ITDG
PRACTICAL ANSWERS TO POVERTY

PACKAGING MATERIALS FOR FOODS

technical brief

Introduction

This brief describes the properties of different packaging materials. It however, only notes the technical properties of the different materials and actual use will depend mostly on the cost and availability in your particular area. Furthermore, there may be particular marketing reasons for choosing a certain type of package and although these are very important in package selection, they are outside the scope of this technical brief.

Figure 1: Packaged Chana Chur that has been prepared for marketing in Bangladesh. ©Zul/ITDG

The importance of packaging

The importance of packaging can be summarised as follows:

- Adequate packaging aids distribution.
- Rapid and reliable distribution helps reduce malnutrition, removes local food surpluses and allows the consumer more choice in the foods available.
- Packaging and distribution reduce post harvest losses, this together with a larger market allows producers to increase their income.

Therefore, inadequate packaging in developing countries has profound effects on the whole pattern and total amount of food consumed.

Functions of packaging

Packaging is a means of providing the correct environmental conditions for food during the length of time it is stored and/or distributed to the consumer. A good package has to perform the following functions:

- It must keep the product clean and provide a barrier against dirt and other contaminants.
- It should prevent losses. Its design should provide protection and convenience in handling, during transport, distribution and marketing. In particular, the size, shape and weight of the packages must be considered.
- It must provide protection to the food against physical and chemical damage (eg water and water vapour, oxidation, light) and insects and rodents.
- It must provide identification and instruction so that the food is used correctly and have sales appeal.

Packaging materials

Textiles

Textile containers have poor gas and moisture barrier properties and have a poorer appearance than plastics. Woven jute sacks, which are chemically treated to prevent rotting and to reduce their flammability, are non-slip, have a high tear resistance, and good durability. They are used to transport a wide variety of bulk foods including grain, flour, sugar and salt.

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Cotton
Calico is usually a closely woven, strong, plain, cotton fabric which is inexpensive and is satisfactory as a wrapper for flour, grains, legumes, coffee beans and powdered or granulated sugar. It can be re-used as many times as the material withstands washing and is easily marked to indicate the contents of the bag.

Muslin and cheesecloth are open-mesh, light fabrics used to wrap soft foods, which they help hold together in the desired shape. Processed meats, smoked shoulders of ham, etc, are tightly wrapped in cheesecloth, before being packaged into cellophane, wax paper etc.

Both muslin bags and cheesecloth wrappers have to be cut open and can seldom be re-used. It is a very cheap material, made in huge quantities because of its multiple applications, but it gives very little protection to food, and simply holds it together.

Kenaf
The kenaf plant grows in Central Asia, India, Africa and Cuba. It is chiefly used for making ropes and string but can be spun into a yarn which is fine enough to make a coarse canvas. In India, it is known as ambari or deccan hemp and in Africa, lipatam or gombo.

Sisal
Sisal is a fibre that comes from the agave family of plants. Sisal is resistant to salt water and therefore makes an ideal natural material from which to make rope. The nets in which hard fruits are transported are often hand-made from vegetable fibre.

Wood
Wooden shipping containers have traditionally been used for a wide range of solid and liquid foods including fruits, vegetables, tea and beer. Wood offers good mechanical protection, good stacking characteristics and a high weight-to-strength ratio. However, plastic containers have a lower cost and have largely replaced wood in many applications. The use of wood continues for some wines and spirits because the transfer of flavour compounds from the wooden barrels improves the quality of the product. Wooden tea chests are produced more cheaply than other containers in tea-producing countries and are still widely used. Wooden crates are imported for transporting fresh fruit and vegetables, fish etc. They are used to hold foods together and protect them from crushing, but otherwise offer little protection.

Traditional packaging materials

In general these materials are used to hold foods but they offer little in the way of barrier properties needed for a long shelf life. The exception is glazed pottery, which although heavy, has excellent properties.

Leaves
Banana or plantain leaves are the most common and widespread leaves used for wrapping foods, such as certain kinds of cheese and confectionery (guava cheese). Cornhusk is used to wrap corn paste or block brown sugar, and cooked foods of all sorts are wrapped into leaves. 'Pan' leaves are used for wrapping spices (India), they are an excellent solution for products that are quickly consumed, as they are cheap and readily available.

Vegetable fibres
These natural raw materials are converted into fibres to produce the yarn, string or cord for packaging materials. Such materials, although categorised by the nature of the constituent fibre, have certain common characteristics. They are very flexible, to some extent resistant to tearing and permeable to water and water vapour. Their lightweight is an advantage in handling and transport.

The rough surface makes stacking easier in comparison to man-made fibre sacks, which slide due to their smooth surface. Another difference with man-made fibres is that the natural raw materials are

bio-degradable when left in their pure state. However, they rot when moist limiting the number of times that they can be re-used.

Bamboo and rattan
These are widely used materials for basket making. Bamboo pots, cut out of the bamboo stem are also found.

Coconut palm
Green coconut palm and papyrus leaves are frequently woven into bags or baskets, which are used for carrying meat and vegetables in many parts of the world. Palyra palm leaves are used to weave boxes in which items such as cooked foods are transported.

Treated skins
Leather has been used for many centuries as a non-breakable container or bottle. Water and wine are frequently stored and transported in leather containers (camel, pig and kid goat hides). Manioc flour and solidified sugar are also packed in leather cases and pouches.

Earthenware
Earthenware is used worldwide for storage of liquids and solid foods such as curd, yoghurt, beer, dried food, honey, etc. Corks, wooden lids, leaves, wax, plastic sheets, or combinations of these are used to seal the pots. If well sealed, it is a gas, moisture and lightproof container. Unglazed earthenware is porous and is very suitable for products that need cooling e.g. curd. Glazed pots are better for storing liquids e.g. oils, wine, as they are moisture proof and airtight, if properly sealed. All are lightproof and if clean, restrict the entry and growth of micro-organisms, insects and rodents. One should ensure that the glazing of the earthenware does not contain lead. Most traditionally glazed pots do have lead glazings which, although they are not really harmful for serving coffee or soup, should not be used for acid drinks and other products which are to be stored for a long time.

Metal
Metal cans have a number of advantages over other types of container, including the following:

- they provide total protection of the contents
- they are convenient for ambient storage and presentation
- they are tamperproof.

However, the high cost of metal and the high manufacturing costs make cans expensive. They are heavier than other materials, except glass, and therefore have higher transport costs.

Glass
Glass containers have the following advantages:

- they are impervious to moisture, gases, odours and micro-organisms
- they are inert and do not react with or migrate into food products
- they are suitable for heat processing when hermetically sealed
- they are re-useable and recyclable
- they are resealable
- they are transparent to display the contents
- they are rigid, to allow stacking without container damage.

The disadvantages of glass include:

- higher weight which incurs higher transport costs than other types of packaging
- lower resistance than other materials to fractures, scratches and thermal shock
- more variable dimensions than metal or plastic containers
- potentially serious hazards from glass splinters or fragments in foods.

Flexible films
In general, flexible films have the following properties:

- their cost is relatively low
- they have good barrier properties against moisture and gases
- they are heat sealable to prevent leakage of contents
- they have wet and dry strength
- they are easy to handle and convenient for the manufacturer, retailer and consumer
- they add little weight to the product
- they fit closely to the shape of the food, thereby wasting little space during storage and distribution.

A summary of the different types of flexible films is as follows:

Cellulose
Plain cellulose is a glossy transparent film which is odourless, tasteless and biodegradable (within approximately 100 days). It is tough and puncture resistant, although it tears easily. However, it is not heat sealable and the dimensions and permeability of the film vary with changes in humidity. It is used for foods that do not require a complete moisture or gas barrier.


Figure 2: High quality chocolates sold in Lima, Peru following an ITDG small enterprise training course. ©Roger Bassil/ITDG

Polypropylene
Polypropylene is a clear glossy film with a high strength and is puncture resistance. It has moderate permeability to moisture, gases and odours, which is not affected by changes in humidity. It stretches, although less than polyethylene.

Polyethylene
Low-density polyethylene is heat sealable, inert, odour free and shrinks when heated. It is a good moisture barrier but has a relatively high gas permeability, sensitivity to oils and poor odour resistance. It is less expensive than most films and is therefore widely used.

High-density polyethylene is stronger, thicker, less flexible and more brittle than low-density polyethylene and has lower permeability to gases and moisture. It has higher softening temperature (121ºC) and can therefore be heat sterilised. Sacks made from 0.03 0.15mm high-density polyethylene have a high tear strength, penetration resistance and seal strength. They are waterproof and chemically resistant and are used instead of paper sacks.

Other films
Polystyrene is a brittle clear sparkling film which has high gas permeability. Polyvinylidene chloride is very strong and is therefore used in thin films. It has very low gas and water vapour permeabilities and is heat shrinkable and heat sealable. However, it has a brown tint which limits its use in some applications. Nylon has good mechanical properties a wide temperature range (from 60 to 200°C). However, the films are expensive to produce, they require high temperatures to form a heat seal, and the permeability changes at different storage humidities.

Coated films

Films are coated with other polymers or aluminium to improve the barrier properties or to import heat sealability. For example, nitrocellulose is coated on one side of cellulose film to provide a moisture barrier but to retain oxygen permeability. A nitrocellulose coating on both sides of the film improves the barrier to oxygen, moisture and odours and enables the film to be heat sealed when broad seals are used. A coating of vinyl chloride or vinyl acetate gives a stiffer film which has intermediate permeability. Sleeves of this material are tough, stretchable and permeable to air, smoke and moisture. They are used, for example, for packaging meats before smoking and cooking.

A thin coating of aluminium produces a very good barrier to oils, gases, moisture, odours and light. The properties are shown in Table 1.

Film Type	Coating	Barriers to Moisture	Air/Odours	Strength	Clarity	Normal Thickness Micrometers
Cellulose	-	*	***	*	***	21 - 40
Cellulose	PVDC	***	***	*	***	19 - 42
Cellulose	Aluminium	***	***	*	-	21 - 42
Cellulose	Nitro-cellulose	***	***	*	-	21 - 24
Polythene (low density)	-	**	*	**	*	25 - 200
Polythene (high density)	-	***	**	***	*	350 - 1000
Polypropylene	-	***	*	***	***	20 - 40
Polypropylene	PVDC	***	***	***	***	18 - 34
Polypropylene	Aluminium	***	***	***	-	20 - 30
Polyester		**	**	***	**	12 -23
Polyester		***	***	***	**	-
Polyester		***	***	***	-	20 -30

Table 1: Properties of selected packaging materials

* = low ** = medium *** = high. Thicker films of each type have better barrier properties than thinner films. PVDC = polyvinylidene chloride.

Laminated films

Lamination of two or more films improves the appearance, barrier properties or mechanical strength of a package.

Coextruded films

This is the simultaneous extrusion of two or more layers of different polymers. Coextruded films have three main advantages over other types of film:

- They have very high barrier properties, similar to laminates but produced at a lower cost.
- They are thinner than laminates and are therefore easier to use on filling equipment.
- The layers do not separate.

Examples of the use of laminated and coextruded films are as follows:

Type of laminate	Typical food application
Polyvinylidene chloride coated polypropylene (2 layers)	Crisps, snackfoods, confectionery, ice cream, biscuits, chocolate
Polyvinylidene chloride coated polypropylene-polyethylene	Bakery products, cheese, confectionery, dried fruit, frozen vegetables
Cellulose-polyethylene-cellulose	Pies, crusty bread, bacon, coffee, cooked meats, cheese
Cellulose-acetate-paper-foil- polyethylene	Dried soups
Metallised polyester-polyethylene	Coffee, dried milk
Polyethylene-aluminium-paper	Dried soup, dried vegetables, chocolate

Table 2: Selected laminated films used for food packaging

Type of coextrusion	Application
High impact polystyrene- polyethylene terephthalate	Margarine, butter tubs
Polystyrene-polystyrene- polyvinylidene chloride-polystyrene	Juices, milk bottles
Polystyrene-polystyrene- polyvinylidene chloride-polyethylene	Butter, cheese, margarine, coffee, mayonnaise, sauce tubs and bottles

Table 3: Selected applications of coextruded films

Paper & cardboard

'Sulphate' paper is strong and hence used for paper sacks for flour, sugar, fruits and vegetables. 'Sulphite' paper is lighter and weaker and is used for grocery bags and sweet wrappers, as an inner liner for biscuits and in laminations. Greaseproof paper is sulphite paper made resistant to oils and fats, for meat and dairy products. Glassine is a greaseproof sulphite paper which is given a high gloss. It is resistant to water when dry but loses its resistance once it becomes wet. Tissue paper is a soft paper used for example to protect fruits against dust and bruising.

Many papers are also treated with wax to provide a moisture barrier and allow the paper to be heat sealed. However, a simple wax coating is easily damaged by folding or by abrasive foods. This is overcome by laminating the wax between layers of paper and/or polyethylene. Waxed papers are used for bread wrappers and inner liners for cereal cartons.

Boards are made in a similar way to paper but are thicker to protect foods from mechanical damage. The main characteristics of board are thickness, stiffness, the ability to crease without cracking and the degree of whiteness. White board is suitable for contact with food and is often coated with polyethylene, polyvinyl chloride or wax for heat sealability. It is used for ice cream, chocolate and frozen food cartons. Chipboard is made from recycled paper and is not used in contact with foods (for example the outer cartons for tea and cereals). It is often lined with white board to improve the appearance and strength. Other types include paperboard and moulded paperboard trays (for example egg cartons).

References and Further Reading

- *How to Package Food in Glass,* ITDG Technical Brief
- *Solids Filling and Packaging,* ITDG Technical Brief
- *Packaging, Food Cycle Technology Source Book,* IT Publications/UNIFEM, 1996
- *Appropriate Food Packaging,* Peter Fellows, Barry Axtell, ILO/TOOL, 1993
- *Small-scale Food Processing: A Guide to Appropriate Equipment,* Peter Fellows, Ann Hampton, IT Publications/ CTA, 1992
- *Starting A Small Food Processing Enterprise,* Peter Fellows, Ernesto Franco, and Walter Rios, IT Publications/ACP-EU, 1996
- *Training in Food Processing; Successful Approaches,* Mike Battcock, Sue Azam-Ali, Barrie Axtell, and Peter Fellows, IT Publication, 1998

Further information

Further information can be obtained about local costs and availability of different types of packaging from the following institutions:

International Packaging Research Institutes
World Packaging Organisation
1 Vere Street
London
W1M 9HQ
United Kingdom

Asian Packaging Federation
c/o Japan Packaging Institute
Honshu Building
2-5-chome
Ginza Higashi
Chou-ku
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Indian Institute of Packaging
H-24 Green Park Extension
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