Chapter 9: VARIOUS METHODS OF PACKAGING- PACKAGING MATERIALS AND TRANSPORT

Packaging fresh fruits and vegetables is one of the more important steps in the long and complicated journey from grower to consumer. Bags, crates, hampers, baskets, cartons, bulk bins, and palletized containers are convenient containers for handling, transporting, and marketing fresh produce. More than 1,500 different types of packages are used for produce in the U.S. and the number continues to increase as the industry introduces new packaging materials and concepts. Although the industry generally agrees that container standardization is one way to reduce cost, the trend in recent years has moved toward a wider range of package sizes to accommodate the diverse needs of wholesalers, consumers, food service buyers, and processing operations.

Packing and packaging materials contribute a significant cost to the produce industry; therefore it is important that packers, shippers, buyers, and consumers have a clear understanding of the wide range of packaging options available. This fact sheet describes some of the many types of packaging, including their functions, uses, and limitations. Also included is a listing, by commodity, of the common produce containers standard to the industry.

The Function of Packaging or Why package Produce?

A significant percentage of produce buyer and consumer complaints may be traced to container failure because of poor design or inappropriate selection and use. A properly designed produce container should contain, protect, and identify the produce, satisfying everyone from grower to consumer.

PACKAGING POINTS

Recyclability/Biodegradability

A growing number of U.S. markets and many export markets have waste disposal restrictions for packaging materials. In the near future, almost all produce packaging will be recyclable or biodegradable, or both. Many of the largest buyers of fresh produce are also those most concerned about environmental issues.

Variety

The trend is toward greater use of bulk packages for processors and wholesale buyers and smaller packages for consumers. There are now more than 1,500 different sizes and styles of produce packages.

Sales Appeal

High quality graphics are increasingly being used to boost sales appeal. Multi-color printing, distinctive lettering, and logos are now common.

Shelf Life

Modern produce packaging can be custom engineered for each commodity to extend shelf life and reduce waste.

Containment

The container must enclose the produce in convenient units for handling and distribution. The produce should fit well inside the container, with little wasted space. Small produce items that are spherical or oblong (such as potatoes, onions, and apples) may be packaged efficiently utilizing a variety of different package shapes and sizes. However, many produce items such as asparagus, berries, or soft fruit may require containers specially designed for that item. packages of produce commonly handled by hand are usually limited to 50 pounds. Bulk packages moved by fork lifts may weigh as much as 1,200 pounds.

Protection

The package must protect the produce from mechanical damage and poor environmental conditions during handling and distribution. To produce buyers, torn, dented, or collapsed produce packages usually indicate lack of care in handling the contents. Produce containers must be sturdy enough to resist damage during packaging, storage, and transportation to market. Because almost all produce packages are palletized, produce containers should have sufficient stacking strength to resist crushing in a low temperature, high humidity environment. Although the cost of packaging materials has escalated sharply in recent years, poor quality, lightweight containers that are easily damaged by handling or moisture are no longer tolerated by packers or buyers. Produce destined for export markets requires that containers to be extra sturdy. Air-freighted produce may require special packing, package sizes, and insulation. Marketers who export fresh produce should consult with freight companies about any special packaging requirements. Additionally, the USDA and various state export agencies may be able to provide specific packaging information.

Damage resulting from poor environmental control during handling and transit is one of the leading causes of rejected produce and low buyer and consumer satisfaction. Each fresh fruit and vegetable commodity has its own requirements for temperature, humidity, and environmental gas composition. Produce containers should be produce friendly - helping to maintain an optimum environment for the longest shelf life. This may include special materials to slow the loss of water from the produce, insulation materials to keep out the heat, or engineered plastic liners that maintain a favorable mix of oxygen and carbon dioxide.

Identification

The package must identify and provide useful information about the produce. It is customary (and may be required in some cases) to provide information such as the produce name, brand, size, grade, variety, net weight, count, grower, shipper, and country of origin. It is also becoming more common to find included on the package, nutritional information, recipes, and other useful information directed specifically at the consumer. In consumer marketing, package appearance has also become an important part of point of sale displays.

Universal Product Codes (UPC or bar codes) may be included as part of the labeling. The UPCs used in the food industry consist of a ten-digit machine readable code. The first five digits are a number assigned to the specific producer (packer or shipper) and the second five digits represent specific product information such as type of produce and size of package. Although no price information is included, UPCs are used more and more by packers, shippers, buyers, and Example of a UPC retailers as a fast and convenient method of inventory control and cost accounting. Efficient use of UPCs requires coordination with everyone who handles the package.

Types of Packaging Materials

Wood

Pallets literally form the base on which most fresh produce is delivered to the consumer. Pallets were first used during World War II as an efficient way to move goods. The produce industry uses approximately 190 of the 700 million pallets produced per year in

the U.S.. About 40 percent of these are single-use pallets. Because many are of a non-standard size, the pallets are built as inexpensively as possible and discarded after a single use. Although standardization efforts have been slowly under way for many years, the efforts have been accelerated by pressure from environmental groups, in addition to the rising cost of pallets and landfill tipping fees.

Over the years, the 40-inch wide, by 48-inch long pallet has evolved as the unofficial standard size. Standardization encourages re-use, which has many benefits. Besides reducing cost because they may be used many times, most pallet racks and automated pallet handling equipment are designed for standard-size pallets. Standard size pallets make efficient use of truck and van space and can accommodate heavier loads and more stress than lighter single-use pallets. Additionally, the use of a single pallet size could substantially reduce pallet inventory and warehousing costs along with pallet repair and disposal costs. The adoption of a pallet standard throughout the produce industry would also aid efforts toward standardization of produce containers.

In the early 1950s, an alternative to the pallet was introduced. It is a pallet-size sheet (slipsheet) of corrugated fiberboard or plastic (or a combination of these materials) with a narrow lip along one or more sides. packages of produce are stacked directly on this sheet as if it were a pallet. Once the packages are in place, they are moved by a specially equipped fork lift equipped with a thin metal sheet instead of forks.

Slipsheets are considerably less expensive than pallets to buy, store, and maintain; they may be re-used many times; and they reduce the tare weight of the load. However, they require the use of a special fork-lift attachment at each handling point from packer to retailer.

Depending on the size of produce package, a single pallet may carry from 20 to over 100 individual packages. Because these packages are often loosely stacked to allow for air circulation, or are bulging and difficult to stack evenly, they must be secured (unitized) to prevent shifting during handling and transit. Although widely used, plastic straps and tapes may not have completely satisfactory results. Plastic or paper corner tabs should always be used to prevent the straps from crushing the corners of packages.

Plastic stretch film is also widely used to secure produce packages. A good film must stretch, retain its elasticity, and cling to the packages. Plastic film may conform easily to various size loads. It helps protect the packages from loss of moisture, makes the pallet more secure against pilferage, and can be applied using partial automation. However, plastic film severely restricts proper ventilation. A common alternative to stretch film is plastic netting, which is much better for stabilizing some pallet loads, such as those that require forced-air cooling. Used stretch film and plastic netting may be difficult to properly handle and recycle.

A very low-cost and almost fully automated method of pallet stabilization is the application of a small amount of special glue to the top of each package. As the packages are stacked, the glue secures all cartons together. This glue has a low tensile strength so cartons may be easily separated or repositioned, but a high shear strength so they will not slide. The glue does not present disposal or recycling problems.

Pallet Bins

Substantial wooden pallet bins of milled lumber or.plywood are primarily used to move produce from the field or orchard to the packing house. Depending on the application, capacities may range from 12 to more than 50 bushels. Although the height may vary, the length and width is generally the same as a standard pallet (48 inches by 40 inches). More efficient double-wide pallet bins (48 inches by 80 inches) are becoming more common in some produce operations.

Most pallet bins are locally made; therefore it is very important that they be consistent from lot to lot in materials, construction, and especially size. For example, small differences in overall dimensions Pallet bin can add up to big problems when several hundred are stacked together for cooling, ventilation, or storage. It is also important that stress points be adequately reinforced. The average life of a hardwood pallet bin that is stored outside is approximately five years. When properly protected from the weather, pallets bins may have a useful life of 10 years or more.

Uniform voluntary standards for wood pallets and other wood containers are administered by the National Wooden Pallet and Container Association, Washington, DC. Additionally, the American Society of Agricultural Engineers, St. Joseph, Michigan, publishes standards for agricultural pallet bins (ASAE S337.1).

Wire-Bound Crates

Although alternatives are available, wooden wire-bound crates are used extensively for snap beans, sweet corn and several other commodities that require hydrocooling. Wire-bound crates are sturdy, rigid and have very high stacking strength that is essentially unaffected by water. Wire-bound crates come in many different sizes from half- bushel to pallet-bin size and have a great deal of open space to facilitate cooling and ventilation. Although few are re-used, wire-bound crates may be dissembled after use and shipped back to the packer (flat). In some areas, used containers may pose a significant disposal problem. Wirebound crates are not generally acceptable for consumer packaging because of the difficulty in affixing suitable labels.

Wooden Crates and Lugs

Wooden crates, once extensively used for apples, stone fruit, and potatoes have been almost totally replaced by other types of containers. The relative expense of the container, a greater concern for tare weight, and advances in material handling have reduced their use to a few specialty items, such as expensive tropical fruit. The 15-, 20-, and 25-pound wooden lugs still used for bunch grapes and some specialty crops are being gradually replaced with less costly alternatives.

Wooden Baskets and Hampers

Wire-reinforced wood veneer baskets and hampers of different sizes were once used for a wide variety of crops from strawberries to sweet potatoes. They are durable and may be nested for efficient transport when empty. However, cost, disposal problems, and difficulty in efficient palletization have severely limited their use to mostly local grower markets where they may be re-used many times.

Corrugated Fiberboard

Corrugated fiberboard (often mistakenly called cardboard or pasteboard) is manufactured in many different styles and weights. Because of its relativity low cost and versatility, it is the dominant produce container material and will probably remain so in the near future. The strength and serviceability of corrugated fiberboard have been improving in recent years.

Most corrugated fiberboard is made from three or more layers of paperboard manufactured by the kraft process. To be considered paperboard, the paper must be thicker than 0.008 inches. The grades of paperboard are differentiated by their weight (in pounds per 1,000 square feet) and their thickness. Kraft paper made from unbleached pulp has a characteristic brown color and is exceptionally strong. In addition to virgin wood fibers, Kraft paper may have some portion of synthetic fibers for additional strength, sizing (starch), and other materials to give it wet strength and printability. Most fiberboard contains some recycled fibers. Minimum amounts of recycled materials may be specified by law and the percentage is expected to increase in the future. Tests have shown that cartons of fully recycled pulp have about 75 percent of the stacking strength of virgin fiber containers. The use of recycled fibers will inevitably lead to the use of thicker walled containers.

Double-faced corrugated fiberboard is the predominant form used for produce containers. It is produced by sandwiching a layer of corrugated paperboard between an inner and outer liner (facing) of paper-board. The inner and outer liner may be identical, or the outer layer may be preprinted or coated to better accept printing. The inner layer may be given a special coating to resist moisture. Heavy-duty shipping containers, such as corrugated bulk bins that are required to have high stacking strength, may have double- or even triple-wall construction. Corrugated fiberboard manufacturers print box certificates on the bottom of containers to certify certain strength characteristics and limitations. There are two types of certification. The first certifies the minimum combined weight of both the inner and outer facings and that the corrugated fiberboard material is of a minimum bursting strength. The second certifies minimum edge crush test (ETC) strength. Edge crush strength is a much better predictor of stacking strength than is bursting strength. For this reason, users of corrugated fiberboard containers should insist on ECT certification to compare the stackability of various containers. Both certificates give a maximum size limit for the container (sum of length, width, and height) and the maximum gross weight of the contents.

Both cold temperatures and high humidities reduce the strength of fiberboard containers. Unless the container is specially treated, moisture absorbed from the surrounding air and the contents can reduce the strength of the container by as much as 75 percent. New anti-moisture coatings (both wax and plastic) are now available to substantially reduce the effects of moisture.

Waxed fiberboard cartons (the wax is about 20 percent of fiber weight) are used for many produce items that must be either hydrocooled or iced. The main objection to wax cartons is disposal after use— wax cartons cannot be recycled and are increasingly being refused at landfills. Several states and municipalities have recently taxed wax cartons or have instituted rigid back haul regulations. Industry sources suggest that wax cartons will eventually be replaced by plastic or, more likely, the use of ice and hydrocooling will be replaced by highly controlled forced-air cooling and rigid temperature and humidity maintenance on many commodities.

In many applications for corrugated fiberboard containers, the stacking strength of the container is a minor consideration. For example, canned goods carry the majority of their own weight when stacked. Fresh produce usually cannot carry much of the vertical load without some damage. Therefore, one of the primarily desired characteristics of corrugated fiberboard containers is stacking strength to protect the produce from crushing. Because of their geometry, most of the stacking strength of corrugated containers is carried by the corners. For this reason, hand holes and ventilation slots should never be positioned near the corners of produce containers and be limited to no more than 5 to 7 percent of the side area.

Interlocking the packages (cross stacking) is universally practiced to stabilize pallets. Cross stacking places the corner of one produce package at the middle of the one below it, thus reducing its stacking strength. To reduce the possibility of collapse, the first several layers of each pallet should be column stacked (one package directly above the other). The upper layers of packages may be cross stacked as usual with very little loss of pallet stability.

There are numerous styles of corrugated fiberboard containers. The two most used in the produce industry are the one piece, regular slotted container (RSC) and the two piece, full telescoping container (FTC). The RSC is the most popular because it is simple and economical. However, the RSC has relatively low stacking strength and therefore must be used with produce, such as potatoes, that can carry some of the stacking load. The FTC, actually one container inside another, is used when greater stack- ing strength and resistance to bulging is required. A third type of container is the Bliss box, which is — constructed from three separate pieces of corrugated fiberboard. The Bliss box was developed to be used when maximum stacking strength is required. The bottoms and tops of all three types of containers may be closed by glue, staples, or interlocking slots.

Almost all corrugated fiberboard containers are shipped to the packer flat and assembled at the packing house. To conserve space, assembly is usually performed just before use. Assembly may be by hand, machine, or a combination of both. Ease of assembly should be carefully investigated when considering a particular style of package.

In recent years, large double-wall or even triple- wall corrugated fiberboard containers have increasingly been used as one-way pallet bins to ship bulk produce to processors and retailers. Cabbage, melons, potatoes, pumpkins, and citrus have all been shipped successfully in these containers. The container cost per pound of produce is as little as one fourth of traditional size containers. Some bulk containers may be collapsed and re-used.

For many years, labels were printed on heavy paper and glued or stapled to the produce package. The high cost of materials and labor has all but eliminated this practice. The ability to print the brand, size, and grade information directly on the container is one of the greatest benefits of corrugated fiberboard containers. There are basically two methods used to print corrugated fiberboard containers:

Post Printed

When the liner is printed after the corrugated fiberboard has been formed, the process is known as post printing. Post printing is the most widely used printing method for corrugated fiberboard containers because it is economical and may be used for small press runs. However, postprinting produces graphics with less detail and is usually limited to one or two colors.

Preprinted

High quality, full-color graphics may be obtained by preprinting the linerboard before it is attached to the corrugated paperboard. Whereas the cost is about 15 percent more than standard two color containers, the eye catching quality of the graphics makes it very useful for many situations. The visual quality of the package influences the perception of the product because the buyer's first impression is of the outside of the package. Produce managers especially like high quality graphics that they can use in super market floor displays.

Preprinted cartons are usually reserved for the introduction of new products or new brands. Market research has shown that exporters may benefit from sophisticated graphics. The increased cost usually does not justify use for mature products in a stable market, but this may change as the cost of these containers becomes more competitive.

Pulp Containers

Containers made from recycled paper pulp and a starch binder are mainly used for small consumer packages of fresh produce. Pulp containers are available in a large variety of shapes and sizes and are relatively inexpensive in standard sizes. Pulp containers can absorb surface moisture from the product, which is a benefit for small fruit and berries that are easily harmed by water. Pulp containers are also biodegradable, made from recycled materials, and recyclable.

Paper and Mesh Bags

Consumer packs of potatoes and onions are about the only produce items now packed in paper bags. The more sturdy mesh bag has much wider use. In addition to potatoes and onions, cabbage, turnips, citrus, and some specialty items are packed in mesh bags. Sweet corn may still be packaged in mesh bags in some markets. In addition to its low cost, mesh has the advantage of uninhibited air flow. Good ventilation is particularly beneficial to onions. Supermarket produce managers like small mesh bags because they make attractive displays that stimulate purchases.

However, bags of any type have several serious disadvantages. Large bags do not palletize well and small bags do not efficiently fill the space inside corrugated fiberboard containers. Bags do not offer protection from rough handling. Mesh bags provide little protection from light or contaminants. In addition, produce packed in bags is correctly perceived by the consumer to be less than the best grade. Few consumers are willing to pay premium price for bagged produce.

Plastic Bags

Plastic bags (polyethylene film) are the predominant material for fruit and vegetable consumer packaging. Besides the very low material costs, automated bagging machines further reduce packing costs. Film bags are clear, allowing for easy inspection of the contents, and readily accept high quality graphics. Plastic films are available in a wide range of thicknesses and grades and may be engineered to control the environmental gases inside the bag. The film material "breathes" at a rate necessary to maintain the correct mix of oxygen, carbon dioxide, and water vapor inside the bag. Since each produce item has its own unique requirement for environmental gases, modified atmosphere packaging material must be specially engineered for each item. Research has shown that the shelf life of fresh produce is extended considerably by this packaging. The explosive growth of precut produce is due in part to the availability of modified atmosphere packaging.

In addition to engineered plastic films, various patches and valves have been developed that affix to low-cost ordinary plastic film bags. These devices respond to temperature and control the mix of environmental gases.

Shrink Wrap

One of the newest trends in produce packaging is the shrink wrapping of individual produce items. Shrink wrapping has been used successfully to package potatoes, sweet potatoes, apples, onions, sweet corn, cucumbers and a variety of tropical fruit. Shrink wrapping with an engineered plastic wrap can reduce shrinkage, protect the produce from disease, reduce mechanical damage and provide a good surface for stick-on labels.

Rigid Plastic Packages

Packages with a top and bottom that are heat formed from one or two pieces of plastic are known as clamshells. Clamshells are gaining in popularity because they are inexpensive, versatile, provide excellent protection to the produce, and present a very pleasing consumer package. Clamshells are most often used with consumer packs of high value produce items like small fruit, berries, mushrooms, etc., or items that are easily damaged by crushing. Clamshells are used extensively with precut produce and prepared salads. Molded polystyrene and corrugated polystyrene containers have been test marketed as a substitute for waxed corrugated fiberboard. At present they are not generally cost competitive, but as environmental pressures grow, they may be more common. Heavy-molded polystyrene pallet bins have been adopted by a number of growers as a substitute for wooden pallet bins. Although at present their cost is over double that of wooden bins, they have a longer service life, are easier to clean, are recyclable, do not decay when wet, do not harbor disease, and may be nested and made collapsible.

As environmental pressures continue to grow, the disposal and recyclability of packaging material of all kinds will become a very important issue. Common polyethylene may take from 200 to 400 years to breakdown in a landfill. The addition of 6 percent starch will reduce the time to 20 years or less. packaging material companies are developing starch-based polyethylene substitutes that will break down in a landfill as fast as ordinary paper.

The move to biodegradable or recyclable plastic packaging materials may be driven by cost in the long term, but by legislation in the near term. Some authorities have proposed a total ban on plastics. In this case, the supermarket of the early 21st century may resemble the grocery markets of the early 20th century.

Standardization of Packaging

Produce package standardization is interpreted differently by different groups. The wide variety of package sizes and material combinations is a result of the market responding to demands from many different segments of the produce industry. For example, many of the large-volume buyers of fresh produce are those most concerned with the environment. They demand less packaging and the use of more recyclable and biodegradable materials, yet would also like to have many different sizes of packages for convenience. packers want to limit the variety of packages they must carry in stock, yet they have driven the trend toward preprinted, individualized containers. Shippers and trucking companies want to standardize sizes so the packages may be better palletized and handled.

Produce buyers are not a homogeneous group. Buyers for grocery chains have different needs than buyers for food service. For grocery items normally sold in bulk, processors want largest size packages that they can handle efficiently - to minimize unpacking time and reduce the cost of handling or disposing of the used containers. Produce managers, on the other hand, want individualized, high quality graphics to entice retail buyers with in-store displays.

Selecting the right container for fresh produce is seldom a matter of personal choice for the packer. For each commodity, the market has unofficial, but nevertheless rigid standards for packaging; therefore it is very risky to use a nonstandard package. Packaging technology, market acceptability, and disposal regulations are constantly changing. When choosing a package for fresh fruits and vegetables, packers must consult the market, and in some markets, standard packages may be required by law

Packaging materials in use

A great variety of materials are used for the packing of perishable commodities. They include wood, bamboo, rigid and foam plastic, solid cardboard and corrugated fibre board. The kind of material or structure adopted depends on the method of perforation, the distance to its destination, the value of the product and the requirement of the market.

1. CFB Boxes

Corrugated fiberboard is the most widely used material for fruit & vegetable packages because of the following characteristics:

- Light in weight
- Reasonably strong
- Flexibility of shape and size
- Easy to store and use
- Good pointing capability
- Economical

2. Wooden Boxes

Materials used for manufacture of wooden boxes include natural wood and industrially manufactured, wood based sheet materials.

3. Sacks

Sacks are traditionally made of jute fibre or similar natural materials. Most jute sacks are provided in a plain weave. For one tonne transportation of vegetables, materials of 250 grams per square meter or less are used. Natural fibre sacks have in many cases been replaced by sacks made of synthetic materials and paper due to cost factors, appearance, mechanical properties and risk of infestation and spreading of insects. Sacks made of polypropylene of type plain weave are extensively used for root vegetables. The most common fabric weight is 70-80 grams per square meter.

Palletisation

Pallets are widely used for the transport of fruit & vegetable packages, in all developed countries. The advantages of handling packages on pallets are:

- Labour cost in handling is greatly reduced.
- Transport cost may be reduced.
- Goods are protected and damage reduced.
- Mechanized handling can be very rapid.
- Through high stacking, storage space can be more efficiently used.
- Pallets encourage the introduction of standard package sizes.

In designing export packages, their handling on pallets for shipping or for transport and storage within the importing country, is an important factor. The most common pallet size is 1200 mmx1100 mm.

Ventilation of Packages

Reduction of moisture loss from the product is a principal requirement of limited permeability packaging materials. A solution to moisture loss problems from produce appeared with the development and wide distribution of semi permeable plastic films. Airflow through the ventilation holes allows hot fruit or vegetable to slowly cool and avoid the buildup of heat produced by the commodity in respiration. Holes are also important in cooling the fruit when the packages are placed in a cold storage, especially with forced air-cooling. Ventilation holes improve the dispersal of ethylene produced.

Cushioning Materials

The function of cushioning materials is to fix the commodities inside the packages and prevent them from mixing about in relation to each other and the package itself, when there is a vibration or impact. Some cushioning materials can also provide packages with additional stacking strength. The cushioning materials used vary with the commodity and may be made of wrapping papers, Fibreboard (single or double wall), Moulded paper pulp trays, Moulded foam polystyrene trays, Moulded plastic trays, Foam plastic sheet, Plastic bubble pads, Fine shredded wood, Plastic film liners or bags.

Controlled and Modified Atmospheric Packaging (CAP and MAP)

The normal composition of air is 78% Nitrogen, 21% Oxygen, 0.03% Carbon dioxide and trees of the noble gases. Modified atmosphere packaging is the method for extending the shelf-life of perishable and semi-perishable food products by altering the relative proportions of atmospheric gases that surround the produce. Although the terms controlled atmosphere (CA) and modified atmosphere (MA) are often used interchangeably a precise difference exists between these two terms.

Controlled atmosphere (CA)

This refers to a storage atmosphere that is different from the normal atmosphere in its composition, wherein the component gases are precisely adjusted to specific concentrations and maintained throughout the storage and distribution of the perishable foods. Controlled atmosphere relies on the continuous measurement of the composition of the storage atmosphere and injection of the appropriate gases or gas mixtures into it, if and when needed. Hence, the system requires sophisticated instruments to monitor the gas levels and is therefore practical only for refrigerated bulk storage or shipment of commodities in large containers.

If the composition of atmosphere in CA system is not closely controlled or if the storage atmosphere is accidentally modified, potential benefit can turn into actual disaster. The degree of susceptibility to injury and the specific symptoms vary, not only between cultivars, but even between growing areas for the same cultivars and between years for a given location. With tomatoes, excessively low O_2 or high CO_2 prevents proper ripening even after removal of the fruit to air, and CA enhances the danger of chilling injury.

Modified atmospheric packaging (MAP)

Unlike CAPs, there is no means to control precisely the atmospheric components at a specific concentration in MAP once a package has been hermetically sealed. Modified atmosphere conditions are created inside the packages by the commodity itself and / or by active modification. Commodity – generated or passive MA is evolved as a consequence of the commodity's respiration. Active modification involves creating a slight vacuum inside the package and replacing it with a desired mixture of gases, so as to establish desired EMA quickly composed to a passively generated EMA.

Another active modification technique is the use of carbon dioxide or ethyl absorbers (scavengers) within the package to prevent the build-up of the particular gas within the package. This method is called active packaging. Compounds like hydrated lime, activated charcoal, magnesium oxide are known to absorb carbon dioxide while iron powder is known to absorb carbon dioxide. Potassium permanganate, squakna and phenyl methyl silicone can be used to absorb ethylene within the packages. These scavengers can be held in small sachets within the packages or impregnated in the wrappers or into porous materials like vermiculite. With activity respiring commodities like fruits and vegetables, the package atmosphere should contain oxygen and carbon dioxide at levels optimum to the particular commodity. In general, MA containing between 2-5% Oxygen and 3.8% carbon dioxide have been shown to extend the shelf life of a wide variety of fruits and vegetables.

If the shelf life of a commodity at 20-25°C is 1, by employing MAP, it will be doubled, whereas refrigeration can extend the shelf life to 3, and refrigeration combined with MAP can increase it to 4. Few types of films are routinely used for MAP, the important ones are polyvinyl chloride, (PVC), polystyrene, (PS), polyethylene (PE) and polypropylene (PP). The recent developments in co-extrusion technology have made it possible to manufacture films with designed transmission rates of oxygen.

Vacuum packaging

Vacuum packaging offers an extensive barrier against corrosion, oxidation, moisture, drying out, dirt, attraction of dust by electric charge, ultra violet rays and mechanical damages, fungus growth or perishability etc. This technology has commendable relevance for tropical countries with high atmosphere humidity.

In vacuum packaging the product to be packed is put in a vacuum bag (made of special, hermetic fills) that is then evacuated in a vacuum chamber and then sealed hermetically in order to provide a total barrier against air and moisture. If some of the product cannot bear the atmosphere pressure due to vacuum inside the package then the packages are flushed with inert gases like Nitrogen and CO_2 after evacuation.

Edible packaging

An edible film or coating is simply defined as a thin continuous layer of edible material formed on, placed on, or between the foods or food components. The package is an integral part of the food, which can be eaten as a part of the whole food product. Selection of material for use in edible packaging is based on its properties to act as barrier to moisture and gases, mechanical strength, physical properties, and resistance to microbial growth. The types of materials used for edible packaging include lipids, proteins and polysaccharides or a combination of any two or all of these. Many lipid compounds, such as animal and vegetable fats, acetoglycerides have been used in the formulation of edible packaging for fresh produces because of their excellent moisture barrier properties. Lipid coatings on fresh fruits and vegetables reduce weight losses due to dehydration during storage by 40-70 per cent. Research and development effort is required to develop edible films and coatings that have good packaging performance besides being economical.

Conclusion

Improved packaging will become more essential in India as International trade expands. Standardized packaging of sized and graded produce that will protect the quality during marketing can greatly aid transactions between sellers and buyers. Better packaging should be of immediate value in reducing waste. Much background research on packaging of perishable products and flowers is needed simulating the actual handling conditions expected during marketing.

Recommended Controlled Atmosphere Conditions during transport/storage of vegetables

Commodity	Storage temp °C	Optimum Oxygen %	Optimum carbon dioxide %	Approximate storage life
Asparagus	1-5	21	5-10	21 d
Beans, snap	5-10	8-10	5-10	7-10 d
Beets	0-5	None	None	8 m
Brinjal	8-12	-	-	1-2 wks
Cabbage	0-5	3-5	5-7	6-12 m
Carrot	0-5	None	None	405 m
Cauliflower	0-5	2-3	3-4	2-3 m
Cucumber	8-12	3-5	0	14-21 d
Mushrooms	0-5	Air	10-15	3-4 d
Okra	8-12	3-5	0	7-10 d
Onions bulb	0-5	1-2	0	8 m
Pea (green)	0-1	5-10	5	5-10 d
Pepper, bell	8-12	3-5	0	2-3 wks
Pepper, chilli	8-12	3-5	0.5%	
Pumpkin	7-10	-	-	2-4 m
Radish	0-5	None	None	3-4 wks
Spinach	0-5	Air	10-20	2-3 wks
Tomatoes	5-13	3-5	2-3	2 wks
D – days Wks – weeks M - months				

Beneficial effects of controlled atmosphere on some vegetables

Commodity	**Application**	**Benefits**
Asparagus	Storage	Retention of sugars, organic acids and soluble proteins: retardation of toughening and discase
anana, green	Transport	Extension of shelf life
Beans, green	Transport	Extension of storage life, retention of chlorophyll
Broccoli	Storage	Retardation of yellowing
Brussels sprouts	Storage	Extension of storage life.
Cabbage whole	Storage	Retention of green colour and fresh flavour
Sheredded	Storage	Retardation of browning and off-odour development
Cauliflower	Storage	White colour of the curls preserved retention of leaf chlophyll
Lerruce shredded	Storage	Delayed browning
Onion, green	Transport	Retention of chlorophyll in tops
Peas, green	Storage	Extension of storage life, retention of chlorophyll

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