Ecodesign In Food Packaging

UNIT 11: Modified Atmosphere Packaging

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

– Know the main types of food packaging with modified atmosphere and the used materials;
– Know the principles being to the technologies basis for obtaining food packaging with modified atmosphere;
– Know the food packaging applications with modified atmosphere.

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11.1 Definitions, overview

Modified Atmosphere Packaging (MAP) can provide superior quality and a longer life of food, while preserving the original taste, texture and appearance of the food. MAP gas mixtures usually consist of the gases that make up the air: carbon dioxide (CO2), nitrogen (N2) and oxygen (O2). A fair mix of these will depend on the food and its properties, so we will have unique solutions for each food.

• Nitrogen is an inert gas that does not react with food. When used without other gas, its function is to remove oxygen from the food.

• Carbon dioxide reacts easily with food, creating carbonic acid. Carbon dioxide is soluble in water and lipids, and although it is not bactericidal or fungicidal, carbon dioxide has bacteriostatic and fungistatic properties. It can be used in small amounts (10% -30%) together with nitrogen to protect oxygen and to inhibit the growth of bacteria and molds. For maximum antimicrobial effect, storage temperature of MAP should be kept as low as CO2 solubility decreases much with temperature rise. Thus, inappropriate temperature control will usually eliminate the beneficial effects of high CO2 content. The absorption of CO2 depends largely on the moisture and fat content of the product. If the food absorbs excess CO2, the total volume in the pack will be reduced, causing a depression in the packaging known as "collapse of the pack". Excess CO2 absorption can also reduce the ability to maintain water in the meat resulting in unsightly drops. Some dairy products (eg creams) are very sensitive to CO2 concentrations and will be affected if packed in MA with high CO2 levels. Fruits and vegetables can suffer physiological damage due to high, inadequate CO2 levels.

• Carbon monoxide (CO)
It has been found that CO is very effective in maintaining redness in fresh meat due to carboxyhemoglobin[1] formation. It is not, however, used for commercial purposes because carbon monoxide is a highly toxic gas and is not approved by regulators due to the possible danger to packing machine operators. However, its use is enshrined in the United States to prevent browning of packed lettuce. Carbon monoxide has a lower inhibitory effect than CO2 for microorganisms.

• Oxygen is highly reactive to foods, causing both oxidation of oils (grazing) and food for aerobic microorganisms; is usually excluded in food preservation. However, for certain foods, there is reason to keep an amount of oxygen in their packaging. Thus, one of the major functions of O2 in MAP meat is the maintenance of myoglobin[2] in its stable oxygenated form. This is the form responsible for the red color, which most consumers associate with fresh red meat[3]. A similar effect is also obtained when using NO.

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[1]Stable combination of carbon monoxide and hemoglobin, formed during carbon oxide poisoning.
[2]Myoglobin (abbreviated Mb) is a protein present in skeletal and cardiac muscle fibers, with a role in oxygen binding.
[3] http://www.unido.org/fileadmin/import/32124_23MODIFIEDATMOSPACKAGING.5.pdf

Argon (Ar) is inert, colorless, odorless and tasteless. Due to the similarity of its properties to nitrogen, argon can replace nitrogen in many applications. It is believed that certain enzymatic activities are inhibited and argon slows metabolic reactions to some types of vegetables. Due to the marginal effects and the higher price compared to nitrogen, its use is quite rare.

Hydrogen (H2) and helium (He) appear in modified atmospheres in some applications. However, these gases are not used to extend the shelf life. They are used as leak detection gases. The relatively small molecular size of the gas allows rapid evacuation through the packing leaks. Since these gases are expensive and not easy to handle, their use is rare. The most common method for leakage testing is CO2 detection, which is the basic component in many MAP processes.

If foods are packed in a protective atmosphere, they must be indicated on the label. In addition, in accordance with EU Regulation 95/2 / EC, the gases used should be listed with their corresponding E number. EU numbers for the most important gases are shown in table. A.1 in Annex 1.

11.2 Modified atmosphere

So, it is the practice of amending the composition of the interior atmosphere of a package (in the usual packaging of food, medicines, etc.) to increase the duration of their life.

Usually the process of change aims to decrease the amount of oxygen (O2), moving it from 20.9% in air, to 0%, to slow down the growth of aerobic organisms and prevent oxidation reactions. The removed oxygen can be replaced with nitrogen (N2), an inert gas or carbon dioxide (CO2), which can lower the pH or inhibit the growth of bacteria. Carbon monoxide can be used for preserving the red color of the meat[4].

This is the technique used mainly for meat, chicken, bakery and other similar products. However, MAP for fresh fruits and vegetables is a problem more laborious, to which, unlike those shown above, O2 must penetrate into the package and CO2 to get out of the packaging, because the appearance of "fresh" requires the process of "breathing" of fruits and vegetables. The reason is that horticultural products are living organisms and, therefore, continues to breathe even after harvest, to produce the energy for vital biological reactions.

MAP passive

As a result, when fresh fruits and vegetables are placed in the MAP, they naturally change the surrounding atmosphere, consuming O2 and producing CO2 MAP slows down the running processes of life, not by changing the product, but by adjusting his environment.

[4] https://en.wikipedia.org/wiki/Modified_atmosphere

Also, maintaining the concentration of ethylene at low levels is mandatory in order to prolong the shelf life of products sensitive to ethylene. For this purpose, for the reduction of ethylene production of food, they use, in general, the atmosphere not containing O2 and / or rich in CO2.

MAP active

The concept of MAP active (which uses active materials and articles), has been developed to address the shortcomings of the MAP passive. For example, when a film is a good barrier to moisture, but not oxygen, the film can still be used together with an oxygen absorber to exclude oxygen from the pack. In a similar way, absorbers / emitters of carbon dioxide, the emitters of ethanol and absorbers of ethylene can be used to control the levels of oxygen inside the MAP. Absorbent materials suitable are placed alongside the food.

Through their work, they change the atmosphere of the free space of the pack and thus contribute to the extension of the duration of validity of the content. Thus, the system MAP is an active system in which breathing of the product packed and the passage of the gas through the wrapping film takes place simultaneously. Therefore, the oxygen consumed during respiration is replaced simultaneously by the entrance of oxygen. Also, an equal amount of carbon dioxide that is produced by the packaged product is removed from the packaging. As a result, the composition of the air remains constant. This condition is known as steady state. In fig 1 shows a package MAP and the exchange of substances with the exterior.

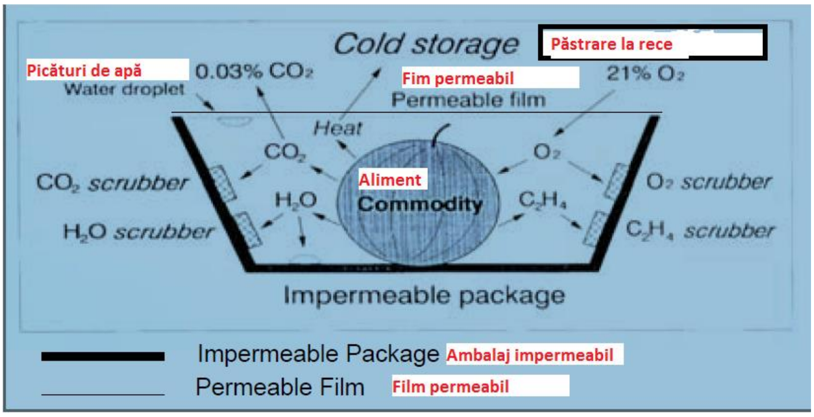

Fig 1. MAP[5] Pack

- Scruber

In short the reasons that preceded the MAP are presented in Tab. 1.

[5] After: Amita Venkatesh, MODIFIED ATMOSPHERE PACKAGING (MAP), (The Half Guide), www.packagingconnections.com

Tab. 1 MAP Considerations

Lower O2 concentrations	To reduce Respiration Rate
Increase CO2 concentration	To prevent microbial growth
Maintain high RH	To avoid dehydration

11.3 The advantages and disadvantages of MAP[6]

Advantages:

• Longer duration of storage / higher quality- Food products packaged under a protective atmosphere degrade much more slowly. In combination with the continuous cooling, the MAP can significantly extend the freshness and shelf-life. As such, this packaged food retains vitamin content, appearance and fat content. These effects vary depending on the type of product. However, it is usually possible a doubling of the period of validity. Normally, MAP products maintains a high quality over a long period of time and reach the consumer in the best possible condition.

• Less waste- Longer durability leads to fewer issues during the shipment to long distances and a longer duration of storage. Accordingly, the elimination of waste due to food damaged is reduced.

• More sales opportunities- Due to the longer duration of storage, using the MAP, open new markets for producers. Perishable goods, can be transported over longer distances.

• Fewer preservatives- Packaging under protective atmosphere extended the shelf life of food products, which means that, in many cases, the use of preservatives can be reduced or even completely eliminated. Thus, consumers obtain products that do not contain artificial additives.

• The design of attractive packages - Besides the functional aspects, the design of the packaging plays a significant role in the competition for consumers. The look and feel of quality influence purchasing behaviour. The MAP is very appropriate for the design and presentation of the most attractive packaging and for the presentation of the food product.

Disadvantages

• High complexity- The process MAP involves requirements relatively high. Possible failures: the composition of the incorrect gas or leaks caused by the distribution of the defective temperature or pressure, contaminated instruments or waste, contamination of the closure materials or imperfect. However, with the technology MAP modern and with quality assurance, the risks can be mastered.

[6] http://www.wittgas.com/consulting-service/white-papers/modified-atmosphere-packaging.html

• Relatively high Cost- In addition to the films of high quality, gas consumption and staff costs for quality control are particularly expensive.

• Influence on the quality of the product- Unlike the use of preservatives, in most cases, the gas of protection are not absorbed by food and thus does not change the nature or taste of the product. But there are exceptions to this rule. For example, a concentration of excessive CO2 may be absorbed from the food and makes them to be more acidic (sour). These effects can be avoided with gas mixtures suitable. The influence of very large of oxygen on meat quality is controversial.

11.4 Gas mixtures

There are three types of gas mixtures used in packaging with a modified atmosphere[7]:

1) inert Gases (N2, Ar)

2) semi - reactive gas Mixtures (CO2 / N2 or O2 / CO2 / N2)

3) reactive gas Mixtures (CO2 or CO2 / O2)

In figure 1, we present some applications of the gas mixtures, and in annex 1, Tab. A1 are presented the recommended mixtures for more food product.

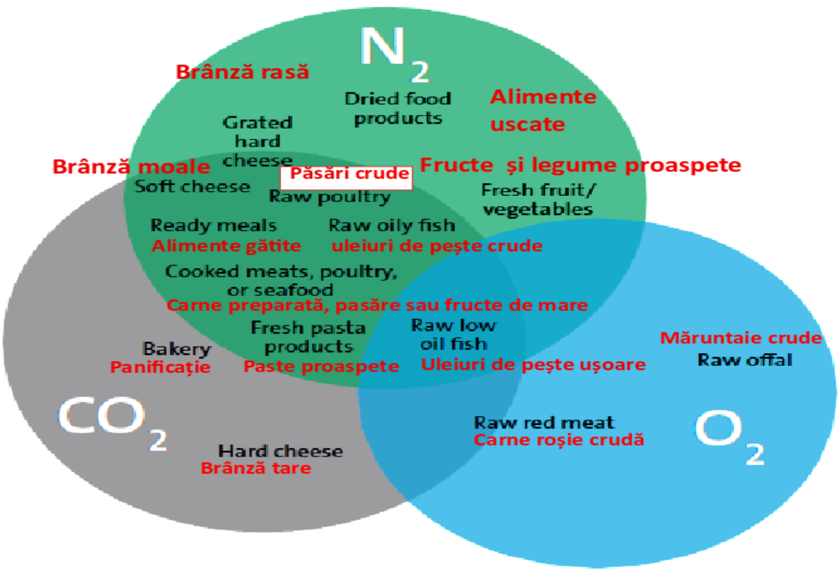

Fig.2 Some applications of gas mixtures

The tab.2 shows the estimates life span increase of certain foods for the use of the MAP[8].

Tab. 2 Extension of shelf life using MAP/ Creșterea duratei de viață la folosirea MAP

[7] Goodburn, K.E., and Halligan, A.C., 1988. Modified Atmosphere Packaging: A Technology Guide, Leatherhead Food RA

[8] http://ftp.feq.ufu.br/Luis_Claudio/Books/EBooks/Food/FOOD_PROCESSING_TECHNOLOGY/35334_20.pdf

Product / Aliment	Shelf life (days) / Durata de viață (zile)	
	Air	MAP
Beef /Vită (a)	4	12
Bread/ Pâine (b)	7	21
Cake/Prăjituri (b)	14	180
Chicken/Carne de pasăre (a)	6	18
Coffee / Cafea (b)	3	548
Cooked meat / Carne gătită (a)	7	28
Fish/Pește (a)	2	10
Fresh pasta/Paste proaspete (a)	2	28
Fresh pizza/ Piza proaspătă (a)	6	21
Pork / Carne de porc (a)	4	9
Sandwiches /Sandvici-uri (a)	2	21

a Refrigerated storage / Stocare prin congelare
b Ambient storage. / Stocare în mediul ambiant

11.5 MAP Materials

The main characteristics that must be taken into account in the selection of materials for the MAP:

1) Resistance to puncture
2) Tightness reliability
3) Anti – fogging properties
4) Carbon dioxide permeability
5) Oxygen Permeability
6) Rate of water transmission

Although a large variety of packing materials is available for the MAP, most packs are still made from the four polymer base: polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP) and polyethylene (PE).

The rate of oxygen transmission, also referred to as "OTR", is the constant rate at which oxygen can permeate through a film. OTR is expressed as a volume of oxygen that penetrates a certain area in a period of a day; cc / m2 / 24 hours ... or ... cc / 100 in2 / 24 hours, measured at a standard temperature of 23 ° C and a relative humidity of 0% (RH). Testing for OTR is done in dry conditions, it is important to shown that the relative high humidity (RH) can have a major impact on the barrier properties of the certain films. The OTR of the EVOH, for example, increases dramatically when the RH exceeds 75%.

The transmission rate of water vapor (**Water Vapor Transmission Rate - WVTR**) measures the transmission of water vapour through a material. WVTR is measured either in grams / 100 in2 / 24 hours, either in grams / m time of 24 hours (according to the standard ASTM - E398).A critical function of flexible packaging is keeping dry products dry and preserve wet food wet. Without packaging protection, products will quickly gain or lose moisture until they are in equilibrium with the relative humidity of the environment. WVTR is the measurement standard by which films are compared for their ability to resist the transmission of moisture. The lower values indicate a better protection to moisture. Only the values reported at the same temperature and humidity can be compared, since the rates of transmission are affected by both parameters.

In Annex 1, tab. A. 3 values of the estimated classification of the barrier to O2 and to water of the polymers are given, and in tab. A. 4 we give some values of OTR and WVTR for the usual polymers.

The permeability of CO2 should be 3 to 5 times the permeability of O2. Many polymers used to fabricate MAP films are located in this area. (Annex 1,table A. 5.). The permeability of polymers to gases is CO2> O2> N2, and the reports the CO2 / O2 and O2 / N2 are usually approx. 5. So, it is often possible to estimate the permeability of the material to CO2 or N2 when it is known the permeability to O2. A few of the polymers most used in the MAP[9]:

Ethylene vinyl alcohol (EVOH)

Polyvinyl alcohol (PVOH) is an excellent gas barrier, with the condition to be dry. In the presence of moisture, PVOH absorbs water, causing swelling and becoming plasticized. In this state, the barrier properties to gases of PVOH are reduced. In order to ensure a higher stability of the polymer in commercial purposes, PVOH is copolimerizat with ethylene to produce EVOH. Regarding the barrier gas properties of EVOH are lower than those of PVOH when they are dry, but the EVOH is less sensitive to the presence of moisture and, therefore, it is widely used as a barrier layer to gas in the MAP apps. EVOH has good properties of mechanical strength to oils and and organic solvents.

Polyamides (nylon)

Nylon is, in general, sensitive to moisture (hydrophilic) and absorbs water from its environment. The humidity in the structure of naylon interferes with the polymer chain and adversely affect the properties, including barrier to the gas. In conditions of high relative humidity, the rate of transmission of the gas from the films of nylon, increases generaly. However, there is commercial nylon which is less affected by humidity. The strength and hardness, relatively high, make it ideal for vacuum bags for fresh meat, where bones can puncture other plastic materials. In this application, nylon is generally laminated with PE, which ensures the properties of tight hot pasting.

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[9] RICHARD COLES, DEREK MCDOWELL, MARK J. KIRWAN FOOD PACKAGING TECHNOLOGY, Blackwell Publishing Ltd, 2003

Polyethylene terephthalate (PET)

PET is the most common polyester used in the packaging of the products supply. PET is a good barrier to gas and water vapor, is durable, offers good clarity and is resistant to temperature. PET crystalline (CPET) is weaker on the optical properties, but has a improved heat resistance, melts at more than 270 ° C. Film, flexible PET film is used for bags of the barrier and for the caps of the cover for the packaging tray type. CPET is used for double pre-formed trays for microwave ovens and ovens with convection for food.

A few other examples of materials used for MAP are shown in Annex 1, Tab A. 6.

Polyethylene (PP) and **Polystyrene PS**

Polypropylene is a versatile polymer that has applications to flexible structures, rigid and semi-rigid. MAP Applications are in general the rigid trays. PP is a good barrier for water vapor, but a poor barrier to gas. Increasing the thickness of the material compensates somewhat the rate of the high gas transmission. PP melts at approximately 170 ° C. therefore, it can be used as container for food products with low fat content in microwave ovens.

Foam PP and also PS foam and PVC are used to ensure the structural properties in laminates for MAP in the case in which they are combined with a EVOH barrier and PE as sealing layer by hot pasting.

Fig. 3 Cling films

Commercial use of MAP:

- Oriented polypropylene Films (OPP);
- Bags (made of several layers of metallised plastic) in cardboard box or boxes made of cardboard laminated with foil;
- Films of tight closure (cling films) see fig 2;
- Films that react to temperature;
- Micro-perforated film;
- Active embedded clay films (a variety of aluminium silicates in the form of fine powder);
- PLA films (lactic acid).

11.6 Technologies for MAP

There are two different techniques for air removal from the packaging:
1) gases washing
2) compensated vacuum

In **the gases washing process**, air removal inside of the MAP is carried out through a continuous gas current. This gas flow dilutes the air in the atmosphere surrounding the food product. The packaging is then sealed. Because the air replacement inside the packaging is carried out by dilution, there is a limit of unit efficiency. The typical levels of residual oxygen in the gas washed packaging are 2-5% O_2.

As a result, if the food product to be packed is very sensitive to oxygen, the washing technique of the gas is not normally suitable.

The washing technique big advantage of the gas is the process speed. Because the action is continuous, the process speed can be very high.

Offset vacuum technology removes the air from the inside, by causing a depression of the atmosphere inside the packaging and then the packaging filling with wanted gas mixture with the help of this depression. Because the air replacement is achieved

in two steps, the operation speed of the equipment is slower than the one given of the washing technology of the gas. However, because the air is removed by vacuum and is not simply diluted, the technology efficiency related to the residual air level is better. Therefore, if the food product is extremely sensitive to oxygen, an offset vacuum machine have to be used.

Sealing. An efficient sealing by hot gluing is essential to maintain the quality and safety of the packed products. The film characteristics (thickness and surface treatments) and the plastic composition (the resin type, the molecular weight distribution and the additives presence) determine the machine settings for the sealing operation. The correct combination of time, temperature and pressure parameters of the closure is essential to produce a good seal.

11.6.1 Packaging machines with modified atmosphere

– Packaging machines by thermoforming[10] (see also Cap. 8, section 8.3.2).

The base thermoforming process (Non-MAP) includes three steps: 1 - the plastic sheet is heated. 2 - the plastic sheet is formed. 3 - the shapes are cut out. The machines

[10] WITT prospect, Modified Atmosphere Packaging (MAP) in the food industry - LMMappe_UK_30722

are generally integrated into production lines that perform other operations, such as automatic filling, compensated vacuum, sealing, the labeling on the lid, the base labeling, the registration of the printed top page.

The packaging lines with one or multiple steps touch 4 to 20 races per minute depending on the packaging and product size. The typical application for the gas mixture is about 20-100 slm[11], and is also dependent on the packaging size and the races number. The larger systems operate with capacities of gases up to 200 slm. In annex 2, fig.A2.1 and A2.5 are shown two examples of such machines, with details.

– Machines with vacuum chamber

These machines use preformed trays and it uses the compensated vacuum technique to replace the air. In the machine of fig.3, the preformed plastic trays are manually inserted into the chamber before air evacuation and then to the washing with the desired gas mixture and the hot sealing. These machines can be used for the small-scale production of vacuum kitchen packaging or MAP packaging.

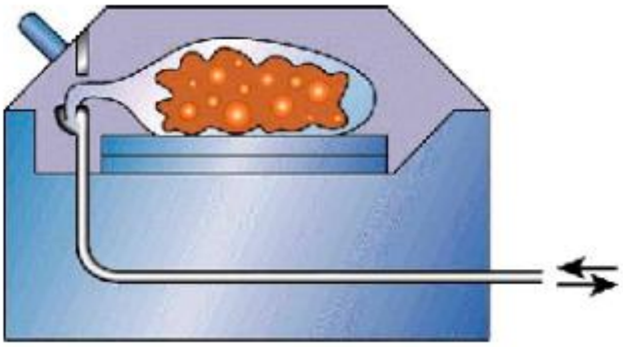


Fig.3 The machine scheme with vacuum chamber[12]

Fig. 4 Products made with VFFS

–**The forming, filling and closing machines with gas washing (** form, fill, seal machine, or the FFS machine) .

It can be vertical (VFFS) or horizontal (HFFS). (See also unit 8, paragraph 8.3.1 and the annex 1.5)

VFFS machines[13] carried out a wide range of products which can be divided into four main groups: - bulk goods, which ranges from nuts and cakes to the screws and bolts, - powder, ex. ground coffee and dehydrated milk, -granules, ex.detergents; - liquids: ex. ketchup, mayonnaise, salad dressing or bath gel.

[11] slm – standard litres per minute
[12] WITT prospect, Modified Atmosphere Packaging (MAP) in the food industry - LMMappe_UK_30722
[13] www.boschpackaging.com, Guide to Vertical Form-Fill-Seal Baggers

They are capable to produce of the order of 120 packages per minute (depending on pack size). Unlike thermoforming , the air is not initially evacuated, but is constantly washed with the gas mixture before sealing. The atmosphere in the packaging is replaced by tubes. The gas mixture consumption in this case is much higher than for discharged packaging because a part of the gas mixture is lost. The gas mixture consumption for a standard shape of this machine is of 30-300 slm. A such machine is shown in fig A2.6, and A2.7.

The bags production- Theoretically, all the vertical packaging machines work in the same way. A plan film layer derived from a big film roll at the entrance to the machine is formed into a tube. This tube is closed at the bottom: this is the lower part of the new bag. After the product is distributed in the bag, the upper side is also closed.

The gas tube- Gas is introduced into the bag through a gas tube which is mounted in the forming tube and it is connected to a gas tank or to a gas mixer (see fig. A. 2.8). A flowmeter regulates the pumped gas amount in the packaging. The diameter and the shape (round, rectangular or oval) of the gas tube depend on the desired gas amount and the space that the forming tube provides. The gas tube has to be embedded without disrupting the process flow.

Tab A. 1 Food Gases approved by the UE for MAP

E-no. /Nr.UE	Gas	Name
E 290	Carbon dioxide	Gourmet C
E 938	Argon	Gourmet A
E 939	Helium	Gourmet He
E 941	Nitrogen	Gourmet N
E 942	Nitrous oxide	Gourmet L
E 948	Oxygen	Gourmet O
E 949	Hydrogen	Gourmet H
E941/E290	70% Nitrogen 30% Carbon dioxide	Gourmet N70
E941/E290	50% Nitrogen 50% Carbon dioxide	Gourmet N50
E948/E290	70% Oxygen 30% Carbon dioxide	Gourmet O70

Tab A.2 Recommended gas mixtures of MAP[1] (Parry, 1993)

Product	**% Oxygen**	**%Carbon dioxide**	**%Nitrogen**
Red meat	60-85	15-40	-
Cooked/cured meats	-	20-35	65-80
Poultry	-	25	75
Fish (white)	30	40	30
Fish (oily)	-	60	40
Salmon	20	60	20
Hard cheese	-	100	-
Soft cheese	-	30	70
Bread	-	60-70	30-40
Non-dairy cakes	-	60	40
Dairy cakes, Pasta (fresh)	-	-	100
Fruits and vegetables	--3-5 -	--3-5 -	85
Dried/roasted foods	-	-	100

[11] Parry, R.T., 1993. Principles and Applications of Modified Atmosphere Packaging of Food, ed. by R.T. Parry, pp. 1-18, Glasgow, UK, Blackie.

Tab. A.3 Classification of the barrier to O_2 and to water of the polymers[2]

Barrier Classification	Oxygen ASTM D3985	Moisture ASTM F1249
Low	> 100 cm3/m2/24 hr	> 100g/m2/24 hr
Medium	6-100 cm3/m2/24 hr	6-100g/m2/24 hr
High	1-5 cm3/m2/24 hr	1-5g/m2/24 hr
Very High	< 1 cm3/m2/24 hr	1g/m2/24 hr <

Tab A.4 Typical values for OTR and WVTR

Source: Jonathan Flowe, Barrier films for packaging, Pira International Ltd, 2005.

OTRS of Bulk materials

Film type		**OTR 73°f (23°C), 0%. RH [CC/100 in 2/day]**	**CC/m2/day**
EVOH (ethylene vinyl alcohol)	Good barrier	0.005-0.12	008-1.9
Biax nylon-6 / nylon-6 biaxial		1.2-2.5	18.6-39
OPET (oriented polyester)		2.0-6.0	31-93
BOPP[3]/ PP biaxial		100-160	1,550-2,500
Cast pp / PP turnată		150-200	2,300-3,100
HDPE (high-density polyethylene)		150-200	2,300-3,100
OPS (oriented polystyrene)		280-400	4,350-6.200
LDPE (low-density polyethylene)	poor barrier	450-550	7.000-8,500

[2] Yahya Ibrahiem Mohamed Khalifa. "Effect of the Printing Remedies and Lamination Techniques on Barrier Properties "WVTR and OTR Value" for Polypropylene Film". *EC Nutrition* 5.2 (2016): 1089-1099.
[3] Biaxially oriented polypropylene

Typical WVTR barrier values

Film type		WYTR.100°(30°C),), 90%. RH G/100 in 2/day	g/m2/day
Biaxial-Oriented PP	Good (BUN) WYTR	0.25-0.40	3.9-6.2
HDPE		0.3-0.5	4.7-7.8
Cast pp		0.6-0.7	9.3-11.0
Biax PET		1.0-1.3	16-23
LDPE		1.0-1.5	16-23
EVOH		1.4-8.0	22-124
OPS		7.0-10.0	109-155
Biax NYLON-6	Poor (SLAB) WYTR	10.0-13.0	155-202

Tab. A.5 Permeability values and the ratio CO_2/O_2 [4]

Film type	Permeabilities (cc/m2/mil/dia a 1 atm)		
	CO2	O2	CO2:O2 ratio
Polyester	180-390	52-130	3.0-3.5
Polyethylene, low density /LDPE	7,700-77,000	3,900-13,000	2.0-5.9
Polypropylene	7,700-21,000	1,300-6,400	3.3-5.9
Polystyrene	10,000-26,000	2,600-7,700	3.4-3.8
Polyvinyl chloride / PVC	4,263-8,138	620-2,248	3.6-6.9

[4] Leonora M. Mattos, Celso L. Moretti and Marcos D. Ferreira, Modified Atmosphere Packaging for Perishable Plant Products

Tab A.6 Examples of materials used for MAP

MAP MATERIALS			
Material	**Properties**	**Structures**	**Uses**
Polyolefins/Poliolefine			
LDPE	Low WVTR, High OTR	Laminated, extrusion coated, co – extrusion	Lidding, Base Webs, Trays
LLDPE	Good impact , tear, tensile, puncture	Laminated, extrusion coated, Co – extrusion	Lidding, Base web
HDPE	Superior barrier properties than above	Co – extrusion	Lidding
OPP	Low WVTR, Low OTR	Co – extrusion	Lidding
COPP	Low WVTR, Low OTR	Laminated, co extusion, perforated	Lidding,breathable films
Inomers	High Tack, similar to LDPE	Co – extrusion	Lidding
Vinyl Polymer			
EVA	High WVTR& OTR (higher than LDPE)	Laminates, extrusion coated, Co – extrusion	Lidding,Base Webs, trays
PVC	Good gas barrier, moderate O2 barrier	Milled and calendared	Thermoformed trays
PVdC	Excellent barrier properties	Extrusion coated, Co – extrusion	Lidding
EVOH	Very high gas barrier, sensitive to moisture	Co – extrusion, laminates	Base webs, lidding
Styrene HIPS (a)	High tensile, low barrier prop.	Laminate, Co -extrusion	Thermoformed Trays
Polyamide Nylon - 6	Good barrier	Laminates, extrusion coated	Lidding
Polyesters PET	High clarity	Lamintes,sheet	Lidding, Therformed trays (APET - PET amorf)
Others PC, ABS (Acrylonitrile butadiene styrene)/altele Policarbonați, ABS		Films	Thermoformed Trays
(a) HIPS HIPS, High Impact Polystyrene. HIPS is a low cost plastic material, easily manufactured and processed on the machines. HIPS is often specific in low resistance structures when the impact resistance, workability and low costs are required.			

Thermoformed membrane

- -200μ UPVC/70μ LDPE
- -400μ UPVC/100μ LDPE
- -650μ UPVC/100μ LDPE
- -400μ APET/100μ LDPE
- -300μ Barex[5]/100μ LDPE

Additionally, there are some PS / EVOH / LDPE specifications and lower APET / EVOH / PE percent.

Laminate seal closing

-15μ polyester-PVdC/60μ LDPE/ covered

-12μ polyester-PVdC/ PE co-extruded -15μ PA targeted(nylon) / 60μ LDPE -21μ covered co-extruded PP/50μ LDPE

[5] The trade name Barex® covers a barrier polymer group consisting of 75% acrylonitrile and 25% methyl acrylate. Barex 210, mainly used for film production, is a butadiene-modified copolymer. The DIN / ISO / ASTM abbreviation is AMAB for methyl-butadiene acrylonitrile-acrylat.

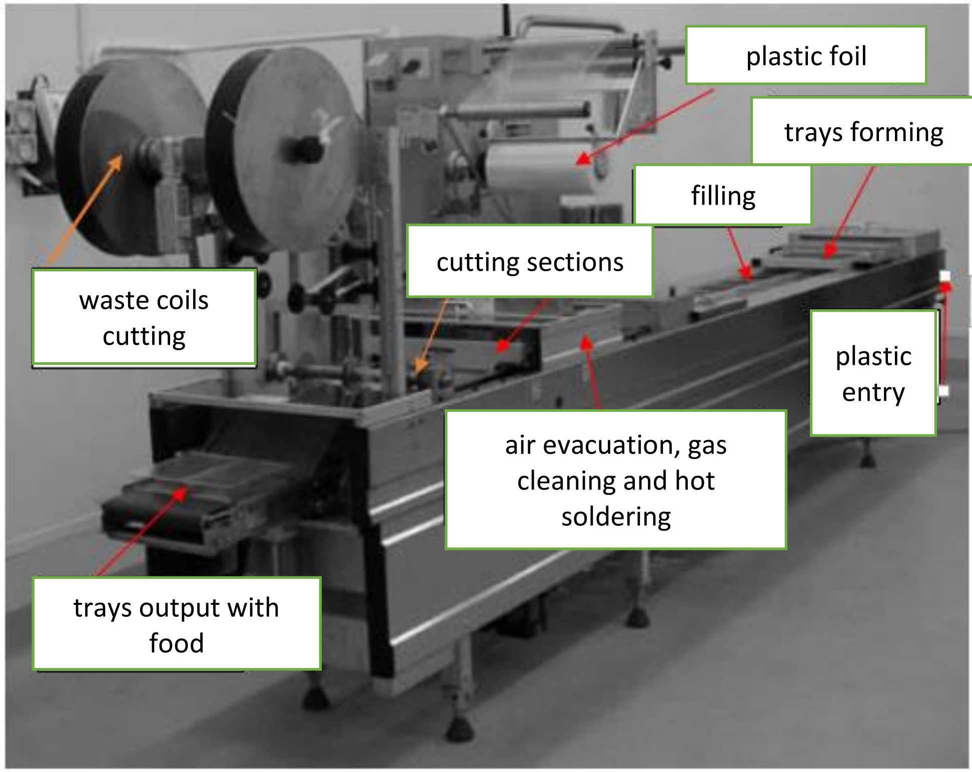


Fig A2.1 Thermoforming machine[1] *(Multivac R230 thermoform fill seal machine)*

Fig A2.2 Plastic entry detail

[1] RICHARD COLES, DEREK MCDOWELL, MARK J. KIRWAN FOOD PACKAGING TECHNOLOGY, Blackwell Publishing Ltd, 2003

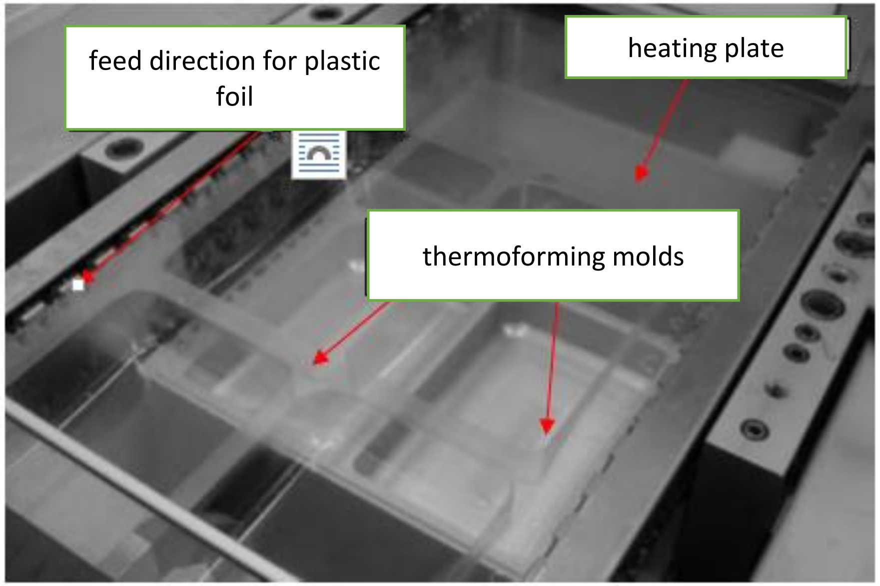


Fig A 2.3 Trays thermoforming detail

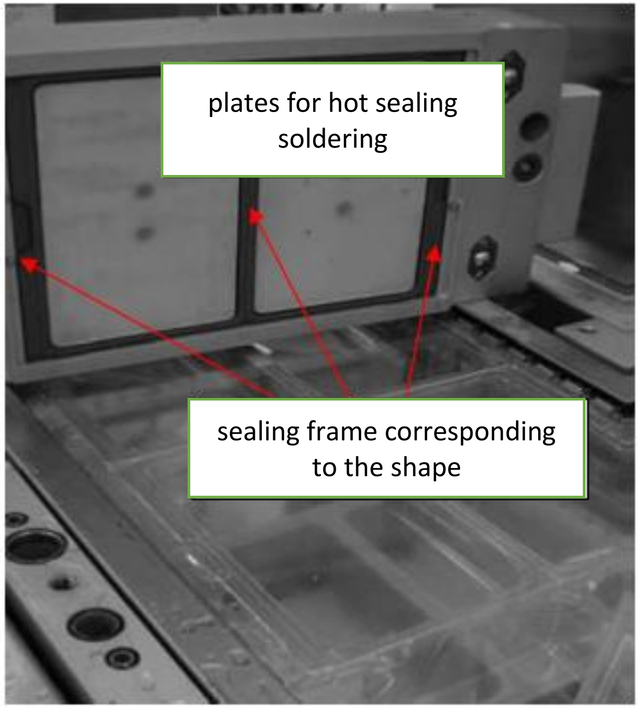


Fig A2.4 Heat sealing adhesive frame detail

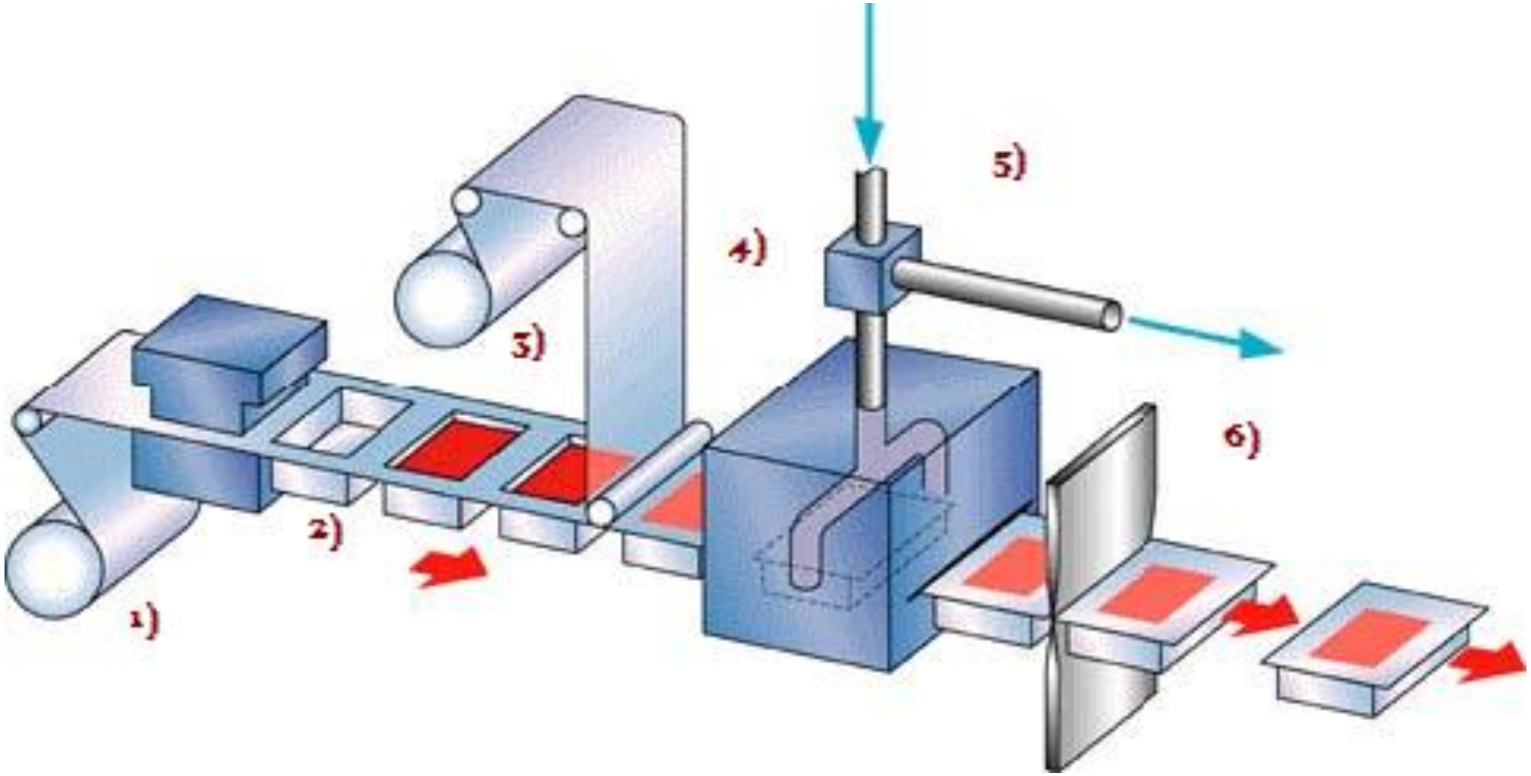
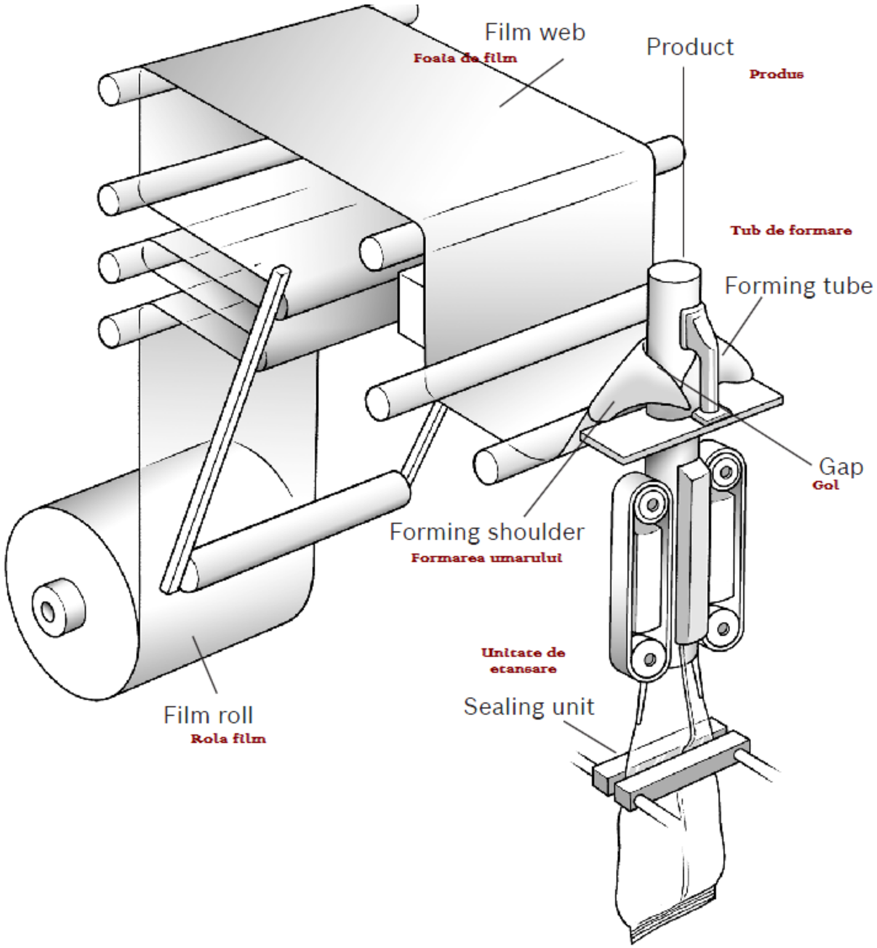


Fig A2.5[2] The scheme of thermoforming packaging machine, with compensated vacuum, fed from two film coils.
A inner thermoformable film (1) is formed in a mould (2). The food product is placed in this tray and it is covered by a top film (3). A vacuum is created (5) in tray and due to him the gas mixture enter (even before the top film is closed by hot soldering).

2 WITT prospect, Modified Atmosphere Packaging (MAP) in the food industry - LMMappe_UK_30722



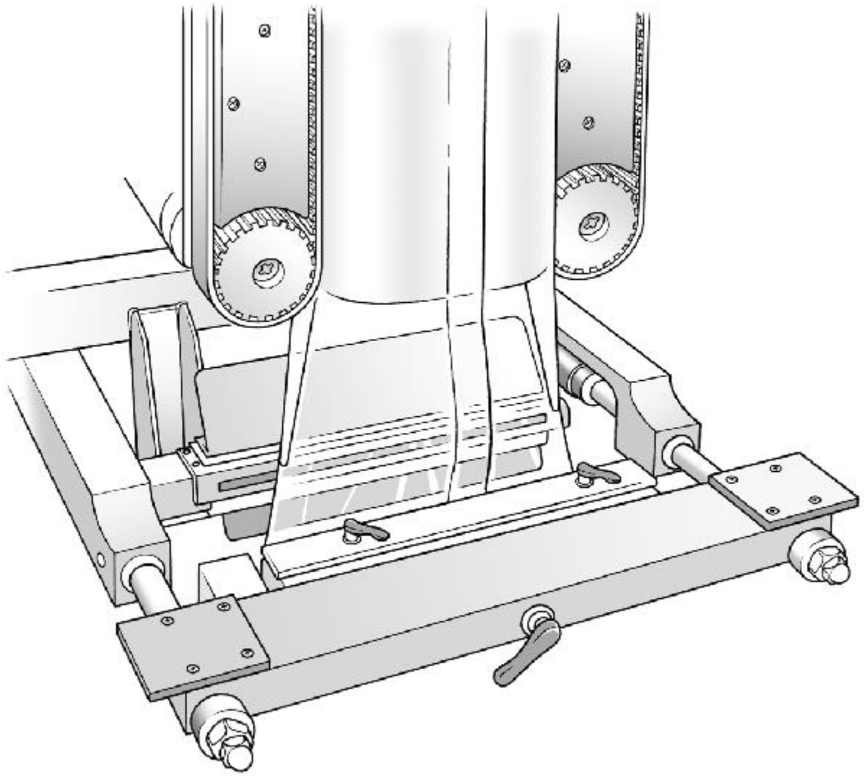


Fig A2.6 VFFS machine

Fig A2.7 Bottom, top and cutting part

The seal unit, at the base of forming tube contains four sealing bars. The two lower sealing jaws form the upper stitch of the bag that has just been filled. At the same time, the two upper jaws are closer deforming the tube from the lowerstitch of the bag next. The blade that cuts and separates the both bags is located between the two sets of sealing jaws. The film material is compressed together and heated by the sealing jaws.

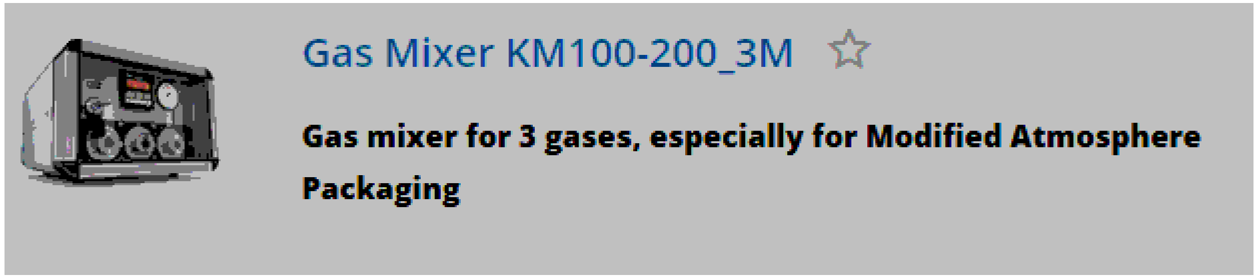


Fig A 2.8. Gas mixer WITT for 3 gases for MAP[3]

Advantages for gas mixer:
· Flexible - Any gas mixture can be obtained with gas mixers in the corresponding location.
· Low installation costs;
· Specific samples of the product can be carried out inside the company;
· Savings of gas costs;
· A mixer instead of multiple bottles, different for pre – mixing;
· The need for the bottles handling disappears.

[3] http://www.wittgas.com/products/gas-mixers/food-technology.html