SHRINK PACKAGING AND STRETCH WRAPPING

Among the specialised plastic packaging systems, shrink packaging or commonly known as shrink wrapping and stretch wrapping are very common and widely used. Though there are some apparent similarities in the two systems, in overall analysis, they are considered to be totally different in terms of material and operation.

In the case of shrink wrapping, shrink film is used as the basic material and heat forms an important part of the operation, whereas, in the case of stretch wrapping, stretch film is used as the basic material and no heat is applied during the operation. Shrink Wrapping is done in 3 or 4 stages, namely:

- wrapping (sleeve wrapping or over-wrapping)
- sealing (necessary only for over-wrapping)
- shrinking (with application of hot air), and
- cooling

Shrink Pack

Stretch wrapping is done only in two stages, namely, wrapping and sealing (most of the time even without a sealer).

However, in many packaging applications, both the systems are considered as alternative to each other. These systems are mainly used for unitisation, but sometime they are also being used as primary packaging system. Both the systems are used for bulk packaging as well as retail packaging.

In fact, both the systems are now being used for some major applications like sleeving for labelling on various containers or sealing, besides wrapping.

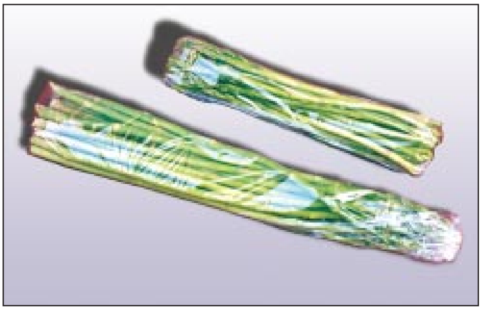
For both the packaging systems, material plays an important role, because without the correct material, proper shrink or stretch wrapping may not be possible. It is therefore, absolutely essential for anyone involved with the subject to either learn about the technical specification of the materials or work very closely with the material supplier, preferably both.

Plastics used for Shrink / Stretch Wrapping

Shrink and stretch wrapping can be quite complex in their structure. Most of the packaging films that are used for shrink and stretch wrapping are from the polyolefin range. These are materials produced from oil based chemicals by what is called a polymerization process, which basically means getting the right molecules and atoms to club together in a way that is required or desirable for a particular application. The most common plastic materials are polyethylene, polypropylene and poly vinyl chloride.

Polypropylene is comparatively less used in shrink and stretch wrapping, because it is slightly harder than the other commonly used materials. It has a higher melting temperature and is less stable when shrinking. However, many over-wrapping machines use polypropylene and some can be put through a shrink tunnel to give a slight tightening effect.

PVC is a dense material. As most polymers are sold by weight and there has been ecological pressure in Europe and America against its use, sometime use of PVC is restricted. However, it is still considered to be a common material in India, when clarity is an important selection criterion, particularly for consumer packaging.



Fresh Asparagus - Stretch Wrapped

Polyethylene is the most commonly used material for shrink and stretch wrapping because it is relatively cheap and can be produced in a range of different densities and modified with additives to perform many functions.

The vast majority of shrink film is LDPE and some of the more sophisticated films have blends of LLDPE as well. Sometimes a little quantity of HDPE material is also added.

For selection of plastic material, besides type of plastics, the yield of the film is also important to be considered from the economy point of view. The yield means the area obtained or number of square meters of film converted from a kilogram of material of a given thickness or gauge.

The gauge may be expressed in micron (0.001 mm), mil (an American terms for thousandths of an inch i.e. 0.001 inch) or simply gauge, which is the old British system where 100 gauge equals one thousandth of an inch. The co-relation of both the systems of measurement of thickness is 25 micron (or 0.025 mm) equals 100 gauge (or 0.001 inch).

For shrink film, the next important factors considered are the shrinkage and the slip of the film. Shrinkage means the percentage shrink in the machine direction, i.e. along the reel of the film, and also in the transverse direction, i.e. across the reel of the film. The slip can be of different types – high, medium or low depending upon how much slippery property in the film is required from the operational point of view. Usually, low slip is desirable.

For shrink wrapping small packs at high speed, particularly for consumer products or display purposes, PVC or specially modified Polyolefin may be used. The "high shrink films" are crystal clear but generally expensive.

For stretch wrapping, majority of films are modified linear low density polyethylene (LLDPE), often three-layer extrusion with "tackifier" added to make them sticky on either one or both sides. Some PVC films are also used.

Plastic Films Used

In short, following plastics films are commonly used for shrink and stretch wrapping:

Polyethylene

- Used almost exclusively or as a combination of LDPE + co-polymers EVA (ethylene vinyl acetate) or EEA (ethylene ethyl acrylate).

  Copolymer Modification: LDPE is sometimes modified by addition of EVA and EEA (up to 8%). EVA is approved by US-FDA for direct contact with food. EEA is approved up to 7% for direct contact with food. However, Vinyl Acetate (VA) or Ethyl Acrylate (EA) content is normally restricted to 3-4%.

- Irradiated polyethylene film containing EVA, shrinks strongly in boiling water and is generally used for wrapping chickens.

- In the form of mono-layer or 3/5 multi-layer, 3 layer wide shrink films of HM-HDPE (rolls/bags), LLDPE (rolls), etc. are available for palletized goods; Diameter > 5m and Lay Flat Width (LFW) > 10m; Film shrinks in area and increases in thickness. This is usually used for protection of industrial products from dust, contamination, rain, etc. Heat required for shrinking PE film: about 200°C for 100g film and 300°C for 500g film.

PVC and PP

- Used for foodstuffs (e.g. meat and vegetables). Both are also used for non-food applications, where increased transparency and gloss justify the increased price in comparison with LDPE.

Manufacturing of Shrink Film

Almost all plastic films shrink to some extent. In most packaging applications, dimensional stability is desirable and shrinkage is considered to be detrimental. However, in some packaging application, controlled shrinkage is deliberately used for certain objectives to be fulfilled. For example, shrink film is used to pack products with a tight pilfer-proof wrap over carton and boxes, so as to utilize number of packs or items on pallet, etc. A variety of shrinkable films have been developed to meet the requirements of many different end-use applications.

Heat-shrinkable film is made by stretching or orienting a conventional film at a temperature close to its softening point (i.e. Tg) and then quenching or freezing the film in the oriented state. The film that undergoes a special stretching and cooling process, causes an orientation in the film and introduces frozen-in shrinkage stresses, which can be given hot air treatment or infra-red radiation.

Figure 1 shows a schematic representation of a single long-chain polymer molecule in the relaxed and considerably curled state that is characterised in an un-oriented film.

Figure 1: Polymer Molecule

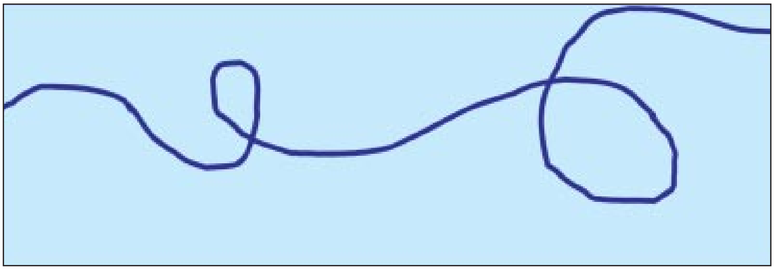
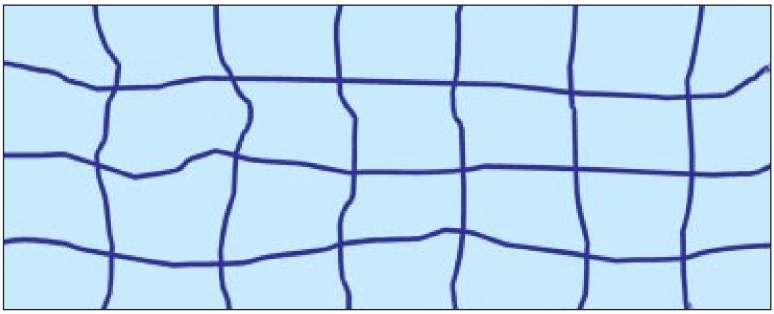


Figure 2: Polymer Molecules in Uni-axially Oriented Film



If the same film is stretched i.e. uni-axially oriented in one direction while it is heated, randomly twisted and intertwined molecules line up as shown in figure 2.

However, if the film is stretched not only in the machine direction, but also in the transverse direction, there will be some orientation of molecules at intermediate angles, but the majority will line up as depicted.

Generally, orientation is imparted by blown-film extrusion process or on tenter frames. When the film is quenched after orientation, the molecules are "frozen" in the oriented position, but they still 'remember' their original shape or regain their memory to return to that shape if the film is reheated or exposed to the orienting temperature. When this does happen, obviously the film shrinks around the product.

Stretch Film

Stretch film is defined as stretchable, elastic, continuous thin plastic film, which is stretched and wrapped around one or more items to protect them from the environment or unitize for handling, storage or shipping. Stretch film is also used to some extent for bundling smaller units and lumber. They are also used for super market tray wraps.

In general, stretch film means a collective name for all types of plastic films, which are wrapped round a package under some form of mechanical stretching. It is a film, which can be cold-stretched in longitudinal and transverse directions without application of heat and which when stretched round a pack maintains a tension for a long period. A strong degree of transverse orientation gives stretch film a good extensibility in longitudinal direction and an increased total strength.

Stretch films entered the market in the early 1970s as a replacement for shrink wrap, used to unitize non-returnable glass bottles, pet jars in a tray, etc. The most common type of stretch film is the 'cling' type which is easy to use since the wrapping is completed by cutting the film between the load and the film roll and merely wiping the loose tail of film against the load. The film to film adhesion i.e. cling, holds the tail in place. Other less common way of attaching the film tail are adhesives, heat sealing, mechanical fasteners and tying.

Shrink Pack of Glass Jars

Advantages and Disadvantages of Stretch Wrap

Advantages

Compared with shrink film and bags, stretch wrapping affords large energy saving and does not require the availability of fuel. Compared with shrink bags in particular, it simplifies inventory. Compared with strapping, stretch wrapping eliminates the need for corner boards and prevents cutting or crushing of the load, since the load-holding force is adjustable and distributed over the film width. Stretch wrapping offers better protection from hostile environments and clear, tinted, or opaque films are available for product identification or pilfer protection. Compared with both shrink films and strapping, stretch films are better suited to withstand shock and vibration owing to their elasticity and memory.

Disadvantages

Stretch wraps generally have less moisture resistance than shrink bags, but a top sheet can be dropped over the top of the load for added protection before stretch wrapping. The cling property that makes stretch wrapping possible, can also promote load-to-load sticking and abrasion. Stretch films cannot be used to compress a pallet load in the vertical direction since it has its primary holding force in the direction of wrap, i.e. horizontal.

Important Material Properties of Shrink / Stretch Film

Low Melt Flow Index (MFI) for PE film (e.g. 0.1 to 0.6) indicates high melt viscosity, which in turn depends upon the fact that the material is composed mainly of long-chain molecules i.e. has a higher molecular weight. Therefore, low MFI of LDPE gives a logical guarantee for high film strength, often a prime requirement for wrapping goods or pallet loads.

As MFI has direct relevance to orientation, stretch properties, strength, etc., shrink / stretch films are divided into 3 MFI classes:

- MFI < 0.6 : For heavy goods and pallet loads
- 0.6 < MFI < 1.0 : For lighter packages where high transparency is valued more than the maximum strength
- MFI > 1.0 : For applications, where strength is of minor importance; used for textiles and such products where a weak shrinkage force is desirable.

Table 1 gives the comparison of performance of various shrink films. The typical properties of the shrink films are given in Table 2.

TABLE 1

Performance Comparison of Shrink Films

Film Type	Advantage	Possible Problems
Polyethylene (low density)	1) Strong heat seals 2) Low temperature shrink 3) Medium shrink force for broad application 4) Lowest cost	1) Narrow shrink temperature range. 2) Low stiffness 3) Poor optical property 4) Sealing wire contamination
Polypropylene	1) Good optical appearance 2) High stiffness 3) High shrink force 4) No heat sealing fumes 5) Good durability	1) High shrink temperature 2) High shrink force, not suitable for delicate or fragile product. 3) Brittle seals 4) High sealing temperature
Co-polymers	1) Strong heat seals 2) Good optical appearance 3) High shrink force 4) No heat sealing vapours	1) High shrink force, not suitable for fragile products 2) Higher shrink temperature 3) Higher heat seal temperature 4) Lower film slip-may give machine problems
Poly Vinyl Chloride	1) Lowest shrink temperature 2) Wide shrink temperature range 3) Excellent optical appearance 4) Controlled stiffness by plasticizer content control 5) Lowest shrink force for wrapping fragile products	1) Weakest heat seals 2) Least durable after plasticizer loss 3) Toxic and corrosive gas emission from heat sealing, therefore good ventilation required 4) Durability problem at low temperature 5) Low shrink force inhibits use as a multiple –unit bundling film 6) Low film slip causes machine wrapping difficulties
Multilayer Co-extrusion	1) Excellent optical appearance 2) Good machineability 3) Low shrink temperature	1) In co-extruded films, one ply compensates for the deficiencies of the other. As a result, they are superior films with no significant performance shortcomings. 2) The wide variability in layer composition and number of layer makes performance analysis difficult.

TABLE 2

Typical Shrink Film Properties

Film Type	Tensile Strength psi (mpa)	Elongation (%)	Tear Strength gf / mil (m N / m)	Maximum shrink (%)	Shrink Tension psi (MPa)	Film shrink temperature range °F(°C)
Polyethylene (low density)	9000 (62)	120	8 (3.1)	80	250 - 400 (1.7-2.8)	150 - 250 (65 -120)
Polyethylene (low density irradiated)	8000-13000 (55-90)	115	5-10 (1.9 - 3.9)	80	400 (2.8)	170 - 250 (75 - 120)
Polyethylene (copolymer)	19000 (131)	130	7 (2.7)	50	450 (3.1)	180 - 260 (85 -125)
Polypropylene	26000 (179)	50-100	5 (1.9)	80	600 (4.1)	250-330 (120-165)
Polyester	30000 (270)	130	10-60 (3.9-23.2)	55	700-1500 (4.8-10.3)	170-300 (75-150)
Poly Vinyl Chloride	9000-14000 (62-97)	140	Variable	60	150-300 (1-2.1)	150-300 (65-150)

Advantages of Polyolefin Film

Strength and Safety of Packs

- Durable and tear-resistant with tough seals
- Neither easily embrittles during packing and delivery nor discolours with ageing
- Strong and flexible packing that ensures tight pack even at refrigerator and freezer temperatures
- Excellent wrap around multipacks and uneven or irregularly shaped product
- Perfects shapes due to high shrinkage
- Ensures consistent and uniform seals

Shrink Wrapped Cartons with Tray

High Shelf Appeal

- High gloss and clarity of added pack value and visual appeal
- Provides tamper evidence and tamper resistance
- Excellent printability for added appeal

Increased Profit and Productivity

- Reduces packaging cost by as much as 50% or more
- Cheaper than other substitutes like carton and packaging (wrapping) paper
- Absence of acids, which corrode machine and sealing wire, thus saving on maintenance costs
- Ease of processing on manual, semi-automatic or automatic shrink-wrapping machine.

Environment Friendly and Safety to User

- Polyolefin films are free from toxic and odour during processing
- Approved for direct food contact by the USDA and FDA in United State of America, Canada and Europe

Comparison of Shrink Wrapping and Stretch Wrapping

Table 3 compares differences of Shrink Wrapping and Stretch Wrapping systems.

TABLE 3

Comparison of Shrink Wrapping and Stretch Wrapping

Shrink Wrapping	Stretch Wrapping
Equipment (heat shrink tunnel) are more expensive	Equipment (relatively simpler and smaller) are generally less expensive.
Sealing required, particularly for overwrapping.	Normally, no sealing is required.
More energy required: Orientation plus heat energy to shrink.	Less total energy - only stretching, but no heat.
May not be suitable for heat sensitive items.	Can even be used under cold conditions (refrigeration).
May distort under transit conditions.	Generally, retains load more tightly.
Wrapped items (two or more) may stick together.	Virtually, no film-to-film sticking.
Stick film takes up uneven contours more readily.	May create areas of higher tension due to irregular products.
Needs different film widths for a range of sizes.	Needs fewer reel widths for a range of sizes.
Can be printed using distortion printing where shrinkage is uniform and well controlled.	Easier to print as stretch is mainly in one direction.
Can provide better weather protection, particularly with a total over-wrap. Adds to general climatic protection.	Less protective, may not be totally waterproof. Lower climatic protection.
Uses generally more film (heavier gauges)	Uses less film

Differences in shrink and stretch wrap for tray packaging are compared in Table 4. Similarly shrink bags and shrink rolls for tray packaging are compared in Table 5.

TABLE 4

Comparison of Stretch Wrap and Shrink Wrap for Tray Packaging

Parameter	Stretch Wrap	Shrink Wrap
Process	Not easy to pack tray by stretch wrapping	It is easy to pack tray by shrink wrapping
Cost	Slight higher than shrink wrap	Less than stretch and CFB box packaging
Machines	No machine for the tray packing	Semi Automatic or Automatic L-sealer with shrink tunnel
Time Required	More time required	Less time required than other process
Manpower	More manpower required	Less manpower required
Production	More production as compared with the other.	Less production as compared with the other.

TABLE 5

Comparison of Shrink Bag (Pouch) and Shrink Roll for Tray Packaging

Parameter	Shrink Bag Pouch	Shrink Roll
Speed of process	Slow speed of operation	Speed of operation is very fast
Steps involved	Steps involved in operation are more	Steps involved in operation are less
Cost of packing	Cost of packing is more	Cost of packing is less
Material required	More material will be used	Less material will be used
Finish of packing	Finish is not uniform	Finish will be uniform and much better
Manpower required	More manpower required	Less manpower required

Cost comparison of various systems of Stretch and Shrink Wrapping with CFB box packaging is given in Table 6.

TABLE 6
Example of Cost Comparison of Three Alternatives for Packaging of Jars

CFB Box Packaging

Item (Lt. Jar)	No. of Jars	Rate of Paper (Rs./kg)	Cost of CFB (Rs.)	Rate of BOPP Tape (Rs./65 mtr.)	Costing of Tape/ CFB (Rs.)	Total Cost (Rs.)	Cost/Jar (Rs.)
1.75	16	13.5	19.27	32	0.52	19.79	1.23
1.5	16	13.5	15.27	32	0.59	15.86	0.99
2.1	16	13.5	23.24	32	0.67	23.91	1.49

Shrink Wrap on Tray Packaging

Item (Lt. Jar)	No. of Jars per Tray	Cost of Tray (Rs.)		Cost of Shrink Film (Rs.)	Total Cost (Rs.)		Cost/Jar (Rs.)	
		With top	Without top		With top	Without top	With top	Without top
1.75	9	2.86	1.68	2.65	5.51	4.33	0.61	0.48
1.5	9	2.82	1.64	2.42	5.24	4.06	0.58	0.45
2.1	9	3.41	1.98	3.12	6.53	5.10	0.72	0.57

Stretch Wrap on Tray Packaging

Item (Lt. Jar)	No. of Jars per Tray	Wt. of Stretch Wrap (gms)	Rate (Rs./kg.)	Cost of Stretch Film (Rs.)	Cost of of tray (Rs.)		Total Cost (Rs.)		Cost/ Jar (Rs.)	
					With top	Without top	With top	Without top	With top	Without top
1.75	9	38.8	100	3.88	2.86	1.19	6.74	5.07	0.75	0.56
1.5	9	40.5	100	4.05	2.82	1.18	6.87	5.23	0.76	0.58
2.1	9	54.6	100	5.46	3.41	1.98	8.87	7.44	0.98	0.83

Comparison of Cost: CFB Box v/s. Stretch/Shrink Wrapping

Item (Lt. Jar)	Cost of CFB Packaging Cost/Jar (Rs.)	Cost of Stretch Wrapping (Rs.)		Cost of Shrink Wrapping (Rs.)	
		Cost/Jar with top	Cost/Jar without top	Cost/Jar with top	Cost/Jar without top
1.75	1.23	0.75	0.56	0.61	0.48
1.5	0.99	0.76	0.58	0.58	0.45
2.1	1.49	0.98	0.83	0.72	0.57

Shrink and Stretch Sleeving

During the past decade, the growth of sleeving has been quite significant. Earlier, sleeving was mostly used for cosmetics, toiletries and personal care product applications. Currently, however it is used for many food packaging applications, including drinking water and other drinks.

Plastic sleeves are basically of two types:

- Stretch sleeves
- Shrink sleeves

Strawberry Punnet - Stretch Wrapped

Stretch sleeve labels are usually manufactured from LDPE, PP and PVC in a tubular form and then flattened and rolled. Depending upon the type of application, machine used, the sleeve manufacturer may need to incorporate perforations between the adjacent sleeves, which helps to separate from one another in order to form the individual sleeves, immediately prior to application to the containers. This separating action takes place as a result of differential speeds within the sleeve transfer station.

The specially designed stretching mandrels open up the sleeves before they are transferred down onto the container. Then the stretch sleeves conform to the contours of the containers.

From the marketing perspective, it is advisable to have cut-off knives as an alternate to perforation, which may result in improper upper and lower edges of the sleeve.

A typical film thickness for stretch sleeves is 55-70µ and application speeds up to 800 containers/ min. are possible, depending upon the type of machine.

As, unlike shrink sleeves, no heat is used, stretch sleeves can be used for applications for a diverse range of plastic containers. This technique is particularly suitable for chilled products like fruit juices where the container is likely to change shape during filling or subsequent storage. Stretch sleeves are generally used on round containers, where the graphics do not require any form of orientation with regard to the geometry of the containers. However, it is possible to orientate the print as is necessary for square or other non-round plastic containers.

Shrink Wrapped Transport Pack for Carbonated Soft Drinks

The method of manufacture, reel feed and application for shrink sleeves are almost similar in many respects to those for stretch sleeves. The main difference is, of course, the fact that heat is necessary in order to create the required degree of shrink to ensure that the sleeve conforms totally to the profile of the containers being labelled, without any evidence or wrinkling or distortion of the graphics. If the plastic film needs to be shrunk by varying degrees in different areas of the container profile, then the original design of the graphics need to take into account the subsequent shrinking operation.

One of the biggest advantage of shrink sleeve labels is their ability to provide 360° graphics around very unusual pack shapes. In addition, shrink-sleeves can serve a dual role, firstly being the products label and secondly providing a seal or tamper evident device. In such cases, the sleeves are designed to encompass all or most of the body area of the containers and in addition, to particularly encapsulate closure area also.

The most common material for shrink sleeves is PVC, but OPP, PET and oriented polystyrene sleeves can also be used.

In conclusion, it can be said that plastics with the application of shrink and stretch technology have not only made the wrapping systems more efficient and cost effective, but also made significant inroads in the arena of consumer packaging, particularly in terms of shrink and stretch sleeving.

PACKAGING LAWS AND REGULATIONS

The link between food packaging and consumer protection is of high significance. A package is a vehicle of safety and achieves the objective of delivering safe, wholesome, nutritious food to the consumer. To safeguard the interests of the consumer and the society at large, Packaging Laws and Regulations have been introduced by the Government.

The Indian Regulatory System falls under the category of compulsory legislations formulated by the various ministries and voluntary standards framed by various organisations to serve the country. The National Regulatory System is shown in Table 1.

The Packaging Laws and Regulations for food products are mainly covered under:

- The Standards of Weights and Measures Act, 1976 and the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 (SWMA).
- The Prevention of Food Adulteration Act, 1954 and the Prevention of Food Adulteration Rules, 1955 and its first ammendment, 2003 (PFA).
- The Fruit Products Order, 1955 (FPO)
- The Meat Food Products Order, 1973 (MFPO)
- The Edible Oil Packaging Order, 1998
- The Agmark Rules

The Standards of Weights & Measures Act (SWMA)

Till about 25 years ago or so, the consumer was not sure that he was getting for his money, the right weight or volume of the packaged products. Things were pretty chaotic with different states having their own system of weights and measures. Adding to the confusion was the common practice of putting the same quantity of products in packs of different sizes, some containers being half-filled, and, as if this was not enough, quantities of contents on the packs were not stated in terms of units of weight or measure but declared as "family pack", "economy size", "full size" and so on. This unhappy state of affairs prevailed till 1976 when the Government of India, brought forward a wise and enlightened piece of legislation in the form of The Standards of Weights and Measures Act, 1976 (SWMA).

Some of the important aspects of SWMA are highlighted here.

Standard Units (section 4)

Chapter I of the Act is on establishment of standard units. This chapter clearly tell us the units of weights and measures to be followed. It states that every unit shall be based on the metric system. For this purpose, the units to be adopted are the International System of units recommended by the General Conference on Weights and Measures and such additional units as may be recommended by the International Organisation of Legal Metrology.

TABLE 1

Food Laws/Regulations and Ministries Involved

Regulations	Ministry of Food and Civil Supplies	Ministry of Food Processing Industries	Ministry of Agriculture	Ministry of Health and Family Welfare	Ministry of Commerce	Ministry of Consumer Affairs
Essential Commodities Act, 1955	Solvent extracted oils, De-oiled Meal and Edible Flour Control Order 1967. Mandatory inspection	Fruits Product Order 1955 Mandatory inspection	Meat Food Product Order 1973 Mandatory inspection			
Standards of Weight Measures Act, 1976	SWMA rules, 1977. Packed foodstuffs must adhere to quality declaration					
Agricultural Produce (Grading and Marketing) Act 1937			Agmark standard for raw and semi-processed products. Voluntary inspection			
Prevention of Food Adulteration Act 1954				Protects consumer against inferior quality and adulteration		
Codex Standard (CAC) 1964 (not a law)				Endorsement by WTO under SPS and TBT. De-facto mandatory		
Export (Quality Control and Inspection) Act, 1963					Pre-shipment inspection	
Bureau of Indian Standards, 1986						HACCP 9000 certification. Voluntary inspection

[Source : Economic and Political weekly, July 28,2001]

The Act also specifies the base units for:

- Length – Metre
- Mass – Kilogram
- Time – Second
- Electric Current – Ampere
- Thermodynamic Temperature – Kelvin
- Luminous Intensity – Candela
- Base Unit of Numeration – International form of Indian numerals

Declaration on Packaged Commodities for Interstate Trade or Commerce

In Chapter IV (section 39), the Act stipulates that for interstate trade or commerce of commodities in packaged form, intended to be sold or distributed, every commodity in packaged form has to bear upon it, on a label securely attached to it, a definite, plain and conspicuous declaration of:

- Identity of the commodity in the package
- Net quantity, in terms of the standard unit of weight or measure, of the commodity in the package
- Where the commodity is packaged or sold by number, the accurate number of commodity contained in the package
- The unit sale price of the commodity in the package
- The sale price of the package

Further requirements include:

- Every package should bear the name of the manufacturer and also of the packer or distributor.
- The statement as to the net weight, measurement or number of the contents should not have any expressions, which tend to qualify such weight, measurement or number. (Exceptions to this are commodities which may undergo changes in weight or measure due to climatic variations; examples – bread, soap, etc. where the qualifying statement "when packed" may be added to the net weight or measure).
- Where there is undue proliferation of weight, measure or number in which any commodity is being sold and such undue proliferation impairs, in the opinion of the Government, the reasonable ability of the consumers to make a comparative assessment of the prices after considering the net quantity or number of such commodity, the Government may prescribe standard quantities or numbers for any commodity.
- Where the retail price of a commodity is stated in any advertisement, the net quantity or number of the commodity must be conspicuously declared in the advertisement along with the price.
- A package containing a commodity, which is filled less than the prescribed capacity of such package cannot be sold or distributed except where it is proved that the package is so filled with a view to (a) giving protection to the contents of the package or (b) meeting the requirements of machines used for enclosing the contents of such packages.

- The Central Government may, by rules, specify reasonable variations in the net contents of the commodity in a package as may be caused by the method of packing or the ordinary exposure which may be undergone by the commodity after it has been introduced in the market place.

  This very comprehensive and far-reaching Act has put an end to the state of near anarchy in the trading of packaged goods. The clearly specified requirements in the Act have also provided a challenge to packaging development experts and label copy specialists who have to include statutory and promotional copy in the limited space available on labels and on packages themselves. However irksome they may appear, the provisions of this Act are welcome because they offer to the consumer a measure of protection which is not so apparent in many other legal requirements.

Standard Packages

Under the Standards of Weights and Measures (Packaged Commodities) Rules, rules have been framed specifying provisions for the retail sale of packaged goods. One of the most important rules is with respect to the requirements that specific commodities are to be packed and sold only in standard packages. As per the Third Schedule, food products and their respective package capacities are given in Table 2.

Maximum Permissible Error

In reference to the same rules as above, under the First Schedule, maximum permissible errors in relation to the quantity contained in individual packages is specified as given in Table 3 for food packages.

Table 4 gives the maximum permissible errors in relation to net quantities of packaged commodities (food) not specified in the First Schedule.

As per the Fifth Schedule of the SWMA Rules, commodities to be sold by weight, measure or number are indicated. Table 5 gives the details of the same with respect to food products.

Label Declarations

In the SWMA Rules, the declaration to be made on every retail package has been detailed. The declarations are to be made with respect to the following:

- The name and address of the manufacturer or where the manufacturer is not the packer, the name and address of the manufacturer and packer.
- The common or generic names of the commodity contained in the package.
- The net quantity in terms of the standard unit of weight or measure, of the commodity contained in the package or where the commodity is packed or sold by number, the number of commodity contained in the package.
- The month and year in which the commodity is manufactured or pre-packed. (Provided that for packages containing food articles, the provisions of the Prevention of Food Adulteration Act (PFA), 1954 (37 of 1954) and the rules made thereunder shall apply).
- The retail price of the package.
- The retail sale price of the package.

TABLE 2
Commodities to be Packed in Specified Quantities (Standard Packages) as per The Third Schedule of SWMA Rules

Commodities	Quantities in which to be Packed
Baby food	200g, 500g, 1 kg, 2 kg, 5 kg and 10 kg – Any manufacturer or packer packing baby food in 400g and weaning food in 500g shall not be allowed to do so beyond 30.6.95
Weaning food	200g, 400g, 1 kg, 2 kg, 5 kg and 10 kg – Publication of this notification in the official gazette
Biscuits	25g, 50g, 75g, 100g, 150g, 200g, 250g, 300g and thereafter in multiples of 100g up to 1 kg
Bread including brown bread but excluding bun	100g and thereafter in multiples of 100g
Uncanned packages of butter and margarine	25g, 50g, 100g, 200g, 500g, 1 kg, 5 kg and thereafter in multiples of 5 kg
Cereals and pulses	100g, 200g, 500g, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg
Coffee	25g, 50g, 100g, 200g, 500g, 1 kg and thereafter in multiples of 1 kg
Tea	25g, 50g, 100g, 200g, 500g, 1 kg and thereafter in multiples of 1 kg
Materials which may be reconstituted as beverages	25g, 50g, 100g, 200g, 500g, 1 kg and thereafter in multiples of 1 kg
Edible oils, vanaspati, Ghee, butter oil	50g, 100g, 200g, 500g, 1kg, 2kg, 3kg, 5kg, and thereafter in multiples of 5kg. If net quantity is declared by volume the same number in millilitres or litres, as the case may be. If the net quantity is declared by volume then the equivalent quantity in terms of mass to be declared in brackets, in same sizes of letters/numerals
Milk Powder	Below 50g no restriction, 50g, 100g, 200g, 500g, 1 kg and thereafter in multiples of 500g
Rice (powdered), flour, atta, rawa and suji	100g, 200g, 500g, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg
Salt	Below 50g. in multiples of 10g; 50g, 100g, 200g, 500g, 750gms, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg
Aerated soft drinks and non-alcoholic beverages	100ml, 150ml, 200ml, 250ml, 300ml, 330ml (in cans only), 500ml, 750ml, 1 litre, 1.5 litre, 2 litre, 3 litre, 4 litre, and 5 litre
Mineral water and drinking water	100ml, 130ml, 150ml, 200ml, 250ml, 300ml, 330ml, 500ml, 600ml, 750ml, 1 litre, 1.2 litre, 1.5 litre, 2 litre, 3 litre, 4 litre, and 5 litre. The sizes 130ml, 330ml, 600ml and 1.2 litre shall be allowed only for a period of 3 years from the date of notification. (26th Nov. 2001)

TABLE 3

Maximum Permissible Error in Relation to Quantity Contained in Individual Package as per the First Schedule of SWMA Rules

Description of Commodity	**Quantity Declared**	**Maximum Permissible Error**
Biscuits	(i) Up to and equal to 500g (ii) Above 500g	7.0% 6.0%
Bread	(i) Up to and equal to 400g (ii) Above 400g up to and equal to 800g (iii) Above 800g up to and equal to 1200g	8.0% 6.0% 4.0%
Ghee, vanaspati and edible oil	(i) Up to and equal to 1 kg/litre (ii) Above 1kg / litre up to and equal to 2kg / litre. (iii) Above 2 kg / litre up to and equal to 4kg / litre. (iv) Above 4kg / litre	2.0% 1.5% 1.25% 0.6%
Infant food including malted milk food	(i) Up to and equal to 100g (ii) Above 100g up to and equal to 1 kg (iii) Above 1 kg	5.0% 4.0% 3.0%
Liquid milk	(i) Up to and equal to 100ml (ii) Above 100 ml up to and equal to 250ml (iii) Above 250 ml	5 ml 8 ml 10 ml
Provisions sold in polythene bags or plastic bags, food grains, pulses, edible seeds, spices (whole or broken but not powdered), powdered commodities, (such as, chilli powder, pepper powder, coffee powder, washing soda, atta, table salt and the like), dry fruits, seeds and other commodities (such as, sugar gur, khandsari and the like)	(i) Up to and equal to 100g (ii) Above 100g up to and equal to 500g (iii) Above 500g up to and equal to 1 kg (iv) Above 1 kg	3.0% 2.0% 1.5% 0.75%
Tea	For all quantities	2.0%

TABLE 4

Maximum Permissible Errors on Net Quantities Declared by Weight or by Volume (not specified in First Schedule) as per SWMA Rules (Second Schedule)

Declared Quantity (g or ml)	Maximum Permissible Error in Excess or in Deficiency	
	As Percentage of Declared Quantity	g or ml
Up to 50	9	–
50 to 100	–	4.5
100 to 200	4.5	–
200 to 300	–	9
300 to 500	3	–
500 to 1000	–	15
1000 to 10000	1.5	–
10000 to 15000	–	150
More than 15000	1.0	–

The maximum permissible error specified as percentage shall be rounded off to the nearest one-tenth of a g or ml, of declared quantities less than or equal to 1000g or ml and to the next whole g or ml for declared quantities above 1000g or ml.

TABLE 5

Commodities to be Sold by Weight, Measure or Number as per The Fifth Schedule of SWMA Rules

Commodity	Whether Declaration to be Expressed in Terms of Weight Measures or Number or two or more of them
Curd	Weight
Fruits, all kinds	Number or weight
Edible oil, vanaspati, ghee and butter oil	Weight or volume
Honey, malt extract, golden syrup treacle	Weight
Ice cream and other similar frozen products	Weight or volume
Rasgulla, Gulab Jamun and other sweet preparations	Weight
Sauce, all kinds	Weight

Where any package material bearing thereon the month in which any commodity was expected to have been pre-packed is not exhausted during that month, such packaging material may be used for pre-packing the concerned commodity produced or manufactured during the next succeeding month and not thereafter, but the Central Government may if it is satisfied that such packaging material could not be exhausted during the period aforesaid by reason of any circumstance beyond the control of the manufacturer or packer, as the case maybe, extend the time during which such packaging material may be used, and where any such packaging material is exhausted before the expiry of the month indicated thereon, the packaging material intended, to be used during the next succeeding month may be used for pre-packing the concerned commodity; provided that the said provision shall not apply to the packages containing food products, where the "Best before or Use before" period is ninety days or less from the date of manufacture or packing.

General Provisions Relating to Declaration of Quantity

1) In declaring the net quantity of the commodity contained in a package, the weight of wrappers and materials other than the commodity shall be excluded; provided that where a package contains a large number of small items of confectionery, each of which is separately wrapped, the net weight declared on the package containing such confectionery or on the label thereof may include the weight of such immediate wrappers, if and only if, the total weight of such immediate wrappers does not exceed:

    (i) 8%, where such immediate wrapper is a waxed paper or any other paper, with wax or aluminium foil (under strip), or

    (ii) 6%, in case of any other paper, of the total net weight of all the items of confectionery contained in the package minus the weight of immediate wrapper.

2) Where a commodity in a package is not likely to undergo any variation in weight or measure, on account of the environmental conditions, the quantity declared on the package shall correspond to the net quantity, which will be received by the consumer, and the declaration of quantity on such package shall not be qualified by the words "when packed" or the like.

3) Save as otherwise provided in sub-rule (4), where a commodity in package is likely to undergo variations in weight or measure on account of environmental conditions and such variation is negligible, the declaration of quantity in relation to such package shall be made after taking into account such variation so that the consumer may receive not less than the net quantity of the commodity as declared on the package, and the declaration of quantity on such package shall not also be qualified by the words "when packed" or the like.

4) The declaration of quantity in relation to commodities specified in the Fourth Schedule, that is to say, commodities which are likely to undergo significant variation in weight or measures on account of environmental or other conditions, may be qualified by the words "when packed".

Symbols for Unit

The symbols for International System of units and none other, shall be used in furnishing the net quantity of the package.

Illustrations:

Kilogram	Kg
Gram	g
Milligram	mg
Litre	l
Millilitre	ml
Metre	m
Centimetre	cm
Millimetre	mm
Squaremetre	m^2
Square centimetre	cm^2
Cubic metre	m^3
Cubic centimetre	cm^3

Symbols shall not be given in capital form except for the unit derived from a proper name, period i.e. a dot after symbols shall not be put. As far as possible symbols shall always be written in the singular form, i.e. 's' shall not be added.

General Guidelines on Giving Declarations

As far as possible, all declarations required to be made under SWMA Rules should appear on the principal display panel. The principal display panel is defined as that part of the package that is intended, or likely to be displayed, presented or shown or examined by the consumer under normal and customary conditions of display, sale or purchase of the commodity contained in the package. Every declaration which is required to be made on a package should be legible, prominent, definite, plain and unambiguous and should be given in a specified minimum size as given in Tables 6 & 7, depending on the area of the principal display panel. Specific guidelines are given for computing the area of the principal display panel.

Violation of Law

What happens if the law is violated? To explore this, let us move to part VI of the Act. This part provides penalty for different offences. The penalty for violation of Section 39 is in Section 63. If any person packs, distributes, stores, delivers or sells commodities, which does not meet the requirements of the Act and the Packaged Commodities Rules, can be punished by a fine which may extend up to Rs.5000. If the offence is repeated, the penalty can be imprisonment of up to five years. Section 72 provides for prosecution before a

TABLE 6
Minimum Height of Numerals

Net Quantity in Weight / Volume	Minimum Height in mm	
	Normal Case	When Blown Formed, Moulded, Embossed or Perforated on Container
Up to 200 g/ml	1	2
Above 200 g/ml up to 500 g/ml	2	4
Above 500 g/ml	4	6

TABLE 7
Minimum Height of Numerals

Net Quantity in Length Area or Number, Area of Principal Display Panel	Minimum Height in mm	
	Normal Case	When Blown Formed, Moulded, Embossed or Perforated on Container
Up to 100 cm square	1	2
Above 100 cm square up to 500 cm square	2	4
Above 500 cm square up to 2500 cm square	4	6
Above 2500 cm square	6	6

magistrate. But in the first instance, the department tries to settle the case with the offender. This is called compounding. The provision on compounding is contained in Section 74. The authorised officer of the department of Legal Metrology can compound a case, with the consent of the offender, by charging a compounding fee. This fee can be up to Rs. 5000. For the next three years, a subsequent offence cannot be compounded, it will have to be taken to the court. But after three years, an offender again becomes eligible to get a case compounded. Similarly, Section 74 provides for offences by companies and other body corporate. Both the persons, master and the servant, are jointly responsible. Thus, when a firm commits an offence, the company and the person who is the cause for commission of the offence, are both jointly responsible.

The Prevention of Food Adulteration Act

Food is one of the basic necessities for sustenance of life. Pure fresh and healthy diet is most essential for the health of the people. It is not wrong to say that community health is national wealth. Adulteration of food was so rampant, widespread and persistent that nothing short of a somewhat drastic remedy in the form of a comprehensive legislation became the need of the hour.

To check this sort of anti-social evil, a concerted and determined onslaught was launched by the Government by introduction of the Prevention of Food Adulteration Bill in the Parliament to herald an era of much needed hope and relief for the consumers at large. The Prevention of Food Adulteration Act and Rules have provided standards for a large variety of food. Unfortunately, the importance on packaging is not adequately reflected except in a few cases such as infant food items, drinking water. The responsibility of adequate packaging of food and its safety falls on the manufacturer of the food product.

The Prevention of Food Adulteration Act, 1954 (PFA) prohibits manufacture, storage and sale of adulterated food. The violation of law is prosecuted before a magistrate's court. The punishment is mandatory imprisonment for a minimum of three months. No surprise, the PFA is dreaded by the food industry. To understand the PFA, one must know what are the items included in the category of food and what the law considers to be adulteration of food.

Food and Adulteration

As per PFA, Food includes everything, which is consumed by human beings or even used for preparing items of human consumption. Thus cereals, oil, sugar, cooked food, drinks, spices, colouring matters, flavouring matter etc. are all included in the category of food. It excludes water and drugs. However, packaged natural water and packaged mineral water are considered to be food.

We ordinarily mean by adulteration to "debase, falsify by mixing with something inferior or spurious". By adulterated food, people also mean rotten, putrefied, insect infested or poisonous food. As per the Act, a food is deemed to be adulterated:

(a) If the article sold by a vendor is not of the nature, substance or quality demanded by the purchaser and is to his prejudice, or is not of the nature, substance or quality which it purports or is represented to be.

(b) If the article contains any other substance, which affects, or if the article is so processed as to affect, injuriously the nature, substance or quality thereof.

(c) If any inferior or cheaper substance has been substituted wholly or in part for the article so as to affect injuriously the nature, substance or quality thereof.

(d) If any constituent of the article has been wholly or in part abstracted so as to affect injuriously the nature, substance or quality thereof.

(e) If the article had been prepared, packed or kept under insanitary conditions whereby it has become contaminated or injurious to health.

(f) If the article consists wholly or in part of any filthy, putrid, rotten, decomposed or diseased animal or vegetable substance or is insect-infested or is otherwise unfit for human consumption.

(g) If the article is obtained from a diseased animal.

(h) If the article contains any poisonous or other ingredient which renders it injurious to health.

(i) If the container of the article is composed, whether wholly or in part, of any poisonous or deleterious substance which renders its contents injurious to health.

(j) If any colouring matter other than prescribed in respect thereof is present in the article, or if the amount of the prescribed colouring matter, which is present in the article are not within the prescribed limits of variability.

(k) If the article contains any prohibited preservative or permitted preservative in excess of the prescribed limits.

(l) If the quality or purity of the article falls below the prescribed standard or its constituents are present in quantities not within the prescribed limits of variability, but, which renders it injurious to health.

(m) If the quality or purity of the article falls below the prescribed standard or its constituents are present in quantities not within the prescribed limits of variability, but which does not render it injurious to health.

Provided that, where the quality or purity of the article, being primary food, has fallen below the prescribed standards or its constituents are present in quantities not within the prescribed limits of variability in either case, solely due to natural causes and beyond the control of human agency, then, such article shall not be deemed to be adulterated within the meaning of this sub-clause.

Packaging and Storage Requirements

Accordingly, Part IX (Rule 49(5)) of the PFA Rule States: A utensil or container made of the following materials or metals, when used in the preparation, packaging and storing of food shall be deemed to render it unfit for human consumption:

- containers which are rusty
- enameled containers which have become chipped and rusty
- copper or brass containers which are not properly tinned
- containers made of aluminium not conforming in chemical composition to IS:20 Specification for cast aluminium and aluminium alloy for utensils or IS:21 specification for wrought aluminium and aluminium alloy for utensils
- container made of plastic materials not conforming to the following Indian Standards Specification, used as appliances or receptacles for packing or storing, whether partly or wholly, food articles, namely:
  - IS: 10146 (Specification for polyethylene in contact with food stuffs)
  - IS: 10142 (Specification for styrene polymers in contact with foodstuffs)
  - IS: 10151 (Specification for Poly Vinyl Chloride (PVC) in contact with food stuffs)
  - IS: 10910 (Specification for polypropylene in contact with foodstuffs)
  - IS: 11434 (Specification for ionomer resins in contact with foodstuffs)
  - IS: 11704 (Specification for Ethylene Acrylic Acid (EAA) co-polymer)
  - IS: 12252 (Specification for Polyalkylene Terephathalates (PET))
  - IS: 12247 (Specification for Nylon 6 polymer)
  - IS: 13601 – Ethylene Vinyl Acetate (EVA)
  - IS: 13576 – Ethylene Metha Acrylic Acid (EMAA)
- Tin and plastic containers once used shall not be re-used for packaging of edible oil and fats.

The PFA Rules also stipulate that certain food items such as confectionery (weighing more than 500 grams), protein rich atta, protein rich maida, blended edible vegetable oil, coloured and flavoured table margarine, fat spread, spices and condiments shall be sold in packed condition only.

Other Packaging Requirements under PFA

- **For infant milk food**, infant formula milk cereal based weaning food and processed cereal based weaning food, the rules state that:

  The product shall be packed in hermetically sealed, clean and sound containers or in flexible packs made from film or combination of any or substrate made of board paper, polyethylene, polyester metallised film or aluminium foil in such a way so as to protect it from deterioration.
- **For meat and meat products,** the product shall be packed in hermetically sealed containers and subjected to heat treatment followed by rapid cooling to ensure that the product is shelf-stable.

  The sealed container shall not show any change on incubation at 35°C for 10 days and 55°C for 5 days.
- **For natural mineral water**, **naturally carbonated natural mineral water**, and **packaged drinking water**, the rules stipulated regarding the packaging materials are:

  It shall be packed in clean, hygienic, colourless, transparent and tamperproof bottles/ containers made of Polyethylene (PE) conforming to IS:10146 or Poly Vinyl Chloride (PVC) conforming to IS:10151 or Polyalkylene Terephthalate (PET and PBT) conforming to IS 12252 or Polypropylene conforming to IS:10910 or food-grade Polycarbonate or sterile glass bottles suitable for preventing possible adulteration or contamination of the water. All packaging materials of plastic origin shall pass the prescribed overall migration and colour migration limits.

Declarations and Labeling

The other aspect of regulations under the PFA is with respect to declarations/labeling. Any packaged food, which does not conform to these requirements under the PFA is deemed “misbranded”. As per the Act, an article of food shall be deemed to be misbranded:

- If it is an imitation of, or is a substitute for, or resembles in a manner likely to deceive, another article of food under the name of which it is sold, and is not plainly and conspicuously labeled so as to indicate its true character.
- If it is falsely stated to be the product of any place or country.
- If it is sold by a name which belongs to another article of food.
- If it is so coloured, flavoured or coated, powdered or polished, that the fact that the article is damaged, is concealed or if the article is made to appear better or of greater value than it really is.
- If false claims are made for it upon the label or otherwise.
- If, when sold in packages, which have been sealed or prepared by or at the instance of the manufacturer or producer and which bear his name and address, the contents of each

packages are not conspicuously and correctly stated on the outside thereof within the limits of variability prescribed under this Act.

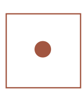
- If the package containing it, or the label on the package bears any statement, design or device regarding the ingredients or the substances contained therein, which is false or misleading in any material particular; or if the package is otherwise deceptive with respect to its contents.
- If the package containing it or the label on the package bears the name of a fictitious individual or company as the manufacturer or producer of the article.
- If it purports to be, or is represented as being, for special dietary uses, unless its label bears such information as may be prescribed concerning its vitamin, mineral, or other dietary properties in order to sufficiently inform its purchaser as to its value for such uses.
- If it contains any artificial flavouring, artificial colouring or chemical preservative, without a declaratory label stating that fact, or in contravention of the requirements of this Act or rules made thereunder.
- If it is not labeled in accordance with the requirements of this Act or rules made thereunder.

Part VII of the Rules deals with the Packing and Labeling of Food. As per these rules, the following are required:

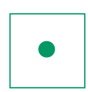
- The name, trade name or description of food contained in the package.
- The names of ingredients used in the product in descending order of their composition by weight or volume as the case may be. If artificial flavouring is used, the chemical names of the flavour need not be declared, but, in the case of natural flavouring substances or nature-identical flavouring substances, the common name of the flavour is to be mentioned on the pack.

If the food contains any ingredient in part or whole from animal origin (meat, fish, poultry eggs), a declaration is to be made by a symbol and a colour code stipulated for this purpose, to indicate the product as Non-vegetarian Food. The symbol should be on the principal display panel in close proximity to the name or brand name of the food as indicated in clause (16) of sub-rule (zzz) of rule 42. The symbol shall consist of a brown colour filled circle having a diameter not less than the minimum size specified in Table 8.

Similarly, for vegetarian food a similar symbol with green colour circle and square as indicated in clause (17) of sub-rule (zzz) of rule 42 will be displayed.



Non-vegetarian Food



Vegetarian Food

The symbol shall be prominently displayed on the package having contrast background and in close proximity to the name or brand name of product, and also on the labels, pamphlets, leaflets, and advertisements in any media.

TABLE 8

Symbol Sizes

Area of Principal Display Panel	Minimum Size of Diameter in mm
Up to 100 cm square	3
Above 100 cm square up to 500 cm square	4
Above 500 cm square up to 2500 cm square	6
Above 2500 cm square	8

- The name and complete address of the manufacturer, or importer, or vendor or packer to be declared.
- A declaration is to be made for the net weight or number or measure of volume of content in the case of biscuits, breads, confectionery and sweets where the weight may be expressed as average net weight or minimum net weight.
- The batch number or lot number or code number may be declared either in numericals or alphabets or in combination, preceded by the words "Batch No." or "Batch" or "Lot No." or "Lot" or any distinguishing prefix.
- The month and year in which the product was manufactured or pre-packed is to be declared except in case of carbonated water containers and packages of biscuits containing 60 grams to 120 grams and packages of food weighing less than 60 grams, bread, milk and for all packages of irradiated food to bear the following declaration and logo:

PROCESSED BY IRRADIATION METHOD

DATE OF IRRADIATION

- The package should declare:

  The month and year in capital letters up to which the product is best for consumption, in the following manner, namely:-

  "BEST BEFORE …………….. MONTHS AND YEAR" or

  "BEST BEFORE …………….. MONTHS FROM PACKAGING" or

  "BEST BEFORE …………….. MONTHS FROM MANUFACTURE" or

  "BEST BEFORE UPTO MONTH AND YEAR …………"

In case of package or bottle containing sterilised or ultra high temperature treated milk, soya milk, flavoured milk, any package containing bread, dhokla, bhelpuri, pizza, doughnuts, khoa, paneer, or any uncanned package of fruits, vegetable, meat, fish or any other like commodity, the declaration be made as follows:

" BEST BEFORE .... DATE/MONTH/YEAR"

or

" BEST BEFORE .... DAYS FROM PACKAGING".

- The declaration to be made on packages of **infant milk substitute** and **infant milk** as per rule 37B states that:

  Every container of infant milk substitute or infant food or any label affixed thereto shall indicate in a clear, conspicuous and in an easily readable manner, the words **"IMPORTANT NOTICE"** in capital letters and indicating thereunder the following particulars, namely:

(a) a statement **"MOTHER'S MILK IS BEST FOR YOUR BABY"** in capital letters. The types of letters used shall not be less than five millimetres and the text of such statement shall be in the Central Penal of every container of infant milk substitute or infant food or any label affixed thereto. The colour of the text printed or used shall be different from that of the background of the label, container or the advertisement, as the case may be. In case of infant food, a statement indicating **"infant food shall be introduced only after four months of age"** shall also be given.

(b) a statement that infant milk substitute of infant food should be used only on the advice of a health worker as to the need for its use and the proper method of its use.

(c) a warning that infant milk substitute or infant food is not the sole source of nourishment of an infant.

(d) a statement indicating the process of manufacture (spray or roller dried) except in case of infant food, instruction for appropriate and hygienic preparation including cleaning of utensils, bottles and teats and warning against health hazards of in-appropriate preparations, as under:

"Warning/caution-Careful and hygienic preparation of infant food/infant milk substitute is most essential for health. Do not use fewer scoops than directed since diluted feeding will not provide adequate nutrients needed by your infant. Do not use more scoops than directed since concentrated feed will not provide the water needed by your infant".

(e) the approximate composition of nutrients per 100 grams of the product including its energy value in Kilo Calories/Joules.

(f) the storage condition specifically stating "**store in a cool and dry place in an air tight container**" or the like.

(g) the feeding chart and directions for use and instruction for discarding left over feed

(h) instruction for use of measuring scoop (level or heaped) and the quantity per scoop (scoop to be given with pack)

(i) indicating the Batch No., Month and Year of its manufacture and month and year before which it is to be consumed

(j) the protein efficiency ratio (PER) which shall be minimum 2.5 if the product other than infant milk substitute is claimed to have higher quality protein

Enforcement of the PFA

Under the PFA, Food Inspectors are appointed by the State governments. They are often a part of the Food and Drug Administration or Local Health Authority. The Food Inspector has the power to take a sample of the food from the place of manufacture, storage or from seller and send it to a Public Analyst for testing. Public Analysts have been created under the Act to analyse sample of article of food sent to them.

A Food Inspector who intends to take a sample has to disclose his identity and inform the retailer his intention of taking a particular product as a sample for analysis. The Food Inspector takes three samples, which are to be sealed and labeled. He sends one sample with a memorandum to a Public Analyst. The other two samples are deposited in the office of the department to which the Food Inspector belongs. The Public Analyst sends his report. If the Analyst's report declares that the sample is not in conformity with the provisions of the PFA, the Food Inspector initiates prosecution of the PFA, the Food Inspector initiates prosecution in the court of a first class magistrate. The Food Inspector while taking sample asks the retailer to disclose the name of the wholesaler/distributor. From the package, the Food Inspector also gets to know the name of the manufacturer and distributor. Thus, he knows the entire chain. The Food Inspector can, and often does, make all the parties in the chain accused in the first instance itself. Along with initiating prosecution, the Food Inspector sends letters to manufacturer, distributor and wholesaler. The letter informs that a case has been initiated and that the accused can make an application before the court to have their sample re-tested by a Central Food Laboratory within ten days from the receipt of the letter. The analysis by the Central Food Laboratory is considered superior to the report of the Public Analyst. It is a right of the accused to get a sample re-tested from a Central Food Laboratory.

If an accused makes an application to the Magistrate, the court directs the department to produce the remaining two samples. After inspecting the seal, the court sends one sample to a Central Food Laboratory. The Central Food Laboratory sends the report. If the report declares the sample to be in conformity with the provisions of the PFA and Rules, the court discharges the case. If the sample fails, trial by the magistrate starts.

Corporate bodies like companies, co-operatives or firms are also persons in the eyes of the law. These can be prosecuted and punished as corporate bodies under the Act. A fine can always be paid out of their corporate account. However, a company or co-operative is not a real person, who can be imprisoned. There have to be specific persons who can be held responsible. The PFA makes provisions that corporate bodies can authorise a person, like a director, manager or secretary to exercise all such powers and take all steps to prevent food adulteration and inform the local (health) authority of such an authorisation. The authorised person is called a PFA nominee. The nominee represents the organisation for all matters dealing with the PFA. He is held responsible for any violation committed by the firm. If an organisation has not appointed a nominee, the court holds the person who was responsible to the corporate body for the commission or omission of the action, which led to the violation of the PFA.

The PFA is a legislation of the 1950s. Its dominant horizon is articles of food being sold loose. In the past five decades, the nature of food industry has changed. The market for processed and pre-packed food has expanded tremendously. The food industry deploys sophisticated and expensive food processing technology.

There has been a revolution in creation and use of newer packaging materials to give protection to articles of food. The law needs to be revised to take stock of these practices. Law should not only continue to deter food adulterators, but it should also be revised to be optimum in its effect, severe on violators and facilitators to others.

Fruit Products Order (FPO)

The Fruit Products Order is concerned with fruit and vegetable products including synthetic beverages, syrups, sharbats and vinegar. The objective of this law is mainly to regulate the quality and hygiene of these products.

The important labeling rule under FPO is that all labels should have the approval of the authorities concerned, and carry the license number allotted. When a bottle is used as the package, it should be so sealed that it cannot be opened without destroying the license number, and the special identification mark of the manufacturer should be displayed on the top or neck of the bottle. The batch/code number along with the date of manufacturing should also be declared.

As contained in PFA, FPO also prohibits use of any statement, design or device, which is false or misleading concerning the fruit product. Synthetic products associated with fruits and vegetables should clearly be marked “SYNTHETIC” and the word, “SYNTHETIC”, whenever used, should be as bold and in the same size and colour of the letters used for the name of the product, and should immediately precede such name.

Meat Food Products Order (MFPO)

Meat Food Products Order, similar to FPO, regulates the licensing and labeling of all meat products. All labels have got to be approved by the licensing authority, and the license number and category of manufacturer should be declared on the label.

The name of the product, always a common name understood by the consumer, should be given along with net quantity. Trade names should have prior approval of the licensing authority. When any preservative or colouring agent is used, a statement to that effect should be given. When permitted artificial flavouring agent is used, the words, “**Artificially Flavoured**”, should appear on the label in prominent letters and in continuance of the name of the product. The list of ingredients should also be given. Terms which may bear some geographical significance with reference to a locality other than in which either the factory is located, or the product is manufactured, can be given on the label after being qualified by the word, "STYLE", "BRAND", or "TYPE", as the case may be. No statement, word, picture or design, which may convey a false impression or give a false indication of origin or quality, can appear on the label.

Agricultural Grading & Marking (AGMARK) Rules

Agmark rules relate to the quality specifications and needs of certain agricultural products to be eligible for Agmark Certification. They also specify the type of packages that can be used for various products and labeling declarations that have to be given. Some of the food products that have been covered under these rules are edible nuts, ghee, honey, pulses, spices and condiments and vegetable oil.

Edible Oil Packaging (Regulation) Order, 1998

In order to ensure availability of safe and quality edible oil in packed form, the Central Government promulgated on 17th September,1998 a Packaging Order under the Essential Commodities Act, 1955 to make packaging of edible oil, sold in retail, compulsory unless specifically exempted by the concerned State Governments.

Uniform methods for testing the quality of edible oil, including the Thin Layer Chromatography (TLC) method for detection of Argemone oil was prescribed and circulated to all State Governments and manufacturers.

The salient features of the Packaging Order are:

- Edible oil including edible mustard oil will be allowed to be sold only in packed form from 15th December,1998.
- Packers will have to register themselves with a registering authority.
- The packer will have to have his own analytical facilities or adequate arrangements for testing the samples of edible oil to the satisfaction of the Government.
- Only oil which conform to the standards of quality as specified in the Prevention of Food Adulteration Act, 1954 and Rules made thereunder will be allowed to be packed.
- Each container or pack will have to show all relevant particulars so that the consumer is not misled, so also the identity of the packer becomes clear.
- Edible oil shall be packed in conformity with the Standards of Weights and Measures (Packaged Commodities) Rules, 1977, and the Prevention of Food Adulteration Act, 1954 and Rules made thereunder.
- The State Governments will have power to relax any requirements of the packaging order for meeting special circumstances.

The power for implementation of the Order is basically delegated to the State Governments. The Central Government is aware that the production of edible oils is a highly de-centralised industry. A substantial quantity of oil production is in the small-scale or unorganised sector. Further, a sizeable proportion of the population is living below the poverty line. It may be difficult for them to afford the additional cost of packaged oils. It is in view of these situations that the State Governments have been empowered to exempt any edible oil from the provisions of this order in specific circumstances.

Conclusion

Packaging is being recognised as a major industry in all developing countries. This is not surprising as all the products manufactured or processed are packed in some way or the other, so as to safeguard the interests of the consumer and the society. The laws and regulations that apply to these products are very critical. These laws act as a measure of protection and self-satisfaction for the customers in terms of quality and quantity.

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Paper No.: 12
Paper Title: FOOD PACKAGING TECHNOLOGY
Module – 22: Aseptic Packaging of Food

1. INTRODUCTION:

Heat sterilization is the unit operation in which foods are heated at a sufficiently high temperature for a sufficiently long time to destroy microbial and enzymatic activity present in the raw food. As a result, sterilized foods have a shelf life of 6 to 12 months or more. The most common method of sterilizing solid and viscous food products is in-container sterilization, e.g., canning; however, the main disadvantages associated with in-container sterilization of food products are

(1) The low rate of heat penetration to the thermal center of the container.

(2) Long processing times to achieve the desired sterility.

(3) Damage to the nutritional and sensory characteristics of the product.

(4) Low productivity, and

(5) High energy costs.

To overcome the constraints of in-container sterilization, products can be sterilized at higher temperatures for a shorter time prior to filling into presterilized containers under sterile conditions. This forms the basis of ultra-high-temperature (UHT) processing and aseptic packaging, which has been defined as "the independent sterilization of food and packaging and assembly under sterile conditions". OR. Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the containers so that re-infection is prevented. This results in a product, which is shelf-stable at ambient temperature conditions. OR

Aseptic packaging refers to the filling of a cold, commercially sterile product under sterile conditions into a presterilized container and closure under sterile conditions to form a seal that effectively excludes microorganisms.

Aseptic processing was developed in the early 1940s and has been used effectively in Europe and Japan for over three decades. It has been rapidly gaining reputation as a thermal processing technique in North America since the use of hydrogen peroxide was approved for sterilizing of packaging materials in 1981. The process has long been effectively employed to sterilize a wide range of liquid products, e.g., milk, fruit juices and concentrates, cream, yogurt, salad dressing, egg, and ice cream. Current developments in high-barrier plastic packaging materials and aseptic processing and filling technology have resulted in the process being expanded to sterilize both acid-low and acid-viscous, and semisolid foods that contain discrete particles, such as tomato paste, baby foods, fruit pulp etc.

2. SCOPE OF ASEPTIC PACKAGING:

There are number of limitations and disadvantages during actual application of this technology. However, we can't ignore the benefits over various lacunas of the process. Thus, it can be concluded that aseptic packaging of sterile/non sterile food and food products is the most significant innovation in the field of food science and technology and there is a big scope in this area.

3. MAJOR CATEGORIES OF ASEPTIC PACKAGING SYSTEMS

- *Can system*: It includes hermetically sealed cans
- *Bottle systems*: Glass containers and plastics bottles fall into this category. The bottles can further be divided into; a) Non-sterile bottles; b) Sterile blown bottles; c) Single station blowing, filling & sealing
- *Sachet and pouch systems*: This system is classified into Form-fill-seal systems and Lay flat tubing
- *Cup systems*: The aseptic packaging of food into cups can be into; Pre-formed plastic cups and Form-fill and seal cups
- *Carton systems*: This type of aseptic packaging system includes Form-fill-seal cartons and Prefabricated cartons
- *Bulk packaging systems*: This type of system classified into; Metal drum and Bag-in-box Packaging Lines for Aseptic Processing.

3.1 There are five basic types of aseptic packaging lines as given below;

i. *Film & Seal*: Pre-formed containers made up of thermoformed plastic, glass or metal are sterilized, filled in aseptic environment and sealed.

ii. *Form, Fill & Seal*: Roll of material is sterilized, formed in sterile environment, filled and sealed. e.g. Ex tetra packs

iii. *Erect, Fill & seal*: Using knocked, down blanks, erected, sterilized, filled sealed. e.g. Ex. Gable-top cartons, Cambri-block.

iv. *Thermoform, Fill:* sealed roll stock sterilized, thermoformed, filled, sealed aseptically. e.g. Ex. Creamers, plastic soup cans.

v. *Blow, Mold, Fill & Seal*: e.g. Different package forms used in Aseptic UHT processing are cans, paperboards/plastic/foil/plastic laminates/flexible pouches, thermoformed plastic containers, bag in box, bulk totes.

4. PRE-REQUISITE CONDITIONS FOR ASEPTIC PACKAGING:

- It should contain the product.
- It should prevent physical damage to packaged product.
- It should run effortlessly on filling lines.
- It should survive packaging processes.
- It should be easy to handle throughout distribution process.
- It should avoid dirt and other contamination.
- It should be able to protect the product from odours and taints.
- It should be resistant to rodent attack.
- It should be able to stop insect infestation.
- It should be biologically safe i.e. non toxic.
- It should be compatible to foodstuff.
- It should maintain sterility of product.
- It should prevent entry of microorganisms.
- It should show evidence of tampering.
- It should control moisture loss or gain.
- It should offer a barrier to oxygen.
- It should be protective against the light.
- It should maintain gas atmospheres, i.e.CO_2/N_2.
- It should communicate all the information regarding product and manufacturer.
- It should have good sales appeal.
- It should be easy to open and handle.
- It should be cost efficient.

4.1 The above given pack criteria are separated into seven areas, mainly as follows:

1. **Product Containment**: The need to contain the product in the sense that liquids or powders do not leak out.
2. **Physical Protection**: This is required when dealing with fragile foods like eggs or snack foods, but minor impacts on fresh fruits, for example, will release enzymes and

lead to browning and softening. Equally important is the adverse effects on sales of damaged packages themselves-even though the product is in good condition.

3. **Food Safety**: The need to ensure that the aseptically packed food retains its sterility, through a package that prevents adventitious contamination by microorganisms. Tamper evidence is also a desirable requirement. The other aspect of food safety is the avoidance of long-term chronic effects from the food packaging materials themselves.
4. **Shelf-Life**: For dried foods moisture gain is a major factor in determining shelf-life. Atmospheric oxidation, often catalyzed by light, is more critical for aseptically packed foods such as milk, fruit juices, or cream soups. Hence a good oxygen and light barrier, as provided by tinplate or aluminum foil, is needed to ensure maximum shelf life for aseptically packed products.
5. **Communication of Information**: The package should need to tell the purchaser what food is inside it and whose product it is. Apart from this, more information should be passed on to the customer, such as net weight, list of ingredients, batch number, use-by date, nutritional information etc.
6. **Sale-Appeal**: The package must look attractive and 'catch the eye' of prospective purchasers, and it should also be easy to open and dispense the product.
7. **Cost-Effectiveness**: Value for money in packaging is more important than looking for the lowest price. A cheap but dimensionally variable container could cause more damage during production or an increase of 'leakers' in the market place, thereby affects the sale of the product.

A currently popular packaging material used for aseptic packaging is a paperboard/foil/plastic laminate made by Tetra-Pak. This laminated structure consists of as many as six layers of materials viz. polypropylene, surlyn, aluminum foil, polyethylene, paperboard, and polyethylene as the innermost layer.

Other variations that can also be used for thermal sterilization include laminates consisting of saran, ethyl vinyl alcohol (EVOH), polyethylene, and polystyrene or metalized polyester consisting of vinyl ethyl acetate, nylon, foil, and polyethylene. Aluminum foil is the most commonly used barrier material, with polypropylene or polyolefin (type of polyethylene) being the universal heat-sealing and food contact surfaces. When foil is used, it needs to be protected against mechanical harm, which is usually provided by paperboard. All of these composite packages yield the desirable moisture, oxygen, light and microbial barrier properties, strength and heat stability needed for successful aseptic package.

5. ASEPTIC TANK:

The aseptic tank is used for intermediate storage of UHT treated food products. It can be used in different ways in UHT lines, depending on plant design and the capacities of the various units in the process and packaging lines.

- If one of the packaging machines incidentally stops, the aseptic tank can take care of the surplus product during the stoppage.
- Simultaneous packaging of two products.

The aseptic tank is first filled with one product, sufficient to last for a full shift of packaging. Then the UHT plant is switched over to another product which is packed directly in the line of packaging machines. One or more aseptic tanks included in the production line offer flexibility in production planning.

Direct packaging from a UHT plant requires recirculation of a minimum extra volume of 300 litres per hour to maintain a constant pressure to the filling machines. Products which are sensitive to overtreatment cannot tolerate this and the required overcapacity must then be fed from an aseptic tank.

The optimum arrangement must thus be decided for each individual process with UHT plants, aseptic tanks and aseptic packaging machines.

6. ROLE OF MICROPROCESSORS IN ASEPTIC PACKAGING

Microprocessors & microcomputers are first used in packaging machines in 1973. Microprocessor-based equipment controls were first used in 1977. Microprocessor-controlled packaging machinery was first commercially used in 1978. Microprocessor-based aseptic packaging has capability of monitoring one or more process variables simultaneously.

6.1 Main operations that are taken care by microprocessors are

1. Feeding of film to the machine
2. Converting of film into required shape of specific dimensions
3. Filling the product with specific volume of product
4. Heat sealing
5. Collecting up of specific no of packs and shrink wrapping them into one single pack.

All these operations are taken care by Microprocessors.

7. STERILIZATION OF PACKAGING MATERIAL:

Whatever the choice of packaging material used, it must be pre-sterilized prior to filling. Sterilization of the packaging material should not impair that material. Methods commonly used for sterilization of packaging materials or packages include steam (saturated or superheated), hot air, hydrogen peroxide, ultraviolet light, irradiation, or the heat generated during co-extrusion of certain films.

7.1 Precautions to be taken: Since aseptic packaging systems are complex, there is considerable scope for packaging faults to occur, which will lead to spoiled products. Thus, following precautions are to be taken.

1. Packages should be inspected regularly to ensure that they are airtight, again focusing upon those more critical parts of the process, such as start-up, shutdown, product changeovers and, for carton systems, reel splices and paper splices.
2. Pipes, storage tank, and surfaces of the packaging machine come into contact with the sterilized product have to be sterilized.
3. Sterilization procedures should be verified.
4. The seal integrity of the package should be monitored as well as the overall microbial quality of packaging material itself.
5. Care should be taken to minimize contamination during subsequent handling. All these could result in an increase in spoilage rate.
6. Rinsing, cleaning and disinfecting procedures are also very important, especially the removal of fouling deposits, which may provide a breeding ground for the growth of micro-organisms, especially thermofiles.

8. QUALITY ASSURANCE ASPECTS OF ASEPTIC PACKAGING

Aseptic packaging has to be meticulously checked. Not only must the packaged product be examined, but so must all preceding steps, as well as the operators, which are potential carriers of pathogens. If just one bacterium reaches the product, and that bacterium is pathogenic and can proliferate (for example, *Staphylococcus aureus*), the result could be disastrous. In addition to regular sampling during production, further samples should be taken at the times or in situations known to be associated with an increased risk of contamination. It is advisable to incubate these samples long enough, in most cases from 5 to 7 days at 30^0C to allow sub-lethally damaged bacteria also to grow to detectable counts. The products should only be delivered if the result of the shelf-life test is Satisfactory.

9. CONCLUSION

Packaging of aseptically processed food is the most critical key for a successful operation. The product has to be packaged in the form desired, which will yield the benefits anticipated after the product has been sterilized, but, this quality of aseptic packaging provides more shelf life to the food product and thus, more transportability, which will incur more profit to the processor. The cost of aseptic package is still more, which needs to be brought down, so that customers can have long life products at lower prices.

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Component – I

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Component-I (B) Description of Module

Items	Description of Module
Subject Name	Home Science
Paper Name	Quantity Food Production
Module Name	PFA and Other Standards
Module ID	H06QF08
Pre-	Previous knowledge about consumer education and food science

requisites	
Objectives	• Know about the different food laws and regulations existing in India. • Know about the different Indian and International food standards.
Keywords	PFA, FPO, MPCO, MMO, BIS, Agmark, CCFS, CFL, ISO, Codex Alimentarius

PFA AND OTHER STANDARDS

1. INTRODUCTION

Different laws govern the food processing sector in India. Multiple laws/regulations prescribe varied standards regarding food additives, contaminants, food colours, preservatives and labeling. The food laws in India are enforced by the Director General of f Health Services, Ministry of Health and Family Welfare, Government of India.

2. OBJEVTIVES

After studying this chapter, you should be able to:

- Know about the different food laws and regulations existing in India.
- Know about the different Indian and International food standards.

3. NEED FOR FOOD LAWS

Food laws came into existence for a number of reasons:

(i) To maintain the quality of food produced in the county.
(ii) To prevent exploitation of the consumers by the sellers. This could only be done by making consumers aware of what to expect in terms of quality when they buy food.
(iii) To establish a criteria for quality of food products, since more and more foods are eaten in processed forms rather than natural forms. This has resulted in the inability of the consumer to identify the quality of the contents of a packet or can, except through the label, or a mark of quality that could be identified easily.

4. DIFFERENT FOOD LAWS IN INDIA

4.1. Prevention of Food Adulteration, (PFA) Act (1954)

The PFA Act, 1954 lays down the guidelines for setting up standards for various food items like cereals and cereal products, pulses, ghee, etc. All processed items which are mass produced for public use are expected to conform to these standards. Amendments to the Act have been made and standards laid down by the Central Committee for Food Standards, on the basis of the standards laid down by the International Codex Alimentarius Commission, a body set up jointly by the FAO and the WHO to prepare international food standards, for the protection of consumers and to ensure fair food trade practices.

The PFA Act states that an article of food shall be deemed to be adulterated:

(a) If the article sold by a vendor is not of the nature, substance or quality demanded by the purchaser, and is to his prejudice, or is not of the nature, substance or quality thereof.
(b) If the article contains any other substance which affects, or if the article is so processed as to affect injuriously the nature, substance or quality thereof.
(c) If any inferior or cheaper substance has been substitutes wholly or in part fo the article so as to affect injuriously the nature, substance or quality thereof.
(d) If any constituent of the article has wholly or in part been abstracted so as to affect injuriously the nature, substance or quality thereof.
(e) If the article has been prepared, baked, or kept under insanitary conditions whereby it has become contaminated or injurious to health.
(f) If the article consists wholly or in part of any filthy, putrid, disgusting, rotten, decomposed or diseased animal or vegetable substance or is insect infested or otherwise unfit for human consumption.
(g) If the article is obtained from a diseased animal.
(h) If the article contains any poisonous or other ingredient which renders it injurious to health.
(i) If the container of the article is composed whether wholly or in par, of any poisonous or deleterious substance which renders the contents injurious to health.
(j) If any colouring matter other than that prescribed in respect thereof and in amounts not within the prescribed limits of variability is present in the article.
(k) If the article contains any prohibited preservative or permitted preservative in excess of the prescribed limits.
(l) If the quality or purity of the article falls below the prescribed standard or its constituents are present in quantities which are in excess of the prescribed limits of variability.

Consumers can also take samples from shops and file complaints to the Consumer forums established under the Consumer Protection Act (CPA), if they get adulterated foods. The PFA department can also be contacted by phone.

4.2.Essential Commodities Act, 1955

Under this act, there are a number of control orders. The main objectives of this act are to regulate the manufacture, commerce, distribution of essential commodities including food. The following orders are include under this act:

4.2.1.The Fruit Products Order, (FPO) 1955: The manufacture and distribution of all fruit and vegetable products, synthetic syrups, aerated beverages and vinegar is regulated under this order. It lays the limits for the presence of poisonous elements, permitted food colours, preservatives and additives. The order specifies the standards of sanitation and hygiene followed in factories. It gives directions regarding packing, marking and labeling of containers. It stipulates the standards for quality products. Under this order, it is mandatory for manufacturers of fruit and vegetable products to secure a valid license from the Ministry of Food Processing Industries.

4.2.2. Meat Products Control Order, 1973: This order controls the manufacture, quality and distribution of all raw and processed meat and meat products. The order is regulated by the Directorate of Marketing and Inspection and requires that the meat be obtained from healthy animals, slaughtered in a licensed slaughter house and is fit for human consumption.

4.2.3. Milk and Milk Products Order, 1992: This order is applicable to large units handling more than 10,000 litres milk per day or milk products containing milk solids in excess of 500 tonnes per year. The production, sales, purchase and distribution of milk powder and milk products are covered under this.

4.2.4. Solvent Extracted oils, De-oiled meal and Edible Flour Control Order, 1967 and Vegetable Products Control Order, 1976: The manufacture and distribution of solvent extracted oils, de-oiled meals, edible flours and hydrogenated vegetable oils is controlled by this order. The order stipulates that any vegetable oil product like vanaspathi or bakery shortening or margarine, unless it conforms to the standards of quality shall not be manufactured, stocked or sold. A license is granted by the Directorate of Vanaspathi, Vegetable oils and fats under the Ministry of Civil Supplies consumer Affairs and Public Distribution. The Directorate also controls the market price of vanaspathi.

4.2.5. Standards on Weights and Measures (Packaged Commodities) Rules, 1977: Under this rule, it is obligatory to declare the quantity of the packed commodity on the label.

4.3. The Edible Oils Packaging (Regulation) Order, 1998

All edible vegetable oils and fats excluding margarine, vanaspathi, , bakeryshortening and fat spreads are included in this Act. From December 15th,1998, no person shall sell or expose for sale, or distribute or offer for sale, or dispatch or deliver to any person for the purpose of saleany edible oil that does not conform to the standards of quality as provided in the Prevention of Food Adulteration Ac, 1954 and rules thereunder and that is not packed in a container, marked and labeled in the specified manner.

All edible oil packers need a certificate of registration. This certificate is issued only when sanitary requirements are fulfilled and the plant has qualified, experienced chemists and a laboratory for testing samples of edible oils.

The container/pouch in which the edible oil is packed should have the following particulars:

- Name/trade name
- Name and address of packer
- Name/description of contents
- Net mass/volume of contents
- Batch no., month and year of manufacture
- Registration number

The label should not contain any statement or claim that is false or misleading with respect to the quality or nutritive value of the edible oil.

5. VOLUNTARY STANDADS AND CERTIFICATION SYSTEMS IN INDIA

In addition to the mandatory acts and orders, agencies such as Bureau of Indian Standards (BIS) and the Directorate of Marketing and Inspection have also laid down quality standards for foods. These are however voluntary.

5.1. Bureau of Indian Standards (BIS)

BIS, formerly known as Indian Standards Institution (ISI) have the following aspects:

- Food Safety Management Certification as per IS/ISO 2200
- Laboratory Testing, Calibration and Management
- Training of personnel in the field of Standardisation, Quality control, etc

Safety, performance and reliability are assured when the product is BIS marked. The Bureau of Indian standards operates a Certification Mark Scheme under the BIS Act, 1987. Standards covering more than 450 different food products have been published.

The organization runs a voluntary certification scheme for certification of processed food items. Standards are laid for vegetable and food products, spices and condiments, animal products and processed foods. Once these standards are accepted, manufacturers whose products conform to these standardsare allowed to use BIS label on each unit of their product. The products are checked for the quality by the BIS in their own network of testing laboratories at Delhi, Mumbai, Kolkatta, Chennai, Chandigarh and Patna or in a number of public and private laboratories recognized by them.

The certification system is basically voluntary in character but some of the items require compulsory BIS certification under PFA. They are food colours and food colour preparation, natural food colours, food additives, infant milk foods, infant formula, milk-cereal based weaning food, milk powder and condensed milk.

Activities of BIS for benefit of industry and common consumers

- Formulation of standards
- Mark on products under BIS Certification Scheme
- Certification of Foreign Manufacturers and importers
- ECO mark for Environment Friendly Products

5.2. The AGMARK Standard

The word ñAGMARKò is derived from Agricultural marketing. The AGMARK standard was set up by the Directorate of Marketing and Inspection of the Government of India by introducing an Agricultural Products Act 1937. The word ñAGMARKò on the product ensures quality and purity. Before affixing the AGMARK seal, there are four stages:

- Preliminary testing
- From the product, Inspecting officers take representative samples
- Technically qualified and experienced officers test the samples and assign AGMARK quality grades
- Afterwards the commodity is packed using AGMARK labels or AGMARK replica on pouches or containers
- Even after sending to the distribution markets, AGMARK products are subjected to continuous inspection

A lot of care is taken in laying down the AGMARK grade and in affixing the AGMARK quality label. The quality of the product is determined with reference to the size, variety, weight, colour, moisture, fat content and other factors. The act defines quality of cereals, spices, oil seeds, oil, butter, ghee, legumes and eggs and provides for the categorisation of commodities into various grades depending on the degree of purity in each case. The grades incorporated are grades 1, 2, 3 and 4 or special, good, fair and ordinary. The standards also specify the types of packaging to be used for different products. The physical and chemical characteristics of products are kept in mind while formulating the AGMARK specifications.

The ñCertificate of Authorisationò is granted only to those in the trade having adequate experience and standing in the market. The staff of the Directorate of Marketing and Inspection or of the State Government is generally present at the time of selection of goods, their processing, gradingand packing before applying the AGMARK label.

Products available under AGMARK are pulses, wheat products, vegetable oils, whole and ground spices, milk products, honey, asafoetida, rice, tapioca, sago, seedless tamarind and gram flour. Grading of these commodities are voluntary. On the other hand, grading of commodities like wlnuts, spices, basmati rice, essential oils, and onions and potatoes meant for export. AGMARK ensures the quality of produce to the importers.

The process of grading and administering the grades entails some cost, hence graded products are priced slightly more. Considering the quality assured, the little extra cost is worth paying.

Grading of agricultural commodities has three main purposes:

1. It protects the producer from exploitation. By knowing the quality and of his produce, he is in better bargaining position against the trader.
2. It serves as a means of describing the quality of commodities to be purchased by the buyers and sellers all over the country and abroad.This establishes a common trade language avoids the need for physical checking and handling at many points.
3. It protects the consumer by ensuring the quality of the products he purchases.

The Directorate of Marketing and Inspection of Central Government has 21 laboratories and 50 sub offices spread all over the country. The Central AGMARK Laboratory at Nagpur, continuously carries out research and development work in this field.

6. FOOD STANDARDISATION AND REGULATION AGENCIES IN INDIA

6.1. Central Committee for Food Standards (CCFS)

It is concerned with prevention of food adulteration and fraudulent practices. Since 1947, CCFS has been functioning to advise the Central and State Government on matters arising out of the administration of Food Safety and Standards Act. It provides guidelines for:

- Minimum basic requirements for food quality during handling, storage, preparation and serving of food under sanitary conditions.
- Freedom from extraneous matters, foreign matters, impurities and mixed inferior materials.
- Proper packaging, branding and declaration of net weight as well as dates of manufacturing and packing.
- Use of approved food additives for flavor and colour.

The guidelines are primarily intended to protect consumers from the health hazards of the poisoning food and also exploitation by malpractices such as misbranding, adulteration, incorrect labeling, false claims, less weight, excess and indiscriminate use of food additives, etc.

6.2. Central Food Laboratories (CFL)

The Government of India has established four central food laboratories serving as appellate laboratories for analysis of food supplies. These are:

1. Central food Laboratory, Kolkatta
2. Food Research and Standardisation laboratory, Ghaziabad
3. Public Health Laboratory, Pune
4. Central Food Technological Research Institute Laboratory, Mysore.

In addition to these, every state has established their own food analyzing food laboratories in their states.

7. INTERNATIONAL STANDARDS

7.1. International Organisation for standardization (ISO)

The objective of ISO is to promote the development of standardsin the world with a view to facilitate international exchange of goods and services and to develop mutual cooperation in the sphere of intellectual, scientific, technological and economic activity. Other functions of ISO are:

- Harmonisation of food standards throughout the world.
- Promotion of economic development.
- Exchange of goods.
- Standards help to revise the levels of quality, safety, reliability, efficient compatibility and inter exchangeability.
- Safeguards consumers and users.
- Global exchange of goods and services incorporating rationality, practical applicability, environmental protection, safe guards of safety and health and equal opportunities in world trade.

As a nongovernmental organization, ISO has no legal authority to enforce their implementation.

ISO develops standards in response to market demand. ISO standards are technical agreements, which handle the framework for compatible technology worldwide. In business, suppliers can base the development of their products and services on specifications that has wide acceptance standards. Customers are benefitted from the effect of competition among suppliers. For the Government, it provides the technological and scientific based underpinning health safety and environmental legislation.

International standards give developing countries a basis for making the right decisions, when investing their scarce resources. For consumers conformity of products and services to international standards provides assurance about their quality, safety and reliability.

7.2. Codex Alimentarius

Codex Alimentarius Commission was established in 1962. The Codex Alimentarius which means ñFood Lawò or :Food Codeò in Latin is a combined set of standards , codes or practices and other model regulations available for countries to use and apply to food in international trade. The dual objectives of Codex Alimentarius Commission Fare are to protect the health of consumers and increase international trade.

The elaboration of Codex Standards, guidelines and other recommendations is based ion the principles of sound scientific analysis and evidence in order that the standards assure the quality and safety of the food supply.

The Codex Secretariat is located in Rome and is financed jointly by the FAO and WHO. At present, there are 165 countries including Indiaas Codexôs members and this covers ninety eight percent of the worldôs population. The codex commission meets every two years either in Rome or in Geneva.

Codex can be divided in to three main groups:

1. The commodity standards committee work vertically dealing with food products such as processed fruits and vegetables, fats and oil, fresh fruits and vegetables, natural mineral water, cocoa products and chocolates, fish and fishery products, 3sugar, milk and milk products, cereals and meat products.
2. The general subject committees work horizontally on standards such as food additives and contaminants, pesticide residues, hygiene, labeling, inspection and certification systems, analysis and sampling, nutrition and foods for special dietary uses. They are used by processors to ensure that foods are microbiologically safe and are fit for human consumption. ñMaximum Residue Limits (MRLS) have been set for pesticides. Specifications for ñfood grade qualityò of additives form an important part of codex work.
3. The six regional coordinating committees are based in Africa, Asia, Europe, Latin America and Caribbean, North America and South West Pacific and the near East.

The Codex Alimentarius officially covers all foods, whether processed, semiprocessed or raw. Specific standards have ben worked out for foods that are marketed directly to the consumer such as

- Meat products (fresh, frozen, processed meats and poultry)
- Fish and Fishery products (marine, fresh water and aquaculture)

- Milk and Milk products (all fresh, processed and frozen items)
- Foods for special dietary uses (including infant formulae and baby foods)
- Fresh and processed vegetables, fruits and fruit juices
- Cereals and derived products, dried legumes
- Fats, oils and derived products such as margarine
- Miscallaneous food products (chocolate, sugar, honey, mineral water)

Codex food standards, codes of practice and other guidelines protect consumers from unsafe food and fraudulent practices. Codex alimentarius brings together all the interested parties- scientists, technical experts, governments, consumers and industry representatives to help develop standards for food manufacturing trade.

Codex has provided the nations with guides for good agricultural practices, including how to use pesticides, commodity food standards for processing products and with hygiene codes for making food safe for citizens and acceptable in international trade.

Codex India is the National codex Contact Point (NCCP) for India. It is located at the directorate General of Health Services, Ministry of Health and Family Welfare, New Delhi. It coordinates and promotes codex activities in India.

Foods everywhere will ultimately be influenced by codex in many different dimensions ï in safety standards, food additive, pesticide uses, labeling of pre packed foods, international trade, competition and pricing, be the foods locally grown or imported from the other side of the world.No food is nutritious if it is not safe. By following the standards laid down by Codex Alimentarius, countries and individual business can help to ensure that the foods are safe and nutritious.

The Codex Alimentarius is published in five languages namely Arabic, Chinese, English, French and Spanish. Codex Alimentarius is recognized by the World Trade Organisation (WTO) as an international reference standard for resolving disputes concerning food safety and consumer protection.

8. SUMMARY

Today, food safety is an important issue with public health implications. Effective means of food quality can be legislative measures, certification schemes and public participation and involvement in the program. There are several acts and regulations that are in force. Violation of these acts is against the law and any person who fails to comply with these codes may have to pay a heavy fine or undergo prosecution. The food operator has a lot to gain by cooperating with the regulatory agencies and conforming to the rules laid down by them.

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Module – 24: Modified Atmosphere Packaging & Controlled Atmosphere Packaging

1.0 Introduction

The normal gaseous composition of air is nitrogen (N_2) 78.08% (v/v), oxygen (O_2) 20.96% and carbon dioxide (CO_2) 0.04%, variable concentrations of water vapour and traces of noble gases. Food spoils rapidly in air due to moisture loss or gain, reaction with oxygen and the growth of aerobic microorganisms, i.e. bacteria and moulds. Microbial growth causes changes in texture, colour, flavour and nutritional value of the food which can make food unpalatable and potentially unsafe for human consumption. Storage of foods in a modified gaseous atmosphere can maintain quality and extend product shelf life, by slowing chemical and biochemical deteriorative reactions and by slowing or preventing the growth of spoilage organisms.

Modified atmosphere packaging (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* (Hintlian & Hotchkiss, 1986) while controlled atmosphere storage (CAS) involves maintaining a fixed concentration of gases surrounding the product by careful monitoring and addition of gases, the gaseous composition of fresh MAP foods is constantly changing due to chemical reactions and microbial activity. Gas exchange between the pack headspace and the external environment may also occur as a result of permeation across the package material.

1.1 Historical development

The first fresh carcass meat was exported from New Zealand and Australia under CAS in the early 1930s. Early developments were generally for storage and transportation of bulk foods. Scientific investigations on the effect of gases on extending the shelf life of foods were conducted in 1930 on fresh meat and poultry. Fresh poultry was stored in an atmosphere of 100% CO_2 which was found to considerably extend shelf life (Killefer, 1930).

Commercial retailing of fresh meat in MAP tray systems was introduced in the early 1970s. European meat processing and packaging developed during the 1980s with centralised production of MAP meat in consumer packs for distribution to retail outlets. In the past few years, there has been a considerable increase in the range of foods packed in modified atmospheres for retail sale including meat, poultry, fish, bacon, bread, cakes, crisps, cheese and salad vegetables. UK retail sales of products packed under MAP grew from approximately 2 billion packs in the mid 1990s to 2.8 billion packs in 1998. Carcass meat and cooked meat and meat products accounted for 29% and 15% of the total volume of MAP retail foods (Anon, 1999).

2.0 Gaseous environment

2.1 Gases used in MAP

The three main gases used in MAP are O_2, CO_2 and N_2. The choice of gas depends upon the food product being packed. Used singly or in combination, these gases are commonly used to increase shelf life with optimal organoleptic properties of the food. Inert or noble gases, such as argon, are used commercially for products like coffee and snacks, however, the literature on their application and benefits is limited. Experimental use of carbon monoxide (CO) and sulphur dioxide (SO_2) has also been reported.

2.1.1 Carbon dioxide (CO_2)

It is a colourless gas with a slight pungent odour at very high concentrations. It is a suffocating and slightly corrosive in the presence of moisture. It dissolves readily in water (1.57 g/kg at 100 kPa, 20°C) to produce carbonic acid (H_2CO_3) that increases the acidity of the solution and reduces the pH. It is also soluble in lipids and some other organic compounds. The solubility of CO_2 increases with decreasing temperature. Therefore, the antimicrobial activity of CO_2 is markedly greater at refrigeration temperature. It has significant implications for MAP of foods. The high solubility of CO_2 can result in pack collapse due to the reduction of headspace volume.

2.1.2 Oxygen (O_2)

It is a colourless, odourless and highly reactive gas which supports combustion. It has a low solubility in water (0.040 g/kg at 100 kPa, 20°C). Oxygen promotes several types of deteriorative reactions in foods including fat oxidation, browning reactions and pigment oxidation. Most of the common spoilage bacteria and fungi require O_2 for growth. Therefore, to increase the shelf life of foods, the pack atmosphere should contain a low concentration of residual O_2.

2.1.3 Nitrogen (N_2)

It is an inert gas with no odour, taste or colour. It has a lower density than air, non-flammable and has a low solubility in water (0.018 g/kg at 100 kPa, 20°C) and other food constituents. Nitrogen does not support the growth of aerobic microbes and therefore inhibits the growth of aerobic spoilage but does not prevent the growth of anaerobic bacteria. The low solubility of N_2 in foods can be used to prevent pack collapse by including sufficient N_2 in the gas mix to balance the volume decrease due to CO_2 going into solution.

2.2 Effect of the gaseous environment on the activity of bacteria, yeasts and moulds

Food may contain a wide range of microorganisms including bacteria and their spores, yeasts, moulds, protozoa and viruses. The major concern is to prevent the growth of bacteria, yeasts and moulds in foods. Some microorganisms may survive during the shelf life period and cause food poisoning or disease in consumers.

2.2.1 Effect of oxygen

Bacteria, yeasts and moulds have different respiratory and metabolic needs and can be grouped according to their O_2 needs (Table 1).

Table 1: Oxygen requirements of some microorganisms of relevance in modified atmosphere packaging

Group	Spoilage organisms	Pathogens
Aerobes	*Micrococcussp*	*Bacillus cereus*
	Moulds e.g. Botrytis cinerea	*Yersinia enterocolitica*
	Pseudomonas spp.	*Vibrio parahaemolyticus*
		Camplobacter jejuni
Microaerophiles	*Lactobacillus spp.*	*Listeria monocytogenes*

	Bacillus spp.	*Aeromonas hydrophilia*
	Enterobacteriaceae	*Escherichia coli*
Facultative anaerobes	*Brocothrix thermosphacta*	*Salmonella spp.*
	Shewanella putrefaciens	*Staphylococcus spp.*
	Yeasts	*Vibrio spp.*
Anaerobes	*Clostridium sporogenes*	*Clostridium perfringens*
	Clostridium tyrobutyricum	*Clostridium botulinum*

2.2.2 Effect of carbon dioxide

The antibacterial properties of CO_2 have been known for some time (Valley & Rettger, 1927). More recent work has shown that CO_2 is effective against psychrotrophs (King & Nagel, 1975) and has potential for extending the shelf life of food stored at low temperatures.

There are several theories regarding the actual mechanism of CO_2 action. In general, CO_2 increases the lag phase and generation time of microorganisms, and these effects are enhanced at lower temperatures. There appears to be an array of antimicrobial mechanisms including CO_2 lowering pH, inhibition of succinic oxidase at CO_2 concentrations greater than 10%, inhibition of certain decarboxylation enzymes and disruption of the cell membrane (Valley & Rettger, 1927; King & Nagel, 1975; Gill & Tan, 1979; Enfors & Molin, 1981, Daniels et al., 1985).

The sensitivity of selected spoilage and pathogenic bacteria to CO_2 is shown in Table 2. The growth of Gram-negative bacteria is inhibited more than that of Gram-positive bacteria. The effects of CO_2 are markedly temperature dependent, and it is therefore imperative that the integrity of temperature control across the supply chain be maintained. It has been observed that germination of spores of *Clostridium botulinum* may be stimulated by CO_2 (Eklund, 1982).

Table 10.2 Sensitivity of microorganisms relevant to modified atmosphere packaging to carbon dioxide

Inhibited by CO_2	CO_2 has little or no effect on growth	Growth is stimulated by CO_2
Pseudomonas spp.	*Enterococcus* spp.	Lactobacillus spp.
Aeromonas spp.	*Brochothrix* spp.	*Clostridium botulinum*
Bacillus spp.	*Lactobacillus* spp.	
Moulds including *Botrytis cinerea*	*Clostridium* spp.	
Enterobacteriaceae including *E. coli*	*Listeria monocytogenes*	
Staphylococcus aureus	*Aeromonas hydrophilia*	
Yersinia enterocolitica		

CO_2 is soluble in water and lipids at low temperature, and adjustment for adsorption is required. A high concentration of CO_2 can lead to defects, e.g. increased drip in fresh meats, and to container collapse. The latter can occur where CO_2 is the major gas present, and where the gas goes into solution in the water and lipid phases of the product. To counteract this effect, an insoluble gas such as nitrogen may be added to the gas mix. When CO_2 is required to control the bacterial and mould growth, a minimum of 20% is generally used. Optimal levels appear to be in the region of 20–30%. Concentrations of 100% CO_2 may be used in bulk packs of meat and poultry.

2.2.3 Effect of nitrogen

Nitrogen is a relatively inert gas. It is used to displace air and, in particular, O_2 from MAP. Since air and consequently O_2 have been removed, growth of aerobic spoilage organisms is inhibited. It is also used to balance gas pressure inside packs, so as to prevent the collapse of packs containing high moisture and fat-containing foods, e.g. meat. Because of the solubility of CO_2 in water and fat, these foods tend to absorb CO_2 from the pack atmosphere.

2.3 Effect of the gaseous environment on the chemical and biochemical properties of foods

Food spoilage can also be caused by chemical and biochemical, including enzyme-catalysed, reactions in food.

2.3.1 Effect of oxygen

Apart from its effect on microorganisms, O_2 can promote oxidation of lipids, influence the colour of some food pigments, contribute to enzymic browning and promote off-flavours in some foods.

2.3.1.1 Lipid oxidation

Lipid oxidation is often called oxidative rancidity and is promoted by O_2. Oxidative rancidity is a major cause of food spoilage. The reaction of O_2 with unsaturated fatty acids in fat-containing foods is a major cause of deterioration. Oxidation of unsaturated fat is referred to as autoxidation, since the rate of oxidation increases as the reaction proceeds. Hydroperoxides are the predominant initial reaction products of fatty acids with oxygen. Subsequent reactions control both the rate of reaction and the nature of the products formed. Some of these products, viz. acids and aldehydes, are largely responsible for the off-flavour characteristics of rancid foods. Removal of O_2 and its replacement with N_2 or CO_2 or mixtures thereof can inhibit the development of rancidity.

2.3.1.2 Pigment colour in meat

There are three major pigments in meat, oxymyoglobin (red), myoglobin (purple) and metmyoglobin (brown). The colour cycle in fresh meat is reversible and dynamic with constant formation and reformation of the three pigments. Brown metmyoglobin, the oxidised or ferric form of the pigment, cannot bind O_2. The purple myoglobin, in the presence of O_2, may be oxygenated to the bright red pigment oxymyoglobin, producing the familiar bloom of fresh meat, or it may be oxidised to metmyoglobin, producing the undesirable brown. The conversion of myoglobin to oxymyoglobin or metmyoglobin is depended on O_2 concentration. Under low O_2 environments, the reduced myoglobin is oxidized to the undesirable brown metmyoglobin pigment. Conversely, high O_2 environments favour the formation of oxymyoglobin.

2.3.1.3 Photo-oxidation of chlorophyll

The green colour of chlorophyll changes to brown/grey when oxidised to pheophytin which is not desirable. The photo-oxidation of chlorophyll and loss of desirable green colour can be significantly reduced by MAP under low O_2 levels and in opaque packages.

2.3.1.4 Oxidative off-flavours

Oxidative off-flavours can be caused by numerous oxidative reactions in food and drink products. Oxidative warmed-over flavour is a characteristic off-flavour primarily associated with cooked meats and poultry. Commercially, this affects mainly the chilled ready meals and other cook-chill products. In cooked meats and poultry held at chilled storage temperatures, this stale, oxidised flavour may become apparent within a short time.

Meat, fish, poultry, beverage and dairy products are highly susceptible to oxidative processes which can initiate a chain of reactions resulting in flavour impairment. This can occur relatively quickly. MAP under low O_2 levels can delay the onset of oxidative off-flavours.

2.3.2 Effects of other MAP gases

Nitrogen is inert and has no direct effect on the chemical and biochemical properties of foods. Because of the high solubility of CO_2 and its reaction with water to form carbonic acid, there is potential for some adverse effects on particular foods. These are probably due to the production of localised areas of low pH on or near the food surface. These effects if they do occur, and there is debate whether they occur in practice, may result in the loss of blooming some meats for example. The mechanism is likely to be associated with pH-induced protein changes including denaturation and other changes in conformation, resulting in atypical values for light absorption and reflection from the product surface.

Carbon monoxide can combine with myogloblin to form the bright red compound carboxymyogloblin that is similar in colour to oxymyogloblin. This compound is much more stable than oxymyogloblin and is one of the reasons why CO is toxic. CO also retards fat oxidation and the formation of metmyogloblin. Currently, CO is not approved for use in MAP.

3.0 Packaging materials

Plastic packaging materials may consist of a monolayer formed from a single plastic, but most MAP films are multilayer structures formed from several layers of different plastics. Plastics packaging for MAP applications is most commonly found in the form of flexible films for bags, pouches, pillow packs and top webs or as rigid and semi-rigid structures for base trays, dishes, cups and tubs. Commonly used plastic flexible laminates are produced from polyethylene (PE), polypropylene (PP), polyamide (nylons), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polyvinylidene chloride (PVdC) and ethylene vinyl alcohol (EVOH). Rigid and semi-rigid structures are commonly produced from PP, PET, unplasticised PVC and expanded polystyrene.

Table 10.3 Typical plastic-based packaging structures for MAP applications

Material	Application
UPVC/PE	Thermoformed base tray, Pre-formed base tray
PET/PE	Thermoformed base tray
XPP/EVOH/PE	Thermoformed base tray
PS/EVOH/PE	Thermoformed base tray
PET/EVOH/PE	Thermoformed base tray
PVdC coated PP/PE	Lidding film
PVdC coated PET/PE	Lidding film
PA/PE	Lidding film, Flow wrap film
PA/ionomer	Flow wrap film
PA/EVOH/PE	Flow wrap film
PET	Pre-formed base tray

PP	Pre-formed base tray

3.1 Selection of plastic packaging materials

Several factors must be considered when selecting package materials for MAP applications.

3.1.1 Food contact approval

Packaging materials in contact with food must not transfer components from the packaging to the food product in amounts that could harm the consumer..

3.1.2 Gas and vapour barrier properties

Packaging materials for MAP must have the required degree of gas and vapour barrier for the particular food application.

3.1.3 Optical properties

Good optical properties, such as high gloss and transparency, are essential for bag, pouch and top web materials to satisfy consumer demand for a clear view of the product. To provide attractive appearance and shelf impact, some base tray materials are available in various colours which enhances the visual appeal of the product. PET, PP and EPS trays are supplied in a range of colours. PVC trays are generally used in their natural form to provide a transparent pack.

3.1.4 Antifogging properties

Condensation (fogging) of water vapour on the inner surface of food packs can occur when the temperature of the pack environment is reduced, resulting in a temperature differential between the pack contents and the packaging material. Fogging of the inner surface of lidding film is a result of light scattering by the small droplets of condensed moisture that leads to poor product visibility and an aesthetically unpleasing appearance of the pack. This can be overcome by applying antifogging agents to the plastic heat sealing layer, either as an internal additive or as an external coating. These chemicals decrease the surface energy of the packaging film which enables moisture to spread as a thin film across the under surface of the pack rather than collecting as visible droplets. Antifogging agents include fatty acid esters. Most lidding materials are available with antifog properties, and commonly treated plastics include LDPE, LLDPE, EVA and PET.

3.1.5 Mechanical properties

Resistance to tearing and puncture and good machine handling characteristics are important in optimising the packaging operation and maintaining pack integrity during forming and subsequent handling and distribution.

3.1.6 Heat sealing properties

Effective heat seals are essential for maintaining the desired gas composition within the pack. Heat seal quality is dependent on many factors including seal material, seal width and machine settings such as temperature, pressure and dwell time.

3.2 Modified atmosphere packaging machines

The function of MAP machines is to retain the product on a thermoformed or pre-formed base tray, or within a flexible pouch or bag, modify the atmosphere, apply a top web if required, seal the pack and cut and remove waste trim to produce the final pack. Different types of MAP machines are discussed below.

3.2.1 Chamber machines

They are generally used for low production throughput, with pre-formed pouches, though tray machines. The filled pack is loaded into the machine, the chamber closes, a vacuum is created on the pack and back flushed with the modified atmosphere. Heated sealing bars seal the pack, the chamber opens, packs are removed and the cycle continues. These machines are cheap and easy to operate but relatively slow and labour intensive. Some chamber machines can handle large packages and are suitable for bulk packs.

3.2.2 Snorkel machines

They operate without a chamber and use pre-formed bags or pouches. The bags are filled and positioned in the machine. The snorkel is introduced into the bag, draws a vacuum and introduces the modified atmosphere. The snorkels withdraw and the bag is heat sealed. Bag in-box bulk products and retail packs in large MAP master packs can be produced on these machines.

3.2.3 Form-fill-seal tray machines

Form-fill-seal (FFS) machines form pouches from a continuous sheet of roll stock (flow wrap), or form flexible or semirigid tray systems comprising a thermoformed tray with a heat sealed lid. FFS machines may be orientated in a vertical plane or a horizontal plane. FFS machines using pre-formed trays or producing thermoformed trays are almost exclusively horizontal machines. Horizontal form-fill-seal MAP machines are used extensively in the food industry.

4.0 Modification of the pack atmosphere

4.1 MAP machines use mainly one of the two techniques to modify the pack atmosphere.

4.1.1 Gas flushing

This method employs a continuous gas stream that flushes air out from the package prior to sealing. This method is less effective at flushing air out of the pack results in residual oxygen levels of 2–5%. Hence, it is not suited for oxygen-sensitive food products. Generally, gas flushing machines have a simple and rapid operation and therefore a high packing rate.

4.1.2 Compensated vacuum gas flushing

This method uses a two-stage process:

The evacuation stage – a vacuum is pulled on the pack to remove air. Generally, it is not possible to achieve a full vacuum, since reduced pressures will result in water to boil. The vacuum achieved is generally between 5 and 10 mm of Hg. As a general rule, the cooler and drier the food, the lower the achievable vacuum.

Gas flushing stage – the pack is flushed with the modified gas mix. The evacuation of air from the pack results in lower residual oxygen levels than that achieved by gas flushing, and therefore this method is better suited for packing oxygen-sensitive products.

The two-stage process employed by the compensated vacuum method results in a lower packaging rate than that possible with gas flushing.

4.2 Sealing

An effective heat seal is critical for maintaining the quality and safety of the packaged product. Film factors (thickness and surface treatments) and plastic composition (resin type, molecular weight distribution and presence of additives) will determine the machine settings for the sealing operation. The correct combination of time, temperature and pressure of the seal bars is necessary to produce a good seal. Insufficient dwell time or temperature can result in ineffective seals that separate at the bond interface. Excessive dwell time or temperature can result in weakness adjacent to the seal area.

4.3 Cutting

Packs are discharged as a continuous arrangement of filled and sealed packs from a thermoform-fill-seal machine, and therefore, the final operation is to separate into individual packs. This can be carried out by two methods – die cutting and longitudinal and transverse cutting.

Die cutting is achieved in one operation. A shaped blade is forced through the film which is clamped in place by a frame assembly. Transverse cutting separates packs into rows and is carried out by guillotines or punches which are driven through the film that is supported by anvils. This may be carried out in conjunction with longitudinal cutting where circular knives cut through the tray flanges parallel to the length of the film.

5. MAIN FOOD TYPES

5.1 Raw red meat

The major causes of spoilage of meat are microbial growth and oxidation of the red oxymyoglobin pigment. The desirable red colour of the oxymyoglobin pigment has to be maintained, by having an appropriate O_2 concentration in the pack atmosphere, and at the same time minimise the growth of aerobic microorganisms. Highly pigmented red meats, such as venison and wild boar, require higher concentrations of O_2.

Aerobic spoilage bacteria, such as *Pseudomonas* species, normally constitute the major flora on red meats. Since these bacteria are inhibited by CO_2, it is possible to achieve both red colour stability and microbial inhibition by using gas mixtures containing 20–30% CO_2 and 70–80% O_2. These mixtures can extend the chilled shelf life of red meats from 2–4 days to 5–8 days. A gas/product ratio of 2:1 is recommended.

5.2 Raw poultry

Microbial growth, particularly growth of *Pseudomonas* and *Achromobacter* species, is the major factor limiting the shelf life of raw poultry which are effectively inhibited by CO_2. The inclusion of CO_2 in MAP at a concentration in excess of 20% can significantly extend the shelf life of raw poultry products. CO_2 concentrations higher than 35% in the gas mixture of retail packs are not recommended because of the risks of pack collapse and excessive drip. Nitrogen is used as an inert filler gas, and a gas/product ratio of 2:1 is recommended. Since pack collapse is not a problem for bulk MAP master packs, gas atmospheres of 100% CO_2 are frequently used. It is advisable to maintain refrigeration temperature as some pathogens are not inhibited by CO_2.

5.3 Cooked meat products

The principal spoilage mechanisms that limit the shelf life of cooked meat products are microbial growth, colour change and oxidative rancidity. For cooked meat products, the heating process should kill vegetative bacterial cells, inactivate degradative enzymes and fix the colour. Hence, spoilage of cooked meat products is primarily due to post-process contamination by microorganisms. The colour of cooked meats is susceptible to oxidation, so low levels of O_2 is maintained in packs. MAP using CO_2/N_2 mixes (25–50% CO_2 and 50–75% N_2) along with a gas/product ratio of 2:1 is widely used to maximise the shelf life and inhibit the development of oxidative off-flavours and rancidity.

5.4 Fish and fish products

Spoilage of fish and shellfish results from changes caused by three major mechanisms: (i) the breakdown of tissue by the fish's own enzymes (autolysis of cells), (ii) growth of microorganisms, and (iii) oxidative reactions. MAP can be used to control mechanisms (ii) and (iii) but has no direct effect on autolysis which is major cause of spoilage and reduces the effect of MAP.

The major spoilage bacteria in processed fish are *Pseudomonas, Moraxella, Acinetobacter, Flavobacterium, Cytophagaspecies* and *Clostridium botulinum*.

Generally, O_2 is included in MAP of white non-processed (i.e. non-fatty) fish to control the growth of *clostridia*. Gas mixtures of 30% O_2, 40% CO_2 and 30% N_2 are used but it will not significantly enhance the shelf life of oily or fatty fish. High, 40%, CO_2 mixes along with 60% N_2 are generally used for smoked and fatty fish.

5.5 Fruits and vegetables

Fresh produce continues to respire after harvesting and produce CO_2, water vapour and ethane. Ethane promotes ripening and softening of tissues and reduces the shelf life if not controlled. Hence, the goal of MAP for fruits and vegetables is to reduce respiration to extend shelf life while maintaining quality. Respiration can be reduced by lowering the temperature, lowering the O_2 concentration, increasing the CO_2 concentration and by the combined use of O_2 depletion and CO_2 enhancement of pack atmospheres. If the O_2 concentration is reduced beyond a critical concentration, anaerobic respiration will be started and produce ethanol, acetaldehyde and organic acids, which leads to undesirable odours and flavours and a marked deterioration in product quality. While increasing the CO_2 concentration will also inhibit respiration, high concentrations may cause damage in some species and cultivars. O_2 concentrations below about 3% can induce anaerobic respiration in many species of fresh produce.

The use of low concentrations of O_2 and elevated levels of CO_2 can have a synergistic effect on slowing down respiration and ripening. While the mechanisms whereby MAP can extend the shelf life of fresh produce are not fully understood, it is known that the low O_2/high CO_2 conditions reduce the conversion of chlorophyll to pheophytin, decrease the sensitivity of plant tissue to C_2H_4, inhibit the synthesis of carotenoids, reduce oxidative browning and discolouration and inhibit the growth of microorganisms.

Major pathogens as far as fresh produce is concerned are *L. monocytogenes* and *C. botulinum*. *L. monocytogenescan* grow under reduced O_2 levels and is not markedly inhibited by CO_2 and can also grow at lower temperature.

Equilibrium MAP has been used for fresh produce. Essentially, this involves using knowledge of the permeability characteristics of particular packaging films, along with the respiration characteristics of the product to balance the gas transfer rates of O_2 and CO_2 through the package with the respiration rate of the particular product.

Increasingly, gas packing fresh produce along with $CO_2/O_2/N_2$ gas mixtures is being used. This approach may have benefit in reducing enzymic browning reactions before a passively generated equilibrium modified atmosphere has been established.

5.6 Dairy products

MAP can increase the shelf life of a number of dairy products viz. whole milk powders, cheeses and fat spreads.

Whole milk powder is particularly susceptible to the development of off-flavours due to fat oxidation. Commercially, the air is removed under vacuum and replaced with 100% N_2 or N_2/CO_2 mixes and the powder is hermetically sealed in metal cans.

Cheddar cheese is traditionally vacuum packed. Increasingly MAP is being used with high CO_2 concentration gas mixes. This has the advantage of obtaining a low residual O_2 content and a tight pack due to the CO_2 going into solution. It is important to balance this process using the correct N_2 level in the gas mix so as to avoid excessive pressure being put on the pack seal.

Use of N_2/CO_2 atmospheres has significant potential for extending the shelf life of cottage cheese. The cottage cheese is a high-moisture, low-fat product that is susceptible to a number of spoilage organisms including *Pseudomonas* spp. Use of gas mixtures containing 40% CO_2 balanced with 60% N_2 can increase the shelf life significantly.

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Paper no.: 12
Paper Title: Food Packaging Technology
Module-27: Packaging of microwaveable and irradiated foods

27.1 Introduction

The story of the microwave oven begins in Britain in 1940 when two scientists working at Birmingham University (namely Professors Randall and Boot) devised an electronic tube (which they called as cavity magnetron) that generated large amounts of microwave energy very efficiently. The unique ability of the magnetron to transmit microwaves at very high power enabled radar equipment to be built that was much smaller, more powerful and more accurate than anything previously designed.

The magnetron was taken to the USA in September 1940 and Dr. Percy Spencer at Raytheon received a contract to make copies of it. In 1945, Spencer first popped some corn in front of a waveguide horn and the idea of using microwaves for heating foods was born; he filed a patent application that year which was issued in 1950. The first commercial microwave oven was released in 1947 for institutional and restaurant use.

In the decade of 1980, there was prolific growth of the consumer microwave oven resulting in a new category of food products. Development of the new products spawned a new market for packaging materials, some of which were capable of being rethermalized in a conventional oven as well as the microwave oven (known as microwaveable products and materials), while still other new products and their packages evolved that were developed strictly for heating in the microwave oven. The penetration of microwave ovens into U.S. homes and lifestyles grew rapidly from a mere 15% of households owning a microwave oven in 1980 to an impressive 78% by 1989. Consumers were hungry for food products designed for cooking and rethermalization in the microwave oven, and a new category known as *microwave foods*. The new category was supported by microwave popcorn, a product that was developed specifically for preparation in the microwave oven. The standard was now set for other new food products that attempted to cater to consumers’ desires for foods offering quickness and convenience in their preparation. In the mid-1980s, a wave of premium-priced frozen dinners had been witnessed, positioned as a higher quality ‘‘TV dinner,’’ that are now available on thermoset polyester plates, capable of being heated in the conventional-oven environment (up to 400°F) or the microwave.

27.2 Microwaveable Packaging Material

27.2.1 Coated Paperboard

Paperboard is available as a microwaveable material in the form of trays, plates, and cartons. Generally, the paperboard used is solid bleached sulphate (SBS), but solid unbleached sulphate (SUS), also referred to as natural or kraft paperboard, can also be used; however, market applications are strongly skewed to SBS use. To make an microwaveable material, the paperboard is coated, generally with a fine clay on one side to impart higher surface gloss and a proper surface for printing, along with an extrusion coating of a film made of polyester (PET) or, in some cases, 4-methyl-pentane-1 copolymer (TPX). The thin layer of a high-temperature plastic provides a relatively inexpensive method to produce containers that capitalize on the structural strength and economics of the paperboard component while adding the barrier required to keep fats and moisture in the food from entering the paperboard. Other plastics are also extrusion coated onto paperboard, notably low-density polyethylene (LDPE) and polypropylene (PP); however, the maximum temperature resistance of LDPE is 215°F and 260°F for PP. The upper temperature limit for LDPE- and PP-coated paperboard will dictate the packaging application. With a maximum temperature limit of 215°F, LDPE-coated paperboard provides excellent properties for milk cartons and cold and hot-drink cups; however, its use in the microwave oven will be limited to products that will not get hot, such as a frozen dessert that may be microwaved to only soften the contents. Similarly, PP-coated paperboard is available for microwave-only packages in which there is no risk that the hot spots within a package can reach a temperature where the PP softens, causing structural changes in the package or the PP to break down, allowing some of its constituents to enter the food. The dominant ovenable paperboard is PET-extrusion coated. With a maximum temperature use of 400°F, PET coated paperboard is well suited for forming containers to be used in microwaveable containers for a variety of food products. TPX-coated paperboard is preferred in baking applications because of its higher temperature resistance and its release characteristics for sugars that may become caramelized during the cooking cycle. TPX-coated paperboard is more expensive than PET-coated paperboard.

The clay coating is put on the paperboard either in-line on the paperboard-making machine or at a remote station. The clay coating in both cases is done on mill-size rolls of paperboard. The coated mill roll can then be slit to widths more appropriate for laminating equipment and forming and carton-making machines. To form a tray from a roll of PET-coated paperboard, the paperboard is first moistened with water to a level of 8–11%. This softens the paperboard to allow pressure forming. The roll of paperboard is first cut into blanks that have the flange dimension of the finished container. The blank is then indexed into a heated matched metal mould that, when closed, forms the blank into the mould shape, i.e., the shape of the container. The heat in the mould dries the paperboard. Since the paperboard does not stretch, this type of forming will produce a square container with small creases in the corners or creases around the base of a round or oval container.

27.2.2 PET-Film-Laminated Moulded Pulp

PET-film-laminated moulded pulp trays are cellulose-based containers most commonly seen as plates and trays. The PET film is required to provide the barrier resistance to fats and oils to go along with the structural characteristics of the lower cost pulp. The cellulose fibres are suspended in a slurry (which may contain other components such as sizing and treatments to provide better barrier properties) and pumped to the compression moulds, which form the pulp into the desired container shape. The slurry is held into the mould by vacuum, which also draws most of the water out through a screen. Pressure and heat are applied as the mould closes to form the pulp into the container shape and draw out the remaining water. An advantage to this type of moulding is the flexibility in the shape of the finished container, which may include divided compartments and areas with varying dimensional thickness for strength. After the moulding cycle, the containers are laminated with a cast PET film, which is then trimmed of any excess and packaged. PET-laminated moulded pulp trays will withstand oven temperatures of 400°F with good stiffness and structural characteristics.

27.2.3 Crystallized polyester (polyethylene terephthalate) (CPET)

CPET is a rigid plastic material that can be thermoformed into containers, generally shallow plates and trays. To become microwaveable, the PET must be crystallized during the thermoforming process. The PET contains nucleating agents that assist in the molecular crystallization. A key factor to consider when thermoforming CPET is the intrinsic viscosity (IV) of the material. The amount of crystallization and the intrinsic viscosity will determine the balance between the container's stiffness at low (–40°F) and high (400°F) temperatures. Generally the crystallinity of the finished container will be 28–32% and the intrinsic viscosity will range from 0.85 to 0.95. Prior to extruding, the PET must be thoroughly dried to a level of 0.003% to remove inherent water. For thermoforming, great care must be given to temperature control to ensure consistency. The ovens used to heat the sheet on the thermoformer prior to forming must heat the sheet evenly across its dimensions. CPET is considered to be a difficult material to work with because of its toughness and narrow window of operating temperatures, so proper mould design is a consideration. Aluminium moulds are used to promote even thermal conductivity during forming. Female moulds are used, and the design should allow for generous radii and minimize undercuts. Often a second stage used in the moulding process is a cooling mould that assists in shortening the cycle time, helps to stabilize the material after it is formed in the heated mould, and makes trimming easier. Because of its toughness, CPET is difficult to trim. Matched metal dies are used and should be sharpened periodically. Additionally, heavy-duty trim presses with quick cycle times should be used. CPET has a temperature resistance of 400°F, has a high gloss, has a hard surface, and can be coloured with pigment effectively, although the preferred colours in the market are black, white, and ivory.

27.2.4 Polymer of cyclohexanedimethanol and terephthalic acid (PCTA)

PCTA is an another material in the polyester family that has higher temperature-resistance properties than CPET is a co-polyester resin composed of a polymer of cyclohexanedimethanol and terephthalic acid (PCTA), often referred to by Eastman Chemical Company's trade name, Thermx. PCTA is a thermoformable material capable of withstanding temperatures in the range of 425–450°F. Processing is generally considered to be more difficult than CPET because of the higher temperatures required for extrusion and thermoforming and greater cooling requirements. A special nucleating agent is required; however, equipment specified for running CPET will generally be able to run PCTA with the proper adjustments. PCTA, like CPET, is able to be marked with the Society of the Plastics Industry (SPI) code as number 1—PETE for recycling purposes.

27.2.5 Foamed CPET

Shell Chemical Company has developed a method of making foamed CPET that it markets under the trade name PETLITE. The objective of this material is to produce containers with 35–40% less material than conventional CPET. Extrusion equipment used for CPET must be modified for running foamed CPET; however, a single-screw extruder can be used. The blowing agent used for the expansion is an inert gas. Generally, processing temperatures for extrusion and thermoforming are comparable with CPET as are pigmenting and trimming requirements. PETLITE containers have a temperature resistance of 400°F. Currently, commercial applications include containers for baked goods such as muffins and cakes.

27.2.6 Thermoset Polyester

Thermoset polyester plates were the first commercial application of microwaveable materials when used for frozen meals in the mid-1980s. The compound used is an unsaturated polyester that is highly filled with minerals such as talc and calcium carbonate, along with glass fibres and catalyst materials to produce the chemical reaction to convert the compound into material that is irreversibly set. The polyester compound is mixed and extruded to form logs that are cut to the proper size and weight for the finished container. The material is placed into a heated mould in a hydraulic press that closes the mould. The pressure causes the material to flow into the shape of the mould, and the heat cures the compound while under pressure into the finished and irreversible material. Typically, the container must be sanded to remove any flashing around the edges and often is run through a conveyor oven for a postbake cycle to drive off any residual uncured compound, and washed to remove any dust from sanding. This process produces containers that are very strong and stiff, even at high temperatures (425°F), and are heavy with a china-like feel and appearance. Unlike thermoforming from a sheet of material with consistent thickness, thus producing containers having essentially the same material thickness throughout, compression moulding permits the finished containers to have varying degrees of thickness throughout the dimension to add strength or design features where desired. Because of the amount of material used, the multiple steps in the manufacturing process, and the relatively low output per machine cycle for compression moulding presses, the price for a thermoset polyester plate is proportionally higher than competitive thermoformed plastic materials that can be produced at much higher rates with less material and cellulose-based containers that have a lower material cost.

27.2.7 Nylon 6/6

Mineral-filled nylon (or polyamides) is a microwaveable material that today is no longer commercially available. Developed by DuPont Canada during the mid-1980s, mineral-filled nylon was also converted by DuPont Canada by injection moulding into containers. Mineral-filled nylon plates have a higher temperature resistance and stiffness (500°F) than does CPET and were priced between CPET and thermoset polyester containers. Although the material was successfully introduced commercially, the use was limited because of the higher cost than CPET; also, the hydroscopic nature of filled nylon plates sometimes caused performance problems in the microwave oven. Nylon has good resistance to oils and fats; however, within the moist operating environment of the microwave oven, some of the water present in the food would be absorbed into the nylon plate, resulting in a loss of dimensional stability. Nylon plates' strength was in the conventional oven, where unlike some competitive thermoplastic materials, it retained its rigidity. Nylon plates were injection-moulded, a process that generally has higher tooling costs and higher operating costs when compared with thermoforming comparable unit volumes.

27.2.8 Polyetherimide (PEI)

PEI is a high-temperature thermoplastic resin. PEI provides a microwaveable material for applications of about 350°F. PEI is available only in injection-moulding grades, and with its high price per pound, it is generally better suited for multiple-use versus single-use applications. PEI also has good chemical and stain resistance, allowing for it to effectively be cycled through commercial dishwashing systems. PEI has been used for plates and containers in institutional feeding programs and airline meals.

27.2.9 Polysulfone (PSO)

PSO is an amorphous thermoplastic with good rigidity and toughness. PSO is capable of withstanding oven temperatures below 325°F, making it well suited to low-temperature and microwave applications. PSO is available in transparent form, lending its use in appliances as a replacement for glass and other multiple-use applications. Because of its high price, PSO has not been used in single-use applications.

27.2.10 Liquid-Crystal Polymer (LCP)

LCPs offer very good high-temperature resistance up to about 500°F in some grades. LCP can be injection-moulded and is generally pigmented from its natural beige colour. LCP is transparent to microwave energy; however, the high price of this resin limits its use to specialized applications. At one time, LCP was in commercial use as microwaveable cookware marketed by Tupperware.

27.2.11 Aluminium

Prior to the explosion of microwavable foods during the mid-1980s, aluminium trays dominated the prepared- and frozen-meals market as well as food-service applications such as school-lunch programs. As a package material for use only in conventional ovens, aluminium was ideal. It was capable of withstanding very high temperatures for long times—certainly exceeding the temperature limitations of the food, was usually available at attractive prices, and could be run at a high speed on packaging equipment. During the early stages of the microwave oven, arcing occurred when metal objects were placed in the oven cavity during operation, sometimes disabling the unit. This was largely corrected when the electronics were improved so that energy could not be reflected back into the magnetron. Even though it was safe for metal objects to be used in the microwave oven, consumers did not want to take the risk.

In the mid-1980s, Alcoa developed a plastic-coated aluminium tray that was formed without the typical wrinkled corners. The vinyl/epoxy coating was often pigmented to appear more like plastic and allowed the tray to work in both conventional and microwave ovens. Performance in the microwave oven is different from that of plastic- or cellulose-based materials since the aluminium shields microwave energy, often leading to longer heating times than for similar trays of competitive materials. This lends the design of the tray shape to be shallow to lessen the amount of microwave energy shielded. Coated aluminium foil trays were used commercially for pot pies where they were able to maintain high filling line speeds.

27.2.12 Polycarbonate (PC)

PC is an amorphous thermoplastic resin that is capable of withstanding temperatures above 400°F. PC can be injection-moulded, blow-moulded, and thermoformed. PC has been used in applications for multiple-use products such as microwavable cookware. PC is virtually unbreakable, making it a good replacement for glass. PC was used in a commercial package during the late 1980s for microwaveable meals. The structure used was thermoformed from a three-layer coextruded sheet; however, because of its high price per pound, it was replaced by competitive materials that offered acceptable performance for a much lower cost.

27.2.13 Polypropylene (PP)

During the late 1980s, PP grew as a microwave material because of its flexibility and relatively low cost. Polypropylene (PP) use in packaging was bolstered by the rapid growth of shelf-stable meals such as Lunch Buckets (registered trademark) and the like, in which ethyl vinyl alcohol (EVOH) is used to improve the oxygen-barrier properties required to safely preserve the cooked food at ambient temperatures. Microwavable containers of PP can be thermoformed or injection-moulded, generally in two different types: homopolymer PP and random copolymer PP. Homopolymer PP is produced using propylene monomer without the addition of other monomers. Random copolymer PP is similar in polymeric structure to homopolymer PP but also includes the random addition of ethylene to a polypropylene chain as it grows. Random copolymer PP gains some molecular orientation, providing certain advantages over homopolymer PP such as improved impact strength and much better clarity. Homopolymer PP can also be filled with minerals such as talc or calcium carbonate at levels of 20–40%. Filled homopolymer PP will have a slightly higher end-use temperature and greater stiffness than its unfilled form.

27.2.14 Polyphenylene Oxide/Polystyrene

Polystyrene (PS) by itself does not have a sufficiently high-temperature resistance (about 180°F), but when blended with polyphenylene oxide (PPO), the temperature-resistance properties are increased depending on the ratio of PS to PPO. For temperature resistance in the range of 212–230°F, a blend of 25% PPO and 75% PS is recommended. PPO has a low resin flow and is therefore difficult to form; however, when it is blended with PS, the flow characteristics and processing requirements are improved. PPO/PS can be thermoformed on equipment used for PS forming with only minor modifications. It is important to have accurate blending during the extrusion process; therefore, a high-intensity mixing screw is required. Additionally, PPO/PS is able to be foamed (much like expanded polystyrene) by extruding with tandem extruder systems and blowing agents used for polystyrene such as pentane.

27.2.15 High-Density Polyethylene (HDPE)

HDPE is an acceptable thermoplastic resin for some microwave applications. HDPE starts to lose its rigidity at temperatures above 200°F, resulting in distortion of the tray or container, so care must be given in selecting this material for food products that will not exceed this temperature. This means that foods that have a high fat or oil content or those that generate steam will not be good candidates for HDPE. Generally, applications for HDPE are for foods that do not have a long heating cycle and have a homogenous texture to balance heating throughout the food, thereby eliminating hot spots. The advantages of HDPE are relatively low cost in comparison with other resins, processing ease, and good impact properties at frozen temperatures. HDPE for food trays is most commonly thermoformed but also can be injection-moulded.

27.2.16 Glass

Although glass usage as a packaging material has declined steadily, it is a material that is able to withstand the rigors of microwave heating. Because of the advantages plastic has over glass in consumer safety, transportation costs, and design flexibility, there are very few applications where glass is selected as a packaging material because of its ability to be used in the microwave.

27.3 Conclusion

The development of microwavable foods promises to be one of the big growth areas during this decade. However, to avoid failure in the market place, product and package development must be thoroughly researched. An understanding of the fundamental principles involved in the microwave heating of foods is essential to successful development. The package is an integral part of a microwave product, and development of microwavable foods must go hand-in-hand with development of suitable packaging. A holistic approach to product and package design is likely to lead to significant improvements in the quality and convenience of microwave-heated meals.

Paper No.: 12
Paper Title: Food Packaging Technology
Module – 4: Packaged Food Quality and Shelf Life

4.1 Introduction

Shelf life is the period of time during which the food product will remain safe; be certain to retain desired sensory, chemical, physical and microbiological characteristics; and comply with any label declaration of nutritional data.

The shelf life of a product is determined as a part of the product development cycle. Packaging is one of the means by which shelf life limiting processes are controlled. Shelf life testing is carried out by holding representative samples of the final product under conditions likely to mimic those that the product will encounter from manufacture to consumption. Product shelf life is based on microbial numbers, chemical specifications and sensory assessment. For products with long shelf lives it is desirable to have indirect or predictive methods for determining shelf life. Increasing temperature is the most common means of accelerating shelf life, but other parameters such as humidity, shaking or exposure to light, also affect product stability.

Another approach to accelerated shelf life testing is predictive modeling, where mathematical models are used to predict either the shelf life or the level of a shelf life limiting attribute as a function of the composition of the product.

4.2 Factors affecting product quality and shelf life

For many foods, the product shelf life is limited by specific attributes that can be predicted at the time of product development. This is either on the basis of experience with similar products or observations of them, or from a consideration of

- the make-up of the product (intrinsic factors)
- the environment that it will encounter during its life (extrinsic factors)
- the *shelf life limiting processes* that is combination of intrinsic and extrinsic factors.

Intrinsic factors are the properties resulting from the make-up of the final product and include the following:

- water activity (a_w) (available water)
- pH/total acidity; type of acid
- natural microflora and surviving microbiological counts in final product
- availablility of oxygen
- redox potential (Eh)
- natural biochemistry/chemistry of the product
- added preservatives (e.g. salt, spices, antioxidants)
- product formulation
- packaging interactions (e.g. tin pickup, migration)

Selection of raw materials is important for controlling intrinsic factors, since subsequent processing can rarely compensate for poor-quality raw materials.

Extrinsic factors are a result of the environment that the product encounters during life and include the following:

- time–temperature profile during processing
- temperature control during storage and distribution
- relative humidity (RH) during storage and distribution
- exposure to light (UV and IR) during storage and distribution
- composition of gas atmosphere within packaging
- consumer handling

Product packaging can have significant effects on many of these extrinsic factors, and many developments in packaging materials have been driven by the need to reduce the impact of these environmental factors and extend shelf life. In some instances the packaging alone may be effective in extending shelf life, e.g. a complete light and oxygen barrier, whereas in most instances it acts as one of a number of *hurdles* each of which is ineffective alone, but which together affect a shelf life limiting factor.

The interactions of intrinsic and extrinsic factors affect the likelihood of the occurrence of reactions or processes that affect shelf life. The shelf life limiting reactions can be classified as: chemical/biochemical, microbiological and physical.

4.3 Chemical/biochemical processes

Many important deteriorative changes can occur as a result of reactions between components within the food, or between components of the food and the environment. Chemical reactions will proceed if reactants are available and if the activation energy threshold of the reaction is exceeded. The rate of reaction is dependent on the concentration of reactants and on the temperature and/or other energy, e.g. light induced reactions. A general assumption is that for every 10°C rise in temperature, the rate of reaction doubles.

Enzymes catalyse biochemical reactions. They can be highly specific catalysts, lowering the activation threshold so that the rate of reaction (of thermodynamically possible reactions) is dramatically increased.

4.3.1 *Oxidation*

Numerous chemical components of food react with oxygen affecting the colour, flavour, nutritional status and occasionally the physical characteristics of foods. In some cases, the effects are deleterious and limit shelf life; in others they are essential to achieve the desired product characteristics. Packaging is used to exclude, control or contain oxygen at the level most suited for a particular product. Foods differ in their avidity for oxygen, i.e. the amount that they take up, and their sensitivity to oxygen, i.e. the amount that results in quality changes.

Foods containing a high percentage of fats, particularly unsaturated fats, are susceptible to oxidative rancidity and changes in flavour. Saturated fatty acids oxidise slowly compared with unsaturated fatty acids. Antioxidants that occur naturally or are added, either slow the rate of, or increase the lag time to, the onset of rancidity. Three different chemical routes can initiate the oxidation of fatty acids: the formation of free radicals in the presence of metal ion catalysts such as iron, or heat, or light – termed the classical free radical route; photooxidation in which photo-sensitisers such as chlorophyll or myoglobin affect the energetic state of oxygen; or an enzymic route catalysed by lipoxygenase. Once oxygen has been introduced into the unsaturated fatty acids to form hydroperoxides by any of these routes, the subsequent breakdown of these colourless, odourless intermediates, proceeds along similar routes regardless of how oxidation was initiated. It is the breakdown products of the hydroperoxides – the aldehydes, alcohols and ketones that are responsible for the characteristic *stale*, *rancid* and *cardboard* odours associated with lipid oxidation.

Lowering the storage temperature does not stop oxidative rancidity because both the first and second steps in the reaction have low activation energies. Reduction of the concentration of oxygen (both dissolved and in the headspace) to below 1%, removal of factors that initiate oxidation and the use of antioxidants are strategies employed to extend shelf life where rancidity is a shelf life limiting factor.

In milk chocolate, the presence of tocopherol (vitamin E), a natural antioxidant in cocoa liquor provides a high degree of protection against rancidity. However, white chocolate does not have the antioxidant protection of cocoa liquor and so is prone to oxidative rancidity, particularly light induced. Even with light barrier packaging, its shelf life is shorter than that of milk or plain chocolate. However, the cost of eliminating oxygen from the pack would be prohibitive and not worth the additional cost for the relatively small increase in shelf life that this change would result in.

In snack products and particularly nuts the onset of rancidity is the shelf life limiting factor. Such sensitive products are often packed gas flushed to remove oxygen and packed with 100% nitrogen to protect against oxidation and provide a cushion to protect against physical damage. The packaging material generally used for commodity products with short shelf life is PVdC-coated OPP/LDPE laminates, whilst higher added value products with longer shelf life requirements are often packed in metallised polyester/LDPE laminates.

Investigations of rancidity in potato chips in relation to the light barrier properties of various films showed that improved light barrier properties of packaging films gave extended shelf life with respect to rancidity. Prolonged storage under fluorescent lights at ambient humidity caused the shelf life of crisps to become limited by rancidity rather than texture changes due to moisture uptake.

Oxidation of lycopene, a red/orange carotenoid pigment in tomatoes, causes an adverse colour change from red to brown and affects flavour. In canned tomato products this can be minimised by using plain unlacquered cans. The purpose of the tin coating is to provide protection of the underlying steel, but it also provides a chemically reducing environment within the can. Residual oxygen is consumed by tin dissolution into the product, minimising product oxidation that would otherwise lead to quality loss. However, the extent of dissolution of tin into the product needs to be taken into account in the assigned shelf life of the product as the maximum permitted level of tin in canned foods in the UK is 200mg kg^{-1}. Tin dissolution can be avoided by using fully lacquered cans but oxygen-induced quality loss is more likely to occur.

4.3.2 Enzyme activity

Fruits and vegetables are living commodities and their rate of respiration affects shelf life – generally the greater the rate of respiration, the shorter the shelf life. Immature products such as peas and beans have much higher respiration rates and shorter shelf life than products that are mature storage organs such as potatoes and onions. Respiration is the metabolic process whereby sugars and oxygen are converted to more usable sources of energy for living cells. Highly organised and controlled biochemical pathways promote this metabolic process. Depletion and exhaustion of reserves used for respiration leads to metabolic collapse and an appearance associated with senescence. Disruption of tissues that occurs during the preparation of fruits and vegetables for the fresh-cut market leads to leakage of cell contents and encourages invasion by microorganisms. It also leads to an increase in respiration rate that depletes reserves and results in quality loss. In non-storage tissues where there are few reserves, such as lettuce and spinach, or immature flower crops such as broccoli, this effect is even greater. Use of temperature control reduces the respiration rate, extending the life of the product. Temperature control combined with MAP further suppresses the growth of yeasts, moulds and bacteria, extending shelf life further.

Ethylene is a plant growth regulator that accelerates senescence and the ripening process. It is a colourless gas with a sweet ether-like odour. All plants produce ethylene to differing degrees and some parts of plants produce more than others. The effect of ethylene is commodity dependent but also dependent on temperature, exposure time and concentration. Many commodities if exposed over lengthy periods are sensitive to ethylene concentrations as low as 0.1 ppm. Climacteric fruits such as apples, avocados, melons and tomatoes are particularly sensitive to ethylene. Physical (cutting) or chill injury induces the production of ethylene particularly in fruiting tissue due to its effect on the rate limiting enzyme (1-aminocyclopropane-1-carboxylic acid synthase) in the biochemical pathway leading to ethylene formation and increases tissue sensitivity to ethylene. As ethylene induces senescence it has a significant impact on quality loss. Removal of ethylene by absorption using activated carbon or potassium permangante has been shown to be effective in extending the shelf life of a number of whole and cut fruits and vegetables by extending the time of ripening. The storage life of MAP packaged mangoes was extended from 16 to 21 days by the inclusion of activated carbon and potassium permanganate.

4.4 Microbiological growth

Under suitable conditions, most microorganisms will grow or multiply. Bacteria multiply by dividing to produce two organisms from one, their numbers increasing exponentially. Under ideal conditions some bacteria may grow and divide every 20 min, so one bacterial cell may increase to 16 million cells in 8 hrs. Under adverse conditions this doubling or generation time is prevented or extended – a feature that is exploited when developing food products and processes to achieve the desired shelf life.

During growth in foods, microorganisms will consume nutrients from the food and produce metabolic by-products such as gases or acids. They may release extra-cellular enzymes (e.g. amylases, lipases, proteases) that affect the texture, flavour, odour and appearance of the product. Some of these enzymes will continue to exist after the death of the microorganisms that produced them, continuing to cause product spoilage.

4.4.1 Role of packaging in controlling microbiological growth

Heat processing kills microorganisms is a widely used means of achieving safe products and extending shelf life. The amount of heat treatment required depends on the characteristics of the most harmful microorganism present, the nature of the food in terms of its viscosity, the pH of the food, the shape of the pack and the shelf life required. However, the heat process also changes the texture, taste and appearance of the product. This has prompted the move to minimally processed foods where a number of factors are combined to achieve the desired shelf life, e.g. a mild heat treatment, antioxidant action and controlled atmosphere packaging each restricting microbial growth, such that their combined effect allows the product to retain its sensory and nutritional properties.

In canning, low acid foods are filled into containers that are hermetically sealed and sterilised, typically at 115.5–121°C or above, to ensure all pathogens, especially *Clostridium botulinum*, are destroyed. The size and shape of the container is important. Retort pouches are flat in shape, hence processing time can be reduced compared to a conventional cylindrical can and the reduced processing time generally results in improved taste and texture. Foods are cooked in vacuum in sealed evacuated heat stable pouches or thermoformed trays. In aseptic processing, the barrier that the packaging poses to heat transfer is removed completely – the product and packaging being sterilised separately and then brought together under clean (aseptic) conditions. Where heat processing has been used to achieve sterility, the use of packaging to maintain sterility throughout the subsequent life becomes a key factor to achieving the desired product shelf life – both the packaging and the pack seals must provide a barrier to ingress of microorganisms.

Vacuum packaging or modified atmospheres are the key shelf life limiting factors controlling microbiological growth; packaging is a critical factor in achieving the desired shelf life.

In MAP, the gas mixture must be chosen to meet the needs of the specific product; this is usually some combination of oxygen, nitrogen and carbon dioxide. Carbon dioxide at 20–60% has bacteriostatic and fungistatic properties and will retard the growth of mould and aerobic bacteria by increasing the lag phase and generation time of susceptible microorganisms. Several factors influence the antimicrobial effect of carbon dioxide, especially the microbial load, gas concentration, temperature and permeability of the packaging film.

Packaging materials designed to have antimicrobial activity provide a hurdle for microbial growth but seldom act alone as the key shelf life limiting factor. Antimicrobial activity can be obtained in two ways. Preservative-releasing or migrating systems contain a preservative intended for migration into the food. Non-migrating systems contain or produce a compound that has antimicrobial activity when the target organism comes into contact. For both systems, the antimicrobial substance can be incorporated into the packaging material or applied to the surface. Maximum contact is required between food and packaging to ensure adequate protection. Therefore, it is particularly suitable for vacuum packed foods. A number of antimicrobial packaging materials are commercially available and their activities and effectiveness have been reviewed.

4.5 Physical and physico-chemical processes

Physical changes affecting shelf life can be brought about directly by physical damage or by physico-chemical processes resulting from the underlying food chemistry. Many packaging functions such as protection of the product from environmental factors and contamination such as dust and dirt, dehydration and rehydration, insect and rodent infestation, containment of the product to avoid leakage and spillage, and physical protection action against hazards during storage and distribution are taken for granted by the consumer. However, careful consideration of the extent of protection required for the product in the context of the rigours of the storage and distribution chain through which it is to pass, is required if the product is to achieve its shelf life. Packaging is very often the key factor to limiting the effects of physical damage on product shelf life. Whilst the threat of careless or deliberate tampering cannot be accounted for when assigning product shelf life, the use of tamper-evident packaging provides a means of signaling whether packaging and potentially a preservative system has been breached.

4.5.1 Physical damage

During product life, particularly in storage, distribution and consumer handling, products are subjected to vibration on vehicles, compressive loads during stacking in warehouses and sudden jolts and knocks. The formulation of the product must be sufficient to tolerate such shocks or extended periods of vibration (for example, emulsions must be stable enough to withstand vibration), and the packaging must be able to withstand and protect against such forces. Vulnerable areas on packs are heat seals and screw caps, where damage resulting in leakage may result in loss of the preservation effect provided by the packaging. For fragile products, that are susceptible to crushing, such as soft cheeses, breakfast cereals and biscuits, the outer carton provides protection from physical damage and from potential tampering. Fruit and vegetables that are susceptible to bruising require protection from rough handling and the outer packaging used for distribution purposes needs to withstand stacking to considerable heights and high and variable humidity. The design of packaging for this purpose should be based on the properties of the commodity in terms of the humidity level it can withstand, the airflow allowed, the rate of respiration of the product and its susceptibility to bruising.

4.5.2 Insect damage

Infestation of foods with insects can be extremely unpleasant for the consumer because it is often not detected until the opening of the product. Insect infestation can occur at any point after manufacture, but is most likely during extended storage periods or during shipment. Although the problem may not be the fault of the food manufacturer, loss of materials can be expensive and legal cases can severely damage the reputation of brands. Package pests are classified in two groups – penetrators and invaders. Penetrators are capable of boring through one or more layers of flexible packaging materials. It is possible to reduce infestation with penetrators by preventing the escape of odours from the package through the use of barrier materials. A rapid method to evaluate the usefulness of odour barriers has been developed. Invaders are more common and enter packages through existing openings, usually created from poor seals, openings made by other insects or mechanical damage. It is therefore important that seals are not vulnerable to attack from insects. The corners of square packages can also be potential points of entry for insects. Various new packaging systems have been devised to minimise potential infestation.

4.5.3 Moisture changes

Moisture changes leading to loss or gain of moisture is a significant physical cause of the loss of shelf life of foods. Hygroscopic foods require protection from moisture take up which in dry products such as breakfast cereals and biscuits causes loss of texture, particularly crispness. For breakfast cereals the inner liner provides most protection to the food. Its main purpose is to protect from moisture transfer so as to preserve the product characteristics. The most effective type of liner will be determined during shelf life testing or by combining information from break point testing (holding at increasing humidities) and knowledge about the characteristics of the moisture permeability of the packaging material.

Protection or prevention of moisture loss is best achieved by maintaining the correct temperature and humidity in storage. In chilled and frozen foods, water loss (desiccation, dehydration or evaporation) can result in quality loss. However, it is often the resulting weight loss that is of greater importance due to the high monetary value of the products sold on a weight basis. The impact that packaging can have is illustrated by the losses that occur in chilled foods sold unwrapped from delicatessen counters, particularly cooked fresh meat, fish, pâtés and cheese. The shelf life of such products differs markedly from the wrapped equivalent –six hours versus a few days to weeks. Evaporative losses result in a change in appearance, to such an extent that the consumer will select products that have been loaded into the cabinet most recently in preference to those which have been held in the display cabinet. In stores where the rate of turnover of products is high, the average weight loss will be greater because of the continual exposure of freshly wetted surfaces to the air stream.

Weight loss during storage of fruit and vegetables is mainly due to transpiration. Most have an equilibrium humidity of 97–98% and will lose water if kept at humidities less than this. For practical reasons, the recommended range for storage humidity is 80–100%. The rate of water loss is dependent on the difference between the water vapour pressure exerted by the produce and the water vapour pressure in the air, and air speed over the product. Loss of as little as 5% moisture by weight causes fruit and vegetables to shrivel or wilt. Films used in MAP packaging should have low water vapour transmission rates (WVTR) to minimise changes in moisture content inside the pack. As the temperature of air increases, the amount of water required to saturate it increases (approximately doubling for each 10°C rise in temperature).