Historical Perspective

Man has always been interested in the preservation of food to extend its storage life. Preservation methods may have begun with sun drying in the tropics; or in temperate zones, with sun drying during the summer, and atmospheric freezing during the winter.

Natural fermentation is another means of food preservation used since ancient times, especially by the Asians.

The modern food processing industry began in 1810 when Nicolas Appert invented the canning process. This was followed by the invention of a mechanical ammonia refrigeration system in 1875. In the 1860s Louis Pasteur had discovered the connection between the micro-organism and food spoilage, this put the development of food processing and preservation techniques on a firm scientific foundation. The two word wars and the Korean war during the first half of 20th century accelerated these developments.

The current growing demand for “near-fresh” quality and shelf stable products has spurred the development of many innovative processing and preservation techniques. Foremost among these are retortable pouches, aseptic packaging, controlled-atmosphere storage and **vacuum and modified atmosphere packaging**, the last being one of the most promising and most extensively studied at the present time.

What does the “vacuum packaging” mean?

Vacuum packaging is a modern technique for packaging food products. It involves the extraction of the air contained in the package and then hermetically sealing it. In this way oxygen and all chemical and biological contaminants such as pollution substances, bacteria and mould that are normally present in the air, are eliminated from being in contact with the product.

Different degrees of vacuum can be used as a function of packaging machine regulation and product characteristics, to arrive at an almost complete extraction of air and an oxygen residue equal to one hundredth of the initial value. Any food product preserved at low temperature in a rarefied and purified atmosphere, maintains its characteristics of colour, flavour and nutritional value longer. In other words, it maintains all of its quality and economic value.

Large systems are not necessary to attain these results. Small, easy to use units with transparent covers can be used, allowing all phases of packaging to be followed.

Hygiene and freshness of vacuum packed products

The main enemies of food quality are oxygen contained in the air and micro-organisms (bacteria and mould). They are present everywhere in the environment and can be found on tools, equipment, operator's hands, etc.

Oxygen is an indispensable element to human beings. It is also a very reactive gas and is able to combine with many substances contained in food products. When reacting with food product ingredients, oxygen can cause negative changes in the colour, flavour and odours, compromising quality and acceptability.

Most micro-organisms that can multiply in food are of aerobic type, which means they need an adequate air supply to live. Without it, their proliferation is blocked and their fermentation and degenerative activities are strongly inhibited.

In vacuum conditions and at low temperature, only a few microbial species can develop and they, for the most part, are not negative. In fact, they can even be considered positive for the flavour quality of most foods (lactobacillus).

The immediate elimination of air from a food package (and therefore of the oxygen it contains) ensures a longer preservation of any perishable food product. It also ensures good presentation and effective protection against accidental recontamination.

Production

Vacuum packaging a food product immediately after its processing is the best way to protect its quality and preserve its value.

Before ambient air begins to directly deteriorate (drying out, oxidation, denature of aromas) or indirectly deteriorate (favouring the development of bacteria, yeast, mould and their metabolisms) the food product, vacuum packaging can "freeze" the quality of the food product at the level reached in the production phase and maintain it intact up to the moment of consumption.

Uncontrolled pollutants and undesirable or unforeseen changes in each successive phase of the food production process can render the effort and care used in production useless. A vacuum packaged product, together with refrigeration, allows avoiding these risks and extending the shelf life of the product.

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In the business place

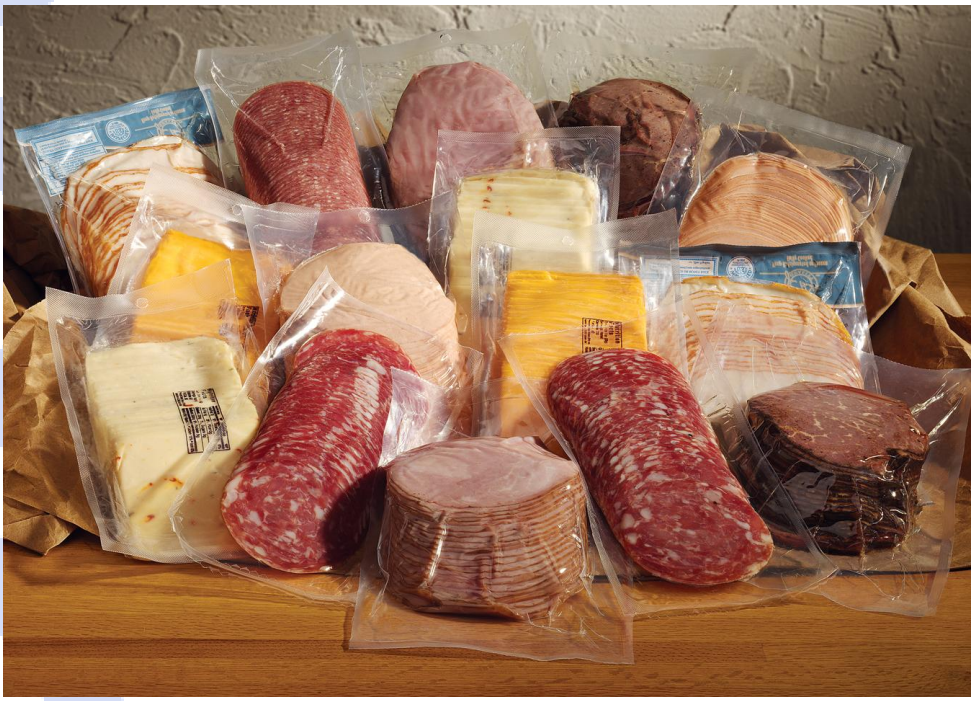
A machine capable of vacuum packaging any food product in practical pouches or plastic trays, can be the key element of success in a business undertaking for the following reasons:

- by offering an additional service to the customer
- by adding value to the item
- by safeguarding the shelf-life during closed business hours
- by recovering any leftover product
- by offering a self-service

Extracting the air from the package and placing the product in the best preservation conditions is easy, fast and increases the life of perishable products.

Restaurants

Elaborate and appetising food preparation is most susceptible to damages that air and time can cause. Flavour, aroma, appearance and consistency change in time with a speed proportional to the air quantity available. It is possible to stop or effectively slow down these changes by protecting the prepared foods in a vacuum package that impedes contamination, slows spontaneous deterioration and preserves the aspect of ready-to-eat, fresh or cooked products.



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MAIN APPLICATIONS OF VP

Fresh meat

The ways fresh meat deteriorates during preservation are many:

- multiplication of aerobic bacteria;
- red meat colour turning to brown
- spoiling of the fatty parts
- surface dehydration, or drying out

The elimination of the air in a vacuum package permits the slowing down of all forms of qualitative degradation. In a rarefied atmosphere with little oxygen in a vacuum package, damaging bacteria cannot multiply allowing lactic bacteria to take over to improve the flavour and consistency of the meat. The fats do not change and the product does not undergo dehydration due to evaporation or loss of meat juices. In the absence of oxygen, the meat darkens but this is a transitory, not permanent, phenomenon if the meat is packaged immediately after being cut. As soon as the meat is again exposed to air, its colour assumes an appetising appearance to the customer.

Cooked products

In cooked products (meats or vegetables) the original micro-flora is changed by the thermal treatment, the natural enzymes have been denatured and the fats are more exposed to deterioration. For these reasons, changes in colour, flavour and smell can happen very quickly, even though they do not cause actual product degradation.

Vacuum packaging is particularly useful to slow down any deteriorating phenomenon by eliminating the oxygen and isolating the product in a waterproof package. In this way, the product does not take on any unwanted odours or undesired and dangerous contaminants.

Cheeses

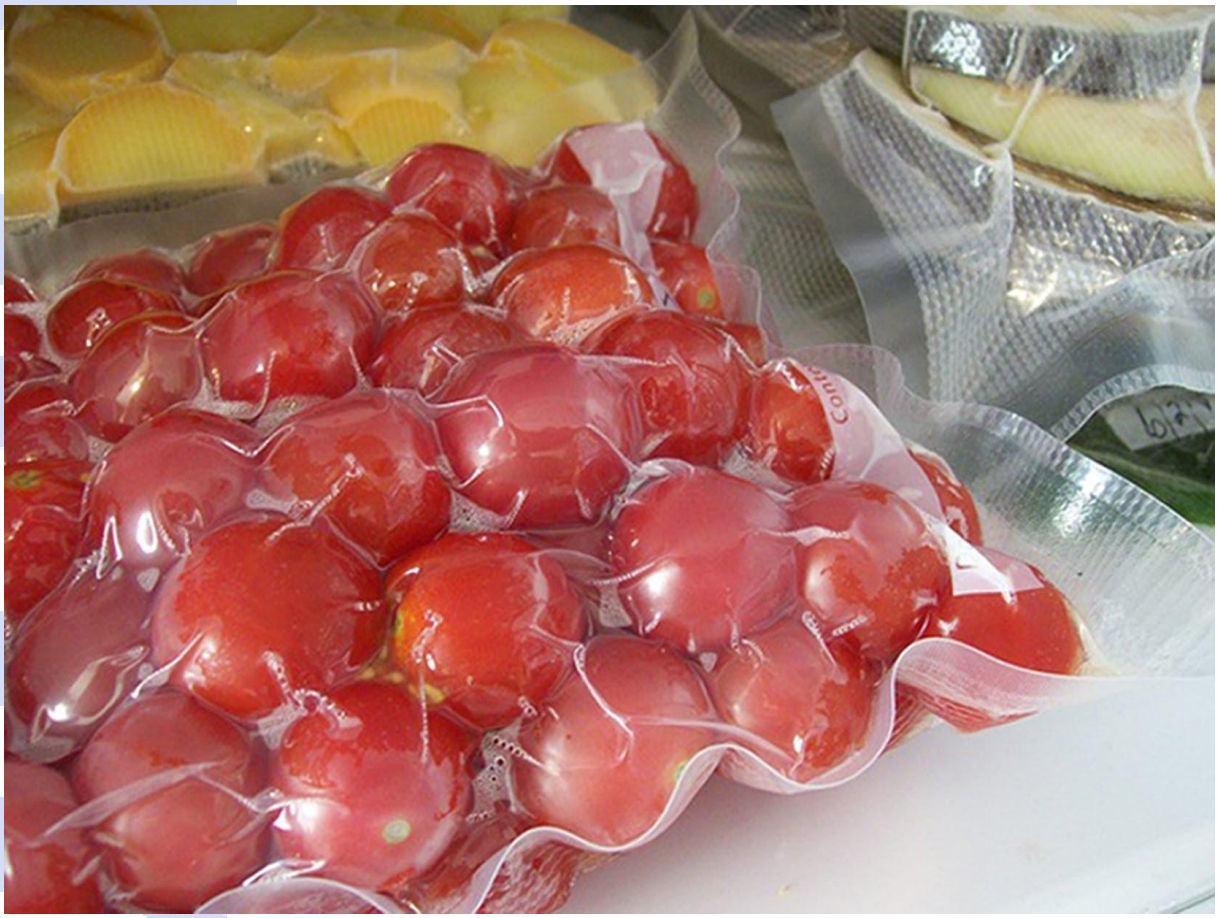
All cheeses, hard or soft, are easily subject to fungus contamination. Mould spores are always present in ambient air and they can easily proliferate on cheese surfaces due to the high humidity content of these products. Vacuum packaging allows avoiding this inconvenience that can deteriorate the aspect and flavour of cheese products, by the almost complete elimination of oxygen which is indispensable for the growth of these micro-organisms.

Vacuum packaging impedes the drying out of the cheese surface and the oxidative changes that can compromise flavour and aroma of cheese derivatives. Vacuum packaging and preservation at refrigeration temperatures can extend the shelf life of cheeses allowing a more logical and effective distribution of entire forms or portioned products.

Delicatessen meats

The deterioration process of delicatessen meats happens in many different ways: rotting, moulding and greening can impair the preservation of deli meat products. All these phenomena, whether chemical or biological, can be effectively opposed by vacuum packaging, which ensures the absence of air.

The most important characteristics of these products are their colour (pink or red), odour and flavour. These characteristics are strongly conditioned by the oxygen level present in the package. Therefore, excluding the air from the vacuum package represents the best guarantee of quality maintenance of the product. Vacuum packaging deli meat products is a proven method used successfully by all major producers for some time now.



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THE MAIN SECRETS OF THE TRADE

Moist food products

When a moist product, one containing free water, is vacuum packaged, it is never possible to reach a very low vacuum pressure. This happens because evacuating the container allows the evaporation of a small part of contained water.

The vapour liberated in this way has its own pressure (vapour pressure) that has different values in relation to the temperature. This natural phenomenon does not impair the effectiveness of the vacuum packaging.

Even if the absolute value of the pressure remains at some mercury value (even 20 or 30 mm) and does not reach a high vacuum, the residual pressure is due exclusively to the vapour pressure released while the air (and therefore the oxygen contained in it) is being entirely extracted.

"Critical" products

The success of vacuum packaging depends on a number of factors that have to do with the effectiveness of the packaging machine and its reliability, the packaging material used and the characteristics of the food product to be packaged.

Sometimes the form, nature and consistency of food products can be a problem for the packaging operation.

This is the case for granular or porous products. Due to their structure, they comprise and hold a discreet quantity of air in the gaps between one particle and another or in the pores. To effectively evacuate the package of these types of products, it may be necessary to prolong the packaging time or arrange the products in such a way as to facilitate the air extraction.

The same problem can be applied to oversized products with unusual forms that are characterised by pockets of "dead air". It is necessary to arrange the product in such a way as to ensure that no air is trapped in these critical points.

Powder products also cause problems in the packaging phase.

During air evacuation, the lighter powder particles can be dragged by the outgoing airflow creating problems in the sealing phase of packaging. The solution in this case may be found by regulating the filling level.

Choice of packaging material

Vacuum packaging effectiveness can be rendered useless by an inadequate choice of packaging material. Care needs to be taken when selecting the plastic film or the tray used in packaging. The plastic materials are, in differing degrees, all permeable to gas and the vacuum of the package tends to accelerate the air return from the environment. For long term preservation of the vacuum effects, “barrier” materials are needed to impede the entrance of oxygen for the time required.

The “Flexible Packaging” industry has numerous options available to users. It is worth noting that the thicker the material, the slower (proportionally) the entrance of oxygen will be. Also, the less package surface area there is, there will be a proportionally slower permeation of gas. Finally, the entrance of the oxygen has different speeds as a function of the temperature and the lower it is, the slower the phenomenon.

GAS INSERTION

Terminology

Modified atmosphere packaging (MAP) has been erroneously described as a synonymous with controlled atmosphere storage (CAS) or packaging (CAP). MAP is defined as “the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air”. This is in contrast with CAS, which involves maintaining a precisely defined atmosphere in the storage chamber and vacuum packaging, which is the packaging of a product in a high-barrier package from which the air is removed. CAP may be regarded as a misnomer for MAP, since it is technically impossible or impractical to maintain the original atmosphere around the product once it is sealed inside a package. This is particularly true with fresh and nonsterile products, owing to their dynamic chemical and microbial nature and the physical characteristics of the package and packaging material.

The potential for use of gases in the storage atmosphere to improve keeping quality of food was recognised more than half a century ago, however the science and technology of gas preservation evolved slowly. In the last two decades, with the rising costs of raw food products, labour and energy and the tightening controls on some preservatives and additives, interest in the use of gases for food preservation has been renewed.

The availability of packaging films with a wide range of physical characteristics and versatile packaging equipment has enabled attention to be turned to MAP of food in small, convenient retail or distribution units. In the MAP system, the cumbersome continuous control of the atmosphere surrounding the product is eliminated. This makes it much cheaper for a large-scale operation and the process became practical for application at the retail level.

Preservation of food products

The flavour, hygiene and nutritional quality of a food product has three main enemies:

the oxygen contained in the air that can oxidise the product damaging its flavour or favour reproduction of damaging micro-organisms (bacteria and mould);

the micro-organisms commonly present in the environment, on tools, equipment, operator's hands, etc. that, with their proliferation, can render the product unacceptable for consumption or even dangerous to the health of the consumer;

the enzymatic and/or physiological activity of the food product itself that contributes to accelerate the ageing of the product.

It is possible to intervene on all of these main causes of deterioration on the product quality with adequate atmosphere modification to maintain the colour, taste and nutritional power of the product longer. In short, all of its quality and all of its economic value.

Modified Atmosphere and Vacuum Packaging

Modified atmosphere packaging presents many important prerogatives with respect to vacuum packaging.

First, it can be considered a more delicate technology since the food product is not "stressed" by the evacuation of air.

A fast and violent extraction of the atmosphere can remove useful volatile substances from the food product that are important to its flavour.

It can also cause the evaporation of part of the moisture and bring the fat content to the surface of the product.

Also, modified air packaging should be considered a more powerful technology. In this case, it is not limited to just the elimination of air from the package that can be harmful to the food product.

It also introduces elements (the gases) that can actively combat the qualitative decay of the product.

The formulation possibilities of the atmosphere are so numerous and diverse that it is possible to customise a specific and effective gas mix for every product/package system.

GAS TYPES

Oxygen

Oxygen is used almost exclusively in the packaging of fresh beef. In high percentages, higher than the level in atmospheric air, it allows maintaining the colour of just-butchered meat in the most natural way, for a longer period of time.

In some cases the oxygen can be supplied in the atmosphere composition in order to avoid the development of anaerobic germs that can present a serious hygienic risk for some food products. Generally, its presence inside packages is to be avoided as much as possible in order to avoid the qualitative changes that are associated with its high reactivity.

Carbon dioxide

There are many effects of carbon dioxide and they concern the microbiological as well as chemical and enzymatic aspects of food preservation. In fact, this gas has a high bacteria-static and micro-static action. This means that in the presence of a proportional amount of carbon dioxide that varies within 15-40%, the multiplication of bacteria and mould is strongly inhibited. It doesn't act as a bactericide (if it is not at a very high percentage) but it is able to stop the growth and the proliferation of the main biological agents that alter food products.

The carbon dioxide effects also work on a chemical level. In fact, dissolving in the food, the gas develops a bland acid reaction that denatures those enzymes whose action with time could change the aspect and flavour of the food product and also interact with other ingredients, vegetable or animal, of the foods, slowing down the rise of spontaneous modifications.

The solubility is abundant in water as well as in fats and it involves all components of any food product. As for any other gas, low temperatures favour the solubility of carbon dioxide and in fact refrigerated modified atmosphere packages show better results.

Once dissolved, the gas combines with different substances contained in the food product but does so in a slow, irreversible way. This means that once the package has been opened to ambient air, the conservative effects of the gas are maintained for some time.

The high solubility of the carbon dioxide also presents problems. The volume of dissolved gas (that can be notable in high percentages) is removed from the package that can cause a small contraction and deform the package. For this reason, it is necessary to correctly dose the presence of carbon dioxide in the modified atmosphere.

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Nitrogen

Nitrogen is one of the most inert substances known. Very high temperatures and pressure are necessary to make it react chemically. In spite of this, its use in the formulation of the atmosphere is very important. It allows the correct proportion of the other two gases, excludes the presence of oxygen in the air and slows down negative enzymatic and microbiological changes.

Another important characteristic of nitrogen is that it moves the slowest through plastic films used in packaging. Therefore a nitrogen atmosphere is more stable with time than one with a high percentage of carbon dioxide or oxygen.

MAIN APPLICATIONS OF MAP

Fresh meat

Meat preservation even at low temperatures is always rather brief because the product is very perishable. Yet, when packaging meat portions with the correct atmosphere (for example 60% oxygen, 20% carbon dioxide and 20% nitrogen) it is possible to maintain the colour, flavour and consistency of freshly cut meat for 7-10 days at 2-4 °C. Even if in this case the extension of the shelf-life is very limited with respect to more traditional packaging methods, modified atmosphere packaging can reduce the supply number (rationalising the distribution) and allow superior presentation of the finished package.

Cheeses

Many cheeses during ageing and preservation cause a physiological production of carbon dioxide and a moderate consumption of oxygen, exactly the same as in breathing.

Therefore, an adequate atmosphere (10-30% carbon dioxide with respect to nitrogen) does not damage dairy products nor does it present a risk to the consumer since such gas is a normal product of ageing. Packaging in modified atmosphere protects numerous dairy products from moulding and from other disagreeable odour and taste modifications.

Bakery products

Breads, leavened products, snack-foods, cookies and many other bakery products are all subject to the phenomenon of moulding (with respect to their humidity level), to changes in fatty ingredients (becoming rancid) and changes in their consistency (becoming stale). Their quality for this reason can diminish quickly. Modified atmosphere (from 100% nitrogen to 100% carbon dioxide according to the specific case) is effective against these possible qualitative modifications and doubles and triples the shelf life at ambient temperature of these packaged products.

Fresh pasta

Whatever the production method used for fresh pasta (handmade or industrial, pasteurised or sterilised, packaged or loose) a modified atmosphere with a medium-low content of carbon dioxide (10-30%) with respect to nitrogen allows blocking the multiplication of possible contaminating micro-organisms, avoiding the undesirable appearance of mould and increasing the life of the product at refrigerated temperatures. This allows greater flexibility in production and distribution.

Delicatessen products

For safe preservation without risk of spoilage and colour changes and for innovative and appetising presentation of deli meats, modified atmosphere packaging offers safe guarantees. Nitrogen only atmospheres (absolutely excluding oxygen from the air) or with slight concentrations of carbon dioxide can effectively change the aspect and preservation of all different types of deli meats.

MAIN SECRET OF THE TRADE

Choice of atmosphere

This is certainly the most difficult choice to carry out when deciding to package perishable products in modified atmosphere. In this field of food technology, the applications are numerous and it's always advisable to carry out adequate experiments. It is necessary to try out different gaseous mixes evaluating the packaged product's flavour and hygiene characteristics with time. A useful approach can be to start with the highest carbon dioxide percentages (50-60%) and proceed to a minimum of around 10-15% using systematic and rigorous tests to try to find the best solution for each food/package/atmosphere system.

Choice of materials and techniques

The success of modified atmosphere packaging obviously does not depend only on the definition of the correct atmosphere. The material and packaging technique selection are also very important. All flexible materials used in packaging are gas permeable to some degree. The maintenance of the protective atmosphere inside the package is therefore subordinate to the material characteristics and to the effectiveness of the package seal.

From this point of view it is absolutely necessary to use adequate packaging machines to ensure complete air replacement with the chosen, accurately dosed atmosphere, minimising the oxygen residual in the package.

Preservation times

It is difficult to provide a precise response to this frequently asked question since there are many factors that can influence the increase or decrease of preservation times. The main factors are summarised below:

- Product nature, freshness and temperature at the time of packaging;
- Hygiene in the food processing plant and instruments used in the process;
- Steps taken to keep the product refrigerated up to the moment of consumption (packaging and storing in the food processing plant, transport, display cases in sales locations, etc.);
- Quality of material used for packaging (pouches, trays and film);
- Precision of the packaging machine to reach the level of vacuum and atmosphere quantity necessary for every type of product and package;
- Sealing quality of the package

Varying the above factors obtains different results from the preservation time point of view. Therefore, keep in mind that vacuum packaging represents a packaging method for the preservation of products for brief times. For long periods, other methodologies must be used.

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COMBINATION OF VACUUM AND STERILIZATION

VACUUM

Vacuum is a process which allows an extension of the “shelf life” of food sensitive to oxidation. Using this process, the evacuated air is sometimes substituted by different kinds of Aligal which help to avoid the crushing of the product and/or extend the “shelf life” thanks to their bacterial role (CO^2).

Vacuum nevertheless presents the risk to lower the bowling temperature of the food. This has to be taken into account by hot packaging when the vacuum has to be reached by reducing the temperature progressively.

STERILIZATION

Sterilization is a process which allows an extension of the “shelf life” of food by eliminating or reducing some micro-organisms through an exposure to heath (generally between 105 and 130°C) during a certain period (to be fixed in accordance with the nature and the mass of the product).

In this process, the packages to be treated need to be supported by adding a counter-pressure (in a scale between 0 and 10 kg). If the counter-pressure is absent or insufficient, the packages will present distortions, abnormal stretching of the seal layer and, often, a limited delaminating at the sides of the packages (at the seals or the bottom gusset) and the seals will be less efficient.

If the seal layer looks somewhat blurred, this means that it was submitted to a too high temperature (due to a programming error of the cycle or a auctoglave problem or a bad choice of seal layer).

The tensions undergone by the packages are a result of the dilatation of the product due to the temperature.

It is therefore very important to take the cubic dilatation coefficient and the delta T° (maximum sterilization temperature – filling temperature) of the product into account in order to fix the level of counter-pressure to be used.

A minimum of air must also be left in the packaging and this in order to avoid two negative consequences, which are :

- air is a insulator (double glazing principle) and, therefore, presence of this air requires an increase of temperature and/or of the duration of the sterilization cycle, and
- since air is a gas, it expands seriously by heath.

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Combination of these two processes

Using the combination of these two processes seems to be redundant but, in reality (see above), this allows to reduce the duration of the sterilization cycle by evacuating the air from the packages. The vacuum will have to be mild in order to avoid a distortion of the packages and the usual counter-pressure will have to be strongly increased (more than 2 kg) in order to avoid delaminating problems.

Prepared for

APACK Academic

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