Ecodesign In Food Packaging

UNIT 1: introduction and general approach to food packaging Ecodesign

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After learning this unit, the student will be able to:

–Know what the main food types are
–Understand fitness for purpose requirements (to fulfill a number of functions of packaging design and designing for environment and law).

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The food packaging industry includes a wide range of segments, alternative packaging and packaging materials. Main used sectors include, among others, processed food, fresh food and drinks.

1.1. The main food groups

The main food groups that must be packed are:

- ✓ Dairy products, e.g. milk, butter, yogurt, cheese, cream, ice cream;
- ✓ Fruits: apples, oranges, bananas, berries, lemons, etc.;
- ✓ Cereals, beans and vegetables, are often the broadest category in nutrition;
- ✓ Meat, labeled sometimes as protein. Examples: chicken, fish, turkey, pork and beef.

A classification, which is at the base of the food pyramid, it consists of 6 groups. As you can see below, foods of the group of 6 sitting at the base of the pyramid predominating, while the feed of group 1 is at the top, which means that it must be the most poorly represented in the daily food ration.

GROUP	THE FOODS THAT COMPOSE THE GROUP	THE MAIN CONTRIBUTION
1	Fat and sweets	Anything essential, with the exception of vegetable oils that contain fatty acids.
2	Meat and derivatives, fish, eggs	Protein, iron
3	Milk, dairy, cheese	Vitamins (A, D, B2), essential amino acids
4	Fruits	Carbohydrates healthy, enzymes, vitamin C
5	Vegetables	Fiber, vitamins , mineral salts
6	Starchy (and products derived from cereals and dried pulses)	Vitamin B1, carbohydrates with slow absorption

Table 1: Food groups that make up the food pyramid

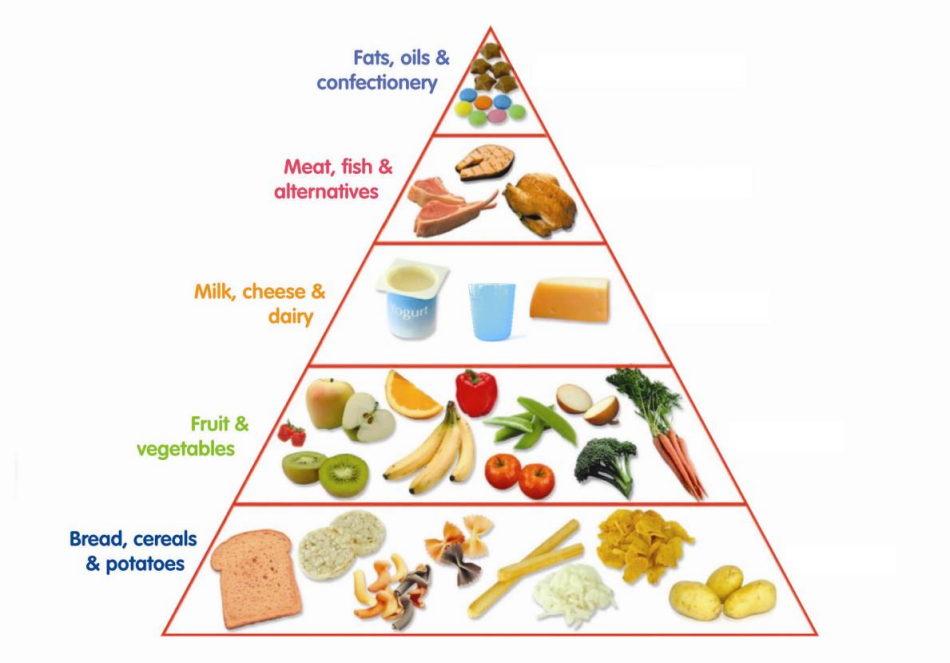


Figure 1. Food pyramid

(Source: https://www.first1000days.ie/toddler-food-pyramid)

Worldwide there is much talk and there are numerous data about the nutritional value and about the effect of various foods on the human body. Further, it's presented a classification of food from this point of view.

CLASS I. (FOOD WITH COMPLETE PROTEIN)

1. Milk and dairy products

- contain easily digestible protein, which contain all essential amino acids in optimum limits;
- are rich in vitamins A, D, B2, and pantothenic acid;
- contain lot of calcium and lactose;

Nutritional disadvantages:

- do not contain fibers;
- are poor in vitamin C;
- have a low content of minerals (iron, magnesium, copper);
- contain fats rich in saturated acids and relatively poor in polyunsaturated acids.

2. Eggs

- they are composed of the most digestible and assimilated protide;
- contain phospholipids;
- contain vitamins of group B, and also fat soluble vitamins such as A and D;

- are rich in iron and phosphorus;

Nutritional disadvantages:
- do not contain fibers;
- are poor in vitamin C;
- can cause allergies to sensitive people;
- are acidifying substances;

3. Meat and fish

- contain proteins that have in their composition all essential amino acids in optimum limits;
- are rich in B vitamins (B2, B6, B12, PP, folic acid);
- contain easily digestible iron, which stimulates erythropoiesis;
- fish contain a high amount of potassium, phosphorus and omega acids;

Nutritional disadvantages:
- have many saturated fat and contain no cholesterol;
- are relatively hard to digest (meat of mammals and poultry);
- contain a low amount of calcium;
- where anions are predominant are acidifying;
- can load the body with irritants nitrogenous catabolites (uric acid, urea, creatine).

CLASS II. (FOOD WITH SEMI-COMPLETE PROTEIN)

4. Vegetables and edible mushrooms

- contain fibers;
- are rich in potassium and magnesium;
- have a high content of carotene (pro-vitamin A) and vitamin C;
- show alkaline properties;

Nutritional disadvantages:
- are poor in protein (with the exception of the mushrooms);
- do not contain all the essential amino acids in the limits needs.

5. Legumes

- are rich in protein with high digestibility;
- contains healthy carbohydrate, with slow absorption;
- are rich in mineral salts;

Nutritional disadvantages:
- insufficient content of some amino acids (methionine, cysteine, tryptophan);
- contain a lot of tough cellulose tough that hinder the digestion;
- contain some of indigestible substances;

6. Cereals and derivatives (except corn and husked rice)

- are important sources of energy with gradual release (should provide almost 50% of energy needs);
- contain vegetable fibers (whole grains);
- their shell contain significant amounts of vitamins, dominated by vitamin B1;
- contain protein with a medium absorption grade and which, in susceptible people, can cause allergies;
- contain low amount of lysine (essential amino acid);

Nutritional disadvantages:
- are poor in calcium, and as a consequence of the presence of the phytic acid, it provides little iron, magnesium and zinc;
- have acidifying action;
- refined flours contain almost nothing but starch;

CLASS III. (Food with incomplete proteins)

7. Corn and husked rice

- in addition to point 6, it can be said, that never causes allergic phenomena;
- rice bran treats beriberi (B1 vitamin deficiency) disease;

Nutritional disadvantages:
- do not contain lysine and tryptophan (essential amino acids);
- corn do not contain niacin (provitamin PP) and husked rice do not contain thiamine (vitamin B1), which, curiously, is present in high amounts in rice bran;

8. Fruits

- are rich in mono-glucide and in di-carbohydrates, which provide relatively fast energy;
- contain a lot of water, thus hydrating the body;
- are sources rich in potassium;
- have a high content of vitamin C;

- containing weak organic acids, that hydrolyze base (form alkali salts with potassium, calcium or magnesium; malaţes, citrates, etc.) and enzymes which stimulate digestion;
- contain vegetable fibers, especially in the shell;

Nutritional disadvantages:

- do not contain all the essential amino acids;
- are poor in vitamins of the B complex;
- lipid content is insignificant in the juicy fruits (excepting olive and white seabuckthorn);
- large quantity can produce digestive fermentation;

9. Oilseeds and unrefined derivatives

- are rich in unsaturated fat, starch and protein;
- do not contain cholesterol and unsaturated fatty acids;
- have high energy value;

Nutritional disadvantages:

- do not contain all the essential amino acids;
- are poor in vitamin C;
- in large quantities they fattening;

CLASS IV. (Free-protein food)

10. Animal fats and refined vegetable oils

- are sources of fats;

Nutritional disadvantages:

- very poor in nutrients;
- very high energy value only due to fats;

11. Sugar and confectionery

- sources that provide energy quickly;
- have more calories;

Nutritional disadvantages:

- contain carbohydrates that are quickly absorbed, causing hyper-insulinism, fattening, or overburdening the endocrine pancreas);
- do not contain proteins, minerals, vitamins or lipids;

12. Non-alcoholic beverages

- ensures proper hydration of the body;
- depending on the water source provide the body a number of benefic substances;

Nutritional disadvantages:
- are poor or do not contain any nutrients;
- can be obtained from the synthetic substances that are unhealthy.

1.2. The main food processing technologies

Traditional food processing relies on heat to kill foodborne pathogens (bacteria, viruses, parasites) to make food safe to eat. For many foods, heating is an effective way to treat. Thermal processing involves heating food, either in a sealed container or by passing it through a heat exchanger, followed by packaging[1]. In all thermal processes, the aim should be to heat and cool the product as quickly as possible.

Recently, have been studied non-thermal processing methods that will destroy pathogens and keep foods safe to eat, while retaining the sensory attributes and nutrient content similar to fresh products. These non-thermal processing methods include high pressure, different form of ionizing radiation, gases or light.

THERMAL PROCESSING OF FOOD

There are two main temperature categories employed in thermal processing: *pasteurization* and *sterilization*. The basic purpose for the thermal processing of foods is to reduce or destroy microbial activity, reduce or destroy enzyme activity and to produce physical or chemical changes to make the food meet a certain quality standard.

Pasteurization is a controlled heating process used in a wide range of different types of food products. The two primary aims of pasteurization are to remove pathogenic bacteria from foods, thereby preventing disease and to remove spoilage bacteria to improve its keeping quality. As well as the application to inactivate bacteria, pasteurization may be considered in relation to enzymes present in the food, which can be inactivated by heat[2]. Pasteurization does not inactivate all microorganisms: those which survive pasteurization are termed thermoduric and those which survive a harsher treatment (80-100 °C for 30 minutes) termed spore formers. In pasteurization, generally a heating temperature below 100 °C is applied. Traditionally it was a batch process at 63 °C for 30 minutes. In heat treatment processes, depending on the product properties can be applied different combinations of time/temperature:

[1] Lewis, M. J. (2005) Thermal Processing, in Food Processing Handbook (ed J. G. Brennan), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, FRG. doi: 10.1002/3527607579.ch2
[2] http://wiki.zero-emissions.at

- 62 – 65 °C, up to 30 minutes (batch wise pasteurization)
- 72 – 75 °C, 15 – 240 seconds (high temperature short time – HTST)
- 85 – 90 °C, 1 – 25 seconds (high heat short time pasteurization – HHST)

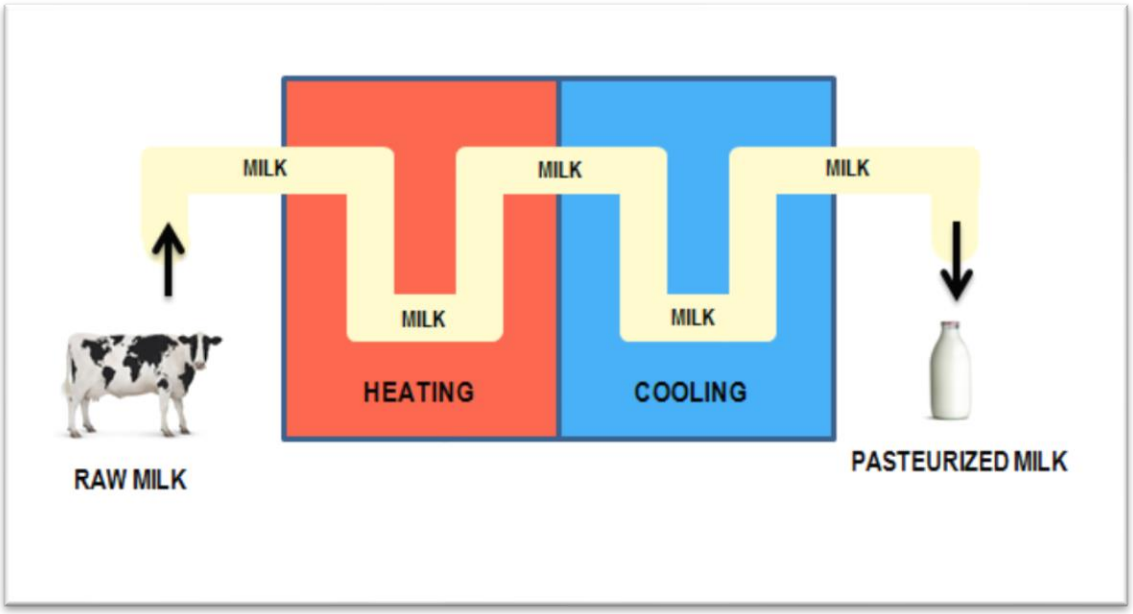


Figure 2. Milk pasteurization process

In the Table below are presented some examples of heat treatment combinations used in the food industries[3]:

Process name	Heating temperature / time	Application
Bulk liquid pasteurization	63 °C / 30 minutes	Vat pasteurization of milk
High temperature short time pasteurization (HTST)	72 °C / 15 seconds	Continuous pasteurization of milk for safety
Cooking of meat products	to 66 - 75 °C internal temperature	Ready-to-eat products (ham, frankfurters, etc.)
Blanching of vegetables	variable (ex. 75 °C / 5 minutes)	Enzyme deactivation, tissue softening
In-bottle pasteurization	60 °C / 10 minutes	Shelf-life extension of beer

Table 2: Heat treatment combinations

Sterilization is a controlled heating process used to completely eliminate all living microorganisms including thermo resistant spores in milk or other food. It can be achieved by moist heat, dry heat, irradiation, etc. compared to pasteurization, a heat

[3] http://wiki.zero-emissions.at

treatment of over 100 °C is applied for a period long enough to lead to a stable product shelf-life[4]. UHT (Ultra-High Temperature) sterilization is a heat treatment of over 100 °C during very short times, applicable especially to low viscous liquid products. The basis of UHT is the sterilization of food before packaging, then filling into pre-sterilized containers in a sterile atmosphere.

The temperature of 121.1 °C is taken as a reference temperature for sterilization processes. This is used in the conjunction with the z value for Clostridium botulinum.

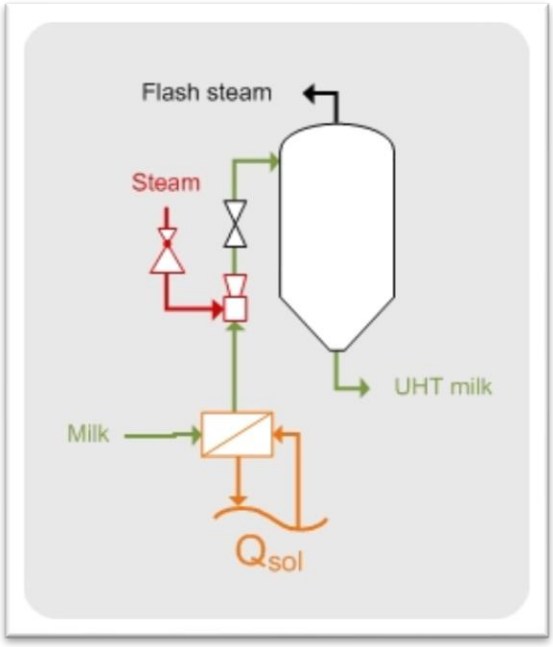


Figure 3. UHT treatment of milk[4]

Sterilization process can be performed in several ways:

- with moist heat – temperatures generally range from 110 to 130 °C for 20 – 40 minutes;
- with dry heat – long exposure times (up to 2 hours) and higher temperatures (160 – 180 °C) for killing bacterial endospores;
- by chemical means – ethylene oxide is used to sterilize food, plastics, glassware and other equipment.

NON-THERMAL PROCESSING OF FOOD

In recent years, researchers have been studying non-thermal processing methods (methods that do not use heat) in order to kill pathogens and keep foods safe to eat, while retaining sensory attributes and nutrient content similar to raw or fresh products.

[4] http://wiki.zero-emissions.at

These non-thermal methods, also called alternative processing methods, include high pressure, different forms of ionizing radiation, gases or light.

High Pressure Processing (HPP) is a non-thermal process currently being used in the food industry to target specific pathogens in specific food products, such as *Vibrio parahaemolyticus* and *Vibrio vulnificus* in oysters, or *Listeria monocytogenes* as post-process treatment on sliced deli meats and juices. High pressure processing kills microorganisms by exposing foods to very high pressures[5].

Cold Plasma Processing is an emerging, non-thermal technology that could potentially decontaminate the surfaces of fresh produce, having the main advantage of being chemical and water-free because the antimicrobial products (UV, radiation, charged particles, "supercharged" oxygen, etc.) are formed in the air[5].

Pulsed Light Processing is a non-thermal technology that uses short, intense pulses of white light which includes ultraviolet, infrared and visible light. Treatment of foods with pulsed light has been approved by the FDA. Pulsed light is at the same as the light seen outside, but is much more intense. When this light is flashed on a food, it kills microorganisms but has minimal impact on the food. Short flashes of this intense light are used to prevent the temperature of the food from increasing[5].

Ultra-Violet Light Processing is a non-thermal technology based on the UV light properties of causing damage to microorganisms DNA. It is used to kill pathogens that are contained in food but does not impart any health concerns to the food. UV processing is being used in the juice and cider industries for pasteurization without heat targeting *Escherichia coli* O157:H7 and *Cryptosporidium parvum*[5].

Electron beam irradiation is another non-thermal technology where high energy accelerated electrons are aimed at solid or liquid foods, reducing the number of or eliminating pathogens, pests or insects and uses no radioactive isotopes[5].

1.3. The main types of food packages

The eco-designer must think packaging design by optimizing its shape and size. In this regard it has to avoided the under sizing or over sizing of the package.

The under sizing can cause package cracking or food damage during transportation, storage or usage. Oversizing leads to resources wasting. In this respect, among others, the optimization involves:

- reducing the package thickness;
- removing the spaces, layers and components which are not necessary, and for some products, increasing of the bulk density by concentration (coffee, juices, detergents, etc.);

[5] Pivarnik L. and Worobo R., 2014, Non-thermal or alternative food processing methods to enhance microbial safety and quality (USDA-NIFA #2011-68003-30005).

- using, when it's possible, of recycled materials;
- optimization of the products quantity inside the package intended for consumption, based on consumer needs.

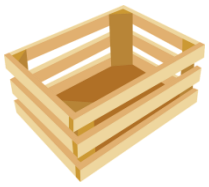
The materials used for food packaging are, in order of use as follows[6]:

☐ **PAPER AND CARDBOARD** - *Kraft paper*; *bleached paper*; *parched paper*; *wax paper*; *paraffin paper*; *paper bags* (for packaging of bakery products, fast food, flour, cornmeal, etc.); *cardboard boxes* (for packaging of pizza, pastries, cakes, cereals, etc.); *cardboard laminated with polyethylene and aluminum boxes* (for packaging of liquid food products that requires hermetically sealing and sterilization); *cardboard crates* (for packaging of fruit and vegetables during transport).

☐ **PLASTIC** – *bags* (for packaging of cereals, seeds, sugar, bakery products, etc.); *bottles and flasks* (for packaging of pasteurized milk, mustard, mayonnaise, tomatoes paste, etc.); *small capacity containers* (for packaging of dairy products: yogurt, cream, fresh cheese, ice cream, etc.); *drums and barrels* (for packaging of milk and dairy products during transportation).

☐ **GLASS** - glass bottles (for packaging of juices, soft drinks, mineral water, milk, alcoholic beverages, oil etc.); glass jars (for packaging of food products preserved by sterilization, honey, yogurt, candy, etc.).

☐ **WOOD** - *wooden crates* (for packaging of fruits and vegetables during transport); *wood barrels* (for production/processing, transport and storage of wine and other alcoholic beverages, etc.).



☐ **METAL** – *aluminum sheets* (for packing of butter, chocolate, candies, etc.); *metallic cans* (for packaging of meat products, stewed fruit, mushrooms, beans, peas, etc.); *aluminum cans* (for packaging of beer, soft drinks, juices, some alcoholic beverages); *tubes* (for packaging of pasty products, mayonnaise, mustard, spicy pasta); *barrels* (for packaging and transport of beer and wine); *aerosol packages (sprays)* (for packaging of flavoring substances, creams, whipped cream, sauces, etc.).

[6] http://www.ambalaje.net/ambalaje-alimentare.php

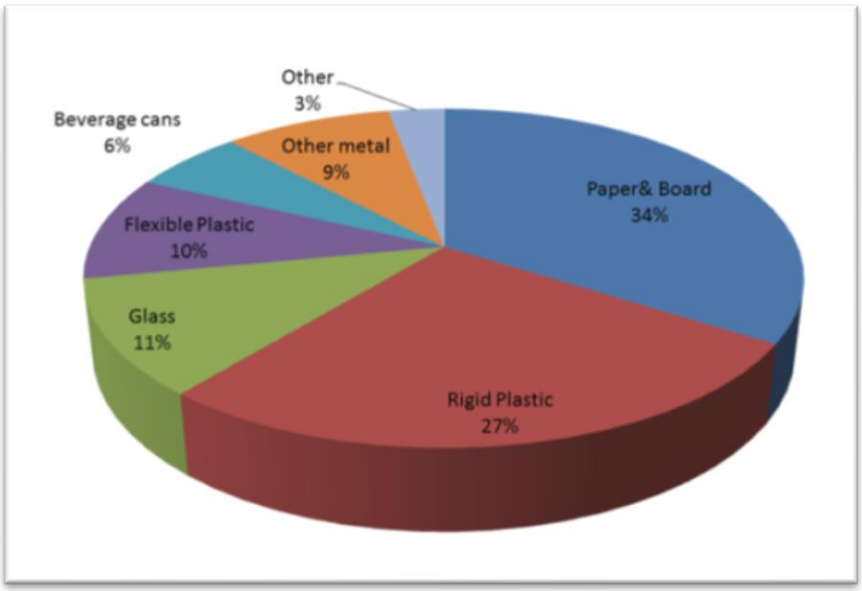


Figure 4. Packaging materials used in food industry in 2012
(Source: http://www.foodpackagingforum.org)

Depending on the type of packaging can be distinguished: primary packaging, secondary (intermediate or transport) and tertiary packaging.

☐ *Primary packaging* (sale packaging), can be any object, whatever the material of which it is made or its nature, being designed to contain, support or preserve the product throughout its lifetime. Examples: septic packages for dairy products, trays for fish or meat, bags for potato chips, cans for vegetables, containers for juices, flexible packaging, etc.



(www.pixabay.com)

☐ *Secondary packaging* (group packaging) is the packaging designed to constitute at the point of purchase, a grouping of a number of sales units, even if it is sold to the final consumer or it serves only as a means of filling the shelves in the point of sale. The secondary packaging can be separated from the product without affecting the product characteristics.




(www.seaplast.com) (www.pixabay.com) (www.evz.ro) (exonia.allshops.ro)

□ *Tertiary packaging* (transport packaging) is the packaging designed to facilitate the handling and transport of a number of sales units or grouped packages in order to prevent damage of the products during transport from one economic operator to another.

(www.pixabay.com)

1.4. Practical strategies for eco-design of packaging

The main purpose of packaging is to protect foods starting from their production to their consumption. The main requirements are to achieve food packaging by optimizing the use of materials, water and energy, by minimizing waste and by maximizing the packaging recovery at the end of their use.

This concept of eco-design for food packaging is summarized in Figure 2.

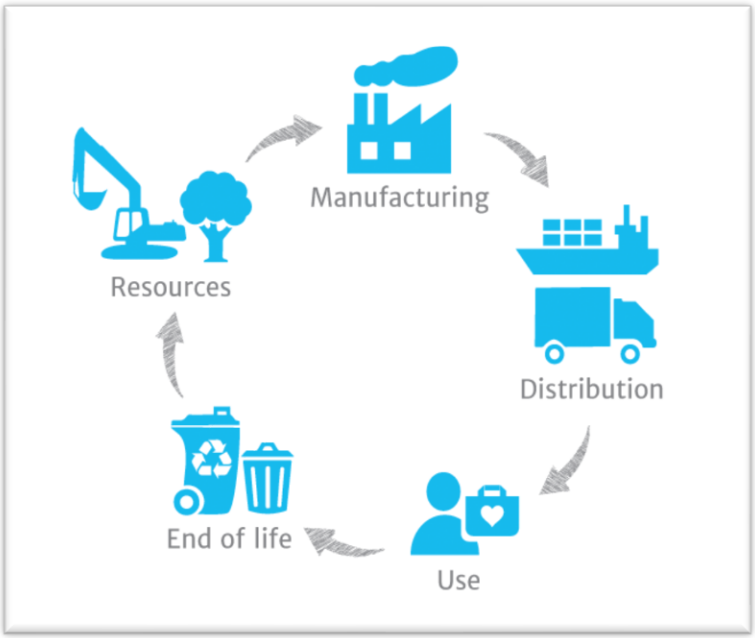


Figure 2. Food packaging Ecodesign concept

(Source: http://downtoearth.danone.com)

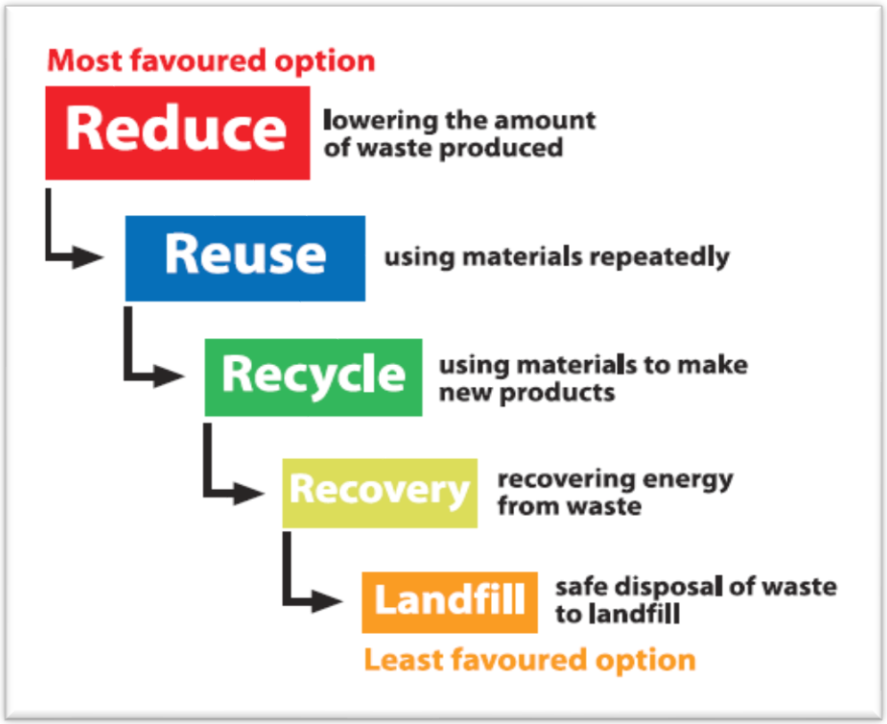


Figure 3. Waste hierarchy
(Source: http://chem-intranet.chem.ox.ac.uk)

The requirements of eco-design include:

- designing for effectiveness;
- designing for optimization of resource consumption;
- designing for minimizing the environmental and social impact of materials;
- technical performance (technical requirements of the product and of its packaging to ensure their functionality, protection / conservation for the whole distribution period storage and storage of the product until its consumption);
- regulatory and environmental requirements and their impact;
- compatibility with the existing technological equipment and distribution systems;
- customer requirements (assessment of the customer concerning packaging and product characteristics, for example, aesthetic, flavor, convenience, functionality and environmental performance);
- improving image and brand value and product positioning towards competition offer (marketing requirements for packaging, innovation etc.);
- considerations of the supply chain such as compatibility with existing range of packaging and/or the manufacturing system;
- legislation and the operational/financial impact, for example, regulations regarding food hygiene, labeling, weights and measurement units, food contact materials etc.

The package must correspond to the functional purpose given by the theme with the minimum of environmental and social impact. Packages must fulfill several functions:

- ☐ They need to ensure the delivery of the food to the consumer in good condition, whatever the stresses to which they are subjected during distribution and storage.
- ☐ They need to protect the content from vibration, moisture, heat, odors, light penetration, microorganisms or pest infestation, and they must not present leak.
- ☐ They must be easy to open (but difficult to open accidentally).
- ☐ They must be as easy to carry.
- ☐ They must be attractive enough to facilitate their purchase.

Based on above mentioned facts the following considerations can be made:

- ☐ A product that is not sold or used becomes a waste of resources and workmanship.
- ☐ Package must provide information about product and instructions for handling and use. The company must take responsibility for this.
- ☐ Package has to contain a logo that indicates the material from which it is made, a symbol or statement about recycling and a symbol for the interdiction of improper storage of the waste resulted after the use of the food.
- ☐ Package must not be open accidentally.
- ☐ Clarifications with regard to the safety of children are necessary.
- ☐ In the case in which the package does not have sufficient area for all necessary information to be displayed a prospect can be inserted or fold-out labels can be used.
- ☐ It is necessary to comply with regulations regarding the reduction of the packaging impact to the environment, and also, to ensure the fulfillment of all performance criteria, relevant to the production, distribution, storage and use.
- ☐ Benefits achieved through efficient eco-design of the packaging must be checked and validated during whole this process.