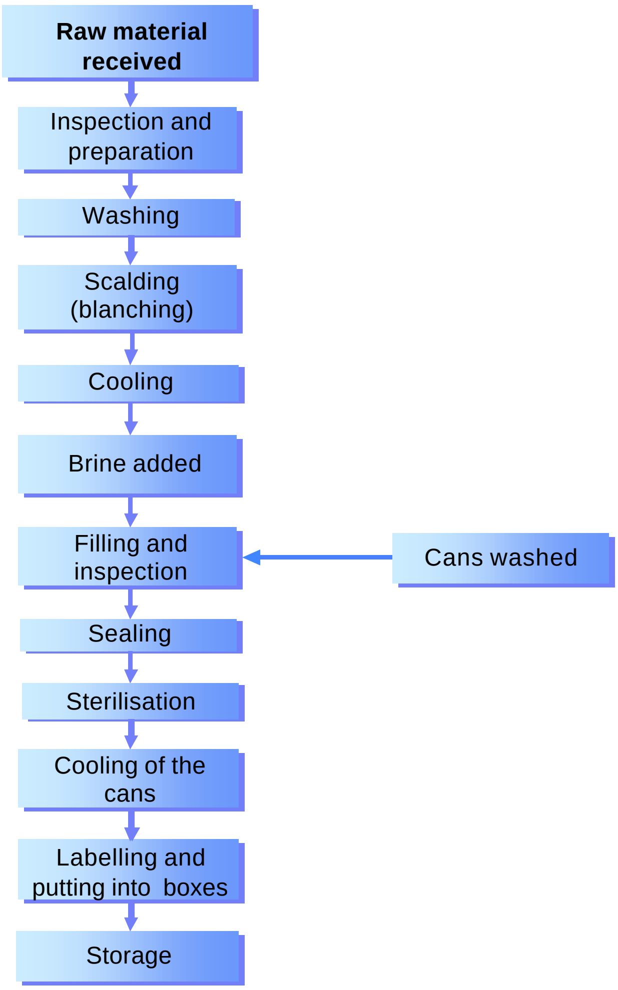


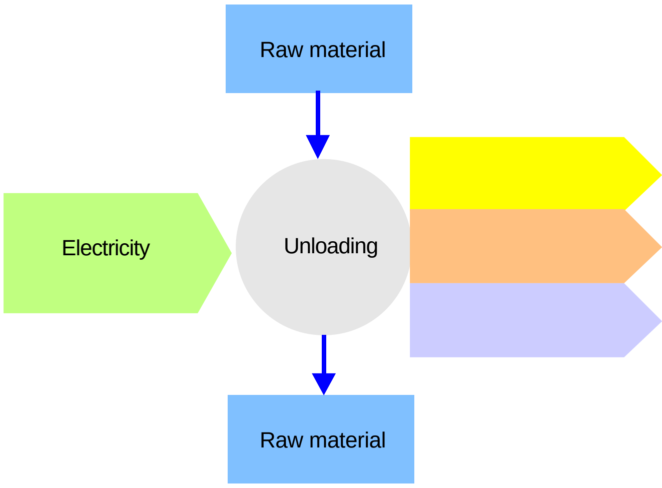
Figure 3.24. The mushroom canning process

3.3.2 Unit operations and environmental aspects

3.3.2.1 Unloading

When the product has to be transported over long distances, it is normally either refrigerated or transported in refrigerator lorries. Cooling methods vary considerably from one product to another. Cold air and immersion in cold water are both fairly common procedures. Crushed ice is also used to keep the product cool.

Once the carrier reaches the factory, the product is unloaded and put into cold storage.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	1000 Kg
Electricity	3 kWh		

Table 3.16. The balance of materials and energy used in unloading

3.2.2.2 Washing

This operation seeks to eliminate the dirt, earth, surface bacteria, mould and other pollutants appearing on the surface of the product.

It is usually done prior to the processing of the product, in order to avoid breakdowns in the installations due to stones, fruit stones or metal objects and to save time and money in processing components that will have to be thrown away. Moreover, the elimination of these small quantities of contaminated food can avoid losses later on that would be produced by the proliferation of microorganisms.

Different types of washer equipment exist on the market and they either use wet or dry methods.

Within the first group, there is the in-soak washing variety that uses sprinklers, flotation and ultrasound. This eliminates the earth from vegetables like beetroot, carrots and other tubers, and pesticide residues from vegetables and soft fruit. High-pressure water spray washing is the most satisfactory method.

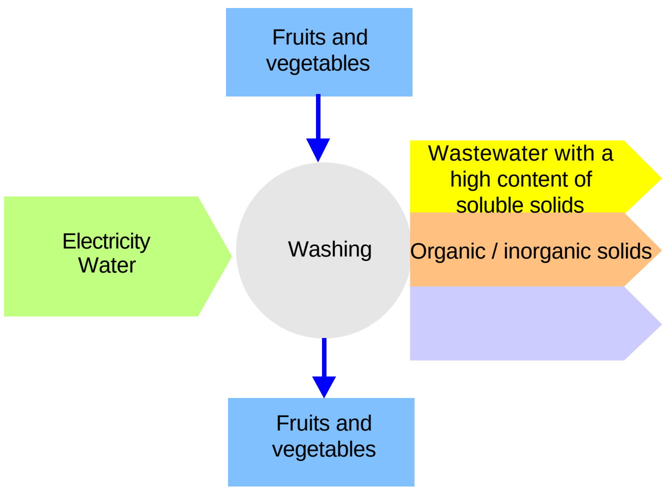
This system does not create any dust and is less damaging to foodstuffs but a negative aspect is that it gives rise to large volumes of effluent that generally carry a high concentration of suspended solids.

Provided that it can be done, the water is reused following a filtration and chlorinating process and this helps to reduce costs.

With small-sized products that have a greater mechanical consistency and a lower water content, the dry cleaning system is used. This system generally requires installations that are less expensive and that produce concentrated effluent that is dry and cheaper to eliminate.

Within the range of equipment that does this type of cleaning are air classifiers and magnetic and sifter separators.

Washing must be followed by effective draining to eliminate any water from the product and to make the following operations easier.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	950-999 Kg
Water	0.1-1 m3	Wastewater	0.1-1m3
Electricity	1 kWh	Soluble solids	1-50 Kg
		Organic/inorganic solids	1-10 Kg

Table 3.17. The balance of materials and energy used in Washing

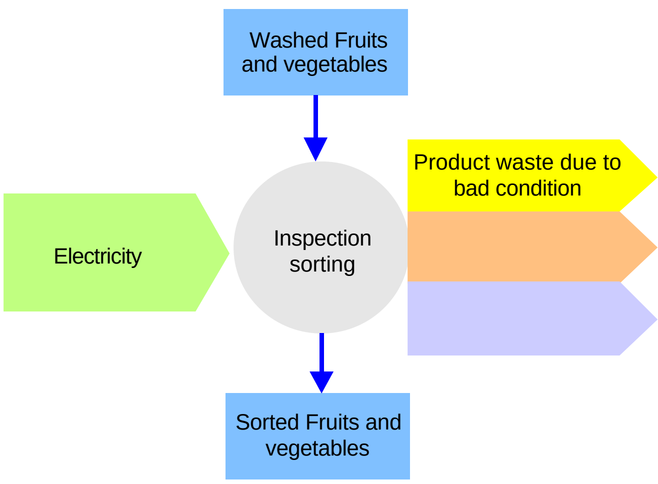
3.3.2.3 <u>Inspection, sorting</u>

The product must be inspected before it is processed. This operation is done visually by a team of people that work on either one or both sides of the belt or inspection table. The product passes through on a conveyor belt and the personnel remove any defective products that they see on the belt. With citrus fruit and tomatoes, equipment fitted with cylindrical bars turns the fruit as it progresses, enabling the whole surface to be inspected.

Nowadays, there are many types of equipment that carry out this operation automatically, such as electronic colour sorters that detect products that are defective or discoloured. An important point is the separation of any metal objects that may be accompanying the product. Magnetic separators are set up on the inspection line to take care of this.

Once the raw material has been sorted, the vegetable products may be pre-stored in chambers at established temperature and relative humidity levels, or go directly on to the following operation.

Important quantities of organic waste are generated in this operation although they can be reused without the need for pre-treatment because the product is whole and there are no chemical residues.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	900-990 Kg
Electricity	0.1-0.5 kWh	Product waste due to bad condition	10-100 Kg

Table 3.18. The balance of materials and energy used in inspection and sorting

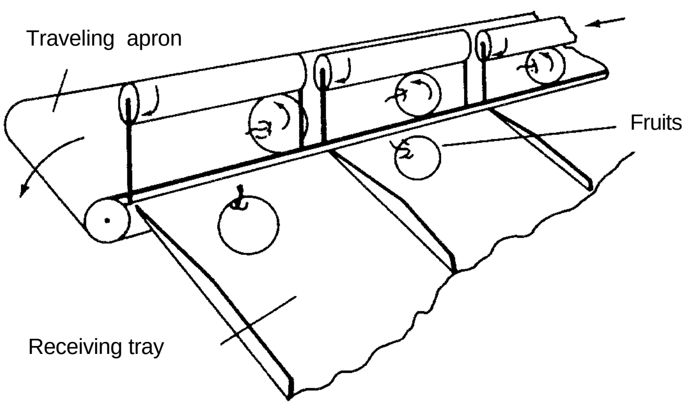
3.3.2.4 Classification or grading

This operation consists of grading the product according to different criteria such as size, colour or weight. Correct grading is very important in the case of the size because the food will undergo heat treatment and product size must be homogeneous for this to be done satisfactorily.

The operation of classifying by size can be done either manually or mechanically. The mechanical versions are based on fixed or variable hole-size sifters.

The most common types of fixed hole sifter are flat sifters and drum sifters. The multiple flat sifters consist of a series of inclined and horizontal sifters with a hole size of between 20 microns and 125 mm that are set inside a vibratory structure. The product units, that are smaller than the size of the holes, fall through them until they reach a smaller size hole sifter.

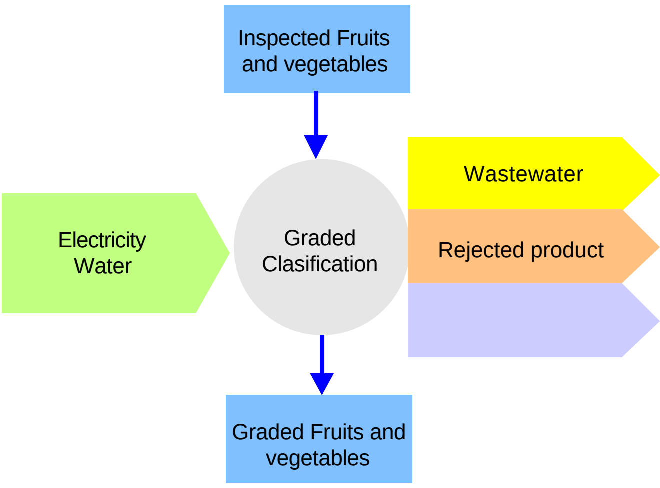
Drum sifters are used for classifying small-sized foodstuffs such as peas and beans. They consist of a wire mesh or perforated metal drum that revolves in an almost horizontal position.



Variable hole-size sifters are used to classify fruit and use divergent rollers, cables or spiral conveyors with a pile surface where the rotation speed is varied so that the fruit passes through the hole in the sifter.

Grading by colour is based on photodetectors that detect the light reflected by each product that is then compared with a predetermined standard. Whatever does not correspond with this standard is rejected by way of a jet of compressed air. This is used for small-sized products.

Grading by weight is more precise than other methods and is used for products with a higher value. Induction and flotation systems that are based on density differences are used. Peas and beans are classified using flotation in brine. Units that are overripe sink whereas those that is more unripe float.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	990-1000 Kg
Electricity	0.1-3 kWh	Wastewater	0-0.1 m3
Water	0-0.1 m3	Product rejected	30-90 Kg

Table 3.19. The balance of materials and energy used in grading

3.3.2.5 Peeling

This is an important preliminary operation for, together with washing, it eliminates surface dirt and any associated microbial contamination.

The methods that are most used are classified into two systems:

Chemical peeling: Based on the action that certain chemical substances in given conditions have on fruit and vegetables.

1. Alkaline peeling
   Characteristics: This system uses caustic soda or bleach to do the peeling and is highly effective and economical. This is the most commonly used system.

   The clean product is put into a tank that contains a solution of caustic soda (from 2 to 20%) that is heated with steam. The product passes through the bath on paddle conveyors either in a drum system that turns and submerges the product in the solution as it passes through it, or on a paddle conveyor located in the upper part of the tank.

   In the case of tomatoes, apples and pears, where wax in the peel interferes with the action of the soda, bipolar surfactant agents are added to the tank.

   Following the treatment, the fruit is well washed in abundant pressurised water and the peel separated from the fruit and any remains of soda eliminated. This operation is often done in revolving rod or rough surface drums fitted with pressurised sprinklers. The product remains some time inside of the drum and accumulates, which causes the peel to work loose by friction.

   The product then goes into a bath that contains an acid solution to neutralise the remains of soda and regulate the pH level of the product. A manual check is done at the end to eliminate any remaining peel.

   This system uses large volumes of water, and it also generates large quantities of wastewater with the pH modified due to the soda and acid content.

2. Dry alkaline peeling
   A system that consists of covering the product in a film of concentrated caustic soda (20%) by immersion or spraying. The product then passes through an infrared unit that consists of a fruit feeder and a swivel roller conveyor.

   During transportation, the fruit is exposed to the action of infrared rays. The combined action of heat and bleach leads to the disintegration of the peel and of a fine layer of pulp, at the same time that it causes the surface to dry out.

   The disintegrated peel that is almost dry is eliminated as a residue due to the effect of friction as the fruit passes through revolving rod or rough surface drums. Any remains of soda and peel that are left are finally eliminated by using pressurised water sprinklers.

   This system is especially used for peeling potatoes. It is a system that leads to a saving in water and it contributes less soda to wastewater flows.

3. Peeling using ammonium salts

   A peeling system with a water solution that contains diammonium orthophosphate with surfactant agents has been designed to improve peeling by caustic soda.

   This procedure can be applied to carrots and potatoes. Effluents have fewer residues and the pH is lower, which makes treatment of waste easier.

4. Acid peeling

   A system used for peeling citrus fruit to eliminate albedo in the segments. The process consists of two parts, first an acid treatment to hydrolyse the pectic substances in the albedo, and then an alkaline treatment to disintegrate and eliminate the rest of the peel.

Mechanical peeling: This was the first system used by the vegetable canning industry. It is based on the use of traditional types of cutter and others especially designed for different products. Other less manual types of mechanism are being used in the industry with satisfactory results.

1. Abrasion

   In this system, the fruit is submitted to a twisting movement whereby the entire surface of the fruit is in contact with the abrasive surface that sheds the skin by friction. Pressurised water then removes this. Brushes or the combined action of both are used in the case of fruit with a thin peel.

   This system is used on tubers and root vegetables.

2. Mechanical cutters

   There are many models of this system due to the specific design for each type of product to be peeled. They are based on the mechanisation of cutting that is done by cutters.

   This system was initially applied to fruit that were not so difficult to peel, although its use then extended to vegetables.

3. Steam peeling

   The fruit is treated with steam during a short yet sufficient time to reduce the adherence of tissues that are underneath the peel and to be able to separate them.

   Different applications of this system exist on the market:

      <u>The use of pressurised steam</u>

      A peeling mechanism that has a better performance rate than caustic soda peeling whereby pressurised steam (3-10 Kg/cm2) is injected for between 5-10 seconds until the temperature below the peel or skin is higher than 100 ºC.

      The peel is then removed by rollers or pressurised jets of water.

The use of pressurised steam and a vacuum

The surface of the product is heated very quickly and intensively followed by the application of a vacuum, which causes the sudden breaking and loosening of the peel or skin. The peel is then removed by rollers or pressurised jets of water.

The use of rotary blades

Tomatoes are scalded and cooled and then pass through a series of rotating cutters and devices made of rough material that eliminates the skin.

4. Flame peeling

   This consists of submitting the fruit to the direct action of flames and is done in rotary ovens.

5. Freeze peeling

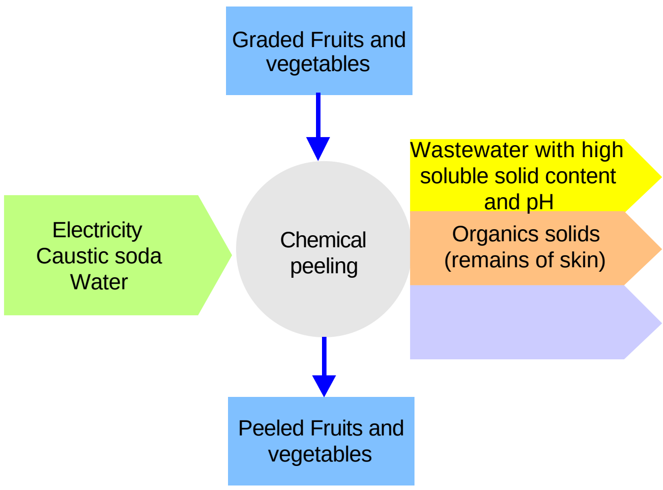
   This is based on quickly freezing and then unfreezing the fruit. The skin is loosened due to the iron crystals that form in the subcutaneous layer and break the tissue. The skin is eliminated afterwards by mechanical means.

6. Pressurised air peeling

This system uses the combined action of mechanical peeling (friction or cutters) and pressurised air to separate and eliminate any remains of skin or peel.

7. Oil peeling

This consists of submerging the product in a bath of neutral mineral oil heated to 430-440 ºC for 30-40 seconds. After the heat treatment, the sweet peppers are transported on a mesh conveyor where the oil drains and they are then exposed to powerful pressurised water sprinklers to separate and eliminate the skin.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	400-950 Kg
Water	0.1-1 m3	Wastewater	0.1-1 m3
Caustic soda	10-200 Kg	Soluble solids	10-100 Kg
Electricity/Thermal energy	1-2 kWh	Remains of skin	50-600 Kg

Table 3.20. The balance of materials and energy used in chemical peeling

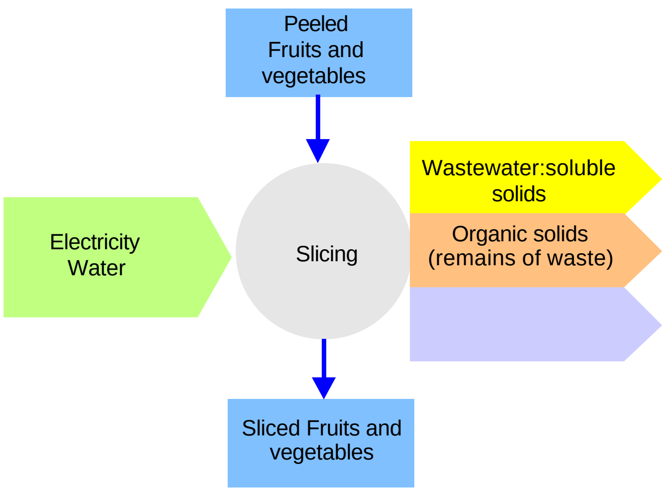
3.3.2.6 Slicing

Once the product is peeled, it is then cut into cubes, slices or segments and the stone removed if it has one.

Although many universal cutting machines exist and are widely used, each product requires different machinery that is often unique to the product.

In the case of green beans, the first step is the elimination of the tips in a cropper that basically consists of a perforated cylinder that rotates on a slight inclination and with fixed cutters on the outside. The ends of the beans pass through the holes and are cut off by the cutter. The bean is then cut crosswise or lengthways in strips.

An important operation with many types of fruit is removing the stone. Peaches are cut in half through the stone and then each half is cut separately.



Input		Output	
Product	Consumption	Waste flow	Quantification
Fruit and vegetables	1000 Kg	Fruit and vegetables	950-1000 kg
Water	0-0.1m3	Wastewater:	0 -0.1 m3
Electricity	1 kWh	Soluble solids	1-10 Kg
		Waste remains	0-50 Kg

Table 3.21. The balance of materials and energy used in slicing

3.3.2.7 Scalding

Scalding is a short heat treatment at a moderate temperature that is done prior to sterilisation. The object of scalding is to eliminate gases that are trapped in product tissues to:

- Increase the density of the product so that it does not float in the covering liquid.
- Ensure that the pressure on the inside the container during sterilisation coincides as precisely as possible with that of saturated steam at the process temperature.
- Prevent the oxidation of the product and corrosion of the can during its shelf life due to the presence of oxygen inside of the container.
- Make the product as flexible as possible, which will allow the use of slightly twisted vegetables and be beneficial to the grading and filling of containers
- In some cases to eliminate unpleasant smells and to set the colour of the product

Scalding can be done either by using immersion in hot water or with steam

1. Steam scalders

   Characteristics: With these scalders, the product is transported on a conveyor belt through a tunnel. Saturated steam at a pressure close to atmospheric pressure is injected through nozzles distributed along the tunnel. Controlling the speed of the conveyor belt regulates the time that the product is inside.

   Various types of equipment are available on the market that has design variations to avoid heat loss at the entry and exit points of the tunnel. Some have water sprinkler systems at the entry and exit points, while others have hydraulic locks. Water that comes in contact with the end product helps it to cool and is then circulated when the entry point is closed, which recovers part of the heat that the product takes with it on leaving the scalder.

   Besides the conveyor belt transport system, modifications exist whereby this is replaced by ascending currents of a mixture of steam and air at a temperature of 95 ºC and a velocity of 4 to 5m/s that heat and fluidise the product.

2. Water scalders

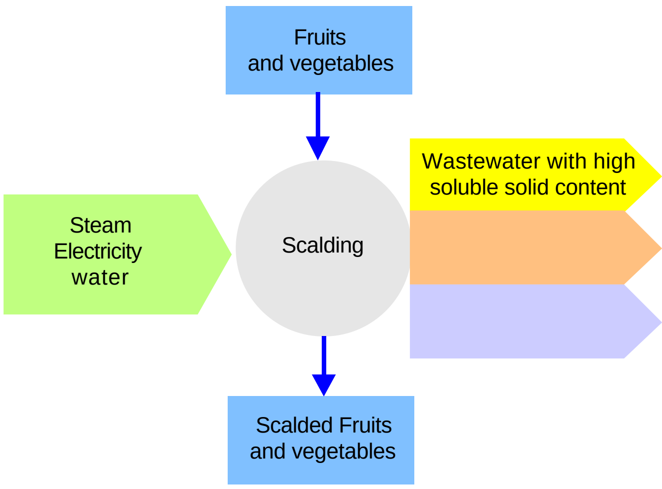
Characteristics: These involve putting the product in a tank of water that is maintained at an adequate temperature and keeping it in the bath for the necessary period of time for the treatment to be completed. A perforated coaxial drum revolves slowly inside the tank that agitates and transports the product by way of a screw inside of the drum.

The water is heated directly by steam injection and the level has to be maintained by continuously adding fresh water, due to the fact that part of the water is absorbed and carried away by the product.

Immediate filling of the containers after scalding reduces the treatment time because the sealing temperature of the container is higher. If it is not immediately filled, the product must be cooled with water to reduce thermal degradation and to prevent the growth of bacteria that rapidly takes place on the hot product.

The figures for water and steam consumption vary from one industry to another, although broadly speaking the following quantities are valid: 1 ton of water for 1 ton of treated product in the case of scalding with water, and 0.150-0.300 ton of steam for 1 ton of product in the case of scalding with steam.

Moreover, the energy flow is far from negligible in terms of the total and represents 40.7% of the total expense in the case of the processing of peas.



Input		Output	
Product	Quantity	Waste flow	Quantification
Vegetable	1000 Kg	Vegetable scalding	980 Kg
Steam	150-300 Kg	Wastewater	0.15-0.3 m3
Electricity	240 kWh	Soluble solids	0.1-20 Kg

Table 3.22. The balance of materials and energy used in the scalding of vegetables

Scalding acts as a solid and liquid extractor and involves the loss of soluble material by washing and diffusion, which causes it to be the main operation source that generates wastewater with high levels of organic waste content.

Other methods, such as the use of microwaves, have been proposed to improve the efficiency of the scalding operation that is necessary for fruit and vegetable canning processes. The method of fast individual scalding consists of submitting each particle to one atmosphere of steam for a relatively short period of time and then to amass the product in a deep layer without applying heat until the temperature balance occurs. This type of scalding produces products of a similar quality to those obtained by scalding with steam or hot water, although the loss of nutrients is not so high and it produces 60% less effluent.

3.3.2.8 Concentration or evaporation

The object of this operation is to concentrate the solution being treated in order to prevent microbiological changes when the total soluble solids content is higher than 65%, as well as to preserve the product longer and reduce storage volume.

Evaporation consists of the concentration of a solution through the evaporation of its solvent liquid. This can lead to the loss of fruit aroma in the evaporated water in juice manufacture and it is for this reason that the most important advances have been made in the field of aroma recovery.

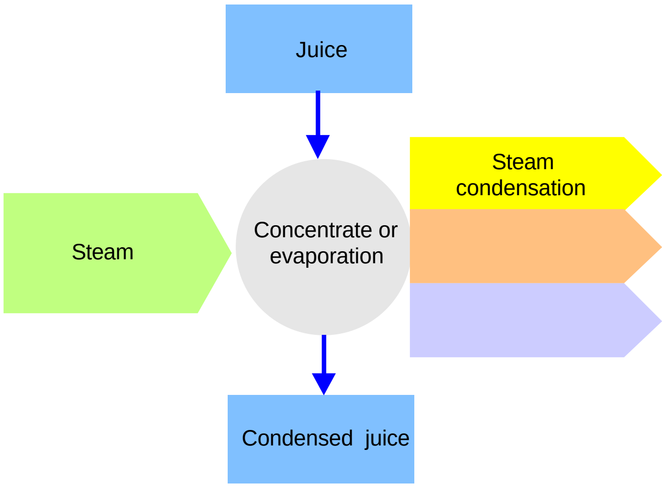
Equipment that is available on the market for carrying out this operation is composed of three basic elements:

- A calendering machine, which is the steam exchanger where the heat transfer takes place between the convector fluid, which is normally steam, and the fluid to be concentrated, in this case fruit juice.

- A system for separating the steam produced by the evaporation of the water in the juice
- A system that eliminates the steam once it has been separated from the concentrate. This may be a mechanical vacuum pump or a steam ejector.

Aroma concentrates are frequently kept separately at a low temperature and in a vacuum so that they can be recombined during the mixing operation.

Fruit juices can also be concentrated by slow freezing and separation of the ice from the juice concentrate. This alternative process avoids heating the product that results in a better taste of the end product. It is not used very much, however, because solids are lost in the ice crystals.



Input		Output	
Product	Quantity	Waste flow	Quantification
Juice	1000 Kg	Concentrated product (70 º Brix)	157 Kg
Steam	200-900 Kg	Condensed	843 Kg

Table 3.23. The balance of materials and energy used in juice concentration

3.3.3 <u>Environmental aspects and impacts</u>

3.3.3.1 <u>General considerations</u>

The industry is very diversified because raw materials can be very different, as well as the source of raw materials and the installations and technologies used.

The main environmental aspects that derive from fruit and vegetable canning processes are:

- Water consumption
- Energy consumption
- Wastewater
- Solid waste

Vegetable processing plants can vary greatly in size and they are normally located near to the areas of production. Due to the high volumes consumed, disposal is often done through public waters.

Waste generally consists of organic remains that are unusable in the product and has traditionally been processed in some cases for animal food.

Environmental aspect	Main characteristics	Operations
Water consumption	The quality of the water depends on the type of operation.	Washing Scalding Cooling Brine preparation Sterilisation Cooling of containers
Energy consumption	Thermal or electric	Unloading Elimination of unwanted parts Washing of the fish Cooking or scalding Sterilisation Concentrated or evaporation Washing of containers
Wastewater	High organic load	Unloading Elimination of unwanted parts Washing of the fish Cooking Sterilisation Washing of containers
Organic waste	Biodegradable	Slicing

3.3.3.2 Energy consumption

Energy is consumed mainly for the operation of machinery, to produce ice, heating, refrigeration and cooking. The size of these industries and:

- The need for industrial cold storage to conserve the product,

- The high degree of automation and
- The sequence of thermal differences that occur in processing

Mean that consumption is high. The approximate fuel consumption per ton of product amounts to 82-Kg fuel/t.

The sources of energy that are used are:
- Electrical energy supplied by utility companies.
- Electrical energy produced by cogeneration
- Fossil fuels for operating the boiler (fuel oil, natural gas, etc.)

The repercussion of energy on the total costs of the sector is 2% and the distribution of the energy used is between 80-90 % for combustible fuel and 20-10% for electricity.

3.3.3.3 Air pollution

Air pollution from the vegetable canning industry is mainly due to:
- Accidental gas leaks in refrigeration circuits (ammonia and CFCs). CFC emissions destroy the ozone layer.
- Direct emissions due to combustion in boilers or indirect emissions caused by the use of electrical energy.

The environmental impact due to combustion is given in the following table:

		Fuel oil	Diesel oil	Coal	Gas
	Consumption	83 kg fuel/t	83 kg gas-oil/t	173 kg Coal/t	229 GJ PCS/t
			Emissions		
SO2	g/t cons.	4,477	497	1,161	0
NOX	g/t cons.	531	222	371	12
CO	g/t cons.	47	54	271	2
CO2	Kg/t cons.	239	247	247	5
COV	g/t cons.	3	2	4	0
CH4	g/t cons.	10	1	4	0
PART	g/t cons.	274	22	705	0
N20	g/t cons.	1	1	34	0

The estimated energy consumption per ton of product that has been taken into account is the total consumption, given that the sources for both electrical and thermal energy are usually fossil fuels with the exception of nuclear energy.

The enormous difference between the air pollution produced by gas and the other fossil fuels can be seen from this table.

The main environmental problems that derive from this are:

- Contribution to the greenhouse effect with important quantities of CO_2.
- Contribution to acid rain in the case of fuel consumption and with possibilities of cross-border problems due to the location of these industries
- Contribution to problems at local level due to the presence of toxic pollutants

In order to be able to somehow see the local impact of this need for energy on the region, an assessment is made below of the immission levels starting from a working hypothesis.

Working hypothesis:

- A working area for canning vegetables that produces 100 t per week.
- Stable meteorological conditions during a week with a temperature inversion at an average of 500 m and a wind regime that permits dispersion within a radius of 100 km2
- The situation prior to the weeklong episode means that the existing immission levels tend towards zero.
- Dispersion at the end of the week is homogeneous in the whole of the region and in all layers below the top layer.

According to this hypothesis and starting with the data from the previous table, the following table has been compiled:

	Fuel oil	**Diesel oil**	**Coal**	**Gas**
		Emissions		
SO2	45	5	12	0
NOX	5	2	4	0
CO	0	1	3	0
CO2	2	2	2	0
COV	0	0	0	0
CH4	0	0	0	0
N20	3	0	7	0
PART	0	0	0	0

Data in µg/m3 except for CO2 which is in mg/ m3

It can be observed from the table that the concentration of SO_2 in this area would be above the average limit established by the EU for protecting ecosystems (20 µg/m3) and approximately half of the immission levels for people's health. Although parameters such as particles and nitrogen oxides do not in themselves exceed the limits laid down, they would however have an important effect. Given that the canning industry has diverse forms of location that are normally remote from industrial nuclei, it is unlikely that any additional effect to these values will be produced.

3.3.3.4 Water consumption

The canning industry uses large amounts of water for processing different products. It needs water to wash the raw material, for peeling, scalding, concentrating and refrigerating finished products, cleaning equipment and installations, as well as for producing condensed steam for refrigerator equipment and domestic consumption.

Only a small amount of the water is used as covering liquids, and this varies according to the type of canned food. The rest makes up the company's liquid disposal or wastewater that, as has been described above, can vary from a large quantity containing organic material to practically nothing although as a whole pollution is high.

The main problem of the vegetable canning industry is that demand for water occurs in very specific, relatively short periods of time.In some areas where the vegetable canning industry is very important, the amount of water consumed can amount to 20 Hm3/year.

The main impact that excessive water harnessing from aquifers in the region can cause is the fact that they can dry out and water shortages. In some areas, the need for irrigation water together with the need for water for processing purposes requires water conveyance from other basins.

3.3.3.5 Wastewater

The seasonal nature of products that are processed within the same company give rise to a big difference in the pollutional loads that are eliminated throughout the year. The wastewater that is generated in these industries contains high quantities of organic material, a high level of biodegradability and variable pH levels.

In some areas where the canning industry is important, it causes practically 50% of the water pollution. In some basins in the Mediterranean, the canning industry contributes around 12,000 tons of biochemical oxygen demand (BOD) every day, out of a total of 22,500 tons of wastewater.

With horticultural crops such as peas, beans, spinach, asparagus, etc., the waste originates from water for washing, solids from sorting and loss from filler machines.

With fruit like peaches, tomatoes, cherries, apples, pears and grapes, the source of effluents is peeling, washing, sorting, cutting and can filling.

Citrus fruit is normally processed in the same factory where juices or concentrates, essential oils, meal or other substitutes are made. Wastewater contains pectins, liquids and pulp from the presses, water from refrigeration, wash water that contains remains of peel from the peeling operation, pips and damaged fruit. All of this waste forms an inconsistent, slimy gelatinous mass with a humidity content of approximately 83%.

Vegetable	Process	BOD (mg/ l)
Peas	Wash water	3 700
	Wastage in filling	13 800
	Bottom of the scalding tank	34 500
	Liquid in the silo	35 000-78 000
Citrus fruit	Washing of the fruit	20-110
	Peeling	30 000
	Slicing	2 500
	Water to remove earth	4 000
	Dripping from the skin	30 000

Scalding and subsequent cooling are operations that most responsible for the pollutional load of the fruit and vegetable canning processes, as is shown in the following table:

Product	% Pollutional load of the total
Asparagus	40%
Pea	50%
Green bean	37%
Spinach	48%

Effluents from the asparagus canning process						
Operation	Flow (l/min)	SST (mg / l)	SSF (mg / l)	DCO (mg / l)	BOD5 (mg / l)	pH
Washing	26	1 860	1 641	109	65	7,2
Scalding	3.3	154	58	2 920	2 125	7,2
Cooling	36.5	95	37	87	72	7,4
Factory output	70	181	104	425	354	7,1

In the case of the processing of pickled vegetables, various types of wastewater are produced that have different characteristics according to the techniques used, although all of them use fermentation brines, which leads to a high NaCl content and a high organic load. In some cases, for example with olives, wastewater contains certain chemical polyphenol substances that have a germicide effect.

Main characteristics of typical brines

Characteristics	Green Olives in brine	Fermented cabagges	Unity
pH	3,60-4,30	3,40-3,90	-
NaCl	60,00-90,00	22,00-45,00	g/l
Free acidity	5,00-10,00	0,40-22,00	g lactic acid/ l
Combined acidity	0,08-0,12	-	eq/ l
Polyphenols	0,18-0,30	-	g tannic acid/ l
Colour	0,20-0,60	-	Abs. ($A_{440} – A_{700}$)
Solids in suspension	0,20-2,00	-	g/ l
Total solids	50,00-80,00	42,00-75,00	g O_2/ l
BOD5	14,00-18,00	8,00-28,00	g O_2/ l
COD	16,00-26,00	14,00-32,00	g O_2/ l

In general terms, the impact of the different types of wastewater appears in the following table:

Product	Flow l/unity	BOD p.p.m	Suspended solids. p.p.m.
Tomatoes	17-295	616-1 870	550-925
Corn	114-439	885-2 936	530-2 325
Green beans	396	93	291
Green beans and corn	377	270	264
Mixed vegetables	46	750	593
Peas	123-161	238-468	340-637
Peaches	142	1.070	250
Apples	101	1.600	300
Cherries	61	800	185

The main environmental impacts that can be caused by the emission of pollutants from this industry are based on a relatively high BOD5 and, in the case of pickles, the high salt concentration.

The organic pollutional load of this water is made up principally of tissue remains that are the material in suspension, sugars and starch that make up the BOD5. Pollution from water coming from the vegetable canning industry is relatively simple to eliminate with a biological wastewater treatment plant.

Given that the system of evacuation is direct disposal into rivers and that river volumes are relatively low, the consequences for the environment are that this contributes to the eutrophication of the rivers, while ecosystems are affected in that limitations are imposed on certain species due to the high presence of salt because of brines.

3.3.3.6 Solid organic waste

Solid waste is generated in the stages of washing the raw material, grading of the raw material, peeling and slicing. This waste gets incorporated into the wastewater flows that are generated in all other operations and this makes collection and treatment difficult.

All solid organic waste that is generated must be reduced to a minimum for there to be adequate levels of efficiency in the production process because waste means a loss of product. A result of this is that more precise peeling methods that are adjusted to the formats of different products are appearing all of the time. The extent of the environmental effect that is generated here depends on the system of peeling that is used.

The quantity of waste varies a lot between the different canning industries. This variation can be seen from the following table.

Product	% Waste	Product	% Waste
Asparagus	45	Pepper	56
Tomatoe	25	Artichoke	67
Green bean	12	Pea	5
Potatoe	10	Mushroom	43
Leek	38	Carrot	30
Peach	33	Plum	17
Pea	15	Melon	31
Pumpkin	35	Cherry	20

This solid waste consists of ligno-cellulosic material formed by plants through the process of photosynthesis. In this respect, its use as a source of energy can be considered a source of renewable energy.

The components of this ligno-cellulosic material are classified into three main groups: other substances, polysaccharides and lignin.

Transformation processes have been developed for these types of waste in recent years that are aimed at obtaining fuel and chemical products that are at present obtained from petroleum.

3.4 Processing Canned Meats and Pre-Cooked Meals

3.4.1 Processes

3.4.1.1 Canned Pates

The procedure after receiving the different ingredients that make up the final product, from raw meat materials to condiments, spices and additives used, is to store them under the conditions required by the product until the moment it is processed.

Before proceeding with canning, the raw materials are prepared through operations such as boning, cutting up, grinding, chopping, thawing, skinning or cleaning.

Once the different raw materials have been prepared, they are all mixed in pre-set order in the cutter to get what is called fine meat paste. The basis of the cutter's function consists in disintegrating and mixing the mass through the movement generated by blades of a resistant material. The cutter can be closed or open. If it is closed, vacuum may be applied in order to prevent the mass from deteriorating due to the entry of air.

Canning can be carried out by vacuum, normally by fitting a vacuum filler to the cutter. The product is extruded from the filler into the empty can or jar. These containers have been placed on a washing belt that takes them to the vacuum filler.

Pates tend to be canned in vacuum piston fillers to prevent air being dragged inside the can by the paste, reducing heat transfer and causing uneven filling.

Containers are vacuum-sealed by injecting steam into the head space before applying the top.

These vacuum-sealing techniques minimise the possibility of having the surface of the product darken due to oxidation.

Because it is a food that is very prone to botulism, pate is sterilised. Following heat treatment, the containers are quickly cooled by taking them to cooling rooms with temperatures as close to 0 ºC as possible. They are later labelled and sent to final storage.

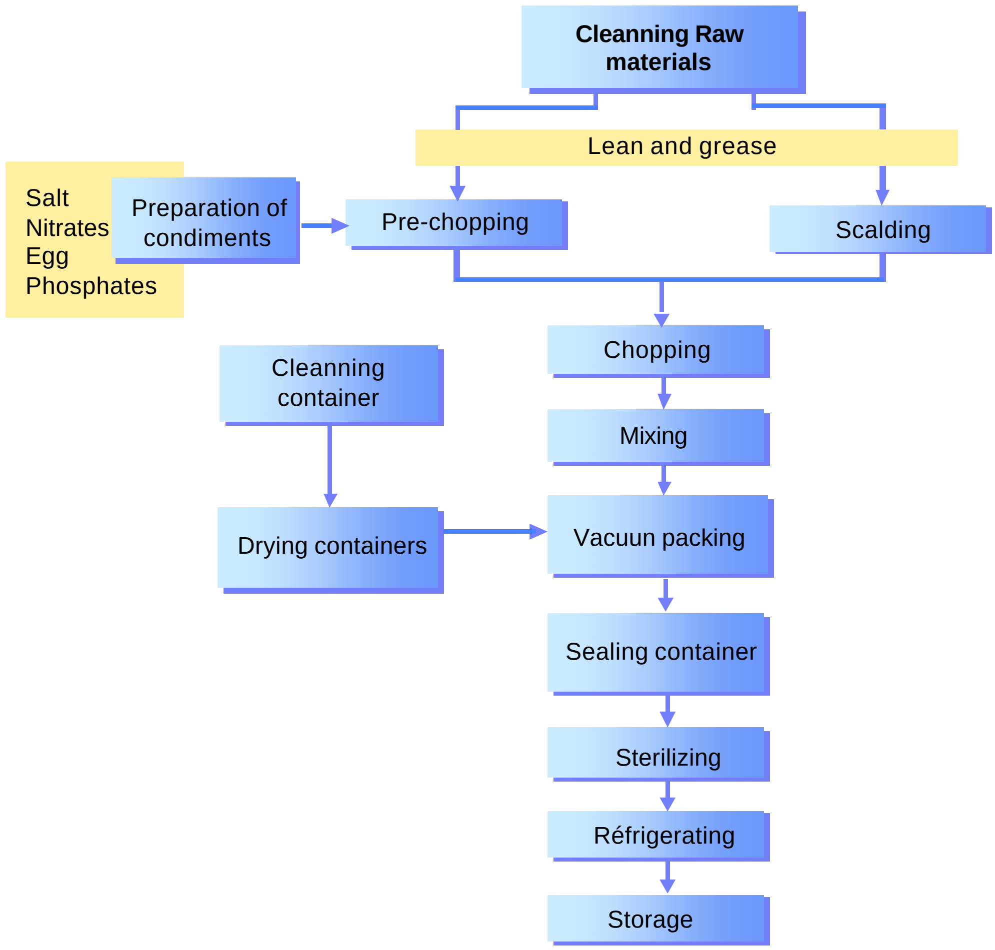


Figure 3.25. Canned pates process elaboration

3.4.1.2 <u>Cooked Sausage</u>

The basic technology for these products may be very similar to that described for pates (making a fine paste emulsified by means of a cutter), although in this case the fine paste is stuffed into a skin and cooked before being packed.

Once chopping/mixing in the cutter is done, the fine paste obtained is stuffed into a skin.

After cooking, it is packed in glass jars or metal containers with covering liquid and undergoes heat treatment to permit long-term preservation.

Cooked ham is a special case. The bone, tendons, conjunctive tissue, hide, part of the subcutaneous fat and other damaged tissue are removed from the pork leg in an attempt to maintain the integrity of muscle bundles. This stage is done quickly, without heat.

Boned parts are injected with curing brine using perforated needles and are discontinuously kneaded. The brine is inserted cold to prevent overheating during kneading. Kneading is done by inserting the product in a drum together with the additives of gelatine, polyphosphates, preservatives, starches, etc.

This product is inserted into moulds for cooking. Kneading tends to last for a length of time dependent upon the drum load, amount injected, drum revolutions, etc.

The purpose of kneading is to distribute the brine inside the piece, facilitate the action of additives and make the proteins soluble to make end binding of the product easier.

After kneading, the product is inserted into moulds that have been cleaned and dried. The meat is pressed and left to settle to eliminate air. The moulds are hermetically sealed and submerged in water at a temperature that is high enough to ensure pasteurisation of the pieces (65-75 ºC), development of the intended organoleptic features and formation of the piece due to protein coagulation.

When heat treatment is over, the product is cooled. The pieces are then taken out of the old and packed in the end container. Packages must be stored at a refrigerated temperature because, in this case, the product has been pasteurised.

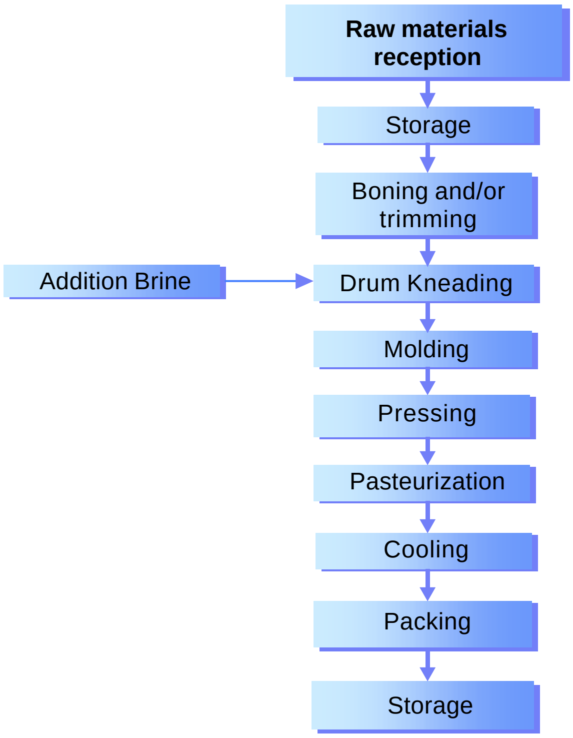


Figure 3.26. Process of making cooked ham

3.4.1.3 Pre-cooked Meals

Pre-cooked meals that are vacuum cooked are made in catering centres and in the food industry.

The vacuum cooking system was originally developed in France in the 70's, although it is currently used in many countries in Europe and North America. It is usually done semi-continuously in large-scale production.

The process begins upon reception of the raw materials of meat, vegetables, sauces, etc., which means that preparation varies according to need.

Meals having transformed or partially cooked food are packed in laminated plastic bags or thermal-shaped trays and sealed with an aluminium sheet. The former is used in catering while the latter is used commercially because it lasts longer.

Vacuum equipment used in this process varies according to the product, the way it is packed and the volume of production. The amount of residual air in the package depends on the type of product, because vulnerable products cannot be subjected to complete vacuum, they are usually left with an internal residual pressure of 12 Pa.

Some packages are subjected to a blast of gas made up by a mixture of CO2 (70%) and N2 (30%) before packing the product in order to prevent delicate products such as shellfish from being crushed. For firm products, residual pressure can be lowered to 1 Pa.

After vacuum has been applied, the food is cooked at pasteurisation temperatures, usually under 100 ºC, for a period of time that is longer than that usually used in traditional cooking (usually double). Temperatures that are not very high, around 70 ºC, are used for fish and meat, while vegetables are cooked at higher temperatures of about 95 ºC.

After this treatment, the product is subjected to quick cooling to a temperature of 1-8 ºC, in order to prevent heat damage and minimise the time interval suited to germination of bacteria (*Clostridium botulinum*). Food is then stored at 0-3 ºC.

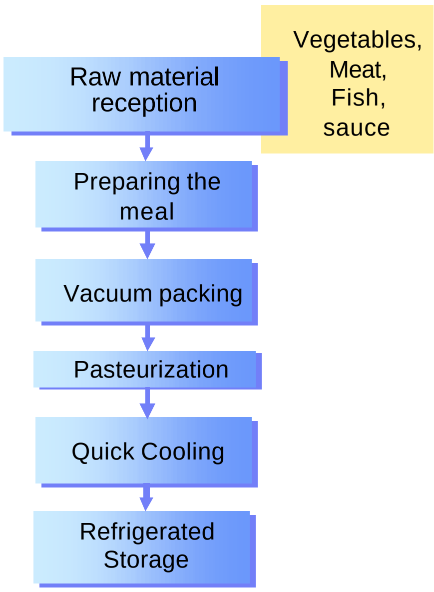


Figure 3.27 Process of making pre-cooked meals

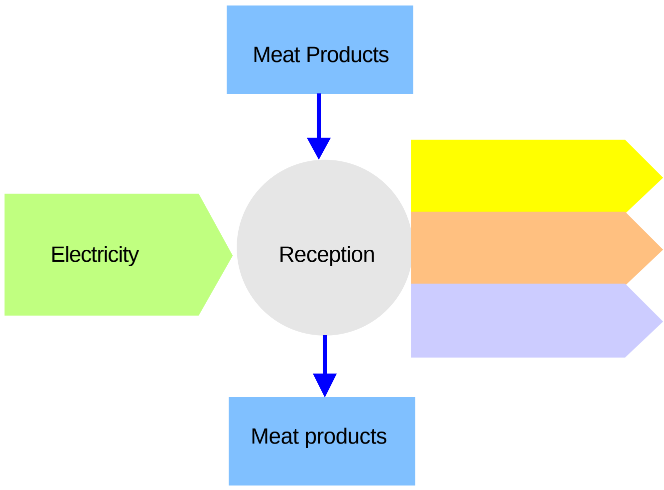
3.4.2 <u>Unitary Operations and Environmental Aspects</u>

3.4.2.1 <u>Reception of Raw Materials</u>

Depending on the type of meat industry being considered (according to its level of integration in the production chain) this unitary operation includes one type of raw material or another. This study does not consider the case of meat industries with slaughterhouses, because these facilities have their own significant and specific environmental problems that do not fall within the scope of this study. Consideration is given to the reception of meat of a different nature.

The commercial portions used have different categories of quality, according to the amount of fat and conjunctive tissue, which naturally determine the end quality of the product that reaches consumers.

The most important part of this unitary operation is the reception of meat at controlled temperatures. This is the point at which the cold chain is often broken and, therefore, product quality is diminished.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1,000 Kg	Meat Products	1,000 Kg
Electricity	1-3 kWh		

Table 3.24. Balance of materials and energy upon reception of raw materials

3.4.2.2 Preparing Raw Materials

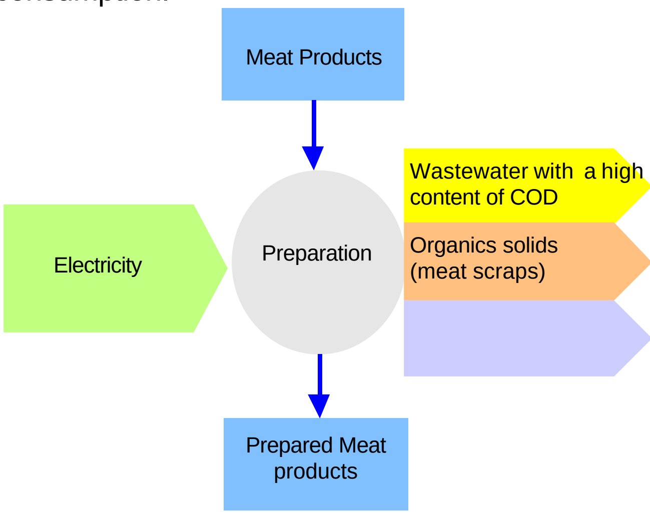
At this point, the different raw materials are prepared for entry into the chopping and mixing process. It is better for preparation to be carried out at a controlled temperature, as this prevents the cold chain from being broken as in the case of reception.

One of the first phases in preparation may certainly be thawing. There are different ways of thawing, and one or the other is used according to the type of meat and size of the pieces.

Examples include thawing at controlled room temperature, thawing under tap water, and thawing in microwave oven or steam thawing. Losses in meat weight during this process range from 0 to 10%, according to the nature and conditions of thawing.

Preparation of the meat itself consists, according to the case, in cutting, boning and removing fat or conjunctive tissue. This phase is much more manual than mechanical, given the heterogeneity of the shapes and qualities of the pieces of meat.

Waste from this operation may be used by other specialised industries, such as those that make meal for animal consumption.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	800-1 000 kg
Electricity	1-2 kw/h	Wastewater:	0-0,1 m^3
		COD	0-1 Kg
		Meat Scraps	0-200Kg

Table 3.25. Balance of materials and energy used in preparation of meat

3.4.2.3 Chopping and mixing

The purpose of this unitary operation is to get an emulsified fine paste from the ingredients making up the formula of the product. Since the number of formulas is infinite, an attempt is made to establish a generalised process for all of them.

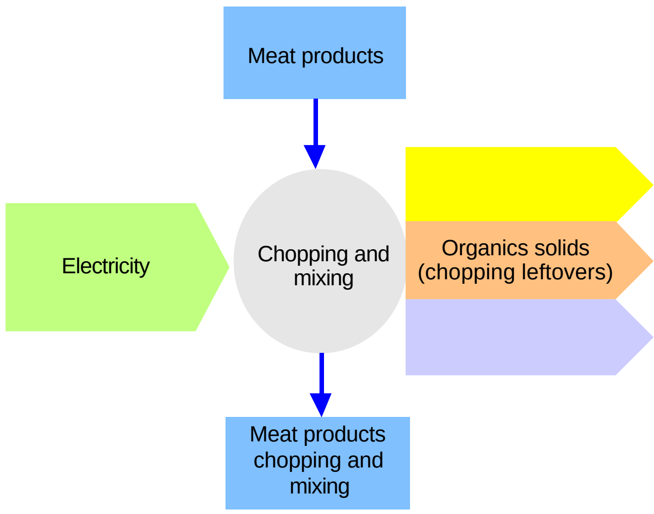
The equipment used is the cutter, which has been mentioned in previous sections.

This operation usually begins by placing lean meat in the cutter for partial chopping. This lean meat must be added from the refrigerator or even slightly frozen.

Salt and other additives such as polyphosphates and emulsifiers are added. The mass is ground, this time more heavily in order to destroy the cellular structure of the meat and free proteins.

Water may be added in the form of ice and mixed in to obtain the lean mixture. The reason for ice comes from the importance of temperature evolution from fine paste to getting the proper emulsion and good quality in the end product.

The last ingredient added is fat, previously chopped into pieces. This must also be added cold. The whole mixture is ground to obtain a fine, smooth paste with the right emulsion.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	990 - 1 000 kg
Electricity	5 - 10 kw/h	Chopping Scraps	0 - 10 Kg

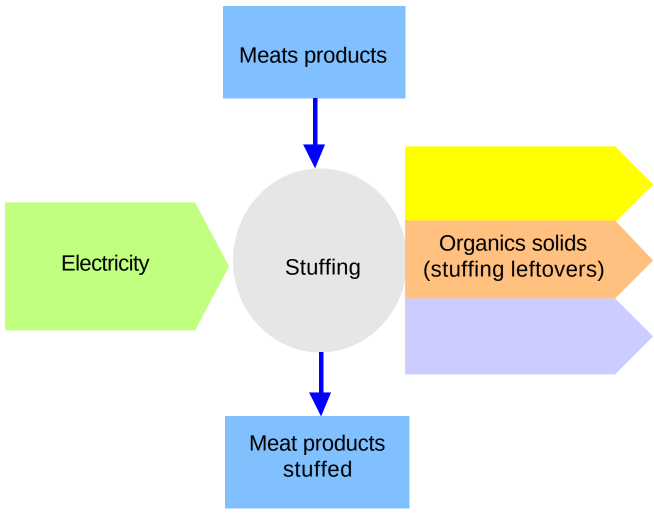
Table 3.26. Balance of material and energy chopping and mixed

3.4.2.4 Stuffing

When chopping/mixing in the cutter has finished, the fine paste obtained may be stuffed or packed. Stuffing machines are used to introduce the raw mass of sausage into their containers (animal intestine or artificial casing, cans or jars), so that they can be treated later. In mechanised industries, the stuffer is often connected to the cutter to avoid unnecessary risks by exposing the mass to the atmosphere.

There are two types of stuffers for working continuously or discontinuously. The type of casing used is artificial for cooked meats that will later be preserved +or canned.

Filling, whatever the type, must be carried out with the fine paste at a temperature that is not too low so that it can be easily moulded. If stuffing is carried out at too low a temperature, the high mechanical overload undergone by the casing during this operation could break the emulsion, allowing for part of the ingredients to separate.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	990 - 1 000 kg
Electricity	1 - 2 kw/h	Stuffing leftovers	0 - 10 Kg

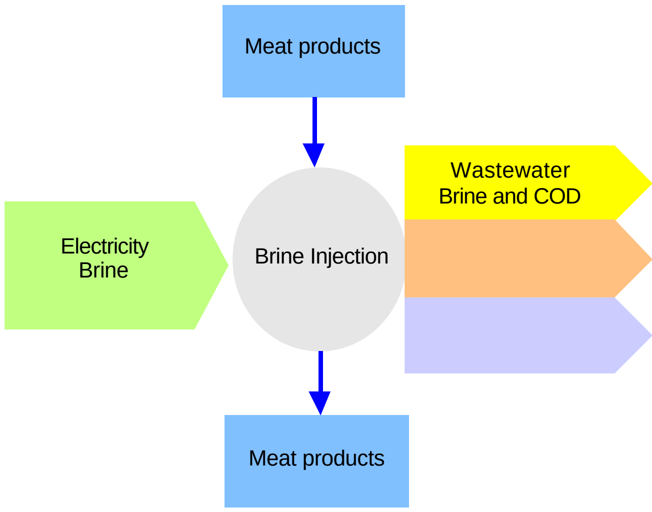
Table 3.27. Balance of material and energy in stuffing

3.4.2.5 Brine Injection

Brine injection in the industry of processed meats, such as cooked ham, can be carried out using manual or automatic injectors.

Manual injectors, which can be transported, are only now used in artisan-type businesses. The pressure needed for inoculation, about 1.5-2.0 bar, is obtained hydraulically or by means of an electric pump. Hydrodynamic injectors (shown in the figure) consist of a cast-steel or fine steel container divided into two chambers by an elastic rubber membrane.

Electric injectors signified an evolutionary step forward in this field. They are not automatic, but they at least permit brine to be injected continuously without interruptions. Currently, the industry uses almost exclusively automatic injectors with several or multiple needles having, however, the same functional principle as manual electric injectors. Brine may be continually injected into pieces of meat with or without bones using these injectors.



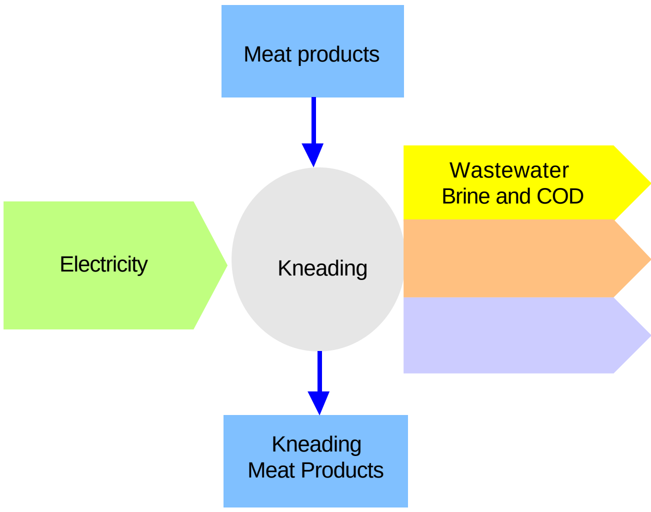
Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	1 050 - 1 250 kg
Electricity	1 - 3 kw/h	Wastewater:	0,01 - 0,1 m^3
Brine	0,1 - 2,5 m^3	Soluble Salts	10 000 - 15 000 ms
		COD	0,01 - 2 Kg

Table 3.28. Balance of material and energy in brine injection

3.4.2.6 Kneading

Kneading consists mechanically in causing friction between pieces of meat, between pieces of meat and the container walls and between the pieces of meat and the blades of the kneading machine. Sometimes, the kneading drums don't just "knead", they also massage.

Artisan-type businesses usually use machines characterised by having multiple applications. They not only knead and hit the meat, but they also add ingredients and mix them. The simplest drums used in these artisan companies operate by the same principle as cement mixers. They have a rotating stainless-steel drum that can be closed with a cover, mounted on a mobile frame and having an electric motor.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	900 - 990 kg
Electricity	2-6 kw/h	Wastewater:	0,01 - 0,1 m^3
		Soluble Salts	7 500 - 10 000 ms
		COD	0,02 - 3 Kg

Table 3.29 Balance of material and energy in kneading

3.4.2.7 Scalding or cooking

Once the sausage has been prepared, it is cooked. The intensity of the heat treatment applied depends on many factors, including the pH of the product, contents in preservatives such as nitrites/nitrates, contamination of initial raw material and that added during the process (this last factor of contamination is the most important in determining cooking parameters).

It must not be forgotten that cooking is what finally gives the product its organoleptic features. The stuffed, emulsified fine paste is stabilised and compressed through the action of heat, and acquires properties of a certain look, smell and taste according to the ingredients included.

For scalding or cooking meat products, open boilers or cookers can be used for discontinuous cooking, and cooking chambers for continuous operation.

Open boilers are round or square containers with capacities that vary from 200 to 1,000 litres and can be made of stone or set in steel or sheet metal frames. Treatment is carried out with water heated to the desired temperature before placing the products in the boiler. Boilers can have single or double walls.

As a general rule, single-wall boilers are heated directly with wood, coal, oil or electrical current. Double-wall boilers are heated by using low-pressure steam for heat, or by inserting between the two walls a filling medium that can be heated directly by electricity. This last system permits heating from all sides, while single-wall boilers only heat from below.

Boilers are equipped with folding covers to reduce heat loss and the constant emission of steam during treatment. Especially when using sets of boilers, exhaust (extraction) fans are installed. Large-size boilers are fed using insertable baskets conveyed by block and tackle or electric feed gear.

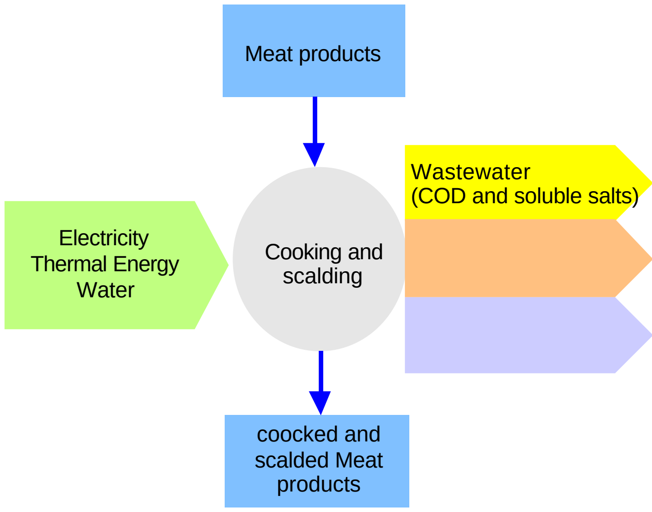
Hot air boilers are made of steel frames lined with a double wall made of sheet metal or aluminium with insulation. The product is introduced in the chamber on insertable perforated sheets or on vertical trolleys equipped with perforated sheets. Heating is carried out by means of electricity, gas, oil or low-pressure steam. During wet phases of the process, hot air saturated with intensely circulating moisture is used.

Treatment with air allows losses due to heat to be reduced by 50% in comparison to water treatment. Losses are also less for aromatic substances and hydrosoluble vitamins.

Continuous operation cooking equipment is a large-sized facility used to continuously scald and cook meat and meat products.

It is made up of a cylindrical double-walled container with a revolving perforated drum inside of which is soldered a feed worm. Heating is carried out indirectly by steam, hot water or heat-bearing oil.

Over the entire heating process, the worm continuously drives the product from the entry to the exit. A circulation pump constantly stirs the cooking stock produced and keeps it at a constant level with the help of measuring probes and a magnetic feed valve.



Input		Output	
Product	Consumption	Waste flow	Quantification
Meat Products	1 000 kg	Meat Products	850 - 1 000 kg
Electricity / Thermal energy	5-15 kw/h	Wastewater:	0,01 - 1 m^3
Water	0,1 - 1 m^3	COD	0 - 10 Kg

Table 3.30. Balance of material and energy in scalding or cooking

3.4.3 Environmental Aspects and Impacts

3.4.3.1 General considerations

The main environmental aspects derived from making canned meat and pre-cooked meals are:

- Consumption of water
- Consumption of energy
- Wastewater

Meat processing plants are not generally large. They are located in a wide variety of places, but mainly near production when they are large (agricultural and farming areas) and near points of consumption when they are small (industrial estates near large cities).

Dumping from large industries located in agricultural areas tends to be done directly into the service water bodies, in the best of circumstances after being treated. Dumping from small industries located on industrial estates tends to be done in common collectors that can be treated by means of an urban or industrial estate wastewater treatment plant.

In regard to waste, it usually does not affect the environment very much because most of the raw material comes from slaughterhouses or other transforming industries. Most waste generated tends to be raw material packaging waste.

Some of the main impacts on a local level for this type of industry are the bad smells due to aromatic emissions during the cooking process.

Consumption of energy, of a thermal nature, is also significant.

Environmental Aspect	Main Characteristics	Operations
Water consumption		Brine injection Cooking or scalding Chopping Cooling Cleaning
Energy consumption	Thermal or electric	Chopping Kneading Cooking or scalding Sterilisation
Wastewater	High content of organic material	Brine injection Cooking Cooling Cleaning

3.4.3.2 Consumption and energy

Energy is mainly consumed in operating machines, heating, cooling and cooking.

Given the dimensions of this industry, as well as:

- The considerable need for industrial cooling for product preservation,
- The need to transmit mechanical energy to the product in order to make it (chopping, kneading)
- The need to do successive cooking

Means there is high consumption. Approximate consumption of fuel per tonne of product amounts to 77 Kg fuel/t.

Energy sources used are:

- Electricity supplied by the electricity company
- Electricity produced by means of cogeneration
- Fossil fuels for boiler operation (Fuel oil, natural gas, etc…)

Energy repercussions on the total cost for the sector are 1.5 % and distribution of the energy used is 40-70 % for fuel and 60-30 % for electricity.

3.4.3.3 Emissions into the atmosphere

Air pollution caused by the meat canning and pre-cooked meal industry can be mainly due to:

- Accidental gas leaks from refrigeration circuits (Ammonia and CFCs). CFC emissions destroy the ozone layer.
- Direct emissions due to the combustion from boilers or indirect emissions caused by the consumption of electricity.

Environmental impact due to combustion is illustrated in the following table:

		Fuel Oil	**Gas Oil**	**Coal**	**Gas**
	Consumption	77 kg fuel/tm	77 kg gas-oil/tm	160 kg coal/tm	212 GJ PCS/tm
			Emissions		
SO2	g/tm cons.	4,148	461	1,075	0
NOX	g/tm cons.	492	205	343	11
CO	g/tm cons.	44	50	251	2
CO2	Kg/tm cons.	221	229	229	4
COV	g/tm cons.	2	2	3	0
CH4	g/tm cons.	9	1	3	0
PART	g/tm cons.	253	21	653	0
N20	g/tm cons.	1	1	32	0

Estimated energy consumption per ton of product considered is total consumption, given the fact that whether the energy is electric or thermal, the sources are usually fossil fuels, except for nuclear energy.

This table reflects the huge difference between air pollution caused by gas and that caused by the rest of the fossil fuels.

The main derived environmental problems are:

- Contribution to the greenhouse effect with significant amounts of CO_2
- Contribution to acid rain in the case of fuel consumption, and with possible cross-border problems due to the location of these industries
- Contribution to problems on local levels due to the presence of toxic pollutants

In order to somehow visualise the local impact this energy need has on the territory, the levels of immission will be evaluated using a work hypothesis.

Work Hypothesis:

- Area producing canned meats or pre-cooked food at a rate of 100 t/week
- Stable weather conditions during one week with an average thermal inversion of 500 m and winds permitting spreading only in a radius of 100 km2
- The situation prior to the weeklong episode makes existing immission levels tend towards zero.
- Spreading at the end of the week is uniform over the territory and on all layers below the final layer.

Given this hypothesis and using data from the previous table, we make the following table:

	Fuel Oil	Gas Oil	Coal	Gas
		Emissions		
SO_2	45	5	12	0
NOX	5	2	4	0
CO	0	1	3	0
CO_2	2	2	2	0
COV	0	0	0	0
CH_4	0	0	0	0
N20	3	0	7	0
PART	0	0	0	0

Data in µg/m3 except for CO_2 which is mg/ m3

This table illustrates that the SO_2 concentration in this area is above the average limit set by the UE for protecting ecosystems (20 µg/m3) and is approximately half the immission levels for human health. For parameters such as particles and nitrogen oxides, even though by themselves they do not exceed the set limits, they do make important contributions. Given the fact that canning industries are dispersed all over the territory and are normally far from industrial centres, it is unlikely that they would add to the effects of these values.

For industries located near large cities, pollution would be added to the rest of the industries, heating and traffic.

3.4.3.4 Water consumption

Canned meat and pre-cooked meal industries consume water mainly for brine injection, cooking or scalding, chopping, cooling and cleaning.

The demand for water is produced all year long on a regular basis, except for points caused by the increase in consumption.

The main impact that could be caused by excessive water catchment that usually comes from area aquifers is having the latter dry up, and a water shortage in the case of large-scale consumption.

3.4.3.5 Wastewater

Part of the water used, which varies according to the type of canning, is consumed in incorporating the product as well as the covering liquids. The rest constitutes the company's liquid dumping, wastewater which, as can be deduced from the aforementioned uses, can vary from a large amount of organic matter to practically nothing, although pollution on the whole is average.

During the operation of injecting brine into the meat product mass, brine waste from loss of brine during injection present high conductivity, although this does not have a large impact due to the low volume of around 15% of the brine used.

The operation having the greatest impact is cooking or scalding, in which wastewater is generated that has a high content of blood, fat, protein, sugar, spices, additives, fragments of skin and other tissues. Dumping volume is medium, but the pollutant load is high. This load varies according to whether the scalding operation is carried out with the packaged product or not.
Approximate water consumption in these industries is highly varied as a consequence of the wide variety of products made. However, a figure for orientation could be between 5 and 10 m3/t. The following table shows the different pollution rates for the different operations:

Operations	Solids (mg/l)		Nitrogen (mg/l)		BOD (mg/l)	pH
	Totals	Suspension	Organic	NH3		
Meat processing room	26 480	1 800	85	12	2 040	7,3
Meat marinating	34 100	1 720	255	25	460	6,7
Cleaning	9 560	920	110	17,5	1 960	7,3
Making the marinade	140 000	-	2 750	40	18 000	5,6
Stuffing	11 380	560	140	4	800	7,3
Lards	4 000	1 380	190	50	2 200	6,7
By-Products	4 000	1 380	190	50	2 200	6,7

The main environmental impacts that could be caused by the emission of pollutants coming from this industry are based on an average BOD5. The organic pollutant load of this water is made up mainly by tissue remains that constitute suspended matter, and proteins, fats and carbohydrates.

Given the strict hygiene requirements for this sector, the presence of detergents and disinfectants coming from cleaning utensils and facilities must be mentioned.

Regarding the consequences for the environment, the level at which ecosystems are affected, considering that the evacuation system is dumping directly into rivers and that the volume of their flows is relatively low, would mean a significant contribution would be made to the eutrophication of the water and limiting certain species due to the high level of salt in the case of brines.

When water is dumped after treatment, the impact is practically null.

3.5 Auxiliary operations in food canning processes and environmental aspects

3.5.1 Structural cleaning

3.5.1.1 Operation description

General cleaning operations are usually carried out using water with added detergents which are usually pH alkaline, (soda being the most typical case), acid or bactericidal. The water is usually added by hosing, and at variable pressure; the greater the pressure the less water is necessary. Foam baths are also used, followed by water. In some plants, detergents of different pH are alternated to avoid calcium build-up from very hard water.

It is also usual procedure to heat the cleaning water to increase its cleaning and disinfecting properties, or to use steam and, in some cases, cryogenic fluids. However, despite their interesting properties, such as waste flow reduction, they are extremely expensive.

In any case, large amounts of water are frequently used at low pressure to clean large areas, floors or walls, with no added detergent, using the force of the water to remove organic remains. A valid alternative to these systems is the use of specialised machinery, battery-operated automatic scrubbers, with optional pre-sweeping and on-board driver.

A further aspect related to cleaning is circuit drainage, basically cooling circuits or boilers, which are made up of water and chemical additives.

3.5.1.2 Environmental aspects

Cleaning tasks are carried out by applying water, as a vehicle for detergents, of differing pH values, and bactericides, with the aim of removing organic remains considered as dirt, which leaves us with an effluent with a variable pollutant load, depending on the premises or machinery cleaned. The pH is also variable, depending on the type of cleaning agent used. Furthermore, we may also find that the use of bactericides inhibits the later biological treatment of wastewater.

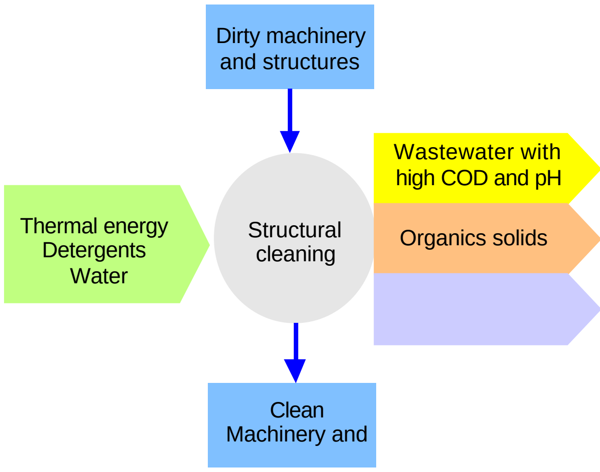
It is also habitual practice to heat the water to increase its detergent qualities, or in some cases to use steam or cryogenic fluids, which, although very expensive have interesting properties, as in the case of CO2 and N2, in themselves produce no waste flow.

The tendency nowadays is to reduce water consumption in cleaning operations through using foam, high-pressure water systems and high temperatures, which, if we bear in mind that in the end the material to be cleaned is the same, we increase the pollutant load concentration.

One aspect to be borne in mind in order to reduce water consumption is the reuse of water at different stages of cleaning, so that in the final stage clean water is used which is reused for subsequent cleaning operations. The use of automatic scrubbers or CIP can also reduce the consumption of water and cleaning products.

It is also important to consider whether the organic remains to be cleaned have a high oil and grease content; the detergents used to clean them produce an emulsion of these products which is difficult to break down in the wastewater pre-treatment by mechanical methods, based on settling and floatage, or by other more sophisticated methods involving variations in pH.

One way of reducing the effluent's pollutant load in terms of suspended organic matter, consists in the dry removal of as many solids and remains as possible prior to using water.



Input		Output	
Product	Consumption	Waste flow	Quantification
Water	High	Wastewater	
Thermal Energy	Medium	COD	100-10 000 mg/lt
Detergents	High	pH	
		Organics solids	High

Table 3.31. Balance of material and energy in structural cleaning

3.5.2 Energy production

Two basic energy sources are used: electricity and those derived from fossil fuels, gas, fuel oil and coal, which are used mostly for steam or hot water production in beds.

3.5.2.1 Electricity

The vast majority of motors that drive machines run off electricity, and, more specifically, are usually three-phase squirrel-cage AC motor. The widespread use of this type of motor is due to the fact that they do not produce emissions into the atmosphere, are silent, cheap, reliable and low-maintenance, and electricity is easily transported. The impact of such motors on the environment is minimal, only the lubricating oil and grease require consideration, which, when changed in periodic maintenance operations, generate waste which requires specific treatment.

In any case, one must bear in mind that the electricity consumed comes mostly from the burning of fossil fuels in power stations, which means that pollution is also generated only miles away from where it is consumed.

3.5.2.2 Fossil fuels

The use of this type of fuel, coal, gas, fuel oil and gas oil, is mostly limited to the production of steam and hot water. Electricity is not used in this case due to its low yield.

Steam is usually produced in boilers, where the water is heated until it boils, by burning fossil fuels, at a typical pressure of 6 to 8 bars.

The water is usually heated in a closed circuit so that it can be reused.

The burning of fossil fuels generates the following pollution: carbon dioxide, nitrogen oxide and sulphur dioxide. The pollution produced will depend largely on the type of fuel, its quality, the technology used, output and the maintenance of equipment. Burning a kilo of fuel oil with sulphur content of 1%, we can produce 3.5 Kg of carbon dioxide, 0.01 Kg of oxides of nitrogen and 0.02 Kg of sulphur dioxide.

In large plants, requiring considerable amounts of hot water, a cogeneration system can be used, with a positive ignition engine or gas turbine, which produce electricity by way of a generating set, making use of the combustion gases for the production of hot water or steam. Cold may even be produced in the same process; thus supplying the plant’s global energy requirements.

One of the great advantages of the cogeneration system is the non-dependence on an external electricity supply, a very important factor in certain situations when this is of poor quality. Another advantage is the possibility to sell off the surplus energy to the electricity company at a profit.

Cogeneration systems are usually installed in pairs or, if not, an alternative connection to the electricity supply is installed.

With regard to emissions, they are usually relatively lower than the electricity and boiler consumption separately, since with this system we achieve greater output. We only have to bear in mind that if there are large positive ignition engines they are usually very noisy and their lubricating oils must be changed periodically.

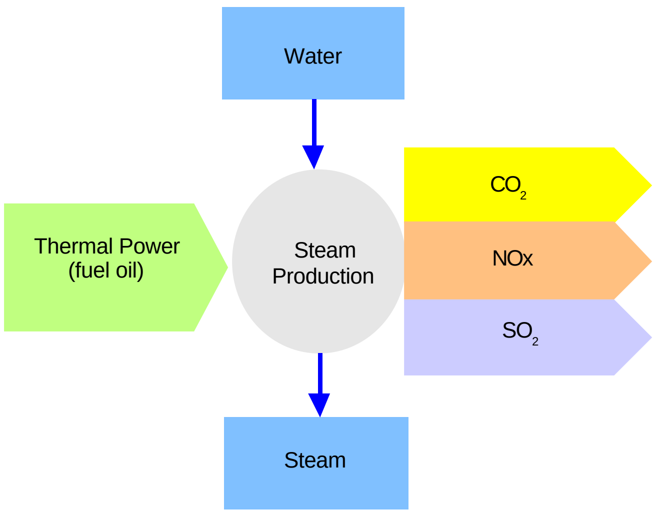
Another environmental improvement that can be introduced for steam and hot water production, is the use of the remains of plants as fuel, or, in the case of treatment plants with anaerobic digestion and biogas production, this is used for the same purpose. In very sunny countries, solar energy may also be converted into heat.

The table below shows typical pollution values produced by the different types of fuel used in steam production.

		T fuel	T gasoil	T coal	GJ PCS
SO2	g	54.000	6.000	14.000	0
NOX	g	6.410	2.673	4.470	140
CO	g	568	647	3.270	20
CO2	Kg	2.880	2.975	2.980	55
COV	g	32	26	45	5
CH4	g	118	8,6	45	2
PART	g	3.300	267	8500	0
N20	g	12,2	14,2	415	0

In any case, it must be pointed out that the values in the table may fluctuate greatly depending on the following factors, which basically affect pollutants such as CO and particle emissions:

- State of burners.
- General state of maintenance of equipment
- Position of equipment.
- Fuel quality
- Technology used



Input		Output	
Product	Consumption	Waste flow	Quantification
Fuel-oil	1 kg	Emissions to atmosphere: Carbon dioxide Oxides of nitrogen Sulphur dioxide	 2,88 kg 6,4 g 54,0 g

Table 3.32. Balance of matter and power for steam production in fueloil boiler

3.5.3 Storage in refrigeration and freezing of raw materials

In refrigeration and freezing systems, a coolant, mostly ammonia for large -scale plants, CFC or its replacement in those countries where its use is forbidden, is compressed and its consequent expansion produces cold. Compression is carried out by piston-type compressors or screw-type compressors for large outputs. These coolants are usually restricted to the so-called primary circuit, which in turn refrigerates the secondary circuit via an interchanger. This secondary circuit transports the cold to its destination, and transmits it via an evaporator. It usually uses glycol, alcohol, etc.. In some cases, a single coolant is used for the whole process, with no distinction made between primary and secondary circuit.

The coolant used in the primary circuit should have as low a toxicity as possible. All coolants except air (which is rarely used), are dangerous to man in high concentrations, as they cause asphyxia due to lack of oxygen. Some fluids are toxic in the strictest sense of the word, that is, their effects can be more or less serious, even causing death, before their concentration in the atmosphere reach the threshold of asphyxia. Some coolants, which at relatively high concentrations are practically harmless, may decompose in the presence of flame and bring about the formation of decomposition products, which are extremely toxic, even lethal, both in small concentrations, and short periods of time.

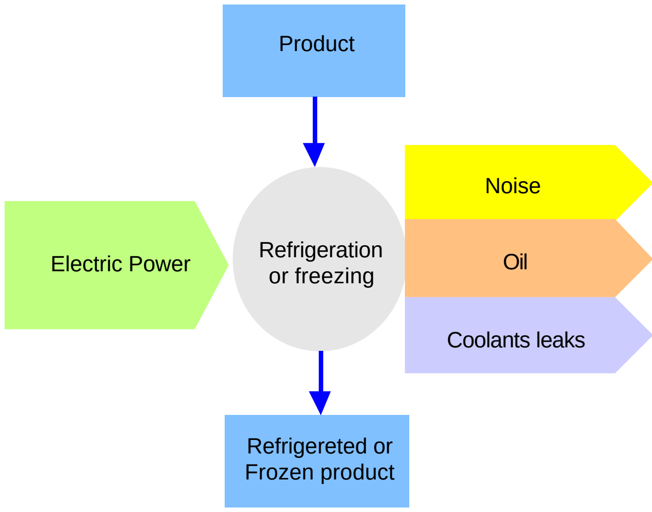
Other cooling media may burn or form explosive mixtures in the presence of a certain amount of air. However, for this to happen they must be present in a certain concentration which differs for each medium. In this respect, the relative danger is determined by the minimum level of said concentration and the range of limits. In large plants ammonia is usually used as a coolant because of its excellent thermodynamic properties, despite its being toxic, somewhat inflammable and explosive in certain conditions.

Typically, the sources of pollution due to cooling systems, are coolant gas leaks, which are particularly dangerous for the environment if the gas is CFC.

Another important pollutant is the noise produced by the compressors in cooling equipment. As compressors are usually accompanied by condensers, especially in middle-sized and small equipment, to reduce the risk of intoxication, asphyxia or explosion in the case of a leakage of primary coolant. Due to the fact that they need very low temperatures to function properly, they are usually installed on the roofs of buildings, which causes serious problems of noise pollution, due to the noise from compressors and, to a lesser extent, from condenser fans.

At the other end of the scale are cold stores, freezing rooms or cooling tunnels, where the priority is their correct thermal insulation. In this case, the cold is driven through the secondary circuit, and as they are closed environments, essential to avoid cold loss, and in contact with food, they must use coolants with as low a toxicity and risk of asphyxia and explosion as possible.

Another point to bear in mind from the environmental point of view is the oil from the compressors, of which there may be a considerable amount if the compressor is a decent size. This oil must be changed periodically and treated as special waste, being sent to a specialised centre for recycling or elimination.



Input		Output	
Product	**Consumption**	**Waste flow**	**Quantification**
Electric power	Medium	Noise pollution	60-100 dB
		Used oil	Low
		Coolant leaks	Medium

Table 3.33. Balance of matter and power for the refrigeration or freezing on the product

3.5.4 Wastewater treatment

The wastewater from these sectors usually has a high content of suspended solids (as water is generally used for transport and product cleaning), high BOD, similar to the COD, because the pollution is basically organic, and pH neutral or close to 7, except when certain chemicals are used. The amount of fats and oils varies greatly depending on the type of product, which gives rise to effluents that are very similar to urban ones but with a higher concentration of pollutants, and even more so, if possible, in those industries that use recirculation to reduce water consumption. This is because, particularly in cleaning operations the total pollutant load must remain constant unless we settle for inferior cleaning quality. The only relevant problem tends to arise in those fish canning industries with effluents with high concentrations of dissolved salts, over 1,500 or 2,000 microsiemens, reaching up to 10,000 microsiemens, or in those using chemicals, acids or alkalis in amounts sufficient to cause considerable variations in pH.

The first step in the treatment process, are medium to coarse solid filters, to a minimum of 10 mm, which removes all organic matter over that size which could be dragged along by effluents and could obstruct or block certain components if allowed to enter the treatment system, as although they can be removed, this is a slow process. An example could be the typical steep screen.

The next step consists of using fine sieves, such as rotosieves, which eliminates all suspended matter in fine particles. One of the greatest problems when using fine sieves is the presence of grease or oil, which in certain circumstances can block the mesh. However, such a problem will not rise, so we can use sieves with fine mesh.

Pre-treatment consisting of degreasing desilting channels, where the effluent is forced through an aerated channel, removing the grease from the surface through increased floatage and the silt deposits from the trapezoidal bottom.

Homogenisation tanks, which can be located at several points at the beginning of the process will be necessary if the processes used are discontinuous, varying greatly the pollutant load and the volume of effluent. In such cases, the homogenisation tank must ensure, as far as possible, a constant inflow of water with a stable pollutant load, to favour optimal treatment conditions, especially when this is biological. It is at this point that the pH of the effluent is corrected so that it remains around 7.

From here, we go on to primary treatment in which we can use flocculent, iron chloride, etc. to increase performance. With this, through the precipitation of suspended solids we can reduce pollutant loads by 60%. This treatment is generally used in wastewater with high loads as in this case.

From this point onwards, and if the amount of dissolved salts, particularly common salt, is not too high, less than 2,000 microsiemens, we can enter a biological treatment process. In this, we have one or more reactors in which we vary the amount of oxygen dissolved in the water by injecting air, either by turbines, diffuser plates, etc. If we also wish to eliminate any nitrates present, we will force the liquor through oxic and anoxic areas.

The liquor then passes through clarifiers, where, through settling and flocculent precipitation by gravity, clean water emerges from the top and precipitated sludge from the bottom. The sludge is recirculated to the biological reactors to maintain its concentration or drained to the sludge line when levels become excessive.

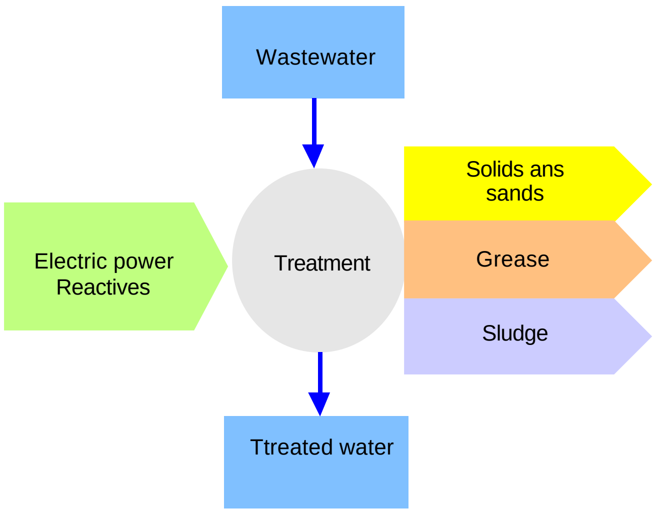
The secondary outflow water, via tertiary treatment, can be reused for irrigation, street cleaning and so on. Tertiary usually consists in passing the water through a self-cleaning sand filter, to remove any remaining suspended elements and exposing it to ultraviolet rays to kill off any faecal bacteria.

Another system used as tertiary treatment, is lagooning which consists in creating wetlands, which are usually large, and planting suitable plant species which complete the water treatment. In such cases, care must be taken when animals are present, as if the waters contain high levels of nitrogen and phosphorous, this may cause eutrophication of the water. This, along with the action of the heat and sun, may have dire consequences for the animals such as, for instance, outbreaks of botulism. One of the most serious disadvantages of lagooning is the large amount of space required.

If we use correctly all the techniques available to us, we can reduce the pollutant load of suspended solids and BOD by almost 99%.

A totally different problem is wastewater with a high content of dissolved salts, above 2,000 microsiemens, which may totally impede its biological treatment, or in the likely case of variable concentrations of dissolved salts, or cause problems in the process such as bulking. The same applies to variations in pH.

It is advisable, to frequently carry out differentiated pre-treatment, depending on the origin of the wastewater and its level of pollution.



Input		**Output**	
Product	Consumption	Waste flow	Quantification
Electric power		Solids and sand	
Reactives		Grease	
		Sludge	

Table 3.34. Balance of matter and power for water treatment

CHAPTER IV
OPPORTUNITIES FOR POLLUTION PREVENTION AT SOURCE

In the following pages we will present alternatives to some of the productive processes and unitary operations described in the previous chapter, which are less aggressive in regard to the environment. Under the umbrella of Opportunities for Pollution Prevention at Source (OPP), we have considered mainly alternatives of Clean Production and Recycling; however, some of the alternatives proposed could be used by following an “end of pipe” strategy.

The Opportunities for Pollution Prevention at Source we present below are not the only ones possible, nor are they original solutions, nor will they be fully applicable in any canning industry. Our criteria for selecting the contents of the following pages has consisted in evaluating the different alternatives projected or experimented with on the part of the canning sector, or other sectors, and selecting those we feel could offer the best solutions to the entire canning industry in the Mediterranean area. Our goal is to have them serve as elements for reflection on the part of technicians, offering a direction in which to take their own processes and a guide for competent authorities to establish specific policies for encouraging environmental improvements.

Table 4.1. Sets the different alternatives against the families of previous sections. A quick glance at the list of OPPs presented in this study reveals that general alternatives are mixed in with specific ones. In order to take on such a diverse field as the canning industry, in regard to size as well as product processes, we have grouped concepts which could really have made up several groups. This structure has allowed us to reflect more profoundly on more generic subjects, taking in a greater range of solutions for this sector. Table 4.2 presents the different OPPs along with the environmental improvements they offer.

The structure followed in developing each OPP is based on the following points:

- Introduction
- Technical Aspects and Conditioners
- Improvements
- Examples

Presented along general lines in the introduction are the most significant aspects of the current process. The technical aspects of the alternative system are discussed, with special emphasis given to the conditioners needed in order to make this alternative system effective and feasible. In the section of “improvements” brief mention is made of the results from using the alternative system for all parties involved (environment, producer and consumer). Finally, an example is given corresponding to a real or fictitious case in order to better illustrate the different aspects of the OPP.

		Reduction at source [1]						
		RM	**E**	**W**	**CA/ BO**	**EA**	**SW**	**WW**
1	Minimising the consumption of water in cleaning raw materials and intermediate products		*	*				*
2	Adapting cutting systems to product size and shape	*		*			*	*
3	Segregating and recirculating wastewater between stages of the process		*	*				*
4	Dry alkaline peeling	*		*				*
5	High efficiency thermal peeling		*	*				*
6	Reducing the concentration of salt and reusing brine			*				*
7	Optimising sterilisation		*	*		*		*
8	Closing cooling circuits	*	*	*				*
9	CIP systems for cleaning equipment and pipes		*	*				*
10	Preventing damaged cans from entering the autoclave	*		*	*	*		*
11	Using pneumatic transportation instead of a water channel as product transport system	*		*			*	*
12	Automatic control of the process with HACCP	*					*	
13	Structural cleaning with a low-pressure system with foam or high pressure.			*				*
14	Drying brine by solar power			*			*	*
15	Bioconversion of fishing waste by acid-lactic fermentation.	*					*	
16	Anaerobic treatment of high-concentration wastewater and making use of biogas		*				*	*
17	Collecting liquids and particles from process facilities before they reach the ground			*				*
18	Making use of steam in fruit concentrate evaporators		*	*		*		
19	Traditional valuation of fish scraps by making fish meal		*	*		*		
20	Optimising provisions of raw materials		*	*		*		
21	Optimising the steam generator and distribution network		*	*		*		
22	Canning/bottling products for cooking		*	*		*		*
23	Valuation of vegetable organic waste	*					*	

X:Minimisation / 0: Increase. [1] RM: Raw materialsn E: energy W: Water Ca Bo: Cans / Bottles
EA: Wmissions in to the atmosphere SW: Solid waste WW: Wastewater

Table 4.1. Environmental improvements from applying OPPs

		Number of Canned Food Family (1)													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Minimising the consumption of water in cleaning raw materials and intermediate products	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Adapting cutting systems to product size and shape	*	*			*	*	*	*	*	*				
3	Segregating and recirculating wastewater between stages of the process	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Dry alkaline peeling								*	*					
5	High efficiency thermal peeling								*	*					
6	Reducing the concentration of salt and reusing brine					*						*	*		
7	Optimising sterilisation	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	Closing cooling circuits	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	CIP systems for cleaning equipment and pipes							*	*					*	*
10	Preventing damaged cans from entering the autoclave	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	Using pneumatic transportation instead of a water channel as product transport system	*	*			*	*								
12	Automatic control of the process with HACCP	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	Structural cleaning with a low-pressure system with foam or high pressure.	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14	Drying brine by solar power					*						*	*		
15	Bioconversion of fishing waste by acid-lactic fermentation.	*	*	*	*	*	*								
16	Anaerobic treatment of high-concentration wastewater and making use of biogas	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17	Collecting liquids and particles from process facilities before they reach the ground	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18	Making use of steam in fruit concentrate evaporators							*							
19	Traditional valuation of fish scraps by making fish meal	*	*	*	*	*	*								
20	Optimising provisions of raw materials	*	*	*	*	*	*	*	*	*	*	*	*		
21	Optimising the steam generator and distribution network	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22	Canning/bottling products for cooking	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23	Valuation of vegetable organic waste							*	*	*	*	*			

X Minimisation (1) 1: tunas; 2: clupeids, mackerel, pipefish; 3: cephalopods; 4: molluscs; 5: anchovy, clupeids; 6: other fish products; 7: juices, nectars; 8: preserves, jams; 9: syrups; 10: natural vegetables; 11: vegetables in brine; 12: natural mushrooms; 13: meat; 14: pre-cooked meals.

Table 4.2. Relation ship between OPP and family

4.1 OPP 1. Minimising the Consumption of Water in Cleaning Raw Materials or Intermediate Products

4.1.1 Introduction

Cleaning raw materials or intermediate products is a necessity that is common to the different families described in the previous section. In general, we can define two large groups of cleaning:

a) Initial cleaning of raw material before processing at reception.
b) Intermediate cleanings during processing.

Initial cleaning is done to eliminate outer dirt from the raw material containing remains of the medium from which it proceeds. In the case of vegetables, dirt consists of bacteria, dirt, stones, bits of pieces, juices from vegetables and pesticides. In the case of fish, foreign elements from the sea, bacteria, mucous, fluids and fragments of fish deteriorated during the process of capturing and transporting them to the plant.

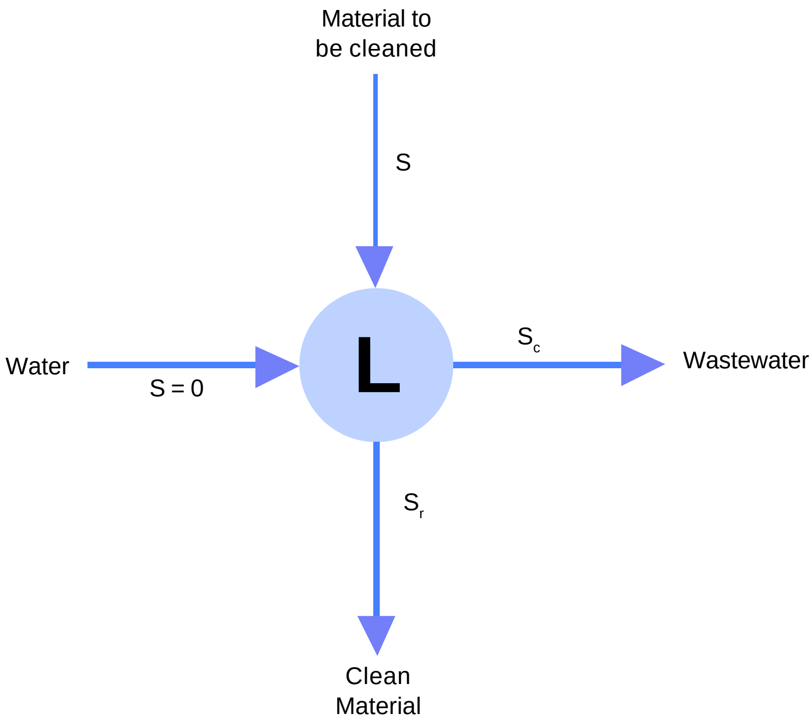
Intermediate cleanings are closely related to the process and are done to remove the remains of undesirable elements left over from a previous stage in which certain undesirable parts of the product were eliminated. This is the case in cleaning after gutting fish or after chemically peeling fruit.

The conventional cleaning operation in the canning industry consists in placing the product to be cleaned in contact with water by means of three main systems:

- Soaking
- Soaking and agitating
- Spraying

When the purpose of cleaning includes reducing the level of microorganisms, a biocide is usually added to the cleaning water (usually sodium hypochlorite).

The basic cleaning diagram is illustrated in figure 4.1.



S : Total dirt   Sc: Polluting dirt   Sr : Residual dirt (not eliminated)

Figure 4.1. Program of cleaning process

4.1.2 Technical aspects and conditioners

4.1.2.1 Optimising the parameters of the operation

The principle in effective cleaning is based on maximising friction and the solubility of the dirt in water.

For soaking systems, an increase in friction can be obtained by means of **increasing water turbulence** using static (deflector) or dynamic (agitating) systems. For spraying systems, this can be obtained by means of **increasing pressure** (by means of pressure pumps or nozzles having smaller diameters). In both cases, **increasing the level of friction** also enhances cleaning. This increase in friction can be obtained by increasing the entry of the product to be washed in continuous facilities, by increasing the rotation speed of rotating drums or by installing rotating brushes.

In regard to increasing solubility, this can be obtained by increasing the temperature and adjusting surface tension by adding wetting agents, salinity or pH of the water.

Most cleaning facilities and operations in the food industry are oversized as a result of the need to make sure there are no risks in hygiene for consumers. Reviewing the operating conditions of the facility by increasing friction and water solubility, without damaging the product, can mean a reduction in water consumption of 40 to 20 %.

For the reasons mentioned in the previous paragraph, the concentration of biocides in cleaning water can be greater than that strictly necessary. Optimising cleaning should include verifying the concentration of biocides in relation to the desired level of microbian contamination before sterilisation or pasteurisation, since the hygiene requirements of vegetables that will later be cooked are not the same as those for a vegetable that will be eaten raw.

When using soaking with continuously added water, the latter must be adjusted to the minimum or even eliminated when working in discontinuous processes with clean water loads due to the fact that, given the low level of agitation, the time required for cleaning is longer, and adding large, continuous volumes of water does nothing more than dilute the dirt removed without increasing the efficiency of its removal.

4.1.2.2 Pre-cleaning with compressed air and/or vibration

Cleaning with air instead of water has the environmental benefit of allowing the easy recovery of dirt removed in the form of solid waste, while cleaning with water leaves the dirt dissolved or suspended in water, which is costly to separate later.

When analysing in detail the dirt of any object to be cleaned, a greater or lesser proportion can be observed of fractions that can be removed without water (compressed air or vibration). For vegetables, the dirt, remains of stalk, leaves, stones and foreign objects in general make up a fraction that is not to be ignored, and removing them by means of compressed air or vibration would reduce the pollution load in wastewater and would segregate waste to be easily returned to crop fields.

Compressed air is present in most canning industries, so investment to start up this system would only include pneumatic installation and placing a set of nozzles that would shoot compressed air along some point of the raw material circuit. When there is no compressed air, installation must be completed with a pressure kettle or additional compressor.

Vibrating the product may be done by means of vibrating tables with vibrating frequencies that are higher or lower according to the cleaning to be done. Vibrating devices usually run on electricity.

The dirt removed from the water in this stage would reduce water consumption in later stages.

4.1.2.3 Recirculation of cleaning water

When the main mechanism of cleaning is friction, a high volume of water must be consumed and the concentration of dirt in the wastewater tends to be relatively low. This is the case in the initial cleaning of fruit or vegetables in general, as well as whole fish. It is also the case in cleaning cans before sterilising to remove remains of the governing liquid used in dosing.

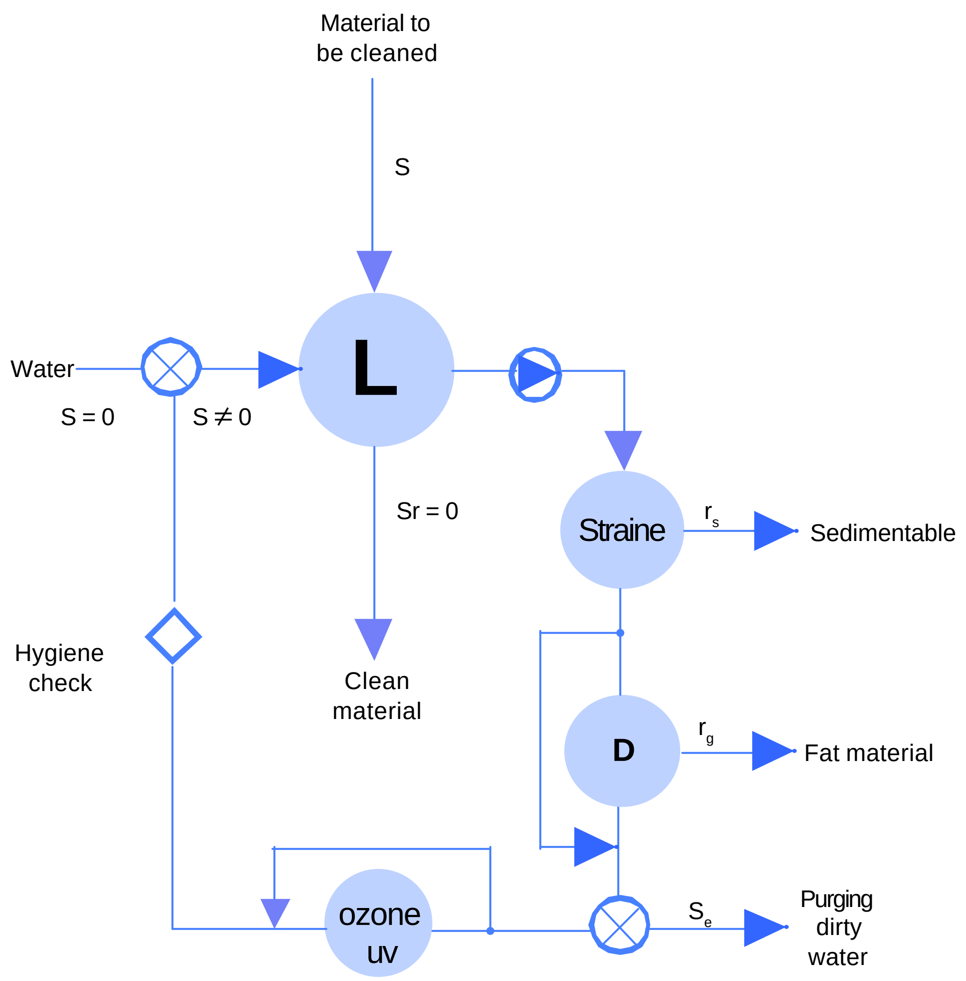
In these circumstances, installing the right recirculating system to maintain an acceptable level of dirt in the rinsing water could signify great savings in the amount of water consumed. A recirculating device basically consists of a filter or strainer for removing solids and a pumping system to supply the desired pressure. Depending on how automatic it is, two adjustable globe valves or ball valves automatically activated by timer could be installed. When dirt in the raw material varies a great deal and a large amount of water is consumed, it could be feasible to install a purging device or automatic feed, based on measurements of water turbidness.

When the concentration of dirt is high, the process can be optimised by means of removing fat materials and pre-coagulation protein by flotation or centrifugation. Another effective system for elimination, which is not very feasible currently due to the high cost of investment and operation, could be the use of membrane technology (ultrafiltration).

The feasibility of these removal projects must include, in addition to water savings, the valuation of waste obtained as a source of fat and protein, mainly. As an example, due to the protein and oil content of water with blood in the fish industry, the waste from treatment prior to recirculation can be used to produce fishmeal, if there is any plant nearby. Installing a rotary strainer and an oil floating tank can reduce the COD by 6-25%, depending on the retention time, and the investment for this type of system is around 54,000 euros.

Another treatment that could be necessary consists in reducing the bacterial load of the water to be recirculated by means of ultraviolet light (UV) or ozone. When low levels of pollution are not necessary, this process can be omitted; however, it is always advisable to make regular checks on the level of microbian contamination of the water.

The following diagram (figure 4.2) shows the main elements of a cleaning system with recirculation.



L:Cleaning D:removing fat S:Total dirt Sc:Polluting dirt Se:Removed dirt

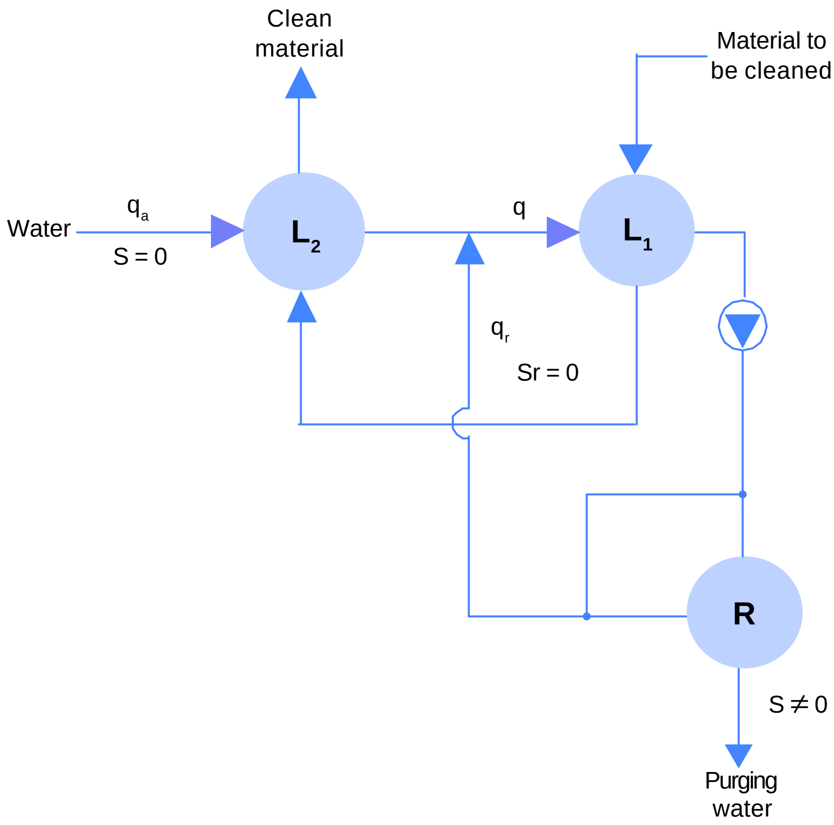
Sr:Residual dirt (not eliminated) rs:Sedimentable waste

Figure 4.2. Diagram of cleaning water recirculation

4.1.2.4 <u>Designing the operation in multiple stages with recirculation</u>

The need to make sure there is a low microbiological level after cleaning could make recirculation in the way we mentioned it above unfeasible from a product-quality point of view. When the final product must be cleaned with fresh water, the process could be divided into at least two stages, using the clean feed water to do cleaning in the last phase of the process with the same flow of recirculating purge water.

The following diagram illustrates this alternative.



L: Cleaning R: Waste treatment S: total dirt q: amount

q_a: amount of water q_r: amount of waste

Figure 4.3. Diagram of two-Stage cleaning with recirculation

4.1.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reduction in water consumption
- Reduction in the volume of flow of wastewater
- Recovery of part of water pollution as solid waste that can be valued by means of the treatment system for water to be reprocessed
- Savings in energy consumed when using hot water

4.1.4 Examples of application

A plant making semi-preserves of small fish processes 1100 Tm/yr of fish and consumes 40m3/ day of water to clean 5 Tm of fish by means of a manual system. Installing an automatic cleaning tunnel according to the principle in figure 4.3 would mean:

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Cleaning tunnel	36 060	n.r.	
Reduction in labour (Average person/day)			6 010
Reduction in water consumption and wastewater dumped to 6 m3/day			1 800
Reduction in the total COD dumped through retention in rotary strainer		n.r.	n.s.
Total	36 060	0	16 828
Return on investment (years)	2.1		

n.r. = Not relevant

4.2 OPP 02. Adapting Product Separation Systems

4.2.1 Introduction

Cutting stages, and in general operations in which the part of the product to be used and the part to be rejected are separated from the pieces of raw material, are centred for the scope of this study on the families of fish and vegetables. In these processes, the main problem in an automated plant is in optimising the process systems in order to remove the greatest amount of the product. In the fish industry, the head-cutting machines used most make a cross or slant cut. Determining the best section is not done mechanically but depends on the experience and ability of the person running the machine.

Mechanical peeling was the first system used by the vegetable canning industry and is done by using traditional knives or specially designed knives. This operation has been automated especially for asparagus and artichokes.

4.2.2 Technical aspects and conditioners

Setting the separation system for the product to be extracted as close as possible for the different elements of the process reduces waste and, therefore, takes the greatest advantage of the raw material. In order to do so, the following actions may be taken:

- Pre-categorising the process
- Setting machine accessories before changing categories
- Using suction systems for small fish
- Automatic adjustment of machine accessories during the process
- Making use of rejections from cut fish in order to obtain small pieces of fish

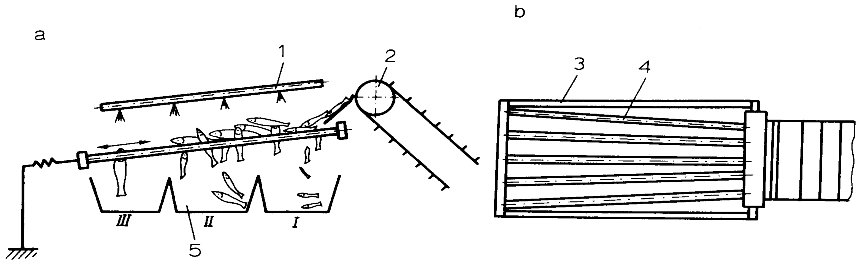
Certain aspects related to the points mentioned are detailed below.

4.2.2.1 Categorising

Categorising raw material allows the product to be separated according to the type and size, as well as the elimination of the altered product or that which is unsuitable for consumption. This operation will permit later conditions of the process to be adjusted to the set category, improving adaptation of the process to the product being made.

Categorising by size is widely done with small pieces, such as herring, mackerel, sardines, tangerines, plums and cherries. Categorising usually takes place on a wire-netting surface made up of a number of vibrating elements or between revolving rollers. The rollers can be laid out in parallel or in a fan. In the case of parallel rollers, the opening of the gap is regulated by its diameter. The precision of machine categorising is greater than that done by hand.

In the case of fish, due to the fish becoming deformed through rigor mortis and the following stage, mechanical categorising is more exact when done immediately after the fish is captured, which would make it more efficient to do it on board the fishing boats, immediately after fishing.



Technology of the sea products

a) side view b) overhead view 1) jets of water 2) carrier 3) frame 4) vibrating ramp 5) receiving containers.

Figure 4.4. Categorising with the help of a vibrating ramp (Source: see Ref.63)

When the raw material is larger, categorising can be done by weight. The system consists of a series of scales that use a mechanical or electronic device to open a trap door when the item to be weighed is within the pre-marked tolerance.

4.2.2.2 Automatic cutting settings in fish

For fish there are different types of cuts:

1. Cross cut: done to cut heads of small fish such as herring, mackerel or sprat
2. V-cut done with two revolving knives making an angle

In both cases, the factors determining the efficiency of the operation are the distance from the head to the cut and the angle of the cut.

The best parameters could theoretically be established by sampling within each category of fish. These parameters could be set by testing on the line, taking advantage of the experience of the operators. Once these parameters are set, they would be documented in order to ensure the use of the right data.

It is recommended during the process to have the operators supervise the ideal measurements by visual inspection or checking wastage from the operation by weighing and, when deemed necessary, stopping the installation to reset the parameters.

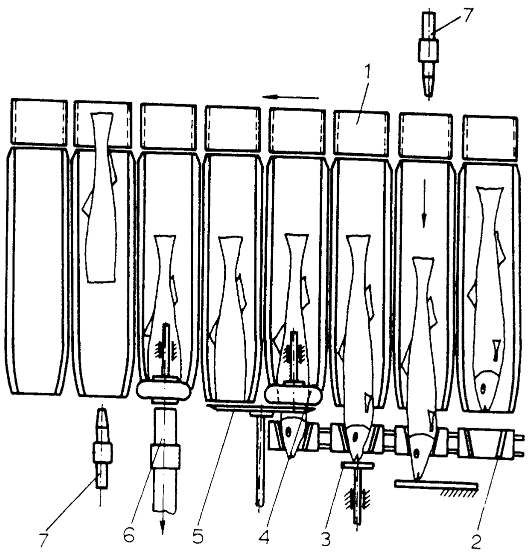
These measurements taken for fish can be done by changing the parameters described for vegetables.

4.2.2.3 Automatically gutting fish by suction

The most common machine gutting consists in opening the abdominal cavity by making an incision before or after cutting heads and mechanically extracting the viscera.

Instead of conventional means of cutting heads and gutting, viscera can be removed by vacuum suction, reducing the consumption of water and, more importantly, preventing the organic content of the fish viscera from entering the water. Gutting precision depends on the design of the suction nozzle and the intensity of the vacuum created.

The main limitation to this system is that it can only be done with small fish.



1) Individual chamber fish carrier 2) head carrier 3) position setting mechanism 4) compression pulley 5) beheading knife 6) suction nozzle 7) water jet

Figure 4.5. Deheading and cutting by suction (Source: see Ref. 63)

4.2.2.4 Automatic machine setting

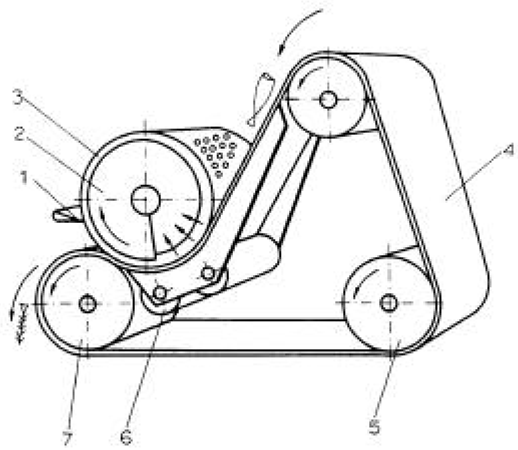
Technologies are being developed on an experimental level to control aspects related to the dimensions of the product to be cut so that the machine learns the product dimensions using detectors or graphic treatment. Using these morphological parameters, automatic knife settings would enable precise settings to be made for cutting, with the subsequent reduction of waste.

In some cases with simple detection systems (micros, photoelectric cells), water consumption can be reduced by stopping the water that usually accompanies cutting processes when the installation is not being used.

In these cases, the amount reduced depends on the installation's down time, which can be up to 50% in installations that are not highly automated.

4.2.2.5 Making use of cutting rejects

Waste from cutting fish still contains an appreciable percentage of meat that can be made use of by using meat-separating machines that use cutting fragments such as bones, fins and skin to obtain small pieces of fish. This meat can be used to make fish pates and surimi. When it is not profitable to install this type of machine, manual extraction can be considered.



(1) Scaler; (2) screw type meat separator; (3) perforated drum; (4) rubber belt; (5) belt tension roller; (6) compression roller; (7) transmission roller

Figure 4.6 Meat separating machine. (Source: see Ref. 63)

The use of separating machines enables 15 to 30% more meat to be obtained in the form of small pieces of fish than in the form of deboned fillets.

One of the main applications of small pieces of fish is found in making surimi. Currently, more than 60 species of fish are used in preparing surimi, but the species of black cod alone makes up 50% of the raw material used.

Because the elasticity and texture of surimi is based on the formation of a gel made up of a mesh of myofibril protein, the prior treatment received by fish (freezing, cooling) is a determining factor in the quality or even feasibility of making small pieces of fish. It is therefore an essential prerequisite in making this type of speciality that the chain of capture and processing conditions be controlled.

The process of making surimi is described in the following figure:

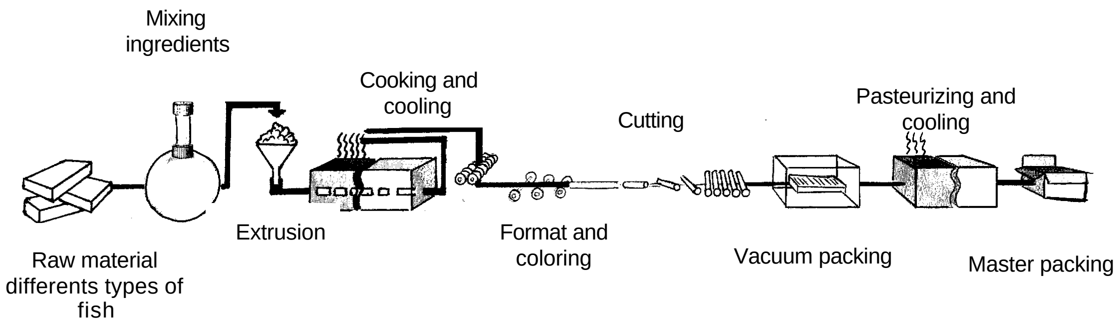


Figure 4.7 Process of making surimi

The pieces of recovered muscle tissue obtained are washed and dried, then mixed with the rest of the ingredients: additives, sucrose, sorbitol, polyphosphates and salts.

The mixture is extruded to texturise the proteins, modifying bonds between their molecules. The product obtained has a very elastic consistency. This extrusion can be done together with the cooking in equipment in which the product is subjected to temperatures of 100-200ºC at high pressure (50-100bar) and highly intense cutting. The product goes from a solid divided phase to being a melted phase with a tendency towards homogeneity.

The product is then cooled, formatted and cut for packing, usually vacuum packing.

4.2.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reduction in the amount of raw material needed. In the case of fish, and given the problems arising from overfishing, this is an environmental element worthy of consideration.
- Reduction in fish waste, which will probably be processed as raw material for making fishmeal. Despite the fact that it is a recycling process, it is highly polluting, which would make it environmentally interesting to minimise its use.

Considering the points of suction gutting and automatic setting of water entry, the following should also be considered:

- Reduction in water consumption
- Reduction in the volume of flow of wastewater
- Reduction in the COD of wastewater given the solid elimination of viscera

4.2.4 Examples of aplication

A fish processing plant that processes 15 t/hr of raw material (50,000 t/yr).

Aspect	Invesment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Recovering meat (15-30%) for sale as surimi			6 010 000
Cost differential between making fish meal and making surimi			4 000 000
Recovery machine (1 t/hr)	8 000 000		
Total	8 000 000	0	4 000 000
Return on investment (years)	2		

n.r. = not relevant

4.3 OPP 3. Segregating and Recirculating Wastewater between Stages of the Process

4.3.1 Introduction

As can be seen in most of the balances of material made, and especially in the analysis of tunas production, the waste flows contributing to the end effluent have two specific models:

a) Water with high content of organic material and low volume of flow, and
b) Sewage with low content of organic material and high volume of flow.

At first glance it seems logical to think that processes with dirtier waste flows can somehow stand the supply of water that is not completely clean.

4.3.2 Tecnical aspects and conditioners

Segregating and recirculating between stages must be studied first of all by means of balances of water material and COD, since this means:

- Defining waste flows,
- Evaluating at what point in the process direct recirculating can be done, or after a little treatment, as indicated in figure 4.2 of OPP 01.

- Verifying the technical and economic feasibility of the connection.
- Making a pilot test verifying compliance with product quality specifications, especially microbiological ones, and the lack of dangers to health in the water to be recirculated.
- Should the pilot test be satisfactory, definitive modification of the installation.

This opportunity for pollution prevention is often a second alternative when the water cannot be used to recirculate in the stage itself (OPP 1).

In practice, the main conditioners making most recirculating opportunities unfeasible are:

- **Investment costs** for connecting the waste flow from the source process to the destination process supply. This investment often means building a collection well and pumping wastewater, corresponding pumps, pipes and valves, and a system for conditioning this water, which usually consists of chlorination and a filter. In many cases, the system must include a pressure set to feed the machine properly. Some machines have safety systems that disable start-up unless they receive a minimal amount of pressure.
- **Operating costs** for defraying the energy for pumping this water and additional treatments. When the wastewater to be reprocessed is susceptible to microbian contamination, and whenever this could have an effect on the finished product, regular checks must be established.
- **Technical aspects** related to the quality of the end product, especially in regard to dangers to consumer health. The main cases in which this appears tend to be the presence of additives added to the cooling or heating circuits, detergents in container cleaning water, remains of pesticides in the initial washing of vegetables and excessive microbiological levels.

As may be deduced from the previous paragraphs, and given the price of water for the industry, this recovery is often not economically feasible unless the origin and destination operations are physically very close. The main conditioner for implementing these alternatives is the lack of water.

Clear examples of flows that could be recirculated to other stages of the process are:

- Water from cleaning empty cans
- Water from cleaning full cans
- Water from sterilisation
- Water from cleaning vegetable raw materials with a low dirt content
- Water from cooling

4.3.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reduction in water consumption
- Reduction in the volume of flow of wastewater
- Recovering part of water pollution as valorisable solid waste by means of the system for treating water to be reprocessed
- Savings in energy consumed when the flow recovered has an energy value (hot or cold)

4.3.4 Examples of aplication

A specific example of water to be reused is using it to clean sealed cans and for other cleaning activities. The investment needed to install pipes and pumps is quite low, and around 85 % of the water can be reused.

A plant making jams and juices has five plants for eliminating chlorine from the water by active carbon with the capacity to produce 100 m3/day of water. Based on a water recirculation study, the conclusion reached was to recycle between 10 and 20% of the cleaning water against the flow of the carbon columns to other processes.

Aspect	Invesment (Euro)	Cost (Euro/year	Savings (Euro/year)
Installing a recovery tank, pipes and additional filter	110 000		
Reduction in water consumption			50 000
Increasing the sewage tax due to the increase in pollution of wastewater after applying the measure		10 000	
Total	110 000	10 000	50 000
Return on investment (years)	2,5		

n.r. = not relevant

A plant making preserves with beets, cabbage and pickles that produces 7000 Tm/yr., and having a main process consisting in cleaning, cooking, steaming, with or without pickling and packing, took on a project for reusing water that gave the results shown in the following table, with a water savings of 10,000 m3/yr.

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Reusing water from pasteurisation	10 000		8 400
Reusing cold water	6 000		1 000
Total	16 000		9 400
Return on investment (years)	1,7		

n.r. = Not relevant

4.4 OPP 04. Dry Alkaline Peeling

4.4.1 Introduction

The operation of eliminating peels from fruits and vegetables is one of the most critical stages from the point of view of quality in making canned vegetables. At the start of the preserving industry (and currently in artisan plants) this operation was done with the help of knives or other utensils.

The importance of labour and the search for regularity in the product brought on the development of automated peeling techniques based mainly on using chemical products. These systems, although they are suitable for obtaining a product with the required quality, have an effect on the environment in:

- High water consumption and
- Dumping with high content in organic material and high base or acid concentrations

4.4.2 Technical aspects and conditioners

The principle of dry alkaline peeling consists in subjecting the peel and adjacent fine layer of pulp to the same conditions as in chemical peeling by immersion, avoiding the use of water baths.

The process is essentially based on lining the product with a film of concentrated caustic soda, heating it by means of infrared light and applying soft abrasion.

Formation of the film on the surface of the fruit is obtained by spraying or bathing it in a concentrated solution of 20% sodium hydroxide. The time for this stage depends on the penetration capacity of the soda solution on the vegetable peel and pulp.

The product is then subjected to infrared heat for 40-60 seconds at temperatures between 500 and 900 ºC. This operation can be done in an infrared unit made up of a fruit feed, rotating roller carrier and radiation unit on the top. The combined action of the soda and the heat produce disintegration of the peel and a fine layer of pulp, while at they same time drying the surface.

Finally, soft abrasion obtained by the friction of the fruits themselves in a rotating rod drum, followed by the friction produced by rubber discs, enable the peel to come off, leaving a semi-dry residue. Remains of soda and peel that remain on the fruit are eliminated by spraying them with water under pressure.

This technology was initiated for peeling potatoes, but its application has been extended to other fruits and vegetables, despite the fact that it involves slightly higher losses in raw materials (1-2% for peaches) than with the conventional system.

4.4.3 Improvements

The main environmental benefits from this technology lie in:

- Reducing the contribution of soda and content of organic material to wastewater, with the subsequent savings in operating costs of the water treatment plant.
- Dry separation of peel scraps during the process, preventing them from entering wastewater
- Reducing water consumption
- Reducing the volume of flow of wastewater
- Increasing the loss of fruit by 1-2%
- Global reduction in the amount of waste in the plant, considering the sludge form the wastewater treatment plant (locally, EDAR).

4.4.4 Examples of Application

The experience of applying this process to making canned peaches permitted a reduction in the consumption of water by 90% as opposed to the conventional process (consumption decreased from 1380 l to 73 l for the process of 10-12 tons/hour of peaches), a reduction of 60% of the COD. On the other hand, water savings added an additional cost due to the management of solid waste and a small increase in fruit wastage (1-2%) during the process.

Aspect	Cost (Euro/t prod.)	Savings (Euro/t prod.)
Savings in waste management		0,676
Savings in water consumption		0,19
Increase in product wastage	0,75	
Total	75	866
Cost savings (Euros /t)	116	

4.5 OPP 05. High Efficiency Thermal Peeling

4.5.1 Introduction

The traditional alternative to chemical peeling consists in injecting steam directly into non-hermetic chambers, where the fruit is heated. Next, quick cooling facilitates separation of the peel. This system does not use chemical products, but uses large amounts of steam and cold water.

4.5.2 Technical aspects

The principle of dry thermal peeling consists in subjecting the peel and adjacent fine layer of pulp to extreme temperature conditions (heat or cold) in order to reduce adherence of the peel and facilitate later separation. During this process, it is important that the entire surface of the fruit be in direct contact with the thermal fluid in order to have even peeling.

The main clean production system alternatives to chemical peeling that are also energy efficient are as follows:

- Pressure steaming
- Pressure and vacuum steaming
- Freezing

4.5.2.1 Pressure steaming

This operation takes place in hermetic chambers into which steam under pressure is injected (between 3 and 10 Kg/cm2). Under these conditions and at intervals of 5 to 10 seconds, the pulp under the peel reaches temperatures over 100 ºC. An immediate reduction in pressure causes the cellular fluids of this layer to boil, with the subsequent formation of steam that tends to escape toward the peel. The pressure this steam exerts on the peel makes this peel away from the pulp. Peels are then separated by friction (drums, rollers or water under pressure).

4.5.2.2 Pressure and vacuum steaming

The initial procedure is equivalent to pressure steaming, but once the fruit reaches temperature conditions over 100 ºC on the inside layer, it is subjected to vacuum conditions so that the pressure exerted by the pulp inside the fruit on the peel is much higher than under room temperature conditions. Once separated, the peel is eliminated the same way as in mechanical systems.

For pressure peeling, an average installation requires an investment of 30,000 Euro for a production of 4,000 Kg/hr.

4.5.2.3 Freezing

In this case, the mechanism for separating the peel from the pulp is based on a freezing-thawing cycle. The product is submerged in a bath at –100 ºC for 20 to 30 seconds. Under these conditions, the ice crystals formed in the subcutaneous layer break the tissues, leaving the peel separated. Next, the product is subjected to thawing for a few minutes. This technology was later tested successfully in other, more severe cryogenic conditions (liquid air, liquid nitrogen and Freon) reducing exposure time.

Application of these systems has been successful mainly for tomatoes and plums, it has improved product quality because no chemical products are added and freezing improved the outer aspect due to greater colour retention.

4.5.3 Conditioners

In regard to chemical peeling, thermal peeling has higher energy requirements (100-250 Kg steam/Tm of product) and requires a greater investment given the conditions of extra pressure in which the process is developed. In the case of steam, additional installation of a boiler is required, and in the case of vacuum, a vacuum system using pumps or injectors is required. Freezing requires an auxiliary installation of cryogenic fluids.

4.5.4 Improvements

The main advantages of using these systems in regard to the environment are:

- Reducing by 50% losses from peeling, with the subsequent reduction in waste
- Dry separation of peeling waste during the process prevents it from entering wastewater
- No chemical products are added to wastewater
- Reducing the consumption of water as opposed to the chemical system or with traditional steam
- Reducing the volume of flow of wastewater
- Lower energy consumption (around 4,800 euros/year for pressure steaming) compared to the conventional thermal system.

4.6 OPP 06. Setting the Dosing of Salt and Reusing Brine

4.6.1 Introduction

In making vegetable products by means of fermentation (pickles, olives, cabbages, capers…), as happens with semi-preserves of fish (smelts, anchovies…) brine is used as a fermentation medium.

This brine usually ends up in wastewater from the plants and, given the high conductivity as well as relatively high organic contamination, this water makes for a difficult problem to solve.

4.6.2 Technical aspects

The main alternatives for minimising at the source are a reduction in concentration of salt and regeneration.

4.6.2.1 Reducing the concentration of salt

While these products are being processed, a lack of salt can cause a loss of the product. This fact, joined with the traditional principles related to making these products, and to the low cost of salt, means that those responsible for the process use too much salt.

The main consequences of this overdosing are as follows:

- Impeding the normal development of desirable bacterial flora that mostly do not grow when the concentration of salt is above 7-8 %.
- Excessively salty taste in the product
- Increasing the concentration of salt in wastewater. This solute is not eliminated by conventional treatment systems and, in high concentrations, it diminishes the effectiveness of biological treatment in water treatment plants.

The main proposals in this regard include:

- Setting for each production the proportions of product:water:salt, and
- Eliminating preservation processes with salt once the fermentation is done, when not strictly necessary.

Studies done using traditional elaboration procedures indicate that in the case of pickles and capers, the maintenance brines used have excessive levels of salt, but this is not the case with cabbage. Maintenance of black olives can be done using an acid medium instead of a saline one.

4.6.2.2 Regenerating brine

Reusing brine can have various purposes, including a new fermenting process, packing or other stages of elaboration.

Adopting one strategy or another will depend on the composition of the preserving solution and on the substances with which the solution was enriched after fermentation. For pickles, using brine for packing is not possible because they are preserved in vinegar.

In order to prevent the concentration of certain undesirable substances prior to reuse, brine is often subjected to preliminary treatment. The processes employed tend to eliminate the organic matter that gives them their colour (whole olives) or other compounds that negatively influence fermentation, such as certain enzymes (pickles). The main systems used are chemical precipitation, adsorption with active carbon and ultrafiltration.

Chemical precipitation consists in modifying the pH to cause precipitation with the use of polyelectrolytes. This causes the loss of making use of lactic acid; however, the resulting solution can be used in new fermenting processes. This system has been used successfully in preparing pickles.

Adding active carbon and later filtering the resulting solution is the system that has been used to regenerate green and black olive brine as preserving solutions. This process can be done discontinuously in an agitated tank, and requires later removal of active carbon in a plate filter.

Ultrafiltration with 1000-dalton membranes leads to results similar to the addition of active carbon.

4.6.3 Conditioners

Regarding the proposals put forward, the primary difficulties in applying these solutions consist mainly in the need to make studies in order to ensure the product retains its qualities when the concentration of salt is diminished or the brine regenerated. When treatment such as that described above is necessary for brine regeneration, the feasibility of the project is greatly compromised due to the high investment in the equipment needed for the addition of active carbon (approx. 36 euros/m3 brine) and ultrafiltration (approx. 180 euros/m3 of brine), in addition to the operating costs.

4.6.4 Improvements

The main benefits these systems offer the environment are as follows:

- Reduction in the amount of salts dumped
- Reduction of the COD dumped in the case of incorporating brine to the product
- Reduction of the amount of water used by 50% in the second case
- Reduction of the volume of flow of wastewater

4.6.5 Examples of application

A plant processes 100 Tm/yr of black olives in the following stages:

1. Treatment with bleach (1.5%) day one
2. Ventilation in brine
1. Treatment with bleach (1%) day two
2. Ventilation in brine
3. Treatment with bleach (1%) day three
4. Ventilation in brine
5. Immersion in brine with gluconate day four
6. Packing and sterilising day five with the gluconate brine

Studies have shown that from a quality point of view a process with bleach regeneration and another with bleach regeneration and ventilation liquids are feasible.
Comparative results between both processes are shown in the following table:

	Conventional	Regeneration of bleach	Regeneration of bleach and ventilation liquid
No of bleaches dumped per production	3	1	1
No of brines dumped per production	3	3	0,3
Reduction in water consumption (%)	0	33	78
Volume of wastewater (l/yr)	450 000	300 000	97 500
Wastewater Pollutants			
NaOH (kg/r)	4 500	1 500	1 500
NaCl (kg/r)	24 750	24 750	2 475
Average NaCl (g/l)	55,0	82,5	25,4

4.7 OPP 07. Optimising Sterilisation

4.7.1 Introduction

In point 3.1 a full description was given of sterilisation facilities. However, for small and medium enterprises, investment in the steriliser and boiler is the most important expense, and because these companies need a great deal of flexibility, there are facilities that operate with installations lacking recirculation of water or steam. These facilities usually have a water bath within which steam gushes, generating large losses in energy and, in the second place, sterilisers are programmable shower-types without heat recovery tanks.

4.7.2 Technical aspects and conditioners

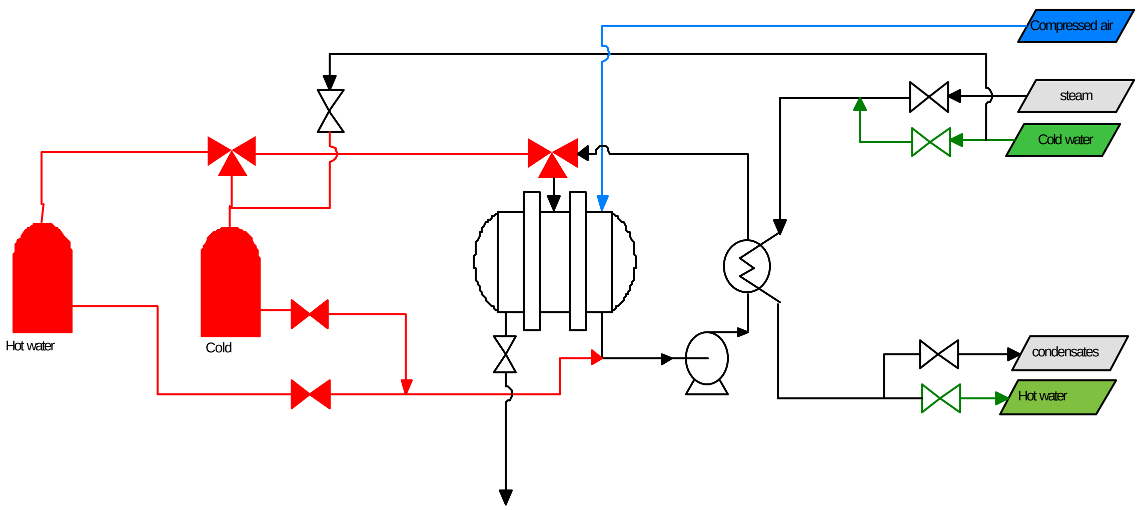
The operation of sterilising, in regard to energy efficiency and water consumption, is a response to a principle of industry of scale, where a plant running by loads consumes more water and energy than a continuous plant.

The following table presents the repercussions on investment, production capacity and optimisation of resources in regard to a low-efficiency plant.

Aspects	Discontinuous			Continuous atmospheric pressure	Continuous using pressure		
	Immersion Autoclave	Injection Autoclave	Horizontal Autoclave heat recov.		FMC	Hydrostatic	Odenberg
Steam consumption (Kg/Tm prod.)	700-800	400-500	300-420		370-500	330-450	350-500
Energy consumption	more			less	less		
Water Consumption	more			Reduction 70%	less		
Investment costs (Euro)	-			more		1 000 000	
Production capacity Tm/r	Small or medium size industries			Products with acid pH	15 000	15 000	15 000

Autoclaves with no facility for storing water use approximately 75% more energy than those having one. The investment required is low, and savings are substantial, approximately 173 kW/h and 5-6 m3 of water per ton of raw material.

Shown below is a diagram of a shower-type sterilisation plant, as well as the system for recovering water and heat shown in black. The new installation for minimising heat and water loss is detailed in red.



This operation saves fuel and prevents energy being dispersed in an intermediate tank, thereby improving the temperature for cooling. This practice reduces fuel gas emissions by 41%.

In the case of a simple bath, it is recommended to have two baths so that, once the thermal treatment time is up, the cage with packings is sent to the cold bath.

Another energy-saving measure is to isolate the autoclave, which could mean savings of 1.4 Kg of fuel oil per ton of canned product. This measure is expensive, at around 18,000 Euro.

Two water tanks can be installed, one for handling heating and another for handling cooling.

4.7.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reducing water vapour consumption. The production of water vapour, in addition to consuming resources (fuel and water), sends emissions of CO2 into the atmosphere, as well as other pollutants, depending on the type of fuel. Furthermore, demineralisation or decalcification plants for treating feed water consume water for regeneration of columns and high conductivity dumping.
- Reducing water consumption
- Reducing the volume of wastewater flows

4.7.4 Examples of aplication

Detailed below is the case of a prepared-meal industry with a shower steriliser without heat recovery, where the following is proposed:

Aspect	Investment (Euro)	Cost (Euro/a)	Savings (Euro/a)
Two 600-liter tanks each and facility for handling fluid exchange	8 000		
Heat and water savings [(1)]			5 000
Total	8 000		5 000
Return on investment (years)	1,6		

The following aspects are considered:[(1)]

Heating by the current system 1500 Kg of product and 600 Kg of water for 15 sterilisations per day	52,29	Euro/day
Kcal saved because water is heated only upon initiating the cycle	504 000	Kcal
Savings in calories	21,68	Euro/day

4.8 OPP 8. Closing Cooling Circuits

4.8.1 Introduction

In the general elaboration of canned food products (figure 3.1) various operations are identified in which cooling is necessary (scalding, cooking, sterilising, pasteurising, cooling containers). In all cases, the need for cooling is a consequence of a preceding phase in which the product was heated in a significant way.

Food products require quick cooling in order to maintain the greatest amount of their organoleptic properties while minimising the risk of cross contamination of microorganisms. This inherent requisite of the food industry is even more relevant in the canning sector due to the volume and successive thermal treatments and later cooling to which products are subjected.

Cooling water is usually water with very low pollutant load when the water does not contact the product, and low when there is contact with the product.

4.8.2 Tecnical aspects and conditioners

Closing cooling circuits, as occurs with cleaning, means saving as much water as can be kept clean. In the case of cooling, this amount tends towards infinity as long as no dirt is contributed.

For sterilisation, purge water can go directly to a cooling tower for reuse in cooling. The number of times the water can be reused depends on how clean it stays. Water can be contaminated by damaged cans and dirty can surfaces. Entry into the autoclave of these damaged cans must be prevented in order to keep the water from becoming polluted.

When the water can no longer be used for recirculation, it can be used to clean sealed cans as well as for other cleaning activities. Investment for installing pipes and pumps is quite low, and about 85% of the water can be reused.

Despite the fact that the cooling tower is the first and most-used device in cooling circuits, there are other strategies:

a) Having a water tank large enough to dissipate all the energy. In this case, the circuit is closed by feeding the tank with purge water.
b) Having a cold water air-conditioning circuit. In cases in which the volume of flow is small

(vacuum pump condensers, coil mills for pulp, etc…), and because the heat dispersed is normally low and the cooling equipment purchased is oversized, it could be worthwhile to use it, depending on the distance, because investment would be minimal.

c) Installing a heat pump in which the cold fluid would be the cooling circuit and hot, for example, would be preheating for degasifying.

The main conditioners on closing cooling circuits are found in the thermal leap between entry water and exit water at the cooling point, and the dirt that gets into this circuit. Should this strategy not prove feasible, consideration can be given to having it recirculate towards another operation (OPP 3).

4.8.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reduction in water consumption
- Reduction in the volume of flow of wastewater
- Saving energy consumed when the recovered current has an energy value (hot or cold).

4.8.4 Examples of aplication

A plant manufacturing 600 Tm/yr of jams on the processing line has a coil mill placed before the packing line. This mill is cooled with water and the cooling circuit is not closed.

Near the area of the mill, there is a cooling circuit servicing other machines with enough volume of flow to feed the mill.

Closing this circuit would mean a water savings of 1200 m3/yr.

The feasibility study for this small modification is detailed in the table below:

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Closing cooling circuit	1 500		
Recirculated water			1 000
Total	1 500		1 000
Return on investment (years)	1,5		

4.9 OPP 9. CIP (Cleaning in Place) Systems for Cleaning Equipment and Pipes

4.9.1 Introduction

It is well known that cleaning operations in facilities and equipment are fundamental in this type of industry. Cleaning operations usually have high costs in labour, energy, water, cleaning products and disinfectants, while generating large volumes of highly polluted wastewater. Cleaning systems that are based on the CIP principle permit appreciable savings in labour, energy, water and cleaning products and disinfectants, while drastically reducing some types of pollution in wastewater.

4.9.2 Technical aspects and conditioners

CIP systems are based on cleaning installations without having to take them apart, and in reusing cleaning and disinfectant liquids.

A traditional cleaning operation is one that is not very rational, in that has only one goal: **eliminating dirt at any cost**.

CIP operations, if they are well designed, include with the objective of eliminating dirt **minimisation of the consumption of energy, water, detergents and the volume and contamination of the wastewater generated**.

Indicated below are some of the most important areas for action that are based on the efficiency of well-designed CIP operations:

4.9.2.1 Making use of the product or elimination of dirt as solid waste.

The first point to consider is the possibility of making use of the product retained in the facility or in its conditions at the end of the process.

Driving compressed air, with or without the help of rubber balls or similar materials, toward the product retained inside the pipes permits large amounts of the product to be recovered, drastically reducing pollution of the wastewater originated by the cleaning process.

In cases in which it is not possible to use compressed air, manual intervention may be recommended, using scrapers or similar items to recover or remove as solid waste most of the product contained in the installations.

4.9.2.2 Making use of the rinsing water or other clean water that may be generated in other activities in the installation.

The first phase of washing is usually done with water. In this phase, it is not essential to use perfectly clean water. Using rinsing water from previous operations or surplus clean water from certain industrial operations enables savings of as many square meters of water as are made use of in the aforementioned operation.

4.9.2.3 Making use of alkaline and acid solutions used as detergents.

If there is a first cleaning phase with water, over 90% of the dirt in the installation can be eliminated. After this phase, the surfaces to be cleaned only have small amounts of dirt left that are very difficult to remove. This is the time, and not before, to begin using detergents. Since most dirt will have been removed previously, the detergent solution, while removing the rest of the dirt during the cleaning process done by the recirculating system of the detergent solution itself, it is not noticeably dirty. After the cleaning is done, it retains its cleaning power, and the slight losses in concentration that may have occurred can be compensated by incorporating concentrated detergent into the cleaning solution. This enables recovery of all the alkaline and acid solutions used in order to use them in later cleaning processes instead of removing them in the form of wastewater. It is easy to see that savings in water, detergents, volume flow and pollution of wastewater are more than appreciable.

4.9.2.4 Recovering the energy used to heat detergent solutions.

It is common knowledge that the effectiveness of cleaning operations is strongly conditioned by the temperature at which they are done. As a general rule, it is accepted that for every 10ºC increase in temperature, the speed of cleaning doubles. That is why cleaning operations are usually done at high temperatures requiring large amounts of energy. CIP installations let a large part of this energy be recovered by means of using heat exchangers and/or recovering and conserving the hot liquids.

4.9.3 Improvements

The main environmental benefits from using the CIP system lie in:

- Reducing water consumption
- Reducing the content of organic material in wastewater
- Minimising problems of pH variation in wastewater
- Minimising the detergent content in wastewater
- Reducing energy consumption

4.10 OPP 10. Preventing Damaged Cans from Entering the Autoclave

4.10.1 Introduction

The sterilisation process is done under high temperature and pressure conditions, so if the containers do not have the proper conditions (proper resistance, proper closure) they will open under pressure or by depression, spilling part or all of the product into the sterilisation water.

Sterilising water must have the right level of cleanliness, because if any dirt is on the outside of the cans or jars, or if one of them opens during the process, this will cause problems of biofilm on the surface of the heat exchanger and, in general, throughout the sterilisation installation

This is precisely why most processes include cleaning the closed containers before they enter the steriliser.

4.10.2 Technical aspects and conditioners

Actions to be taken to minimise the contribution of organic material to water basically consist in:

a) Homologation of container suppliers and regular checks for resistance on the containers themselves
b) Regular checks on packing machines in accordance with the machine supplier’s recommendations
c) Daily quality control by the container operator visually inspecting the container closure.

These measures, in addition to minimising contamination, increase productivity and offer consumers quality guarantees, because if the containers do not close properly, customers would complain and returned products would become waste.

4.10.3 Improvements

Application of the measures described would permit:

- Reductions in water consumption,
- Reductions in the volume of flow of wastewater,
- Reductions in finished product wastage, and
- Savings in water vapour in cases where there are continuous installations or heat recovery.

4.10.4 Examples of aplication

An installation making pasteurised sauces and processing 1000 Tm of product in 2.5-Kg containers would process 400,000 containers. If its quality system accepts a rejection of 0.1% defective containers, this means 400 2.5-Kg jars. These 1000 Kg of product means, in the worst case scenario, that they have been spilled into different sterilisations. With an autoclave of 1500l capacity and given the rule for changing water each time a jar breaks, this would involve the following approximate figures:

Aspect	Cost (million Euro/year)
Finished product and container wastage	4,5-5
Reheating the steriliser water	3-3,5
Changing the water	1,5-2
Labour for cleaning dirty cans	3,5-7
Water consumption for cleaning	1-1,5
Total	**13,5-19**

This data leads to only one course of thought. What percentage of container breakage do I have in the autoclave? How much are we talking about? Can I improve this ratio?

4.11. OPP 11. Using Pneumatic Transportation instead of a Water Channel as Product Transport System

4.11.1 Introduction

In fish canning industries, seawater is used to transport fish inside the processing plant, but in some cases tap water is added in order to maintain enough volume of flow.

Wastewater with fish blood generated on board fishing boats, depending on the type of fish and conditions during unloading, can mean 20-25% of the total content of organic material generated in the fish canning industry.

This problem can also arise in processing vegetables and, although is not a subject of this study, it also occurs in meat industry slaughterhouses.

In vegetable processing, the problem is not as great because it is less likely to have vegetable organic material pass into the water, and dry processing could mean for many cases higher wastage of raw material.

4.11.2 Technical aspects and conditioners

4.11.2.1 Unloading fish

The main pollution problem produced during unloading begins in the fishing boat holds while catching fish and transporting them to processing plants.

The environmental problems are based on:

- High conductivity given the use of seawater as storage medium
- High pollution for transfer of organic material from the fish into the water

The content of organic matter and salinity of wastewater generated in unloading can be reduced during fishing by freezing catches.

Effective freezing improves the quality of fish and reduces losses. Freezing consumes extra energy (approximately 50-60 kWh/t to produce ice and 50-70 kWh/t for freezing), but the content of organic material in wastewater is reduced considerably.

The amount of added water consumed in unloading can be reduced by means of:

- Limiting the amounts of water added to the pump transport system for efficient transportation.
- Installing solenoid valves that cut the flow of water when no fish is being unloaded.
- Recirculating transport water (although it is necessary to use filters to separate the solid part from the water flow before being reused)
- Installing water meters to make sure that personnel doing the unloading do not use more water than is necessary.

Water treated with the aforementioned system can be reused for new fish unloading if it is properly treated with ultraviolet light (UV) or ozone.

As mentioned in OPP1, samples must be analysed regularly in order to make sure there are no dangers to consumer health. Savings in water can be around 2-5 m3 /t of raw material, but the required investment for ultraviolet light or ozone treatment is high.

The quality of treated water with blood can be much greater before dumping if a centrifugal system is used to reduce material and solids in suspension by about 45% (60 Kg/t of raw material). The investment for this system, however, is high.

Due to the protein and oil content of water with blood, this can be used to produce fishmeal, if there is a plant nearby. Another alternative is to treat and dump the water into the sea. Treatment means installing a rotary strainer and oil floating tank.

Use of this system can reduce the COD by 6-25%, depending on the retention time. Investment for this type of system is around 54,000 Euro.

4.11.2.2 Dry transport

To avoid using water in unloading, dry unloading systems can be used by means of belts, screws, buckets, vacuum suction and packet drive. The product is an unloaded on transport belt for transport to the processing plant. Modern dry systems can be as effective as wet systems, but small amounts of water are occasionally needed to increase unloading speed.

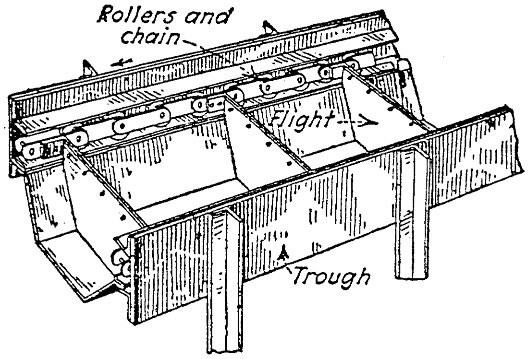


Figure 4.8. System of transporting by worm (Source: see Ref. 79)

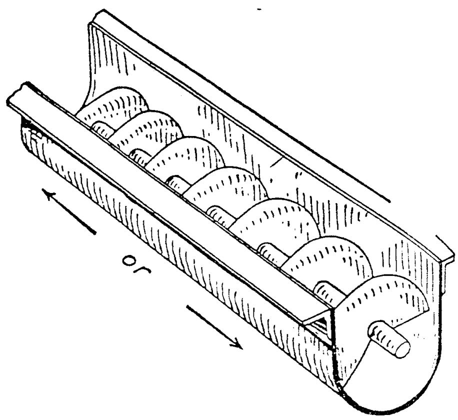


Figure 4.9. System of transporting by worm(Source: see Ref.79)

When raw material is small, single pumps can be used with good results. The investment needed is close to 110,000 Euro for pumps and about 540,000 Euro for storage tanks. Savings are around 1-2 m3 per ton of raw material and dumping organic material is avoided.

The vacuum suction system for fish guts can reduce water consumption as well as the COD load in wastewater at about 67%.

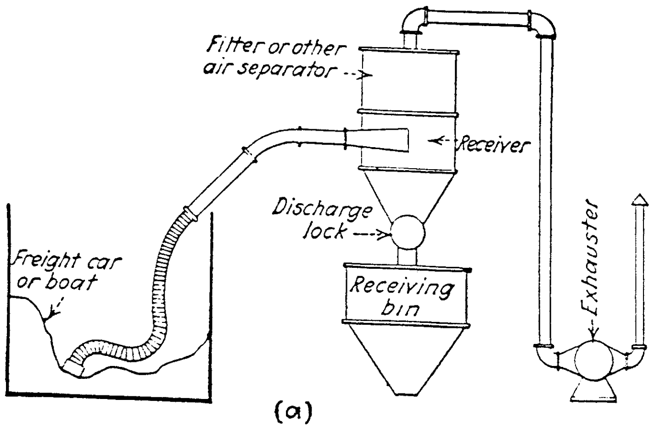


Figure 4.10 System of pneumatic transport by aspiration (Source: see Ref. 79)

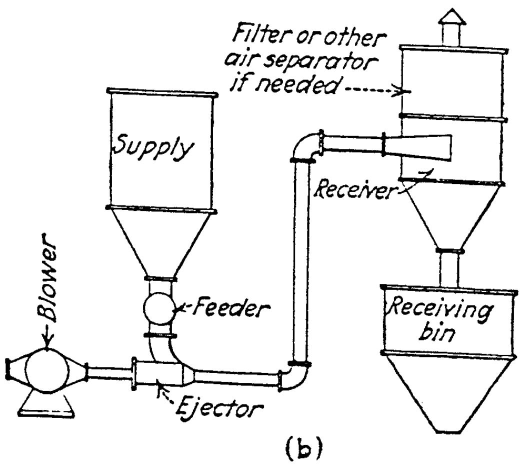


Figure 4.11 System of pneumatic transport by discharge

4.11.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Decrease in the amount of raw material needed because wastage is reduced. For fish, and given the problems arising from overfishing, this is an environmental issue worth consideration.

- Reduction in fish waste that will likely be processed as raw material for making fishmeal. Despite the fact that this is a recycling process, it is highly contaminating; therefore, its use should be minimal in the interests of the environment.

Regarding dry processing, the following should also be kept in mind:

- Reduction in water consumption
- Reduction in the volume of flow of wastewater
- Reduction in the COD of wastewater because pollution does not pass into the water.

4.11.4 Examples of application

A Chilean company producing 612,000 Tm of fishing products annually changed its centrifugal fish unloading system for an aspiration system.

Installation of the aspiration system, together with the additional installation of processes for recovering organic solids by means of rotating filters substantially reduced the content of organic material dumped (48,000 tons of COD/year, when dumping in the area reached 60,000 tons of COD/year).

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Changing from the centrifugal system to the pump system	3 000 000		1 600 000
Total			
Return on investment (years)	2		

4.12 OPP 12. Automatic Control of the Process with HACCP

4.12.1 Introduction

The system for analysing risks and controlling critical points (HACCP) was the result of collaboration in the sixties between the Pillsbury Co., NASA and the laboratory of the U.S. Army in Natick, to design the program of zero defects for food production. It was made known for the first time in 1971, in the National Conference of Food Protection and, in September 1974, E. BAUMAN (Vice President of Science and Technology of the Pillsbury Co.) published in the magazine FOOD TECHNOLOGY the details of the new system developed.

From that time, the scientific and technical communities have assimilated the system, introducing and recommending the system in processes of production, storage and transportation of food.

4.12.2 Technical aspects and conditioners

The HACCP system is based on applying common sense to the defined object (ensuring the absence of harmful elements in food).

A multidisciplinary team that handles all the knowledge in the plant (quality control, production, maintenance) carries out the following:

- Analysis and documentation of potential hygiene risks associated with each operation in the production process for products made by the company.
- Locating points in the operation or process in which these analysed risks might take place.
- Determining, from among all points located, those that are decisive for the product's food safety.
- Designing and implementing effective procedures for controlling, following up and documenting critical points.
- Establishing acceptable limits for the results obtained in the critical point control and for actions to take when values are found to be outside the specified limits.
- Systematic review of the entire system implanted according to the results obtained and the process modifications.

Implementing the HACCP system includes, in addition to process operations, general aspects such as homologation of suppliers, pest control, cleaning, plant maintenance, hygienic design of installations and good handling practices.

Successful implantation of an HACCP system does not necessarily require many material resources in the sense of machine and installation investment. The keys to success lie in choosing the right people to do analysis and design, and to properly transmit to personnel the guidelines drawn up by this team.

An example is offered below of development of a Critical Control Point for the operation of regular refrigerated storage in the fish canning industry:

EFFICIENCY	**2**		**2**	**1**
RISKS	Pathogenic microorganisms, microbial toxins		Pathogenic microorganisms, toxic substances, foreign elements	Pathogenic microorganisms, microbian toxins
PREVENTIVE MEASURES	Inhibit microbial growth		Proper rotation of stored products	Prevent cross contamination between frozen products, meat and fish
ACTION OF THE PREVENTIVE MEASURE	Preserve at 2.5ºC		FIFO management from the warehouse through the merchandise identification system	Store fresh fish in the chamber set up for same
PERSON RESPONSIBLE FOR THE ACTION	**Person in Charge**	**Chamber operators**	**Chamber operators**	**Chamber operators**
CONTROL	Supervision of thermograph record	Quarterly calibration of thermometer and thermograph	Supervision of chamber batches	Supervision of stored products
PERSON RESPONSIBLE FOR CONTROL	Person in Charge	Specialised company	Person in Charge	Person in Charge
QUALITY RECORD	Thermograph record	Calibration record	-	-
CRITICAL LIMITS	Temperature greater than 5 and less than 0.5ºC	Differences of 0.5ºC	Pallets in the right place and rotation	Presence of products other than fresh fish
CORRECTIVE MEASURES	Restore the right cooling conditions	Restore the right measuring conditions	Restore the position, search for quick sale or throw out	Restore the position or throw out
PERSON RESPONSIBLE FOR CORRECTIVE MEASURES	Person in Charge	Specialised company	Head of sales	Head of sales
RECORD OF CORRECTIVE MEASURES	Non-conformity Report	Calibration sheet	Non-conformity Report	Non-conformity Report

4.12.3. Improvements

The main contribution of implanting the HACCP system in clean production consists in decreasing losses in raw material and decreasing finished product rejections due to quality control. This means:

- Reducing the total amount of waste
- Making efficient use of natural resources (raw materials and material resources used during the processing of rejected products)

4.12.4 Examples of application

In some fruit and juice canning plants where studies were done on the level of wastage in raw materials and quality rejections, these reached percentages of up to 15%. After reflecting on each of the processes done, investments were approved for changes in the process, in containers and in improving pest control. Savings of 120,000 euros and 180,000 euros per year were obtained, with decreases in raw material wastage.

4.13. OPP 13. Structural Cleaning with a Low-Pressure System with Foam or High Pressure

4.13.1 Introduction

Hygienic safety of food products requires a level of cleaning in installations that prevents microorganisms from proliferating. This need in the food sector translates into installations (equipment, public works) of materials prepared for frequent cleaning with water and daily or weekly cleaning. When installations process raw material from primary production, the need for hygiene acquires even greater weight given the risk of cross contamination.

The system normally used to clean is the hot water hose with a pressure nozzle in the best of cases.

4.13.2 Technical aspects and conditioners

There are mainly two efficient cleaning systems on the market:

- High-pressure cleaning,
- Low-pressure cleaning with foam

4.13.2.1 High-pressure cleaning

The principle of cleaning is based on projecting on the surface to be cleaned a jet of water at working pressures between 30 and 130 bars. The volumes of flow consumed by this equipment is between 150-840 l/hr, and to do more effective cleaning, work can be done with hot water and automatically dosed detergent.

The advantage of this system is its low water consumption and discaling capacity. Its weakest point is in not leaving much time for contact between the detergent or bactericide in cases where disinfecting is necessary.

Another important conditioner of this system is that, from a hygienic point of view, use is not recommended during production because it causes organic mists that could contaminate the surfaces that are in contact with the product.

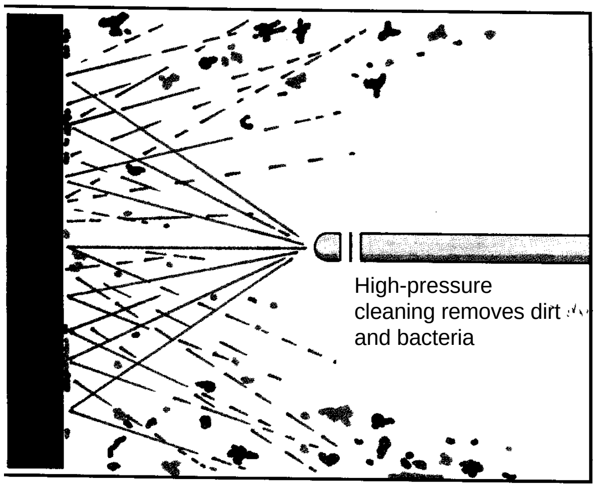


Figure 4.12 High-pressure cleaning (Source: Scanio)

4.13.2.2 Low-pressure cleaning

The principle of cleaning is based on projecting on the surface to be cleaned a foam that is deposited on the wall. This foam is left on for a certain amount of contact time and later rinsed at low pressure (10-25 bars). Volumes of flow consumed by this equipment are 10-100 l/hr. The equipment works with hot water and automatically doses detergent.

The advantage of this system is its low water consumption and disinfectant capacity. Its weakest point is that it has no scouring capacity as does high-pressure cleaning.

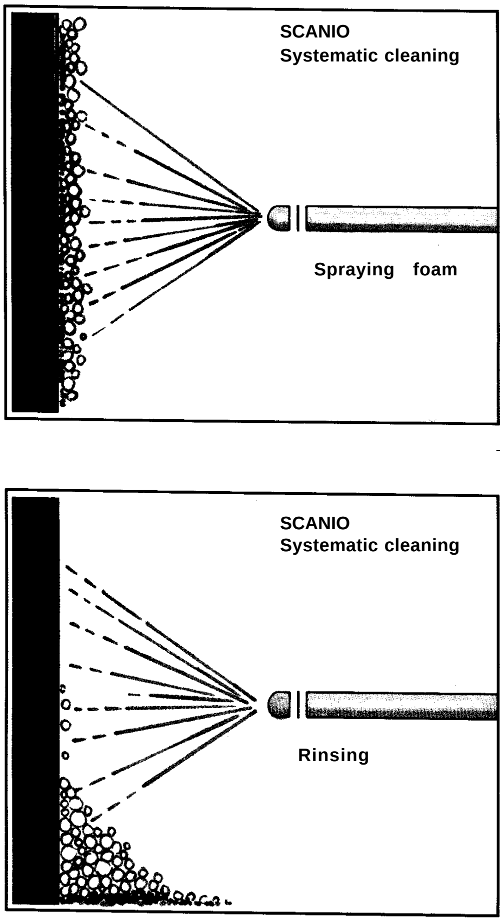


Figure 4.13. Low-pressure cleaning, 1st and 2nd stages. (Source: Scanio)

Equipment installation costs around 6,000 euros for one room.

These installations, apart from meeting the need to structurally clean the plant, are very useful for cleaning machines as scheduled in the maintenance plan (or for customer visits) and various utensils.

4.13.3. <u>Improvements</u>

The environmental improvements offered by this OPP are basically as follows:

- Reducing water consumption by 60%
- Reducing the volume of flow of wastewater
- Reducing the amount of detergent or disinfectant used because dosage is automatic

4.13.4 Examples of application

A 2,000-m2 plant with a conventional cleaning system with hot water at 5-bar pressure generated by steam mixers and powdered detergent dosing directly on the surface to be cleaned modified it by installing a centralised low-pressure cleaning system.

This plant cleans packing rooms daily and cleans all production installations once a week.

This measure meant an annual savings of 500 euros.

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
CIP	8 000	500	
Water and detergent			2 000
Energy			1 500
Total	8 000	500	3 500
Return on investment (years)	2,6		

4.14 OPP 14 Drying Brine by Means of Solar Power

4.14.1 Introduction

The removal of dissolved salt is a type of contamination that is not usually eliminated in conventional processes of final treatment. However, this causes problems for the environment in the Mediterranean which, being characterised by a lack of large rivers, does not have the capacity to dilute this salinity.

Conventional removal with energy contribution, removal by means of resins or systems of reverse osmosis are not usually feasible financially, and are only adopted in very exceptional cases.

In addition to being a system for treating brine, it could also be an alternative system for producing distilled water for a variety of uses such as boiler feeding, incorporation into the product or decreasing the saline concentration of cooling circuits.

Brine waste flows come mainly from fish storage tanks, pickling solutions, ingredient desalting operations (tripe, fish…) and others.

4.14.2 Technical aspects and conditioners

In production processes in which one of the wastewater flows has a high content in dissolved salts (waste brine), use can be considered of a distilling process using solar power to separate the dissolved salts and obtain distilled water that can be reused for example as water feed for boilers.

Conditions to be met in order to implement this process are as follows:

a) Having enough terrain. Distilling by means of sunshine is a linear function of the installed surface because, when the latter is increased, captured solar radiating energy increases in the same proportion. Typically accepted distilling values are around 2 litres per day and square meter, which decreases in winter to 0.5 litres and increases in summer to 4 litres. It is worth mentioning that on days where there is little or no sunshine, there will also be little or no distilled water.
b) Being located in places having strong sunlight because the stronger the sunlight, the more energy is captured, increasing the volume of distilled water. Typical solar radiation values for mid-day in the summer are around 1,000 w/m2.

When there is enough land, building a solar distiller does not mean having to make a large investment. A simplified version is composed of a tank or pool with a black, shallow bottom, even just a few centimetres deep, making up the bottom of an area that is hermetically sealed by a glass or plastic cover. Sunlight heats the water in the tank and the air contained between the tank and the transparent cover, to temperatures that may reach 70ºC, causing the water to evaporate.

The evaporated water condenses on the underside of the transparent cover because the cover, being in contact with the outside, is colder. This water slides along the cover, which is usually sloped, until it is collected in troughs for that purpose. The process can be optimised by using an exchanger, into one side of which enters water having a high dissolved salt content, and into the other side of which enters hot air that is saturated with water vapour from the closed area. The exchanger preheats incoming water and condenses the water vapour, thereby obtaining hot distilled water.

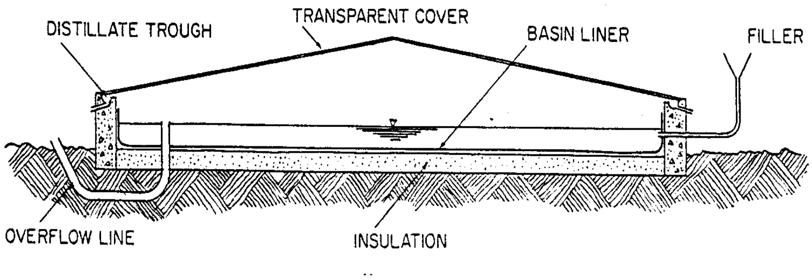


Figure 4.14 Diagram of a water desalinater (Source: see Ref .95)

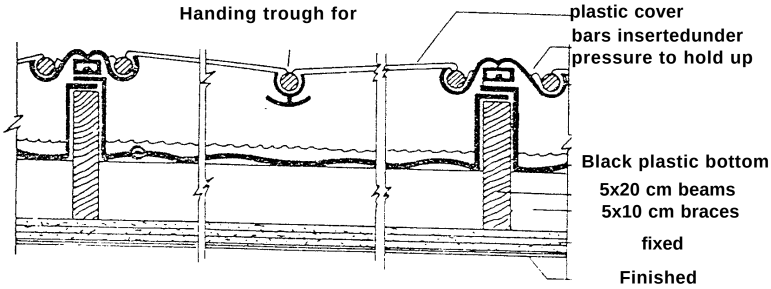


Figure 4.15 Diagram of a water desalinater (Source: see Ref .95)

At the end of the process, on the one hand we have hot distilled water that can be used, for example, to feed the boiler, saving costly decalcification processes for washing, transporting, heating, etc. On the other hand, we obtain salt that is more or less contaminated by organic waste and is much easier to eliminate than brine, having much less of an environmental impact.

Implantation costs, if the necessary land is available, are reduced to construction of the installations, which are simple and not very expensive, construction of the tank, cover and channelling. Regarding the process, energy costs are nil, and at least one of the products can be reused. Distilled water is expensive, and it comes preheated, which depending on its later use can mean energy savings. The only thing to be taken into account is the cost of periodically emptying the tanks of the salt.

An installation having these characteristics must be accompanied by a pressure kettle that accumulates the brine that is produced but cannot be processed due to lack of sunlight, so that it can be processed on days of maximum efficiency in the plant.

4.14.3 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reduction of water consumption
- Reduction of the volume of flow of wastewater
- Reduction in the levels of salts dissolved in wastewater
- Obtaining saline waste that can be reused in making fodder.

4.14.4 Examples of application

A plant produces 100 Kg of brine daily, which means 22,000 l a year of brine at 11%.

The dimensions of a drying station for this installation would roughly take up a 450-m2 area and a 5,000-l accumulation tank, in the case of 7 months being below the average solar level.

The financial results for a plant having these characteristics would approximately be as follows:

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Tank and pump	1 800		
Solar distiller	15 000		
Plant operation (removing salt)		600	
Reusing distilled water			2 000
Total	16 800	600	2 000
Return on investment (years)	12		

The plant would also make use of 1 million kcal of energy because the water is obtained at 70 ºC.

4.15 OPP 15. Bioconversion of Fishing Waste by Acid-Lactic Fermentation[2]

Certain operations result in a significant mass of waste in the form of trimmings or certain parts of fish that are not highly valued. This waste, despite the fact that it has a high nutritional value,

has no economic value and can end up dumped into the exterior medium, with the subsequent pollution this entails. One of the most common uses made of this type of waste is transforming it into fishmeal. In some cases, the small amount generated does not justify installing a fish meal operation; in other cases, the high-energy cost of this type of installation does not make it feasible to make use of it.

Lactic fermentation of this waste in certain cases is an interesting alternative to make use of them. Fermented or acidified fish waste is used as food for certain animals. Waste acidified by lactic fermentation by adding acids does not contain pathogenic microorganisms, and it has a preservation capacity significantly greater than non-acidified waste.

4.15.1 Technical aspects and conditioners

The process of acidification must be done immediately after obtaining the waste.

Acidification can be done in two ways:

a) **Fermentation with lactic bacteria.** In this case, because fish is poor in carbohydrates, some inexpensive source of sugar (whey, molasses, cereal waste, etc.) has to be added to the waste. Waste enriched with sugar is inoculated with a lactic ferment and kept at room temperature until the end of the fermentation (pH 4.5, approximately). Once fermentation is over, it is best for it to be consumed quickly. Nevertheless, it can be kept for a few days if it is kept at low temperatures, or for long periods if it is dried or sterilised.

b) **Acidification with acids.** If fermentation of the product is not desired, the same objective can be obtained by acidifying the product, preferably with an organic acid that is compatible with the animal food. The product, once acidified, must be treated and consumed as above.

The nutritional wealth of these products, as well as their possibilities as animal feed, varies a great deal according to the characteristics of the waste that is used.

[2] At the time of going to press of this study, the following regulations have been developed in regard to the use of animal proteins made from fish waste for animal feedstuff:

- Council Decision 2000/766/EC of 4 December 2000 concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein, prohibits the use of fishmeal in feed for ruminants.
- Commission Decision 2001/9/EC of 29 December 2000, regarding the control measures required for the application of Council Decision 2000/766/EC, concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein, establishes the production, transport and storage conditions of fishmeal and the feedstuffs that contain it, along with the labelling conditions for the latter.

4.15.2 Improvements

The main benefits of this practice to the environment are obvious:

- Reduction in the mass of solid waste generated and decrease in its impact on the environment
- Better use made of natural resources and, therefore, decrease in the pressure on the environment to obtain food for animal production

4.16 OPP 16. Anaerobic Treatment of High-Concentration Wastewater and Making Use of Biogas

4.16.1 Introduction

The traditional system of treating wastewater in the canning industry, because of the biodegradability of water, is aerobe biological treatment.

4.16.2 Technical aspects and conditioners

The process of anaerobic digestion involves breaking the organic molecules to transform them into carbon dioxide and methane. This process is especially applicable to treating wastewater with high content of organic material, because for each Kg of COD removed, 0.6 – 0.7 m3 of biogas can be obtained, which has a calorific capacity of 5000-6000 kcal/m3.

In canning industries using cooking processes (tunas, legumes,…) there are waste flows with high levels of contamination (COD at about 50,000 mg/l). In the balance of these operations, one of the main inputs is the energy used for heating, usually in the form of steam.

Installing an anaerobic treatment system that uses the gas as heat significantly decreases the amount of waste produced. The main feature of this waste is that it is stabilised and can be used in agriculture or reused as raw material for producing fishmeal.

The installation (figure 1) is composed of the following elements and equipment:

[Chimney; BIOGAS; Water separator; Meter; Pressure gauge; sampler; Firewall; EFFLUENT; Pump; INFLUENT; Cold water; Steam; Hot water; Pump; Pump; Drainage; Drainage]

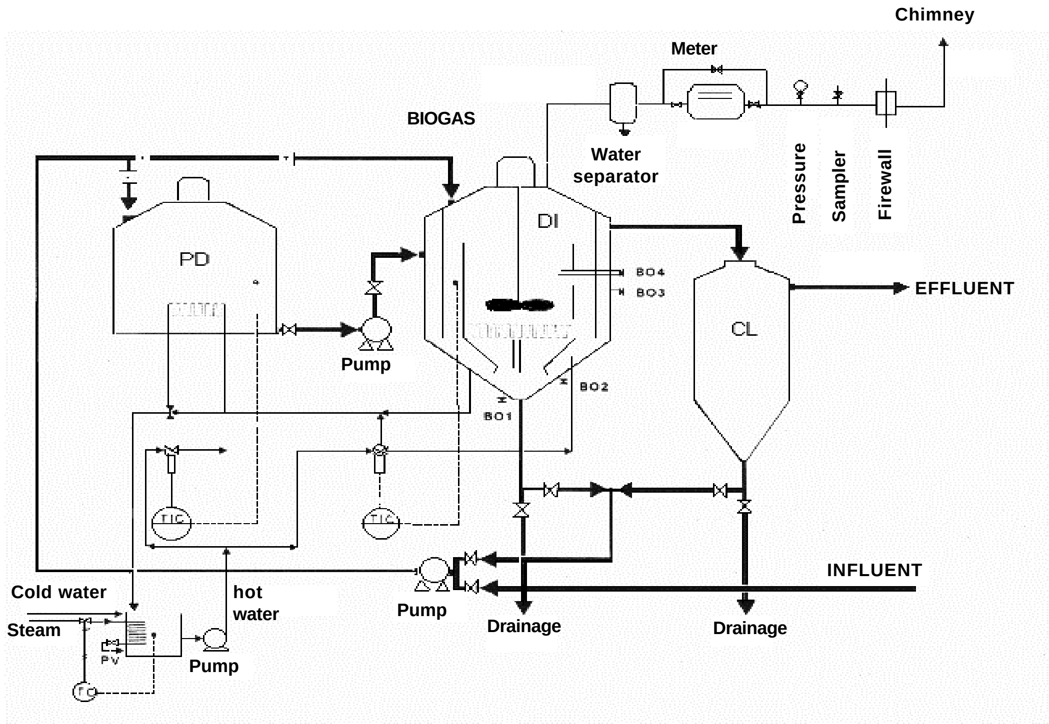


Figure 4.16. Diagram of the industrial pilot plant for wastewater treatment

Predigester. Acts as a homogenising element guaranteeing continuous feed to the reactor. It has temperature control by means of hot water coils.

Digester. This is the main element of the system in which the biological process takes place. It has a mechanical or gas agitation system (methane nozzles) and temperature control by means of hot water coils, as well as sludge pre-concentration systems.

Clarifier. This phase separates sludge from treated water.

Biogas line. The gas accumulates at the top of the digester and exits by the gas line. This line must have a water separator and compressor guaranteeing feed to the gas tank and, when opting to agitate the reactor by means of gas, up to the reactor nozzles. From the gas tank, a gas burner would feed a steam boiler.

4.16.3 <u>Conditioners</u>

In addition to the cost involved, the installation must respect the rules on combustion gases and, therefore, have enough space for it. The largest elements in this installation are the predigester and the digester itself.

Given the scope of the installation and in accordance with economic feasibility conditioners, the solution should not be approached as a solution just for minimising one stage, but as end treatment. Maintaining anaerobic and biological treatments, should it be necessary, could end up not being profitable.

4.16.4 Improvements

The environmental improvements offered by this OPP are basically as follows:

- Reducing the volume of flow of wastewater
- Reducing the levels of COD in wastewater
- Obtaining a stabilised waste that can be reused in agriculture or for making fishmeal.
- Making use of biogas energy.

4.16.5 Examples of application

There have been experiences in tuna plants, and results have been for treatment of up to 61% and gas production up to 12 m3/day for volumes of flow of 2.1 m3 coming from the cooking process.

There have also been experiences with process water from the peppers canning process, obtaining yields of 83%.

4.17 OPP 17. Collecting Liquids and Particles from Process Facilities before They Reach the Ground

4.17.1 Introduction

Today, there is a tendency to reduce product wastage in unitary operations and in this way increase the economic performance involved.

Collaterally, another aspect can arise, which is product loss due to:

1. Improper transportation, with boxes falling off the path, transit area or conveyor belt during unloading, etc. In this case, the products are in their solid state.
2. Improper watertightness, channels, machines, tables, etc. This basically refers to liquids.

A very typical example can be found in juice factories, in which product losses can be high in regard to losses in product transport among the different processes, or in treatment on tables or open surfaces.

4.17.2 Technical aspects and conditioners

The main options for preventing these losses are as follows:

1. Placement on trays or other types of utensils for collection and later reincorporation of these losses.
2. Ensuring the proper watertightness in machines, connectors, barriers, etc. in order to prevent losses due to dripping, overflow, connecting and disconnecting, etc.

One of the most relevant aspects is the fact that all these losses:

- Soil the places in which they are produced, with the subsequent hygienic risks involved.
- Due to the need to be cleaned, they produce pollution in solids and CODs in wastewater coming from cleaning, which must later be treated.

The level of applying measures that tend to prevent this type of loss is not normally high. Having no direct effect on the process, it affects collateral aspects, tending toward installation of barriers or collection systems.

4.17.3 Improvements

The benefits offered by this OPP can be considered quite high, since they:

- Increase productivity,
- Significantly reduce needs for structural cleaning, with savings in water costs, products and labour, as it tends to be floor cleaning, and
- Reduction as well in the pollutant load of wastewater, whereby savings occur in the corresponding treatment costs.

4.17.4 Examples of application

A pineapple juice processing plant with a daily production of 1500 t invested 18,000 Euros in placing trays under the fruit processing tables. 24,000 l of juice was collected in one year, allowing for return on investment in 9 months, without considering the decrease in costs of cleaning and water treatment.

Aspect	Investment (Euro)	Cost (Euro/year)	Savings (Euro/year)
Placing trays under fruit processing tables	18 000		
Recovery of juice			24 000 000
Total			
Return on investment (years)	0,75		

4.18 OPP 18. Making Use of Steam in Fruit Concentrate Evaporators

4.18.1 Introduction

Evaporation, as described in the previous section, is a unitary operation that consists of concentrating a solution of fruit by the evaporation of water.

The purpose of this operation in juice industries is that it reduces the production costs of the subsequent stages, especially warehousing and distribution.

Evaporation technology has developed in the technology of steam exchangers, permitting a number of designs with specific applications and different energy efficiencies. The main types of evaporators can be classified as natural circulation evaporators and forced circulation evaporators.

4.18.1.1 Natural Circulation Evaporators

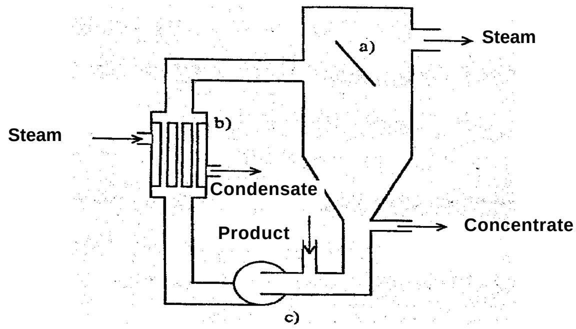
- Open and closed
- With short tubes
- With long tubes
- With external calendar

4.18.1.2 Forced Circulation Evaporators

These evaporators, as opposed to those above, have elements that force the product to circulate as a fine film in order to obtain shorter evaporation times and lower effects on heat-sensitive food.

The main types are those having:

- Plates
- Expanded flow
- Thin mechanical film



a) Impact screen; b) external calender; c) pump for product recirculation.

Figure 4.17 Forced Circulation Evaporator (Source: see Ref 34)

4.18.2 Technical aspects and conditioners

The techniques for making the most use of the steam in evaporation can be summarised as follows:

- Preheating the product before placing it in the evaporator with the steam extracted from the product.
- Preheating the product before placing it in the evaporator with the steam condensates before their return to the boiler.
- Automating evaporation system control (feed to evaporators, fluid level, regulating the brix degree of the outgoing product, vacuum).
- Making pre-concentration by inverse osmosis, after clarification by static sedimentation or by ultrafiltration.
- Using various effects, or several evaporators so that the outgoing steam from an evaporator is used as heating steam for another evaporator.
- Using 100% of the facilities
- Cleaning at a set frequency in order to prevent product film from forming, which would inhibit maximum heat transmission.
- Incorporating a mechanical steam recompression system using compressors to increase efficiency in heating.

4.18.2.1 Multiple effects

Installations with multiple effects can be set up as follows:

Concurrent feed: The main advantages to this system are easy handling, no need for feed pumps for each of the effects and the operating temperature of each effect is reduced as the product advances along the facilities. This reduces the risk of overheating the concentrate, especially in viscous products.

The main disadvantage is that it uses the higher quality steam in the early stages of concentration.

Countercurrent feed: In this case, higher quality steam is used in the later stages, when it is more difficult to concentrate the product. The greatest inconvenience is the need to use pumps among effects in order to make the product circulate.

Parallel feed: This is most used when the purpose is to crystallise the product. This type of feed prevents entry of effects of high viscosity, highly concentrated solutions.

Mixed feed: This is used in processes with evaporators having many effects. There is an attempt to use the advantages of countercurrent feed and concurrent feed, so that some effects work with the former type of feed and the rest with the latter type.
Despite technical considerations in regard to making use of the water and energy, quality conditioners for selecting evaporators are:

- Ability to reach the necessary level of concentration.
- Conditions of pressure and temperature demanded by the product to obtain the least amount of quality losses.
- Possibility of recovering aromas.
- Easy operation, cleaning and maintenance.

4.18.3 Improvements

The main benefits of this OPP are:

- Reduced fuel consumption
- Reduced water consumption for steam production
- Reduced emissions into the atmosphere of gas from combustion, which will be more or less important depending on the fuel

4.18.4 Examples of application

The main energy considerations for the different evaporators are indicated in the following table:

Aspects	Evaporators			Membrane techniques
	Single effect	Multiple effects	Cassettes	
Steam consumption (Kg/t prod.)	825-900	220-260	200	-
Energy consumption (Kw/m3 water removed)	-	-	-	10
Investment	-	85	80	

4.19 OPP 19. Traditional Valorisation of Fish Scraps by Making Fish Meal[3]

4.19.1 Introduction

The fishing industry generates a significant amount of organic waste, which in some cases can be directly dumped, causing degradation of the environment.

These solids correspond to inedible parts of the fish, which can be up to 50% of the mass of caught fish. There are various alternatives for using solid fish offal (head, tail, guts), with one of the most highly developed being fishmeal for animal consumption.

4.19.2 Technical aspects and conditioners

Fish meal is a highly concentrated food, and as a nutritional supplement it contains mainly high quality proteins, minerals and vitamin B complex, as well as other ingredients that contribute to animal growth and which are usually called “unknown growth factors”.

[3] At the time of going to press of this study, the following regulations have been developed in regard to the use of animal proteins made from fish waste for animal feedstuff:

- Council Decision 2000/766/EC of 4 December 2000 concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein, prohibits the use of fishmeal in feed for ruminants.
- Commission Decision 2001/9/EC of 29 December 2000, regarding the control measures required for the application of Council Decision 2000/766/EC, concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein, establishes the production, transport and storage conditions of fishmeal and the feedstuffs that contain it, along with the labelling conditions for the latter.

Meal is obtained though the following process:

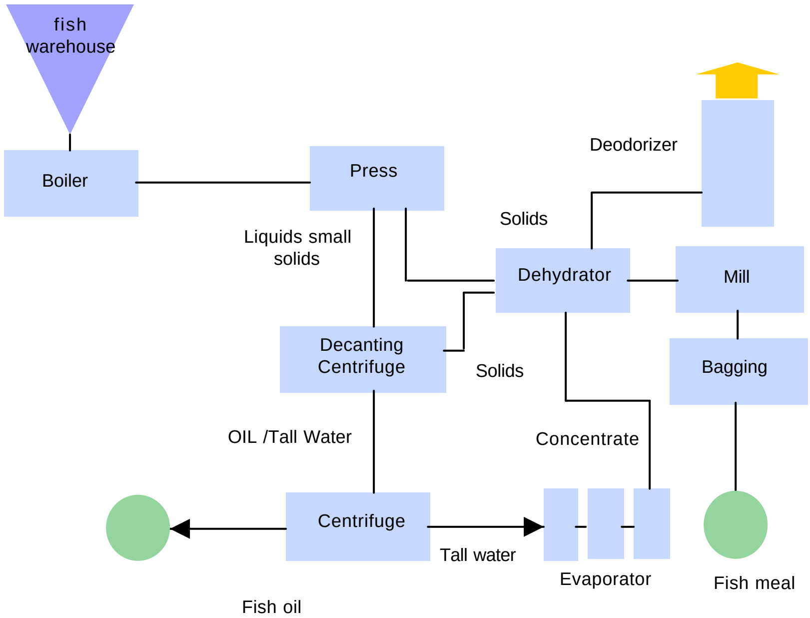


Figure 4.18. Process of making fish meal

The process consists in reducing the fish from cooking in a cooker that heats fish by-products by indirect steam up to 95 ºC for a period of three to twenty minutes, depending on the type of cooker used.
The cooked product is pressed, with liquids and small solids going into a centrifugal decanter in which oil solids and tail water are separated. These last two are separated in a centrifuge that produces clean fish oil (less than 1% in impurities and moisture).

Tail water is concentrated in an evaporator to 5-40% solid matter. If the amount of tail water is small, it can be sent to a wastewater treatment plant. For example, for treating 2-3 t/day of fish by-products, the amount of tail water would be between 500 and 800 l.

All solids obtained are dried in a dehydrator, where indirect steam reduces the moisture contents up to 6-8%, thereby obtaining the fishmeal.

The meal obtained has excellent nutritional value for use as animal feed:

- High-quality protein, containing all essential amino acids and especially high in lysine, which makes it ideal for feeding animals, because only 3% of fish meal in feed rations balances the protein value of cereals (the main component in the diets of chickens and pigs with low protein content).
- Supplies a little bit of vitamin B complex.

- High mineral content (between 12 and 33 %). Rich in minerals making up bones and teeth, calcium and phosphorous and high content in minerals needed for growth and body maintenance in animals, especially iron, copper and some trace elements.
- Low fibre content

4.19.3 Improvements

The environmental improvement offered by this POP is basically valuing the solid waste from the fish canning industry, obtaining fish meal and other by-products such as fish oil and "fish solubles". In the case of oil, it can be refined and used later in making margarines and other products such as fatty acids, paints, etc.

On the other hand, processing meal means energy consumption and dumping wastewater with content of organic matter.

4.19.4 Examples of application

A plant processing 1 ton of fish by-products daily obtains 150-200kg of meal, 50-250kg of fish oil (depending on whether the processed fish is fatty or not) and generates about 700 litres of tail water.

The electrical energy used is 30-40 kW/hr, and about 50-60kg of fuel is consumed, with this consumption corresponding to the following percentages:

Process	Assumed Values	Consumption %
Cooking	Raising the temperature of raw material from 10 to 95 ºC	21
Pressing	Raising the temperature of the pressing liquid from 30 ºC approximately (by direct steam injection) to 95 ºC at exit.	8
Concentrating tail water	Consumption of 0.4 Kg of steam per Kg of evaporated water	33
Dehydration	Press cakes, silts and concentrated tail water dried to water content of 8%. Concentrated tail water preheated to 50 ºC before being dehydrated	38

4.20 OPP 20. Optimising Provisions of Raw Materials

4.20.1 Introduction

One of the most noticeable features of the vegetable canning industry, as in fish, is that production is seasonal. Production campaigns are organised more according to sales needs and market prices for raw material than according to the technical criteria of the plant.

One of the repercussions of this way of working is that the design of plants and equipment is optimal for a short period during the year, and is oversized for the rest of the year. Work is done with specific entries of raw material, and equipment operates well under its design capacity. This means that for a large part of the year, fish and vegetable canning industries are consuming unnecessary amounts of energy and fluids.

4.20.2 Technical aspects and conditioners

Optimising provisions of raw materials means searching for a balance among three main stages in the canning process:

- Harvesting vegetables or catching fish
- Refrigerated storage of raw materials
- Processing

With regard to the first point, in order to minimise storage or the capacity of the elaboration process, the objective would consist in drawing out as long as possible the harvesting or fishing season, decreasing the entry of t/day to the plant for the same tons to be produced.

Reaching this goal means the industries must draw up joint planning with farmers or fishermen for harvesting vegetables or catching fish. With regard to vegetable production, this objective can be reached by selecting species with different harvest times or planning the harvesting by preharvest control.

This planning would benefit the canning industry as well as farmers and fishermen, because often the latter must sell their products at very low prices as a result of the large offer in the market. There have even been situations in which they have preferred throwing away the merchandise rather then selling it.

In regard to the second point, it is clear that the objective should be to reduce as far as possible the volume warehoused. However, the best solution is not necessarily 0, but would be according to the energy consumption of later processing.

With regard to the third point, the objective must be to minimise the investment and optimise the energy efficiency of the operation by attempting to reach an rate of occupation in the plant of 100%, since only in this way will nominal values of energy consumption be right.

Estimated energy savings from a study made for vegetable canning in an EU country show savings of 20% in energy.

4.20.3 Improvements

The main benefits of this OPP are as follows:

- Reduced fuel consumption
- Reduced water consumption for producing steam
- Reduced emissions into the atmosphere of gas from combustion, which is more or less important according to the fuel

4.21 OPP 21. Optimising the Steam Generator and Distribution Network

4.21.1 Introduction

The main source of heat for sterilising the packed product and for most thermal needs in the canning industry is usually steam from water. This is generated in a boiler that usually runs on fuel oil and heats and evaporates water to turn it into steam.

Normally, in order to protect steam network pipes, as well as the boiler itself, which is usually made of iron, demineralised or at least decalcified water is usually used. The production of this water means dumping inorganic salts (mainly chlorides) into the environment and, in cases where the effluent is regenerated without being neutralised, significant and periodic variations in the pH.

4.21.2 Technical aspects

The consumption of fuel and later atmospheric pollution by the boiler depends on a series of aspects upon which all industrialists should at least reflect and begin actions to improve cases where this is necessary.

The criteria for the best steam system are as follows:

1. **Good dimensioning and fractioning of power in steam generators**. Steam boilers tend to have dimensions and be built for a certain amount of steam at optimum temperatures and pressures. The farther away we get from these optimum parameters, the more ostensibly we reduce energy output of the equipment and noticeably increase the emissions of carbon monoxide and particles.
2. **Controlling combustion**, so that it is done with the right mixture of air and at the right temperature and humidity, because deficient combustion tends to increase the emission of particles and of CO. Also essential for proper combustion is working at the point of equipment operation and carrying out mandatory maintenance on the equipment.
3. The water used to produce steam is usually pre-treated to prevent salt deposits during the process of vaporisation. It is very important that the **water used be high quality**, as this helps keep the boiler working at optimum levels for as long as possible.
4. In order to increase overall output of the process, **recovery can be made of the residual heat from boiler purge water, especially from combustion vapours**. This is generally done at high temperatures and, in many cases, the water goes on to be preheated, thereby increasing the overall output and indirectly reducing the volume of pollutants.
5. Preventing energy loss by means of correctly **insulating steam and hot water pipes** and reducing their lengths. A good solution could be to use the service ducts. The pipe insulating material becomes degraded over time, so proper maintenance must be carried out. The calorific energy lost by radiation from pipes acts like heaters, when in many cases it is better to keep the room temperature relatively low. It is also necessary to have the right insulation of all surfaces where work is done at temperatures higher than room temperature in order to avoid heat loss.
6. **Correct use of pressure reducers** at points of steam consumption.
7. In cases where it is possible, **recovery of condensates, or their residual heat,** can allow overall output to be increased.
8. In order to attain optimum performance, the entire system must be **properly maintained** in order to guarantee maximum output and minimal waste flows, as well as to prevent possible accidents with containers under pressure, which are the boilers.

Of all the conditioners detailed, the first three and the last have the most direct influence on the emission of gasses from combustion, and very directly on the amount of carbon monoxide and particles. With an optimum point of work and optimum conditions of the installation, these are reduced to a minimum. In regard to sulphur and nitrogen compounds, they are directly influenced by the type of fuel and its quality. The amount of CO2 emitted will depend directly on the amount of fuel used, so good thermal performance of the installation, by minimising losses and making use of heat recovery, can indirectly lead to its reduction.

One of the most energy efficient systems is cogeneration, the use of which, by means of a gas turbine, can generate electricity, heat and cold, covering all energy and thermal needs. Cogeneration is only feasible on a large scale.

4.21.3 Improvements

The main benefits of this OPP are as follows:

- Reducing fuel consumption
- Reducing the consumption of water for steam production
- Reducing emissions into the atmosphere of gas from combustion, which is more or less important depending on the fuel
- Reducing toxic carbon monoxide emissions.

4.21.4 Examples of application

A study made on fourteen Catalan vegetable and juice canning companies reached the conclusions indicated in the following table in regard to the subjects approached:

Aspect	Investment (Millions of Euro/year)	Cost savings (Millions of Euro/year)	Energy savings (tep/year)
Cogeneration (2 companies)	0,939	0,317	666
Improving insulation (10 companies)	0,023	0,009	71,2
Optimising steam generators (11 companies)	0,222	0,118	360,9

4.22 OPP 22. Optimising Cooking

4.22.1 Introduction

The cooking or scalding operation is one of the most important unitary operations in the canning industry from a quality point of view. Cooking determines the texture and organoleptic properties of the product.

Furthermore, this stage is environmentally important because there is a significant consumption of energy, relative consumption of water and high COD levels in the water dumped.

The traditional cooking system is in open copper cookers of about 100 l without condensate recovery or thermal insulation.

4.22.2 Technical aspects and conditioners

Environmental optimisation of this operation is basically done through two strategies:

- Minimising energy consumption by increasing the efficiency of heat transmission
- Minimising as far as possible transmission of pollution into the water

Energy consumption can be minimised mainly by designing cookers that prevent heat loss through good insulation by doing the cooking process covered or under conditions of vacuum. One emerging technology in this respect is the use of microwaves as an energy source.

Transmission of the product's organic material into the water can be prevented by:

- Cooking the products in a water bath or shower with containers sealed in a plastic bag. This system is ideal for the meat industry due to the size of installations. It has also been tested in vegetable processing
- Cooking by steam pressure cooking in chambers or tunnels
- Cooking by hot air cooking

The main conditioner when changing cooking technologies is that, because the heat transmission system inside the product to be cooked will be different for each foreseen system, the process must be adjusted in order to obtain the desired standard.

In cases where concentrated cooking juices are obtained, these can be handled by recovering protein, making prepared meals or dumping into wastewater. The last case is the most unfavourable, since the reduction in end COD emitted would be minimal.

4.22.3 Improvements

The main benefits of this OPP are as follows:

- Reducing fuel consumption
- Reducing consumption of water for steam production
- Reducing emissions into the atmosphere of gasses from combustion, which is more or less important depending on the type of fuel
- Reducing the volume of flow and pollution of wastewater

4.22.4 Examples of application

For a company producing cooked ham and doing the cooking in a water bath, the economic feasibility of using bags for cooking will not be in the reduction of costs in the operation itself. An initiative of this type is feasible only when there are requirements for decreasing pollution of the plant's wastewater, avoiding construction of a biological treatment plant, or when the intent is to obtain a product with more taste.

4.23 OPP 23. Valuation of Organic Waste from Vegetables

4.23.1 Introduction

The volume of waste generated in canned vegetable preparation stages reaches appreciable amounts, as may be observed in the table on page 97.

This waste is made up of organic material synthesised in plants from solar power.

The main alternatives for valuing this waste currently include:

- Using it as feed for animals
- Energy valuation by means of pyrolisis
- Raw material of composting plants.

Nevertheless, this waste has traditionally been used to obtain certain ingredients or additives that can be used in human food and have a higher added value.

This is the case with pectins, which are found in the skin of apples and lemons and have been used in traditional pastry making as a gelling agent for making fillings and coverings with a sugar base. Currently, pectins constitute a very important hydrocolloid for the food industry, and they still originate in citrus and apple peels.

Pectins are obtained by a process of extraction that basically consists of:

1. Extraction by means of hydrolysis of the protopectin by means of cooking in an acid medium
2. Purification
3. Coagulation in an alcohol medium
4. Standardisation

As in this process, the large amount of organic material is a source of opportunities to obtain materials with high added value, and not just combustible material.

4.23.2 Technical aspects and conditioners

The main alternative ways of valuing this waste have three principle strategies:

- Obtaining certain immediate, basic principles in animal food
- Raw material for obtaining combustibles and chemical products that are currently obtained from petroleum
- Source of ingredients for human consumption

4.23.2.1 Animal food

Despite the fact that it is a traditionally extended practice, specialisation in vegetable canning industries means periodic generation of large quantities of vegetable waste that cannot be absorbed by area cattle farms.

The study of nutritive properties of organic waste and the use of this information in making feed could be a simple alternative to make this type of waste available to wider areas within the territory.

In this sense, studies have been made for using waste from asparagus processing to feed ruminants. The conclusion reached was that it contributed quality protein and improved digestibility as compared to standard feed.

In most cases the use of this waste would require treatment prior to mixing it with the rest of the components of the feed. Mainly, the necessary operations would be the right drying and grinding.

4.23.2.2 Raw material for obtaining combustibles and other chemical products

Making use of lignocellulose materials is done by means of physical-chemical systems (obtaining cellulose pastes, gasification of pyrolisis) or by means of biotechnology prior to waste hydrolysis in acid medium and later fermentation of sugars.

4.23.2.3 Source of ingredients for human consumption

Along general lines, the lignocellulose material obtained in the canning industry can be used as a source of sugar or fibre. Obtaining more specific materials such as pectins (lemon, apple) and essential oils (orange) is also an important path to be studied.

Currently, glucose is obtained from corn, from the milk starch, by means of acid hydrolysis (glucose), enzyme hydrolysis (dextrose) or “acid-enzyme” hydrolysis (fructose).

Lignin and polysaccharid (cellulose) are the main components of waste from the canning industry. Obtaining commercial sugars from polysaccharids of the structural tissues means first removing lignin from these tissues. The best pre-treatment tested to date for removing lignin is done with lye (NaOH) because the cost is reasonable and it does not produce substances that could interfere in later processes.

Enzyme hydrolysis is based on applying an enzyme system made up of three main components:

- Endoglucanase (Cx)1,4-b-D glucan glucano hydrolase: produces a random scission of the chain of cellulose giving glucose, cellobiose and cellotriose.
- Exoglucanase (C1) 1,4-b-D glucan cellobiohydrolase: attacks by the non-reductor side the chain of cellulose giving cellobiose as primary product.
- Cellobiase (b-glucosidase): hydrolyses the cellobiose to glucose.

Obtaining fibre as a food ingredient is done by proper drying and grinding. Currently, companies specialised in supplying ingredients have a very complete range of products available from various sources, which offer solutions to a growing market of products enriched with fibre.

These products, in addition to their use in the food industry, can be used to make cosmetic and pharmaceutical products.

4.23.3 Improvements

The main benefits of this practice for the environment are as follows:

- Reducing the mass of solid waste generated and decreasing its impact on the environment.
- Making better use of natural resources and, therefore, reducing the pressure on the environment to obtain food and chemical products.

CHAPTER V
PROPOSALS AND FINAL CONCLUSIONS

All of the inhabitants of the Mediterranean coastline share the same sea and above all the same climate. The climate that shapes the environment and makes for familiar landscapes, vegetation, agricultural calendar and products is characterised as being temperate with low precipitation. The primary food production of the Mediterranean area benefits from mild temperatures on the one hand but on the other is threatened by the lack of water.

The industrial processing of primary products that takes place in the canning industry confronts two elements of the Mediterranean climate that are unfavourable:

- the temperature, that impairs the preservation of raw materials, and
- the lack of necessary water for separating the product that is finally consumed from the raw material and to ultimately stabilise it by thermal means to give it a long shelf life.

The main impacts of the canning industry on the environment are the following:

- The use of raw materials that in some cases are scarce natural resources and whose present abuse may jeopardise their availability in the future.
- The production of large quantities of organic remains separated from the original raw material during processing.
- The use of large quantities of water for cleaning and the heat treatment of products
- The dumping of highly biodegradable wastewater with a high organic content
- The point or time-specific presence of large quantities of certain components in wastewaters that are hazardous for river life, such as salt, caustic soda or acid that cause variations in the pH, phosphates, nitrates and biocides that are found in detergents.
- A large energy consumption
- The giving off emissions into the atmosphere from the combustion of fuel and diesel oil for producing steam

Given the characteristics of the Mediterranean region, the most important impacts are connected with water. Water availability can be a decisive factor that makes viable an alternative that just in terms of the cost of the water would not be so. Moreover, river dumping is often problematic due to the low capacity of Mediterranean rivers to dilute pollution, even though this may be biodegradable. Rivers in the region have a limited capacity to absorb organic load and which in many basins was exceeded many years ago.

The previous chapter gives mainly technological solutions that are aimed at minimising these effects, and can be summarised as:

- The efficient use of recycled water between process flows and the closing of refrigeration circuits (OPP 3, 7 and 8)
- Obtaining the maximum yield from processed raw materials, especially fish products (OPP 2 and 12)
- The use of efficient cleaning systems for the product and installations that minimise the use of water and the transfer of pollution (OPP 1, 9 and 13)
- Prevent the dumping of salt originating from brine (OPP 6 and 14)
- Prevent the dumping of chemical products (OPP 4 and 5)
- Minimise the transmission of organic pollution to water (OPP 1, 11, 17 and 22)
- Organic waste productivity (OPP 15, 16, 20 and 23)
- Reduce energy consumption, especially that of steam (7, 18, 20 and 21)

The analysis of most of the OPP confirms a principle that although not new must always be taken into account, i.e. that an increase in production capacity provides an opportunity to minimise resources from a general point of view. However, this principle clashes with another one that is well known in environmentalist circles according to which a higher concentration of production means more environmental problems at the local level. In the specific case of the canning industry, a higher concentration will not necessarily mean more pollution if minimisation measures are applied and end-of-pipe treatments scaled appropriately.

The canning sector is polarised mainly into two groups, small companies and medium and large-sized companies. Moreover, the fact that production goes mostly to the end consumer means that pricing policies are determined by large-scale distributors. Putting solutions into practice in small companies means getting access to new technologies, which is normally at high cost, overcoming low production capacity and the seasonal nature of most products. Given that their production is large-scale, big companies on the other hand can offload the costs of new technology more easily, although they still depend on seasonal variations and the margins that distribution permits.

At this point, it would hardly appear feasible to reduce the environmental pressure of the canning sector through large modernisation projects. Nevertheless, improvements can be substantial when a change of technology must be dealt with for different reasons (breakdowns, increase in production capacity). In these cases, in-depth thought must be given to the different alternatives that take account of the environmental aspects that are increasingly becoming determining factors.

A clear example of what is explained in the previous paragraph is OPP 14. The installation of a brine treatment plant involves a large investment that is hardly justifiable in itself. The use of such a device as part of the roofing of a new building for example could even be profitable.

Within the framework of the EU, the application of the IPPC Directive 96/61/EC, clearly focused on reduction at source, based on the Best Available Techniques (BAT), may be an opportunity for companies located in EU countries to act along the lines of the OPPs presented, which require greater technological advance and considerable investment. The Best Available Techniques are the most environmentally sound ways known to carry out an activity, providing that the cost for the companies that must use them falls within reasonable limits. For countries outside the legal framework, it may be an important reference for directing new investment and an opportunity to stand out in facing the challenge of exportation.

The necessary innovation for accepting the new challenges of the market can be a new opportunity to improve the environmental impact of this sector. Nowadays, consumers in more developed countries are demanding more processed products (meal solutions) that enable them to save cooking hours and, on the other hand, foods that are processed using less aggressive forms of treatment that preserve their natural properties more effectively and that are in general more healthy. Responding to these new demands means that the canning industry must reflect on the traditional preservation processes in order to find solutions that are more respectful of foodstuffs and of the environment.

Innovations proposed by applied research in this sector are encouraging with regard to less aggressive solutions with the environment. Most of the ideas that are compiled below have been satisfactorily applied in the laboratory and pilot plants. The rest are technologies that are already consolidated but which circumstances in the sector have not made feasible.

The main alternatives with a future for the canning sector that are beginning to appear are:

- The use of membrane technology for the cold pasteurisation of liquids.
- Cleaning systems that do not use detergents or chemical disinfectants that are found in wastewater (disinfection with ozone or UV, cleaning with CO2),
- The use of enzyme technology and biotechnology as an alternative to chemical treatments.
- The use of irradiation, ultrasound and high-pressure technology as an alternative to thermal pasteurisation.
- The use of combined methods of preservation that are simple, economic, independent of the refrigeration chain and efficient in terms of energy, and that use the principles of intermediate humidity technology for extending the life of foodstuffs.
- The use of alternative sources of energy (natural gas, solar energy and wind energy) that reduce emissions coming from combustion, and cogeneration in large plants.

Just two things remain - to get to work and apply what can be put into practice and to think in such a way that the good ideas of today become reality.

ANNEX I SOURCES OF INFORMATION

1. BOJA, R. ; MARTIN, A ; DURÁN, M. ; HARO, M. ; LUQUE, M. Title: Digestión anaerobia de las aguas residuales del proceso de elaboración del pimiento en conserva. Journal title: Tecnología del agua. 1993.
2. GARRIDO FERNANDEZ, A. Title: Tratamientos de salmueras de la industria de vegetales fermentados. Journal title: Alimentación equipos y tecnología. 1992.
3. GARCÍA BUENDIA, A. Title: Actuaciones en la gestión y tratamiento de los vertidos para la industria conservera de productos pesqueros. Journal title: Alimentación equipos y tecnología. 1992.
4. GARRIDO, A. Title: Estudio de las aguas residuales del proceso de elaboración de aceitunas negras por oxidación y sus reutilizaciones (y II). Influencia sobre la calidad del producto final y sus salmueras de envasado. Journal title: Grasas y aceites. 1984.
5. PÉREZ, A.I. ; GOYTIA, M. ; MUGURUZA, I. ; BLANCO, F. Title: Depuración biológica de efluentes con alto contenido salino. Journal title: Tecnología del agua. 1996.
6. LAZARO BELANCHE, L. ; ARAUZO PEREZ, J. Title: Aprovechamiento de residuos de la industria de conservas vegetales. Hidrólisis enzim tica. Journal title: Zubia. 1994.
7. LAZARO BELANCHE, L. ; ARAUZO PEREZ, J. Title: Impacto ambiental del sector conservero de productos marinos en Galicia. Journal title: Tecnología del agua. 1994.
8. ALONSO, A. A. ; BANGA, J. R. ; GALLARDO, J. M. ; PEREZ MARTIN, R.I. Title: Control mediante ordenador del tratamiento térrmico de conservas de alimentos en autoclaves de vapor. Revista española de ciencia y tecnología de alimentos. 1993.
9. GUZMAN MARTINEZ-VALLS, G. ; GUZMAN JIMENEZ, G. Title: Conservas, evolución y tendencias en la naturaleza, tecnología y funciones de los envases. Journal title: Alimentación equipos y tecnología. 1992.
10. KNORRP, R. Title: Esterilización y refrigeración en continuo de conservas de pescado. Journal title: Alimentación equipos y tecnología. 1992.
11. MORELL CALATAYUD, M. J. ; TARRAZO MORELL, J. Title: Pelado de frutas y hortalizas.
12. Journal title: Alimentación equipos y tecnología. 1991.
13. MUNUERA ALEMAN, J. L. Title: La política de la gama de productos en la industria conservera murciana. Journal title: Revista de estudios agrosociales. 1988.
14. BERMELL, S. ; MORELL, J. ; CARRASCO, J. M. Title: Niveles de contaminación de los vertidos líquidos procedentes de las industrias de conservas vegetales. II. Conservas de alcachofas, judías verdes, esparragos y pimientos. Journal title: Revista de agroquímica y tecnología de alimentos. 1979.
15. SOTO, M. ; MENDEZ, R. ; LEMA, J. M. Title: Efluentes residuales en la industria de procesado de productos marinos. Caracterización, gestión de efluentes y alternativas de tratamiento. Journal title: Ingeniería química (Madrid). 1990.

16. ARRIZABALAGA, B. Title: Sector conservero navarro. Fórmulas para una reestructuración. Journal title: Navarra agraria. 1991.
17. MONTAÑO, A. ; Sanchez Estrada, Mª I. Title: Características del sistema de calidad en coservas vegetales. Journal: Alimentación, equipos y tecnología. September 1999.
18. CALDERÓN J. Title: Tractament d'aigües residuals a la indústria alimentaria. Journal: Tecnologia i Ciència dels Aliments. September 1999.
19. OMIL, F.; MENDEZ, R.; LEMA, J.M. Depuración anaerobia de efluentes en industrias conserveras de productos marinos. Journal: Tecnología del agua. October 1995.
20. Normativa de envases de hojalata, papel, y cartón en la indústria alimentaria. Journal: Equipos y Tecnología. December 1996.
21. DÍAZ, O; COBOS, A. Title: La conservación de los alimentos por métodos combinados. Journal: Alimentación, equipos y tecnología. December 1999.
22. DÍAZ, O; COBOS, A. Title: La conservación de los alimentos por métodos combinados.(II). Journal: Alimentación, equipos y tecnología. December 1999.
23. OMIL, F.; MENDEZ, R.; LEMA, J.M. Impacto Ambiental del sector conservero de productos.
24. BARCELÓ, A; SIRERA, S. Title: Elaboración de una semiconserva light en sodio de filetes de anchoa en aceite de oliva. Journal: Alimentación, equipos y tecnología.
25. NORIEGA DOMÍNGUEZ, Mª J. Title: Gestión de los residuos industriales agroalimentarios. Journal: Alimentación, equipos y tecnología. 2000.
26. Guías Tecnológicas. Epígrafe Elaboración de conservas vegetales. Ainia. Ministerio de Industria y Energía. 2000.
27. PIZARRO CAMACHO, D. Title: Las aguas residuales en la indústria agroalimentaria (II). Journal: Alimentación, equipos y tecnología. 2000.
28. Guías Tecnológicas. Epígrafe, Elaboración de zumos. Ainia. Ministerio de Industria y Energía. 2000.
29. FIESTAS ROS DE URSINOS, J.A. ; BORJA PADILLA, R.; DURAN BARRANTE, Mª M; GONZALEZ, L . Title: Nuevas perspectivas en la depuración de aguas residuales de industrias agroalimentarias. Journal: Alimentación, Equipos y Tecnología. May 1992.
30. JASME MIRANDA, M.E; CHAMY MAGGI, R. Utilización de deshechos sólidos de la industria pesquera. Journal: Alimentación, equipos y tencología. June 1991.
31. CAÑADA, J.; GOMEZ, C.; MORAL., A. Aprovechamiento de residuos de pescados mediante fermentación láctica. Journal: Alimentación, equipos y tecnología. June 1991.
32. RASO, J; ALVAREZ, S; CONDÓN, S; SALA, F.J. Title: La conservación de los alimentos mediante pulsos eléctricos de alto voltaje. Aspectos técnicos. Alimentación, equipos y tecnología. December 1999.
33. VISERDA, P.; APRIL, J.; NIETO, C. Simulacion del proceso de esterilización de conservas vegetales en autoclaves horizontal. Alimentación, equipos y tecnología. 2000.
34. LOPEZ CAPONT, F. Title: Revisión tecnológica de la industria pesquera española. Alimentación, Equipo y Tecnología. November 1992.
35. GARZA, S; ARANTEGUI, J; IBARZ. Evaporadores en la industria de zumos de frutas. Alimentación, Equipos y Tecnología. October 1998.

36. SANCHEZ, Mª T. Title: La ingeniería de proceso de los productos vegetales enlatados. Alimentación, Equipos y Tecnología. December 1998.
37. LOPEZ, A; VIRSEDA, P. Eficiencia energética de las industrias catalanas de conservas vegetales y zumos. Alimentación, Equipo y Tecnología. October 1996.
38. VIEITES BAPTISTA DE SOUSA, J.M. Title: El control de calidad de conservas de moluscos. Alimentación, Equipos y tecnología. November 1999.
39. SERRA, J.A.; ESCRICHE, I.; GOMEZ, M.; MERINO, M. Title: Análisis de riesgos y control de puntos críticos (ARCPC) del proceso de enlatado del champiñón. Alimentación, Equipos y Tecnología. October, 1997.
40. SANCHEZ, Mª T. Title: Tratamientos térmicos de escaldado y congelación. Alimentación, Equipos y Tecnología. June 1996.
41. BELTRAN, A. Title: Elaboración y congelación de platos precocinados. Alimentación, Equipos y Tecnología. July/ August 2000.
42. FONOLLA, J. ; BOZA, J. Utilización de los residuos del espárrago procedentes de la industria conservera, en la alimentación de rumiantes. 1993.
43. Cambios repentinos en el mercado mundial del atún. Productos del Mar. Un mundo Pesquero. May/ June 2000.
44. Plan de innovación para el sector de conservas de pescados y mariscos. Productos del mar. July/ August 2000.
45. El sector industrial transformador de productos del mar. Productos del Mar. April 2000.
46. Datos valores producción conservas pescado. Productos del Mar. April 2000.
47. Intensa actividad en I+D de Anfaco-Cecopesca en 1999. Productos del Mar. March/ April 2000.
48. Estadísticas de comercio exterior del primer trimestre del 2000-09-13. Productos del Mar. July/ August 2000.
49. Conservas de pescado, todavía muy desconocidas. Productos del Mar. March/April 2000.
50. Conservas de pescados y mariscos y semiconservas de anchoa de aceite. Productos del Mar. January/ February 1998.
51. Cogeneración en las industrias de conservas de pescado. Productos del Mar. March/ April 1998.
52. Conservas de pescado: exportaciones e importaciones 96/97. Productos del Mar. March/ April 1998.
53. Asociación Española de Fabricantes de harinas y aceites de pescado. Productos del Mar. July/ August 1998.
54. La modernización de la industria conservera. Productos del Mar. September/ October 1997.
55. Conservas de pescado: datos producción 1996. Productos del Mar. September/October 1997.
56. VIEITEIS BAPTISTA DE SOUSA, J.M. Title: La sardina: datos de producción. Productos del Mar. July/ August 1998.
57. ALONSO GONZALEZ, J.A.. Title: Estudio sobre el uso racional de la energía en el sector conservas. Alimentación, Equipos y Tecnología. June 1998.

58. LOPEZ, A; ARROQUI, C; VIRSEDA, P; PIPAON, J; ESNOZ, A. Title: Modelo matemático del proceso de escaldado de vegetales. Alimentación, Equipos y Tecnología. June 1998.
59. CAMACHO SALAS, E; DIEZ MARQUES, C; CAMARA HURTADO MªM. Title: Conservación de frutas (elaboración de confituras y mermeladas). Alimentación, equipos y tecnología. June 1998.
60. WINDSOR, M; BARLOW, S. Title: Introducción a los subproductos de pesquería. Publishers Acribia. Zaragoza, 1984.
61. MESEGUER, C. Title: Ahorro y eficiencia energética en la industria alimentaria. I Jornada técnica. El Medio Ambiente en la industria alimentaria. Barcelona, 1993.
62. PAINE, F; PAINE, H. Title: Manual de envasado de alimentos. Publishers A. Madrid Vicente. Madrid, 1992.
63. DALZELL, J.M. Title: Food industry and the environment. Publishers Blackie Academic & Professional.
64. SIKORSKI, E. Tecnología de los productos del mar: Recursos, composición nutritiva y conservación. Publishers Acribia, S.A. Zaragoza, 1994.
65. GONZALEZ, I ; ROMERO, PEDRO. Title: Antropología de la alimentación: Nuevos ensayos sobre la dieta mediterránea. University of Seville. Seville, 1996
66. GRANDE, F; FISCHLER, C; GAST, M; LUJAN, N; MASANA, L; MONTANARI, M; DE OYA, M; RIERA, I; TORRES, M; VEGA, G.L.; Title: L'alimentació mediterrània. Publishers F.Xavier Medina. Barcelona, 1996.
67. MESTRE, R; PERIS, A; MASSATS, J. Title: El libro de las Conservas (I); Guía práctica ilustrada. Publishers Primera Plana. January 2000.
68. HEISS, R. Title: Principios de envasado de los alimentos. Publishers Acribia. Zaragoza, 1977.
69. RAVENTOS, M; MAS, C. Title: Tractaments d'aigua residual a la indústria alimentària. Publishers UPC. Barcelona, 1999.
70. PRICE, J.F. ; SCHWEIGERT, B. Title: Ciencia de la carne y de los productos cárnicos. Publishers Acribia, S.A.
71. BELLO, J.; ASTIASARAN, I. Title: Manual sobre carnes y derivados. Facultad de Farmacia. University of Navarra. Pamplona, 1993.
72. MIGAUD, M; FRENTZ., J.C. Title: La charcuterie crue. Publishers Soussana, S.A. Orly, 1978.
73. NEMEROW, N.L.; DASGUPTA, A. Title: Tratamiento de vertidos industriales y peligrosos. Publishers Díaz de Santos, S.A. Madrid, 1998.
74. CASAL, J; CLOTET, R. Title: Operacions unitàries de la indústria alimentària. Published by Sociedad Catalana de Tecnología. Barcelona, 1995.
75. COSTA, J; CERVERA, S; C UNILL, F; ESPLUGAS, S; MANS, C; MATA, J. Title: Curso de Química Técnica, Introducción a los procesos, las operaciones unitarias y los fenómenos de transporte en la Ingeniería Química. Publishers Reverté, S.A. Barcelona, 1985.
76. Gestió de l'aigua a la indústria. Estalvi i depuració. Journal Tecnologies avançades en estalvi i eficiència energètica.

77. SANS, R. Title: Minimización del consumo de agua en la industria. I Jornada Técnica, El medio Ambiente en la industria alimentaria. Barcelona, 1993.
78. Aguas residuales en la industria agroalimentaria. Colegio oficial de ingenieros agrónomos de Murcia. Murcia, 1991.
79. CASP, A; APRIL, J. Title: Procesos de la conservación. 2000.
80. PERRY JOHN H. Title: Chemical Engineers' Handbook. McGraw-hill Book Company, Inc. New York and London, 1941.
81. BARTHOLOMAI, A. Fábricas de alimentos, procesos, equipamiento, costos. Publishers Acribia, S.A. Zaragoza, 1991.
82. Danish Environmental Protection Agency. Cleaner Production Assessment in Meat Processing. Industrial Sector Guide. 2000.
83. Danish Environmental Protection Agency. Cleaner Production Assessment in Fish Processing. Industrial Sector Guide. 2000.
84. Guías Tecnológicas. Epígrafe, Elaboración de productos cárnicos. Ainia. Ministerio de Industria y Energía. 2000.
85. J.WICKS, R. Food Processing Ingredients Sector. Foreign Agricultrual Service Gain Report. September 2000.
86. OFFICE OF AGRICULTURE AFFAIRS. Canned Deciduous Fruit. Foreign Agricultural Service Gain Report. March 2000.
87. PIASON, F.J. Poultry and Products. Foreign Agricultrual Service Gain Report. August 2000.
88. PIASON, F.J. Seafood Preliminary Data on 1999 Fench Seafoof Market 2000. Foreign Agricultural Service Gain Report. April 2000.
89. PIASON, F.J. Tomatoes and Products Annual 2000. Foreign Agricultural Service Gain Report. May 2000.
90. GOMEZ GARCIA, J. Conservas de fruta. Icex. Secretaría de Estado de Comercio, Turismo y de la Pequeña y Mediana Empresa. Ministerio de conomía y Hacienda. October 1998.
91. O.E.C.D. Study on the fishing grounds of the member countries of the OECD. Paris, 1997.
92. GOMEZ GARCIA, J.J. Notas sectoriales: Conservas de Fruta. Icex. Madrid, 1998.
93. DATABANK. Conservas de pescado en Italia. Milan, 1997.
94. ICEX. Fichas País. Madrid, 1997.
95. SAYIGH, A.A.M. Solar Energy Engineering. Academic Press. New York, San Francisco, London, 1977.

ANENEX II
OTHER SOURCES OF INFORMATION

1 The Food and Agriculture Organization of the United Nations (FAO): www.fao.org
2 Barcelona Chamber of Commerce-Camerdata: www.camerdata.es
3 Spanish Institute of Foreigh Trade (ICEX): www.icex.es
4 World Trade Organization (OMC): www.wto.org
5 World Bank: www.worldbank.org

Regional Activity Centre
for Cleaner Production (RAC/CP)

París, 184, 3a planta - 08036 Barcelona (Spain)
Tel.: +34 93 415 11 12 - Fax: +34 93 237 02 86
E-mail: cleanpro@cema-sa.org
http://www.cema-sa.org