

PACKAGING FOR ORGANIC FOODS



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Technical guide focusing on the requirements for organic food packaging aimed at small processors, packers and exporters in developing countries – discusses packaging basics, including its functions; describes sustainable packaging design and eight important steps to take in the sourcing of packaging; reviews the laws relating to food-contact materials in general and organic food in particular; gives an overview of food safety issues; discusses possible damage during travel from farm to packaging houses and how to prevent it; describes packaging material and technology options, transport packaging, and various types of packaging for different types of food.

Descriptors: **Packaging, Organic Food, Food Safety, Packaging Standards**

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English

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The series aims to guide exporters, civil society and policymakers on trends and practical guidance about the growing market for sustainably produced goods and services.

For further information about this series and the TEP, please contact Alexander Kasterine at kasterine@intracen.org.

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Acronyms

ASTM	American Society for Testing and Materials
BOPP	Biaxially-oriented polypropylene
BRC	British Retail Consortium
CFB	Corrugated fibre board
CPET	Crystalline polyethylene terephthalate
EVA	Ethylene-vinyl acetate
EVOH	Ethylene-vinyl alcohol
EPS	Expanded polystyrene
FCM	Food contact material
FIBC	Flexible intermediate bulk container
GMOs	Genetically modified organisms
g/m ²	Grams per square metre
HACCP	Hazard analysis and critical control point
HDPE	High-density polyethylene
IFOAM	International Federation of Organic Agriculture Movements
IFS	International Food Standard
ITC	International Trade Centre
ISO	International Organization for Standardization
kgf	Kilogram force
LCA	Life-cycle analysis
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
MAP	Modified atmosphere packaging
MVTR	Moisture vapour transmission rate
OPP	Oriented polypropylene
PA	Polyamide
PC	Polycarbonate
PE	Polyethylene
PEN	Polyethylene naphthalate
PET	Polyethylene terephthalate
PLA	Poly lactic acid
PP	Polypropylene
ppm	Parts per million
PS	Polystyrene
PVC	Polyvinyl chloride
PVdC	Polyvinylidene chloride
RSC	Regular slotted container
SQF	Safe, Quality Food
USDA	United States Department of Agriculture
UV	Ultraviolet
VOCs	Volatile organic compounds

Executive summary

This guide helps exporters, packers and processors to understand packaging for organic food. Businesses in developing countries, particularly micro and small ones, often lack comprehensive information on market requirements set by importers. This guide on packaging for organic products will help them meet these requirements and formulate their own packaging strategies, thereby creating new opportunities and competitiveness in their business.

Chapter 1 discusses packaging basics, including functions. Chapter 2 presents information on sustainable packaging design and eight important steps to take in the sourcing of packaging. Chapter 3 presents laws relating to food-contact materials in general and organic food in particular. Chapter 4 gives an overview of food safety issues. Chapter 5 covers possible damage during travel from farm to packaging houses and how to prevent it. Chapters 6, 7 and 8 discuss packaging-material and technology options. Transport packaging is summarized in chapter 9. Finally, to give a feel for practical design and sourcing, examples of packages are discussed in chapter 10.

Introduction

The word “organic” is regulated both through international standards (Codex Alimentarius – Organically Produced Foods¹) and through individual domestic regulations. These regulations include requirements on the production, processing and labelling of organic food. Food products described by this term are expected to have been produced holistically to standards which aim at achieving agro-ecosystems which are socially, ecologically and economically sustainable. Where possible, agronomic, biological, and mechanical methods as opposed synthetic materials are used and nutrient cycles are closed. The production system, processing and packaging have to be sustainable to create environment friendly, high quality products. While there is no visual differentiation between food products grown conventionally or organically, differentiation can be created by the use of organic certification and packaging design.

Packaging used for food is often different from non-food product or industrial packaging. Packaging for food has to be compatible with the food product packed within, and food standards and regulations must be met. For instance, the migration of harmful substances from packaging material in direct contact with food must be avoided. Thus, materials used for food packaging, handling and storage must be chosen accordingly.

When it comes to packaging for organic food products, additional concerns must be kept in mind. Organic products normally do not contain any chemicals and are expected to reach consumers in that condition when packed. Safety for human consumption and environment protection are the most important criteria when choosing organic food packaging. In marketing organic products, what *differentiates* them from non-organic options needs to be conveyed to the potential buyer. Primary packaging can offer a solution as it helps to define the uniqueness and saleability of the product.

Sustainable packaging for organic food is characterized by the following criteria:

- Beneficial, safe and healthy for individuals and communities throughout its life cycle;
- Meets market criteria for performance and cost;
- Sourced in a responsible way;
- Sourced, manufactured, transported and tested for its intended use;
- Maximizes the use of renewable or recycled materials wherever possible;
- Manufactured using clean production techniques and best practices;
- Designed to minimize the need for materials and energy;
- Can be recovered and recycled effectively.

¹ Codex Alimentarius is the reference work on food, produced by the United Nations and the World Health Organization. The standard for 'Organically Produced Food' can be accessed here: <http://www.fao.org/docrep/005/y2772e/y2772e00.htm>.

Chapter 1 Basics of packaging

1. Functions of packaging

Packaging for organic food should fulfil the following functions:

Contain: The package must contain and preserve a certain quantity of product as efficiently as possible. The quantity may be measured by volume, by weight or by number. The shape and dimensions of the package often have implications for the cost and strength. Compact packaging, with as little empty space inside as possible, withstands stacking pressure and handling stresses better than loose packaging. A loosely filled package also means a waste of packaging material and unnecessary transport costs. In many countries, environmental and consumer protection organizations campaign against packages that are too big for their contents. Minimum packaging minimizes disposal costs as well as resource the use. Minimizing however does not mean reducing the package to the point where the safety and integrity of the product are at risk.

Protect: The package must protect its contents from external threats including spoilage, breakage, damage from external environmental conditions, pilfering and theft. Primary, secondary and tertiary packaging must be designed so that the product stays in perfect condition until it reaches the end user. The package must be strong and durable enough to protect the product with a reasonable safety margin. A number of examples of how packaging should protect from external threats are given below (table 1).

Table 1. How packaging must protect food from external threats

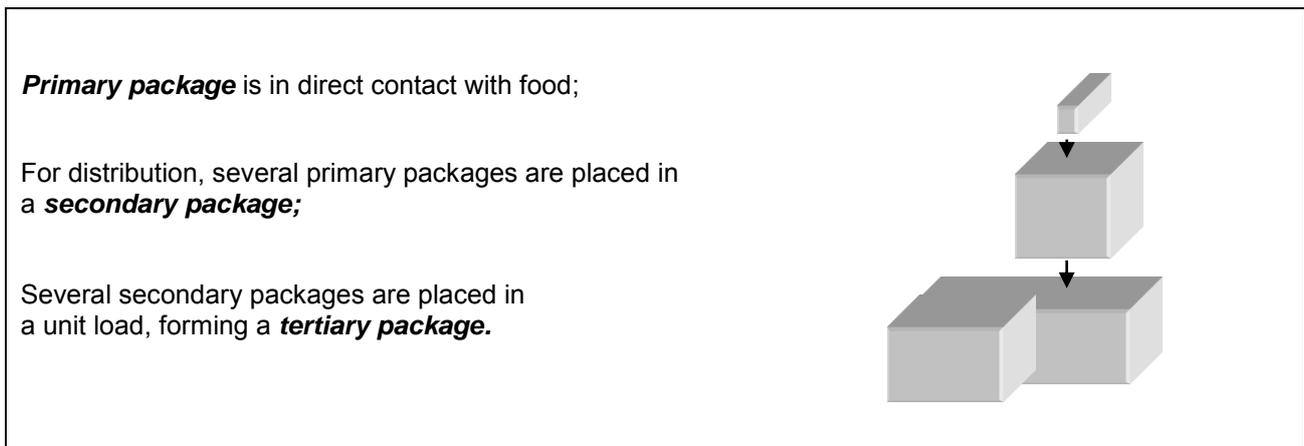
External environmental conditions	Protective packaging functions
Mechanical shock, vibration and compressive loads	Shock and vibration absorption, compressive strength
Biological factors	Resistance
Gases (O, N, CO ₂)	Low permeability (high gas barrier)
Light	Transmission (low or high as required)
Temperature	Thermal conductivity (low or high as required)
Water	Resistance and absorption (high water vapour barrier)

Promote: Packaging should act as a 'silent salesman' for the product, promoting the product at the point of sale. Visual and graphic design can only work if the package's technical and structural designs have done their job. The information on the label must be correct and conform to the legal and environmental requirements of the target market. Additional information – including the product quality and the way it was produced – can also be conveyed through the packaging. Further, sales fall into two categories: first-time sales and repeat sales. The package must attract first-time buyers and build brand loyalty for repeat sales.

The above three basic requirements form the framework within which a package should be designed. The prerequisite step in fulfilling these requirements is the collection of information on each of the functions. Research therefore is an essential component of packaging design.

2. Primary, secondary and tertiary packaging

The range of available packaging can be subdivided into the following three groups (figure 1).

Figure 1. The major groups (or levels) of packaging

Primary package: Primary packs/containers (also called consumer or retail packs) come in direct contact with the food they contain. These unit packs can be of various sizes, to cater to different market requirements. Consumer packs can act as a marketing and branding tool and its effectiveness depends on the correct choice for the market concerned. Important selection considerations include: legal requirements of the importing market, environmental regulations, distribution network, shelf-life and sales estimates, retail shelf-space limitations, consumer buying preferences, point-of-sale display, reuse, recycling and post-consumption disposal. **Examples:** metal cans, glass bottles, jars, rigid and semi-rigid plastic tubs, collapsible tubes, paperboard cartons, and flexible plastic bags, sachets and over wraps.

Secondary package: A secondary container (also called transport packs) is an outer box, case or wrapper that holds a single primary pack – or “unitizes” – several packs together like: cans, jars, or pouches. The main purpose of secondary packaging is to minimize risks to the product in their primary packs during storage, transport, and distribution. Consideration must be given to the stages of the distribution process to foresee and avoid any risks involved. The package chosen should be acceptable throughout the distribution chain. **Examples:** wooden, metal or fibreboard cases, crates and sacks.

Tertiary package: Tertiary packaging (also called unit packs or pallet loads) collects secondary packaging together into pallet loads or shipping units for distribution. The objective is to ease the automated handling of larger amounts of products. Typically, a forklift truck or similar equipment is used to move and transport these tertiary loads. Unitizing is the consolidation of several items into a compact load, secured together and provided with skids and cleats for ease of handling. The particular advantage of pallets is that they are of pre-set sizes and fit the dimensions of containers. Unitized and palletized loads are often shrink-wrapped to protect against moisture and pilferage.

Chapter 2 Packaging design and selection

Packaging design sets out to achieve two goals: safe arrival and effective promotion of the product.

Package design consists of structural design, the technical construction of the package from a functional point of view, graphic (or visual) design, the appearance of the package and its promotional value. Packaging is required to keep a product and its components and accessories secure from the beginning of the production process to the time when it reaches the end user. Such containment ensures that the product reaches the consumer in a usable condition. It also ensures that the product itself and other products, people and the environment are safeguarded from any adverse effects of product loss. These effects may be caused not only by the spilling or dispersal of the product itself but also by the egress of moisture, pressure, heat and cold from the product.

Organic food packaging as an enabler of sustainability

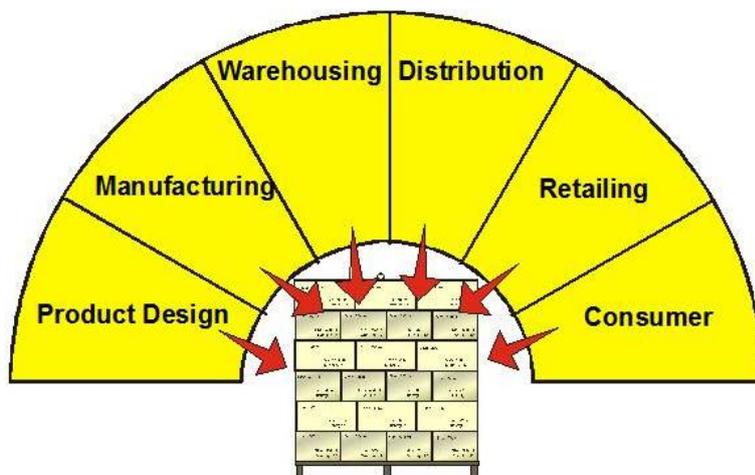
Consumers, governments and industry recognize that we must look to reduce our global footprint in every area of our lives. From a holistic approach, packaging should satisfy economic, social and environmental requirements related to the production, distribution and consumption of the product.

Extra design work must go into the packaging and marketing of organic products to match the characteristics of organic food processing. Organic and natural foods are widely purchased by health-conscious consumers, young and old alike. Organic is typically a premium product and the target audience must be able to observe the difference through the packaging. Organic food can be expensive to produce and many consumers are willing to pay more for visually appealing packaged products. Bold graphics, stylish text and the use of organic materials to package organic products can all catch the eye of the consumer.

1. Packaging design

When buying organic food, consumers expect to buy an all-around ecologically friendly product, including the packaging. On top of guaranteeing food safety and quality, offering space for product information, easy packing operation and easy handling in the integrated transport system, the packaging material for organic food should be environmentally friendly, have a high degree of recyclability and perhaps carry graphic design work characteristic of organic produce for effective advertising. Design inputs that must be considered for organic packs are indicated in figure 2.

Figure 2. Package design inputs



Source: ASTM D6198 Standard Guide for Transport Package Design.

1.1. Packaging and environmental considerations

In planning and designing packaging for export, environmental considerations must be taken into account. Package planners should therefore know the guidelines and regulations concerning the acceptability of the packaging they propose to use in the markets for which it is intended. In certain markets, the packaging used may be subjected to life-cycle analysis (LCA). However, LCA cannot always be used to make objective comparisons between different types of environmental impact and different packages.

Environmental claims can also be made by producers and marketing organizations to gain a market advantage and to attract consumer attention to their products. For example, eco-labels are used in the promotion of products and brands in which the products are rated or endorsed according to their environmental sustainability. Products achieving positive ratings can bear a promotional seal or symbol to this effect. Many countries have their own eco-labelling schemes and systems but international standards are being developed to harmonize environmental practices and reduce the confusion which arises from poorly defined guidelines, regulations and different eco-labelling schemes worldwide.

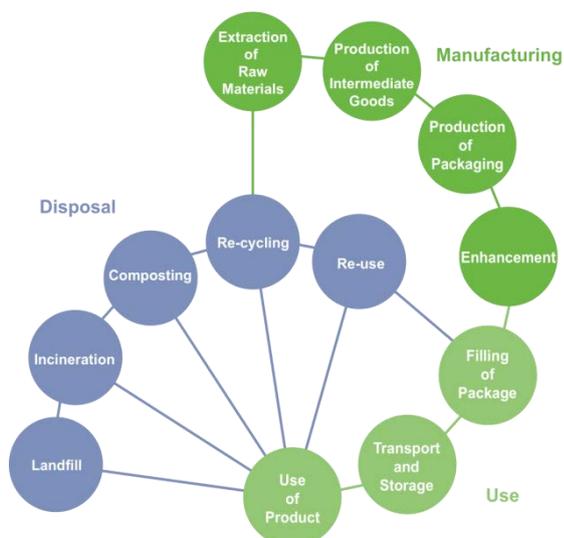
1.2. Environmental impact of the packaging lifecycle

The lifecycle of packaging runs from the extraction of raw materials to processing, use and disposal. Every step needs an input of material and energy and involves an output of emissions and waste, and they all have environmental implications.

There are environmental implications in:

- The use of finite, non-renewable resources, such as oil;
- The use of natural resources, such as trees and water;
- Energy use, such as in manufacture and transport;
- Emissions to air, such as gases which contribute to climate change;
- Discharges into water, which can be toxic to plants and animals;
- The creation of hazardous waste by-products including ash and leachate;
- Extractive industries and landfill sites which affect natural habitats;
- Transport, pollution and littering which hit the natural amenity value of landscapes.

Figure 3. Simplified packaging life cycle



Source: C. Brookes and K. Vrolijk; Soil Association 2006.

Within the packaging lifecycle there exist options to minimize the environmental impact.

Producers can choose to:

- Minimize the amount of packaging material by reducing the thickness and weight of materials, eliminating unnecessary layers, selling produce loose or printing directly on the primary packaging.
- Use packaging materials in secondary and tertiary packs which contain a high percentage of recycled materials or are easy to recycle materials. For recyclability, use packaging from a single type of material or choose components which are easy to separate, use un-pigmented and clear materials and avoid mixing different kinds of plastic.
- Use renewable materials and avoid materials produced out of fossil resources such as plastics from crude oil.
- Avoid marketing-driven over-packaging.

1.3. The recyclability of packaging

Even if packaging has been reduced, it is still necessary to consider re-use and recycling. Producer should consider the following waste hierarchy:

Elimination: consider the role of each component and remove unnecessary layers or parts wherever possible.

Reduction: cut the amount of material used by optimising packaging and reducing the size, thickness or weight of the materials.

Re-use: consider a system where some or all of the packaging is returned to be used again.

Recovery: encourage recycling and composting and choose packaging that is designed for ease of recyclability.

Disposal: the disposal of waste has the greatest environmental impact and is the least cost-effective solution.

2. Packaging selection – eight steps to consider

To gain marketing advantages in international markets, the following steps will aid in sourcing the best packaging for organic food products. There are eight steps to consider. See this chapter's annex for a checklist of the most significant points.

Step 1. Know your product (For more detailed information see chapter 5)

Find out the physical, chemical and mechanical properties of the product to be packaged. Establish a match between procured and demanded product specifications. E.g. if a product is reactive or acidic, the degree needs to be understood; if it is moisture-sensitive, the extent of this sensitivity needs to be determined. Shelf-life should be considered. Is the food ready to eat? Are the products in aseptic packs? Is the food frozen or dried?

To know your product better you should be able to answer the following questions:

- Is the product fresh, dried, frozen or processed?
- What are the physical, chemical and mechanical properties of the product?
- Can the product be handled/filled/packed by machine, and if so, is suitable equipment available?

- What are the shelf-life and product quality requirements (flavour, colour, moisture, organoleptic, size, form (powder, granule, liquid, etc.) and weight)? This helps in determining the barrier properties (gas, water vapour and light) required for effective protection.
- Is the packaging suitable for the product's intended use (e.g. hot filling, sterilisation)?

Step 2. Check the packaging facilities

The requirements and limitations of the packer's machinery should be checked from the standpoint of good manufacturing practices (GMPs), good handling practices (GHPs), production quantities, packaging materials and pack dimensions.

Automated packing operations often have more strict requirements for the accuracy and consistency of package sizes than manual packing systems. If the packing operation is manual, the package types and materials have to be chosen so that this is feasible at the required speeds. If existing machinery is to be used, the availability of sufficient capacity and space should be checked, as should the availability and skills of the personnel required.

The following questions could be helpful:

- Can the product be handled/filled/packed by machine and, if so, is suitable equipment available?
- Could the product be modified for easier packing without affecting its taste or character?
- Are the available packaging (primary, secondary and tertiary) and packing methods affordable and suitable for the product?
- Are there detailed mechanical and technical specifications for every element of packaging?
- Do the specifications comply with the machine requirements?
- Are good manufacturing and handling practices being followed?

Step 3. Know your target market

Packaging can help a company position its product. In doing so, three questions need to be answered: Who sells, what and to whom? Understanding your target market will require considering the following questions:

- Is the labelling correct?
- Are graphics designed with specific marketing inputs?
- Does the packaging offer a wide range of design options?
- Is the package easy and safe to use?
- Does the packaging design fit the target market?
- Are the packaging's printing inks environmentally friendly?
- Have the target market's standards, laws and regulations (including those related to the environment) been observed?
- Can the packaging and designs used on the domestic market also be used for export?
- Can the same export packaging and designs be used for all the target markets?

Step 4. Choose appropriate packaging materials (For more detailed information see chapters 6 and 7)

Choosing packaging material is important. For consumer packaging, it might be glass, plastic, paper-based or metal.

For transport packs it might be wooden boxes, jute or other kind of knitted bags, corrugated boxes or metal or plastic drums. The chosen materials should be suitable and accepted in the target market as regards, for example, their recycling or disposal.

The choice will depend on the availability of suitable packaging materials, reliable suppliers, price and lead times.

Close coordination with the company's procurement operations is essential to ensure cost-effective selection of materials. However, quality requirements should take precedence over material price concerns. The cheapest material is not always the most economical when production and distribution costs are also considered.

Producers need to understand raw material availability, cost (including taxes if imported) and possible changes in export markets regarding non-recyclable packages.

Food safety aspects also have to be considered. Bear in mind the hazards to which the product is likely to be exposed throughout its life-cycle – for instance if the product is being shipped from tropical countries, remember the implications of the climatic conditions.

Step 5. Optimize logistics and supply chain management processes and costs (For more detailed information see chapter 9.)

If several modes of transport are used for export, as is often the case, all the packaging must be designed to endure the toughest stages of the distribution chain, including the number of transshipments and other handling operations.

If goods are normally handled mechanically at the main transshipment points, the packages should be unitized to make this possible. However, cost comparisons may be needed to determine whether manual or mechanical handling on pallets is more economical in each distribution situation. The dimensions of unit loads should be chosen to suit transport modes and handling equipment at the market destination. Many transport modes also have their own package-marking requirements to ensure that packs are correctly handled and safely delivered. Particular product groups such as perishables, fresh fruit and vegetables as well as individual countries often have specific requirements in addition to internationally accepted markings.

Often, in logistics and at point of sale, requirements are different. In logistics, optimal protection and transport capabilities, as well as stable construction, are the decisive factors; at the point of sale, however, the packaging should allow for a sales-promoting attractive presentation with a free view of articles.

Aspects to consider include:

- Types, sizes and dimensions of primary, secondary and tertiary packaging;
- Different modes of transportation (ship, airplane, train, lorry, etc.);
- Quality standards, including both performance and presentation;
- Suitability for shelf display;
- Ease of unpacking and price-marking;
- Recycling or handling of empty transport packaging;
- Knowledge about the climatic conditions throughout the distribution chain and the ability of packaging to protect its contents against climatic hazards such as humidity and changes of temperature;
- Handling methods, number of transshipments, and equipment used throughout the distribution chain;
- The need for palletisation and containerisation in the transport packaging design;
- Common logistics measures (stackability etc.);

- Transport requirements (e.g. the weight and volume of the packaging);
- Ways to minimize contamination (by impurities, germs etc.).

Step 6. Meet all health, safety and environmental requirements (For more detailed information see chapters 3 and 4)

Consumer health and safety, and environmental protection, are essential considerations in the planning of packaging. The many laws, regulations and guidelines applying to these aspects of packaging, especially in industrialized countries, should be taken into account at the package planning stage, as they may affect the choice of both materials and package types.

Consider the following questions:

- Does all packaging follow existing legal guidelines?
- Are the regulations of the organic associations complied with?
- Are there declarations of conformity or other proofs for all used packaging, which verify that the packaging is suitable for its intended use?
- Can the manufacturer verify the confirmed suitability of the packaging by appropriate analysis and test results along the entire packaging chain?
- Is the safety of consumers guaranteed when they handle the packaging and the food product?

Step 7. Use caution with claims on environmentally friendly materials (For more detailing information see chapters 2 and 6)

Sometimes manufacturers and media promote claims on use of biodegradable packaging for food products as environmental friendly materials on the basis of certain standards. Standards such as IS/ISO 17088: 2008 and EN 13432 certify the compost ability of biodegradable plastics – called compostable plastics. These standards are not meant for certifying the safe use of any plastic material or for that matter any biodegradable/ compostable plastic material for its safe use in contact with food, drinking water and pharmaceuticals. Due caution needs to be exercised in this regard. Following are some considerations to keep in mind when making claims on environmentally friendly packaging materials:

- Is there data about the life-cycle of the packaging?
- Are minimum consumption of resources and energy and minimum emissions along the life-cycle guaranteed?
- Are the heavy metal contents (if any) within limits in the packaging material?
- Does the manufacturer attempt to use as little packaging material (volume, weight) as possible to pack the product safely, hygienically and in an acceptable manner?
- Is the end-of-life scenario of the packaging known? Does recycling take place?
- Is freedom from genetically modified organisms (GMOs) guaranteed for all raw materials including relevant auxiliary substances, enzymes and micro-organisms?

Step 8. Test your packaging

Test your packaging for its compatibility with your product, for shelf-life and its performance under simulated transport conditions.

Ideally, shelf-life studies for up to two years should be conducted. However, often packaging technologists can use accelerated ageing analysis and their experience to predict performance. In accelerated testing the product is packed and subjected to accelerated storage temperature and humidity conditions then examined periodically.

However, this requires considerable care. Under-staffed labs with inadequate test facilities can make mistakes. Experience gained with previous designs may no longer be appropriate. For example, printed materials may no longer be acceptable if new inks or laminates are used, or if there are new designs. There have been cases in which ink change caused residual solvents in very minute trace quantities to migrate into the food product and impart an off-flavour. De-lamination may even occur if there is an increase in print although other design conditions remain the same.

Annex Checklist of packaging requirements

This checklist summarizes the most significant points that should be considered when choosing new or optimizing existent packaging. The checklist aims to ensure that you formulate and prioritize your own requirements and demands competently. In this way you can compare different packaging solutions with one another and thus select the best suitable.

The checklist is to be filled out per product and per packaging option and refers to the entire packaging system with primary, secondary and tertiary packaging. The better the individual packaging requirements are fulfilled, the higher the evaluation is. The comment column on the right side of the checklist allows you to enter brief notes in order to ensure that the evaluation is comprehensible also at a later time.

Legend:

Questions underlined are mandatory and must be answered

- n/a: not applicable
- A: completely applicable/fulfilled (20 points – the maximum)
- B: applicable/largely fulfilled (15 points)
- C: partially applicable/partially fulfilled (5 points)
- D: not fulfilled (0 points)

Information about the product and the packaging	
Product (article number):	Date:
Primary packaging (type):	
Secondary packaging (type):	
Tertiary packaging (type):	

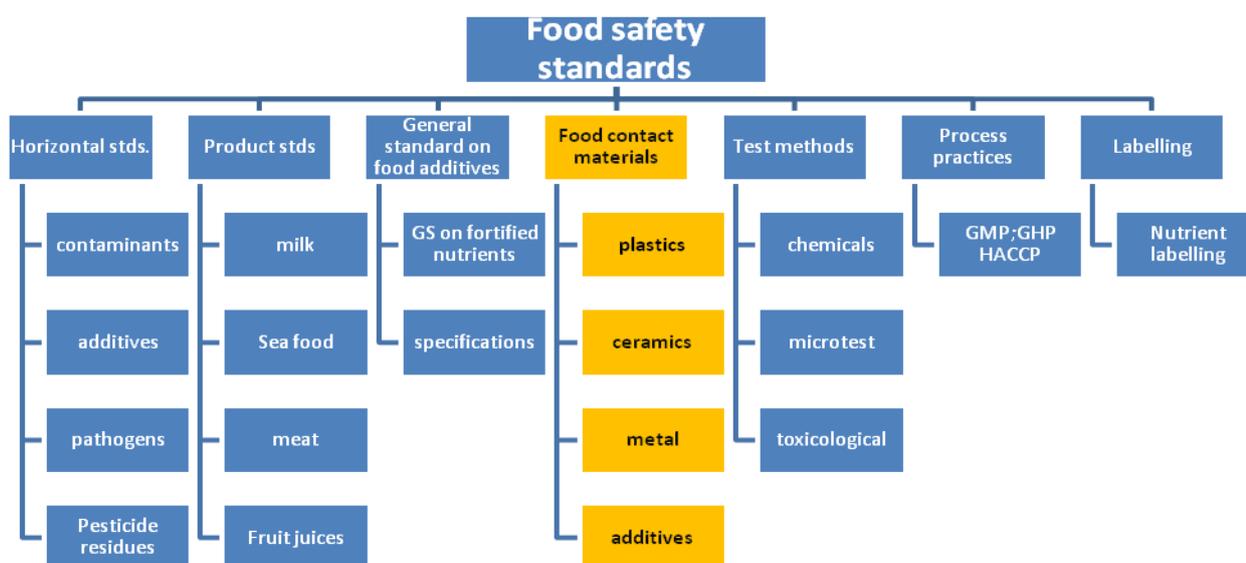
Nr.	Packaging Requirements	n/a	A	B	C	D	Comments
1.	What is the product?						
1.1	Are the product-specific packaging requirements regarding food properties well known? (greasy, liquid, sterilized etc.)						
1.2	Is the packaging material for the product-specific use suitable and tested?						
1.3	<u>Does the packaging guarantee the preservation of the product quality up to the end of the best-before date and is this examined?</u>						
2.	Which packaging facilities are available?						
2.1	<u>Are there detailed specifications (mechanical and technical data) for every used packaging item?</u>						
2.2	Do the specifications comply with the machine requirements?						
3.	What are the target group and marketing-technical requirements?						
3.1	Is the labelling correct?						
3.2	Is the product well presented?						
3.3	Does the packaging offer a wide range of design options?						
3.4	<u>Is the package easy to use?</u>						
5	How can packaging help to optimize logistics and supply chain management processes and costs?						
5.1	Does the packaging comply with common logistics dimensions (for stackability, etc.)?						
5.2	Do the weight and volume of the packaging fulfil transport requirements?						
5.3	Can the packaging costs be classified as reasonable?						
5.4	<u>Are minimum quantities of packaging production economically appropriate?</u>						
6.	Are all health, safety and environmental requirements considered?						
6.1	<u>Are you familiar with all relevant legal conditions?</u>						

Nr.	Packaging Requirements	n/a	A	B	C	D	Comments
6.2	Are you familiar with the guidelines of organic associations?						
6.3	Does all packaging follow the legal guidelines?						
6.4	Are the regulations of organic associations complied with?						
6.5	Are there declarations of conformity or other proofs for all used packaging which verify that the packaging is suitable for its intended use?						
6.6	<u>Can the manufacturer verify the confirmed suitability of the packaging by appropriate analysis and test results along the entire packaging chain?</u>						
6.7	Is there a system of storing packaging materials within and outside production areas that aims at minimizing contamination by impurities, germs etc.?						
6.8	Is the safety of consumers guaranteed when handling the packaging and the food product?						
7.	Is the packaging material environmentally friendly?						
7.1	Is there data about the materials' life cycle (from source to production, use and disposal)? Are minimum consumption of resources and energy and minimum emissions along the packaging life-cycle guaranteed?						
7.2	Does the manufacturer attempt to use as little packaging material as possible to pack the product safely, hygienically and in an acceptable manner?						
7.3	Is the end-of-life scenario of the packaging known? Do recycling processes, if possible, take place in the material cycle?						
7.4	Is freedom from GMOs guaranteed for all raw materials including relevant auxiliary substances, enzymes and micro-organisms?						
8	Is the packaging tested?						

Chapter 3. Regulations and their impact

Food safety standards often vary from country to country. However, the relevant provisions can be analysed within a typical framework, shown in figure 4. Each regulation/guideline can be studied to identify critical regulatory provisions which organic food exporters must keep in mind. For example to know about the food contact material regulations for fruit juices, one must look at the provisions on additives and processing aids under the horizontal standards, plastics (if choice of packaging material) under food contact materials, procedure for migration test under test methods, product standard for fruit juices and finally the GMP/GHP under the process practices.

Figure 4. General framework of food safety standards



1. Legal regulations

Codex Alimentarius on Organically Produced Foods² provides the following information on packaging and transportation:

- **Section 87:** Packaging materials should preferably be chosen from bio-degradable, recycled or recyclable sources.
- **Section 88:** Product integrity should be maintained during any storage and transportation and handling by use of the following precautions:
 - a) Organic products must be protected at all times from co-mingling with non-organic products;
 - b) Organic products must be protected at all times from contact with materials and substances not permitted for use in organic farming and handling.
- **Section 89:** Where only part of the unit is certified, other product not covered by these guidelines should be stored and handled separately and both types of products should be clearly identified.
- **Section 90:** Bulk stores for organic product should be separate from conventional product stores and clearly labelled to that effect.

² Codex Alimentarius – Organically Produced Food can be accessed here: <http://www.fao.org/docrep/005/y2772e/y2772e00.htm>.

- **Section 91:** Storage areas and transport containers for organic product should be cleaned using methods and materials permitted in organic production. Measures should be taken to prevent possible contamination from any pesticide or other treatment not permitted for use in organic production before using a storage area or container that is not dedicated solely.

The above guidelines/regulations specific to organic food packaging in no way supersede or prohibit the existing non-organic food packaging regulations. Some of the suggested approaches are:

- Since Section 82 of Codex³ prohibits ionizing radiation on organic products for the purpose of pest control, food preservation, elimination of pathogens or sanitation, it also puts a restriction on packaging materials for their sterilisation through irradiation.
- Another valid interpretation for organic products packaging comes from the definition of organic production where use of conventional non-organic pesticide (including insecticides, fungicides, and herbicides) is prohibited. This imposes a prohibition of packaging materials, storage containers and bins that contain synthetic fungicides, preservatives or fumigants for the organic food products.
- While specifically complying with the above, all other regulatory provisions valid for food products must also be followed. These are generally in the areas of (for more information see the ITC product-based PACKit modules⁴):
 - Commodity specifications. Food products exported to the European Union, Japan or the United States must meet import requirements relating to size, grade, quality and maturity. A certificate based on an inspection must be issued by the country's relevant authority to indicate compliance with standards. For example the United States Department of Agriculture (USDA) through its AMC (Agriculture Marketing Service) has commodity specifications FV403 CS1 for frozen vegetable⁵ as well as provisions on the use of packaging.
 - Food contact materials: The European Union has a regulation⁶ governing the choice of materials and articles in contact with food. For the specific regulations one should refer to the regulation EC1035/2004.

Table 2. European Union regulations affecting food packaging and organic products

Fresh fruits and vegetables	Processed food
Mandatory regulations	
Quality and grading Regulation (EC) No 2200/96 and amendments. Phytosanitary directive 2000/29/ Hygienic Package COM/2000/0438 (Final). Directives on maximum residue levels.	Product Regulations 2201/96. Authorised Food additives directive 89/107/EEC.95/2/EC. Authorised Flavourings directive 88/388/EEC
Packaging: Regulation 48/2003/EC. The EU law does not stipulate obligations explicitly for the packaging of fresh fruits and vegetables. Nevertheless importers might oblige suppliers to use packaging materials that can be recycled according to the directive.	Packaging marking and labelling directive 75/106/EEC. Obligations for the packaging of: fruits juice and concentrates, dried fruits and vegetables, frozen fruit and vegetables e.g. quick frozen food must be packaged in pre-packaging which protects them against external contamination and drying. Importers can ask suppliers to use packaging materials that can be recycled according to the directive.
Labelling: Directive 2000/13/EC. The needed information pertains to: packers/exporters name address and code, product name variety/type, country of origin, class, sorting, group number, number of fruit row/layer, preservation method. Special provisions for GMOs.	Environment Measures-Organic Production directive 2092/91/EEC

³ Codex Alimentarius – Organically Produced Food can be accessed here: <http://www.fao.org/docrep/005/y2772e/y2772e00.htm>.

⁴ For a complete list of PACKit modules see <http://www.intracen.org/exporters/packaging/description-of-packit-modules/>.

⁵ USDA AMC: <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5075880>.

⁶ Regulation (EC) no 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food; repealing Directives 80/590/EEC and 89/109/EEC.

Voluntary regulations	
Hazard Analysis and Critical Control Points (HACCP), ISO 9000, corporate level private standard, Assured Produce Scheme (APS), Agriculture Raisonnée, EUROGAP, Safe Quality Food (SQF), Quality and Safety (QS), National quality labels, etc.	HACCP, Directive 93/43/EC and legislation COM/2000/0438, ISO 9000, ISO 14001, corporate level standards, private standards, BRC, international standard for auditing food suppliers (IFS), SQF, QS, National quality labels, International Federation of Organic Agriculture Movements (IFOAM), etc.

2. Voluntary standards on food packaging

There are several private standards which specify requirements for a hygiene management system for manufacturers and suppliers of food packaging, including those involved in storage and transportation. IFOAM is an independent, global and non-profit organization. Its goal is the worldwide adoption of ecologically, socially and economically sound systems that are based on the principles of organic agriculture. In line with existing regulations, IFOAM has also made certain recommendations on organic food packaging which are general in nature.

A number of other voluntary standards are listed below:

- The GFSI (Global Food Safety Initiative) is a business-driven initiative for the improvement of food safety management systems.
- The British Retail Consortium (BRC) has developed a global standard for packaging and packaging material.
- The International Food Standard (IFS) has been developed by German and French food trade associations for the auditing of companies that process food or companies that pack loose food products.
- Other standards include the Safe Quality of Food (SQF) programme, the Danish standard DS 3027 and the International Good Manufacturing Practices.

3. Labelling of organic food

Organic labels are designed to give the consumer confidence that the goods they buy are produced in line with organic farming and processing regulations (e.g. EU Directive 834/2007). The organic label is a production process claim as opposed to a product quality claim. Packaging, through a well-designed label, helps convey this information to the consumer. Therefore, the application of labels and logos to organic products follows a four step certification process:

- Production is carried out in line with organic regulations or equivalent standards in specific markets,
- Certification is carried out by a certification body recognized in that market,
- Processed food and blends using organic raw materials claim 'organic' only under specified regulations, and
- Products from that operation are labelled organic with the specified mark.

Labels differ depending on the certification body, the standards against which the production is certified and/or in which national market the product is sold. Some examples are provided below in table 3.

Table 3. Labels and organic food requirements

Logo	Certifying agency	Specific requirements	Remarks
	The Canadian Food Inspection Agency (CFIA) organic food label	At least 95% organic ingredients.	The Organic Products Regulations, 2009. More detailed information can be found at: http://www.inspection.gc.ca/food/organic-products/labelling-and-general-information/questions-and-answers/eng/1328081798738/1328081871795
	United States Department of Agriculture (USDA) organic label	Products must originate from accredited farms and handling operations certified as organic producers. The definition of 'organic production' includes a prohibition of packaging materials, storage containers and bins that contain synthetic fungicides, preservatives or fumigants. Accredited organic products must carry the USDA's own Organic Seal on their labels, as well as any proprietary certification of their own. Depending on what percentage of the product's ingredients is organic, the label can describe the product as '100% organic', 'organic' or 'made with organic ingredients'. If a product contains less than 70% organic ingredients, the company may not use the word organic on the front of the package.	The Organic Foods Production Act (OFPA) of 1990. More detailed information about exporting organic products to the USA can be found the ITC report: 'The United States Market for Organic Food and Beverages', http://www.intracen.org/The-United-States-market-for-organic-food-and-beverage/ or at: http://www.ams.usda.gov/AMSV1.0/ .
	EU organic farming label	Logo guarantees that at least 95% of the product's ingredients of agricultural origin have been organically produced and that the product complies with the rules of the official inspection scheme. The placement of the EU logo is mandatory since 1 July 2010 for pre-packaged food. It remains voluntary for imported products after this date. The EU logo should be accompanied by an indication of the place where the agricultural raw materials were farmed. Must indicate that the raw materials originate from 'EU Agriculture', 'non-EU Agriculture' or 'EU/non-EU Agriculture'.	Regulation 834/2007 and the Implementation Regulation 889/2008. Article 95 in Regulation (EC) 889/2008 for implementing the new rules governing labelling, gave operators until January 2012 to implement the legislation. Until that date, existing packaging material were permitted and packaging could still be used until 2012 if it satisfied the requirements of the new rules but was labelled according to the old labelling legislation. For further information on the new EU organic logo, see http://ec.europa.eu/agriculture/organic/home_en → Consumer Confidence → Logo and labelling.

Logo	Certifying agency	Specific requirements	Remarks
	National organic labels (e.g. France)	National symbols for organic products have been introduced in several countries within the European Union. If operators wish to sell their products in another European Union country than their own, they may place an additional national or private logo that will be recognized by the consumers of that country.	

3.1. Private organic associations

There is a wide range of private organic label standards, mostly owned by farmers' associations.

Examples for important private organic labels include:

- Bio Suisse (Switzerland),
- Demeter (worldwide),
- Naturland (Germany and worldwide),
- Soil Association (the United Kingdom), and
- KRAV (Sweden).

4. Regulations on limits of heavy metals in packaging

In addition to the sustainable packaging concept already discussed in chapter 1, there are a large number of country specific regulatory or voluntary frameworks to reduce the environmental impact associated with the use of packaging through reducing the use of or re-using packaging materials

Several countries have introduced legislation designed to reduce the presence of toxic heavy metals in packaging. In the European Union, Directive 94/62/EC, Article 11, limits the cumulative content of the four heavy metals (lead, mercury, cadmium, and hexavalent chromium to 100 ppm (parts per million) in every component of packaging. In the United States, the Coalition of North-Western Governors has enacted laws that impose the same limits. Procedures for minimizing levels of substances dangerous to the environment are also proposed by the European Union, in the CEN (European Committee for Standardization) Standard EN 13428:2004. These toxicity limits are very low. Therefore, the best way to ensure conformity is to obtain from every supplier of constituents or materials a certified declaration or test certificate attesting that the sum of the four heavy metals present does not exceed 100 ppm (aside from the derogation of recycled plastic or glass).

According to the European Union Directive 94/62/EC on packaging and packaging waste, the levels of dangerous substances and preparations should be minimized in any package component to limit the packaging environmental impact, independent of food safety issues.

Chapter 4. Packaged food safety

Safety of packaged organic food is to be ensured through following:

- Establishing a threshold limit through risk assessment.
- Ensuring compatibility whereby transfer of constituents of the food into the packaging material does not take place. Packaging should also meet the rigours of the packaging manufacturing processes (mechanisation, filling, etc.), and other mechanical stresses (shaping, closing, treatments, conveying and so on).
- Complying with food contact material (FCM) regulatory requirements on migration.
- Selecting a packaging material with desired barrier (for more information see chapters 6,7 and 8):
 - To microorganisms, insects, fungi, dust and other potential contaminants.
 - To prevent loss of product flavour, colour and organoleptic properties with an adequate barrier to oxygen and water vapour.

Risk assessment and food packaging regulations: The first step in any risk assessment is to specify a threshold limit; this is notified in the food safety regulation of each country. The threshold may vary between regulations. However, it is safe to consider a threshold consumption of 1.5 micro gram/person/day as a level 'low enough to ensure that public health is protected even in the event that a substance exempted from regulation as a food additive is later found to be carcinogen' as established by United States Food and Drug Administration⁷ (FDA). This threshold approach has been found to be an excellent model by which majority of packaging materials can be evaluated.

Compatibility studies: Once you have chosen your packing material, you need to ensure compatibility of packaging design with food product and packaging manufacturing process. Tests for compatibility may vary for each type of packaging material. Many plastics are sensitive to high acidity or high alkalinity or both. Ethylene-vinyl acetate (EVA), ethylene-acrylic acid copolymer (EAA) and ionomer are examples of plastics that can be severely altered by products exhibiting pH extremes. This could also include experience and common knowledge e.g. ground coffee is highly abrasive, frozen products with sharp edges can have the tearing effect on the pack, turmeric powder packed in polyethylene (PE) shows a distinct yellowing as the mustard migrates through white PE.

Migration – food to packaging and packaging to food: Legislation on packaging materials is a complex and specialized topic due to the development of new food products and packaging materials. For example, the issue of migration is a critical factor in processed food packaging. The packaging material may absorb low molecular weight components providing flavour to the food but there may also be detrimental migration from the packaging material to the food product. Against the accepted food safety risk, two types of migration are regulated, namely 'specific migration' and 'global migration'. Specific migration refers to the migration of compounds that are considered to present health hazards even when present in quite small quantities. In such cases, their migration into foods needs to be controlled rigorously. The concept of global migration, by contrast, has been adopted to regulate the ingress of compounds which, though they do not present the same degree of risk, are nevertheless undesirable. The advantage of considering global migration is that it avoids having to analyse individual migrating compounds separately.

Legislation on packaging materials in contact with food is a complex and specialized topic and small and medium sized enterprises often requires expert help to get the optimized product-packaging solution. Any combination of product and packaging materials might present a unique case, requiring special consideration. The exporter is therefore strongly advised to seek guidance from packaging and food-research bodies serving the countries of interest. Information on these bodies is available through ITC.

⁷ <http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodIngredientsandPackaging/ucm081825.htm>.

The following general guidelines can be useful in the selection of packaging material:

- Select only approved food-grade packaging materials 'manufactured as per good manufacturing practices'. Only packaging materials (with only the permissible additives incorporated) whose migration into food is below the set limit may be used.
- Avoid packaging materials, which are banned or contain substances legally regarded as hazardous by the importing country. Examples of these are polyvinyl chloride (PVC) with monomer residues exceeding 5 parts per billion in the finished material, residues of acrylonitrile, diphthalic styrene, lead in solder for food cans, hazardous metals/chemicals in printing inks and adhesives.
- Understand clearly what restrictions and bans apply in what territories, which laws are mandatory and which are voluntary.
- Test packaging materials for their acceptability under standard test procedures laid down by the importing country.
- When ordering packaging materials, specify your requirements (physical/chemical) and obtain a certificate confirming conformity.
- Maintain the highest quality standards throughout production and monitor product and packaging as per the European Union directive or according to the HACCP system. Carry out packaging operations under hygienic conditions.
- Check whether the packaging material in contact with the product is regulated by any law in the destination country.
- Ensure that the packaging material contains regulated additives only at or below the permitted concentrations.
- Check to what extent trace amounts of various constituents of the packaging migrate from the material into the product.
- Ensure packaging design guarantees safe packages.
- Discover what conditions the packaged product will be processed in, stored and transported.
- Check compliance documents regarding migration risks.

There are some helpful documents available which support the work on conformity assessment:

The CEN (European Committee for Standardization) harmonized standards were published in July 2004 and subsequently notified by the Commission in the Official Journal of the European Union (2005/C 44/13). Using the CEN standards, the packaging supplier should identify appropriate assessment procedures, verify checklists to ensure that the procedures have been applied, summarize the results and keep the relevant records. These standards are ideal tools for packaging manufacturers and users to demonstrate the conformity of their packaging with the essential requirements of Directive 94/62/EC and will guarantee the free circulation of their packaging around Europe.

To enable packaging manufacturers, fillers and importers to demonstrate the conformity of their packages, European Union legislation guides have been issued by the European Union (Brussels), Laboratories National d'Essais (Paris) and Lacors (Local Authorities Coordinators of Regulatory Services for the United Kingdom) and a guide on packaging reduction has been published by the Conseil National de l'Emballage (CNE-Paris).

Chapter 5. Know your product

An organic product, as an outcome of organic farming, aims to support and strengthen biological processes without recourse to such technical remedies as synthetic fertilizers and pesticides. It relies largely on locally available resources and maintains an ecological balance by developing biological processes. In dealing with organic food packaging, it is important to first establish the nature of food products, in terms of their physical form (size/length/weight, fluid, powder, paste, granules, pieces, etc.), characteristics (ripeness/maturity, pH, volatility, hygroscopic nature, content of fat, etc.), stage of processing, perishability, aspects of spoilage, specific properties and the challenges to be met when handling them. Above all, the problems of preserving food and bringing it to the final consumer in the best possible condition must be addressed. The quality and nutritional value of fresh and processed organic products may be reduced by exposure to air, light, microorganisms, pests or vermin as well as through physical or mechanical damage.

1. Classification based on food perishability

Organically grown tropical fruits and vegetables, herbs and spices, tea, coffee and flowers, as well as processed tropical food products like preserves or juices have different shelf life and packaging requirements and consequently have different best-before dates.

The following food classifications are generic and practical:

Shelf-stable food, packaged in its primary pack, can be kept on a store shelf for long periods of time with no need for specific precautions concerning storage temperatures. Shelf-stable food includes:

- Dried/dehydrated fruits, vegetables, tea, coffee, spices and herbs;
- Aseptically filled foods and liquids, such as juices or other products;
- Heat-treated foods such as most types of preserves;
- Food preparations involving immersion and marinating of the food in a liquid, such as brine, edible oil, acid, or sugar (e.g. anchovies, pickles and some conserves).

'Shelf stability' for dried foods is generally achieved by maintaining low moisture levels of the product through packaging that has a high moisture or water vapour barrier. Shelf-stable dried foods do not require low temperatures during either transportation or storage. However, a best-before date should still apply – over long periods such food may lose its flavour or absorb sufficient moisture to affect its taste.

Perishable food: Fruit and vegetables are living plant organisms that, when growing, exhibit all the normal features of plant life such as respiration, transpiration, synthesis, degradation of chemical constituents and, in some cases, photosynthesis. Perishable products require special treatment and precautions like control in acetylene gas production to delay ripening by maintaining low storage temperatures. Shelf life of fresh vegetables and fresh fruit can be extended by maintaining low temperatures.

2. Reasons for food spoilage⁸

During growth, transport, processing and storage, organically grown food may deteriorate in quality or be lost in quantity through one or more of the following processes:

Physical or mechanical damage: Fresh fruit and vegetables are fragile and easily crushed, scratched, split or otherwise damaged during storage and distribution. Repair by the food cells to cuts, bruises etc., is not possible and so the effects are usually permanent. In the worst case, a weak spot for rotteness is created.

⁸ Processed Food — The Integrated Export Packaging Information Kit, PACKit Product Module (International Trade Centre), available at: <http://www.intracen.org/about/e-shop/>.

Figure 5. Mould and physical damage to fresh products

Physical damage can be avoided with suitable packaging:

- Packaging has to be stable against pressure such as that caused by stacking.
- Packaging has to absorb vibration from transport.
- Food has to be packed in such a way that it does not rub against itself or against container sides (which is also known as scuffing).

Degradation by macro-organisms (e.g. pests and vermin): The main categories of food which are subject to pest attack are cereal grains and products derived from cereal grains. Package pests can be classified in two groups: penetrators and invaders. Penetrators are capable of boring through one or more layers of flexible packaging materials. Invaders are more common and enter packages through existing openings, usually created by poor seals, openings made by other insects or mechanical damage.

Avoid degradation by pests and vermin by remembering that:

- Compact plastic or aluminium foil can prevent pests and vermin invasion.
- Effective control mechanisms compatible with organic standards have to be in place to manage pests during storage and transport.
- Storage and transport temperatures over 35°C or below 10°C inhibit insects' growth.
- Many insects cannot reproduce satisfactorily unless the moisture content of their food is greater than about 1%.

Growth of microorganisms (e.g. bacteria, germs, fungi and yeast): Spoilage could be due to initial contamination of the product as well as bacterial growth. Bacterial growth, on a supporting medium like food is dependent on temperature and the presence or absence of humidity and oxygen.

Possible causes of microbial contamination of foods through packaging are:

- Permeation of contaminated air or water through the pin holes; this could happen in flexible packs as well as other containers when head space vacuum forms after hot filling and sealing the containers;
- Contamination of heat seals by product;
- Poorly aligned lids or caps;
- Damage to the packaging material (tears, creases etc.).

Growth of microorganisms can be avoided by aseptic or sterile packaging, effective barrier systems for humidity and oxygen as well as regulated temperatures.

Chemical reactions through oxidation, by enzymes or through hydrolysis: The oxidation process can take place within the actual molecular chains of the organic substances, especially the fats, constituting the foodstuff. Oxidation can radically change the taste and flavour of organic food. The packaging has to

protect the foodstuff against oxidation by special barrier systems. It is well known that long-term storage of oily and fatty foods in the open air and at ambient temperatures induces bad taste and odour. Enzymes continue to act after the harvesting of crops.

Adverse effects on food and drink can include:

- Oxidative rancidity of unsaturated fats leading to off-flavours and even, in extreme circumstances, to toxic end-products;
- Loss of ascorbic acid or vitamin C, especially in fruit- and vegetable-based foods;
- Hatching of insect eggs and growth of insects;
- Acceleration of fresh fruit and vegetable respiration;
- Enzymatic and non-enzymatic phenolic browning of fresh fruit flesh;
- Oxidation of aromatic flavour oils of beverages such as coffee and tea;
- Discolouration of processed fruit and vegetable pigments.

Physical changes including moisture loss with associated texture effects and contamination by gases and other taints: Undesirable changes can take place in food products during storage. The choice of a suitable packaging with additional barrier functions can reduce quality loss of organic products.

Table 4. Undesirable changes in a food product

Attribute	Undesirable change
Texture	Loss of solubility Loss of water-holding capacity Toughening Softening
Flavour	Development of: <ul style="list-style-type: none"> • Rancidity (hydrolytic or oxidative) • Cooked or caramel flavours • Other off-flavours
Colour	Darkening Bleaching Development of other off-colours
Appearance	Increase in particle size Decrease in particle size Non-uniformity of particle size Caking/solidifying
Nutritive value	Loss/degradation of: <ul style="list-style-type: none"> • Vitamins • Minerals • Lipids • Proteins

3. Control measures

There are measures that can control or retard the quality loss of fresh or processed organic food products. Any kind of spoilage or quality loss can be reduced or even stopped by the right regulation of moisture, oxygen, temperature and light.

Regulation of the moisture level: Depending on the food product, a high or even a low level of moisture can stabilize the product quality and enhance the shelf life. An adequate choice of packaging material and barrier properties regulates the moisture level and supports the end product quality. The moisture vapour transmission rate (MVTR) of the packaging materials (plastic, foil, etc.) is the most important factor and has to fit with the moisture requirements of the food.

The critical moisture content is a useful parameter to ensure product quality. However, once a certain critical amount of moisture is present, changes to the taste or smell can be detected that could make the product unsaleable (but not unhygienic). For example: some biscuits can absorb 2% more moisture than that present when they are freshly baked and the consumer would not be able to detect a difference. However, above this moisture level a distinct lowering of quality and a loss of crispness would be noticed. Table 5 gives an overview of moisture levels to be maintained:

Table 5. Representative moisture levels of packaged food

Food	Moisture level to be maintained (%)
Perishable food	
Fruit	87-95
Vegetables	78-92
Shelf-stable food	
Tomato paste	55-65
Dried fruit	15-25
Flours	12-14
Dehydrated foods	2-5
Dehydrated onions in powders, granulated, ground, minced, chopped, sliced, diced and/or toasted	5 (3-9)
Dehydrated garlic: as a powder, as a granule, ground, minced, chopped and/or roasted.	6.8 (4.5-9)
Dehydrated carrots: diced product, are also marketed as powder, strips and granules.	6-9
Dried dates	26-30
Dried apricots	Max 20
Dried mango:	
- Sugared mango	7-10
- Natural mango	12-18

The moisture that causes spoilage need not come from outside of the package. Fruit or vegetables can give off moisture themselves. This can then condense on the surface of the food, particularly when storage temperature drops. Onions are particularly prone to neck rot if stored under damp conditions or if the bulbs have not been properly dried after harvesting.

Figure 6. Healthy onion and mould-infected onion



Protection from oxygen: Oxygen causes oxidation and promotes the enzymatic and non-enzymatic phenolic browning of fresh fruit and the growth of microorganisms. Packaging without or with less oxygen (e.g. vacuum or modified-atmosphere packaging) extends shelf-life and inhibits deterioration. Hermetically sealed packaging requires oxygen-proof materials and seals that do not leak.

Temperature regulation: A combination of low temperatures and appropriate packaging can be used to extend the shelf life of perishable products. However, different products need different storage temperatures. For example, certain whole tropical fruits are susceptible to chilling injury when exposed to temperatures in the range 0-10°C. Chilling injury causes loss of quality through poor ripening, pitting of the skin, rotting and development of off-flavours.

Table 6. Storage life of agriculture products at different temperatures

Food	0°C	22°C	38°C
Fruit	2-180 days	1-20 days	1-7 days
Dry fruits	1,000 days and more	350 days and more	100 days and more
Leafy vegetables	3-20 days	1-7 days	1-3 days
Root crops	90-300 days	7-50 days	2-20 days
Dry seeds	1,000 days and more	350 days and more	100 days and more

Figure 7. Low temperature damage to bananas



Light protection. Sunlight contains ultraviolet (UV) rays that cause rapid deterioration of some foods (especially oils and fatty foods) or specific components of a food such as certain vitamins. Flavours and colourings can also be destroyed by strong UV light. UV rays can also cause packaging materials to fade or to become brittle and lose their properties (for example polythene). In general all food should be stored in the shade away from direct sunlight. Electric lights do not have the same effects on foods because they do not contain the UV component. If the organic food product is light-sensitive, a suitable packaging material has to be chosen. Aluminium foil, brown glass or plastics with UV-barrier layers can be solutions.

Chapter 6 Packaging material options

Packaging has three major components:

- Material used for creating a basic structure,
- Material used for decoration and forming a shape, and
- Associated fitments or components for it to serve its intended purpose.

For organic products special care needs to be taken to ensure that the selected materials meet all obligations as well as meet the perceptions of the consumers in the targeted markets. For different materials used in packaging, see table 7.

Table 7. Structural materials and components

Basic structural material	Decoration and formation materials	Components
<ul style="list-style-type: none"> - Biodegradable/compostable - Paper - Plastics and master batches - Metals: steel, aluminium - Glass - Composites - Others: jute, wood etc. 	<ul style="list-style-type: none"> - Lacquers - Printing inks (see chapter 7) - Adhesives 	<ul style="list-style-type: none"> - Labels: paper, plastics - Sleeves: plastics - Closures and lids (see chapter 7) - Interior fitments and reinforcements - Pallets (see chapter 7)

Organic and non-organic foods are usually very similarly packaged and the only way they can be distinguished is if the word 'organic' is written somewhere on the package label. Take care that selected materials meet all relevant obligations and as well as the environmental perceptions of consumers in the targeted markets.

1. Environmental profiling of packaging materials

It is useful to understand consumer demands and the environment profiling of packaging materials before they are matched to a product. Such profiling for commonly used materials is shown in table 8.

Table 8. Environmental profiling of packaging materials

Paper packaging		
Life cycle stage	Process	Environmental impact
Raw materials	Wood fibre from hardwoods and softwoods, starch	Forestry operations to obtain natural resources have an impact on land use and biodiversity and can cause, resource depletion and eutrophication
Processing and manufacturing	<p>Manufacture is in two stages: pulping and bleaching.</p> <p>Pulping separates cellulose from lignin, resins and oils. This involves two processes: chemical (sulphate or sulphite) and mechanical.</p> <p>Bleaching can be with elemental-free chlorine, chlorine dioxide, oxygen, hydrogen peroxide or other bleaching practices</p>	<p>Energy consumption</p> <p>Emissions to air</p> <p>Water consumption and emissions</p>
End of life	Recyclable and degradable	<p>Transport energy used to collect paper and process energy used to recycle are offset by recycling</p> <p>Recycling saves virgin material consumption and lowers energy use</p>

Plastic packaging		
Life cycle stage	Process	Environmental impact
Raw materials	Petrochemicals (natural gas or crude oil) New generation from starch and sugars (biopolymers)	Crude oil operations impact upon: - Resource depletion Crop operations impact upon: - Land use - Biodiversity - Water use - Eutrophication
Processing and manufacturing	Extraction of raw materials (crude oil or starch from crops) Cracking of hydrocarbons into constituent parts (e.g. ethane) Processing of hydrocarbons into organic chemicals (e.g. ethylene – the monomers) Linking monomers into chains (e.g. polyethylene: polymers – polymerisation) Compounding, moulding, extrusion etc.	Energy consumption Emissions to air Water consumption and emissions (crop based materials)
End of life	Recyclable but sensitive to degradation and contamination Petrochemical-based plastics do not degrade in landfill Bio-based materials degrade in landfill	Transport energy to collect plastics and process energy to recycle, though this is compensated for by recycling Recycling saves virgin material consumption and lowers energy use If bio-based polymers are sent to landfill, some carbon will remain as C sink and some will degrade to methane (21 times more potent than CO ₂)
Metal-based packaging		
Life cycle stage	Process	Environmental impact
Raw materials	Manufactured from iron ore, coke (from coal) and recycled steel	Mining operations to obtain natural resources impact upon: - Land use - Biodiversity - Resource depletion
Processing and manufacturing	Basic oxygen furnace process uses 28% recycled steel Electric arc furnace can use 100% recycled steel Recycled steel can save virgin materials and energy consumption (60% saving)	Energy consumption Emissions to air
End of life	Steel is recyclable: It can be recycled an unlimited number of times without losing technical properties, though the tin layer needs to be removed In landfill it is inert	Transport energy to collect steel and process energy to recycle, though this is compensated for by recycling Recycling saves virgin material consumption and lowers energy use

Wood packaging		
Life cycle stage	Process	Environmental impact
Raw materials	Timber logged from forest plantations	Forestry operations to obtain natural resources impact upon: <ul style="list-style-type: none"> - Land use - Biodiversity - Resource depletion - Eutrophication
Processing and manufacturing	Drying, sawing, preservation treatments and assembly	Energy consumption Emissions to land and air
End of life	Timber is recyclable into various products or can be used as a fuel source (energy recovery)	Transport energy to collect timber and process energy to recycle, though this is offset by recycling Recycling saves virgin material consumption and lowers energy use

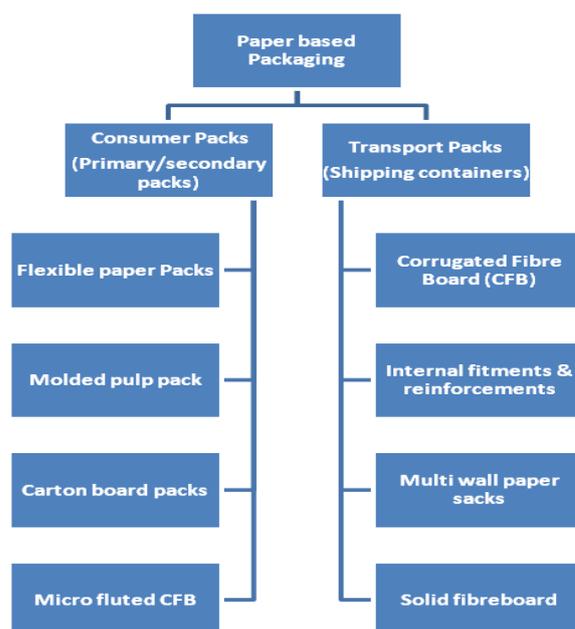
2. Packaging with paper and board

Different types of paper and their common characteristics listed in annex I of this chapter. Paper and board are multi-functional, can be used as primary, secondary and tertiary packaging and are available in many weights and grades, classified as follows (in terms of grams per square metre - g/m²):

Paper	10-120 g/m ²
Board	120-400 g/m ²
Solid fibreboard	> 400 g/m ²
Folding box board	200-800 g/m ²
Corrugated board	250-1500 g/m ²

Paper and board packaging can be relatively inexpensive and can have a good printing surface for graphics. Paper can be used as wrappings; inner packages and outer wraps; folding cartons or micro-corrugated fibreboard boxes can be used as consumer packs and corrugated fibre board (CFB) cartons can be used as the secondary packs. Figure 9 shows some common packaging applications.

Figure 8. Paper-based packaging applications



Paper and board can be produced from renewable as well as recyclable resources. Usually virgin paper is made of wood fibres but cotton, grass, sugar cane and straw are also used for some grades of paper. Recovered paper has a high proportion of recycled paper but this cannot be recycled indefinitely because the fibres get shorter and weaker each time they are recycled.

Points to consider:⁹

- Use products from sustainable sources, preferably those with certification from a registered system such as the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC).
- Bleached paper has to follow environmentally-friendly manufacturing methods and is usually described as totally chlorine-free (TCF) or elemental chlorine-free (ECF) for virgin pulp and process chlorine free (PCF) for recycled paper.
- Even for indirect food applications, paper used must be free of heavy metals.

2.1. Flexible paper packs

A simple paper wrap or bag can act as a barrier to dust and light but provides little mechanical protection. Paper absorbs moisture when the surrounding air is more humid than the paper and it gives up moisture when the surroundings are drier. When used as primary packaging, paper is almost always treated, coated, laminated or impregnated with materials such as waxes, resins or lacquers to improve functional and protective properties. Coated or waxed paper wraps are also used for packaging fresh fruit. Pre-formed paper bags can be used for packaging flour, sugar, potatoes, etc.

2.2. Moulded-pulp packs

Moulded pulp packs are light in weight with good shock-absorption ability and high stacking strength which, in addition to low cost, makes them competitive for applications like hinged-lid retail packages and fresh produce trays for use in transport boxes and corner pads. Permeability to air and water vapour makes them especially useful for fresh produce such as tomatoes, apples etc. which need to breathe during transport. It is common in many countries to produce pulp from used paper so care needs to be taken to choose moulded-pulp packs which are of suitable quality for organic products.

2.3. Carton board packs

For food products carton board is used for making secondary packs and consumer packs. These packs are semi rigid in nature. Examples of packages are shown in figure 9.

Figure 9. Carton board packs for tea



Paper carton for tea bags



Paper box for tea bags (United Republic of Tanzania)



Lined carton 'top tainer' for premium tea leaves

⁹ Soil Association, 'Reduce, Re-use, Recycle – A guide to minimising the environmental impact of packaging', 2006.

Carton boards can be divided into different types:

- **Folding boxboard:** Used for direct food contact and often made of three or four plies. The top and bottom plies are made of bleached chemical pulp, whilst the middle ply or plies are made of mechanical pulp to give bulk. A typical basis weight is 160-450 g/m². Depending on end use, the board may be uncoated, single-coated on the top side, or single-coated on the back side.
- **White lined chipboard:** Often used in indirect food contact. It has a typical basis weight of 200-450 g/m². The structure is usually the same as in folding boxboard, but different furnishes are used. The top ply is mostly made of bleached chemical pulp. Between the top ply and the middle ply or plies, there is a de-inked under-top ply, used in order to keep the amount of expensive top ply pulp to a minimum. The middle ply or plies are made of recycled fibre with low brightness. The back ply is also made of de-inked pulp, or, in some cases, bleached chemical pulp. The material may be used in food packaging, but then combined with a protective plastic bag due to the great variations in fibres in the middle ply or plies. Depending on end use, the board may be coated as with folding boxboard.
- **Solid bleached board:** Typically used for the same types of products as described above for folding boxboard. It is usually a single ply made of bleached hardwood or bleached softwood sulphate pulp. The hardwood pulp gives better formation and better printing properties. Here, however, multiple techniques are used, and furnish composition can be optimized for properties like bulk, stiffness and printing. To meet end user needs, solid bleached board is often coated.
- **Solid unbleached board:** Mostly a multi-ply paperboard, used when printing demands are great and strength is needed (e.g. for consumer beverages packages). The board has two or three plies, and all are made of unbleached furnish. The top ply often has a hardwood furnish to meet requirements for good coating surface. The middle ply, on the other hand, is usually made of unbleached softwood kraft and broke or recycled corrugated board, whilst the back ply is the same but without the broke and recycled material.
- **Liquid packaging board:** bleached or unbleached, is made in two principally different ways. It is two-sided low-density polypropylene-coated paperboard used for long shelf-life products requiring high barrier properties. The basis for the whole structure is the same as for folding boxboard. If package stiffness is important it is produced through two- or three-ply boards. Only virgin fibres are used. Pulp with a high modulus of elasticity is used for the top and back plies, which are of bleached or unbleached soft- or hardwood. The base or middle ply uses unbleached soft- or hardwood pulp, chemi-thermo-mechanical pulp or broke material to obtain maximum bulk. The board is usually combined with various layers of plastics and/or metal foil.

2.4. Corrugated fibreboard (CFB)

Corrugated fibreboard (CFB) is the most popular material for rigid transport packaging and it is used for a wide variety of products including fresh fruit and vegetables. CFB packs are also widely used for consumer packaging. Corrugated boxes are equally suitable for different modes of transport – by sea or air for instance – and they can be tailor-made even in small quantities to almost any requirement of the distribution system concerned. The three main components used in its manufacture are shown in figure 10 and the four main types are shown in table 9.

Figure 10. Structural components of CFB

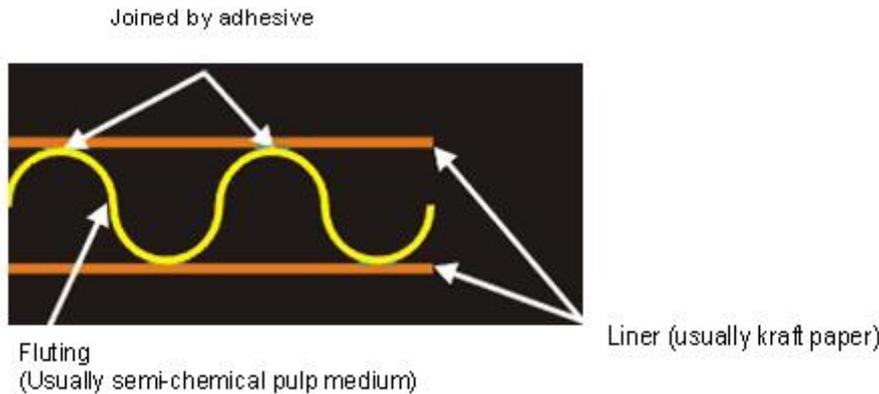
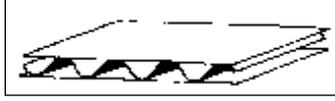
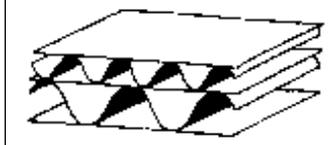
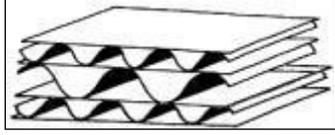


Table 9. Types of CFB box

<p>Composed of a flat facing or liner, glued to a corrugated medium,</p>	 <p>Single-faced board</p>	<p>Used only for wrapping purposes or as interior fitments and cushioning pads. Not used for box production. Usually supplied in rolls.</p>
<p>Made from two facings or liners, with one layer of corrugated medium or fluting between them</p>	 <p>Single-wall CFB</p>	<p>More than 90 per cent of all corrugated boxes are manufactured from this type of board.</p>
<p>Made from two facings, two layers of corrugated medium and an inner liner between the two corrugated layers, giving a total of five paper layers</p>	 <p>Double-wall CFB</p>	<p>Used for heavy weight loads as secondary packaging for export.</p>
<p>Made from two facings, three layers of corrugated medium and two inner liners between the three corrugated layers, giving a total of seven paper layers</p>	 <p>Triple-wall CFB</p>	<p>Used for heavy-duty applications, particularly when packaging for export.</p>

More information about the composition, performance, production and application of fibreboard transport packaging is provided both in ITC’s PACKit Transport Packaging Cross-cutting Module and in its Packaging Materials Profile on Paper and Board.

2.4.1. Structural design of corrugated boxes

The main styles of paperboard cases are slotted-type boxes that are made of one blank with a stitched, taped or glued manufacturer’s joint and top and bottom flaps. The most frequently used corrugated board package is the regular slotted container (RSC), with features that provide the most economical use of material. The box has flaps with dimensions that are equal in depth to that of the box and the width of the outer flaps equals one-half that of the box, so they meet at the centre line of the package when folded. The boxes are shipped flat and ready to use and are used as secondary packaging. The bottom of the box is hinged to form two or all side walls and the cover. Locking tabs, handles, display panels, etc. can be incorporated in the design.

The International Fibreboard Case Code has been established with clear, internationally understood symbols. Several more popular box designs, with case code references as well as other design considerations for the CFB box, can be seen in the ITC PACKit on paper packaging. Further considerations are:

- While it is important to design the box proportions so that it uses board economically, it should be appreciated that a box can be economical in board usage but not necessarily in total cost, due to converting machinery limitations and the available standard paper widths.
- Another factor to be considered is the box-stacking strength, which tends to be lower for boxes with more economic proportions.

Figure 11. CFB box dimensions



(1) RSC Regular slotted container; (2) Transport/Consumer pack for fresh fruits; (3) Bulk pack for fresh fruit; (4) Box with inserts at the corner

2.4.2. Box dimensions and fitments

The dimensions are defined as the inside measurements of the box, measured from centre of crease to centre of crease. Often additional fitments in the shape of fruit trays, separators or inserts for strengthening the corners are used. Some examples are shown in figure 11.

Corrugated fibreboard boxes are normally joined along one side using a waterproof adhesive. Hot-melt adhesives are often used for case-sealing. A second method uses metal stitching of the side overlap and flaps. Double-wall boxes should always be joined and sealed by stitching rather than glue. Plastic tape may also be employed – this allows savings in board as minimal overlaps are required but box strength is reduced.

3. Packaging with plastics

Plastics can be chemical-resistant, inexpensive and lightweight with a wide range of properties. The specific properties of the packaging are determined by the nature of the particular polymers used. The major disadvantages of plastics are their variable permeability to light, gas, vapour, and low molecular weight molecules as well as a high risk that substances will migrate into the food product.

Although usually made from non-renewable oil resources, plastic packaging can be both recycled and made using recycled material. However, their use for food contact application especially for organic food should be avoided. A broad grouping of plastics commonly used for food packaging is shown in annex II of this chapter.

Commonly used polymers are listed below.

Polyolefin: polyolefin is a collective term for polyethylene (PE) and polypropylene (PP), the two most widely used plastics in food packaging.

Low-density polyethylene (LDPE): LDPE is heat sealable, chemically inert, with good moisture barrier qualities but relatively high gas permeability and sensitivity to oils and poor odour resistance. Therefore LDPE cannot be used as a packaging material in applications that require a high barrier to gases. Low-slip properties can be introduced for safe stacking or, conversely, high-slip properties permit easy movement of

wrapped packs into an outer container. This material is the easiest of the polyethylene family to process. Some applications include shrink film, stretch film and commodity packaging bags where clarity, strength and good moisture vapour transmission rate (MVTR) are required.

High density polyethylene (HDPE): With a slightly higher density range (0.941 g/cm³ to 0.969 g/cm³), HDPE is commonly used for rigid and semi-rigid structures. It has linear chains that pack well together resulting in a higher crystallinity than LDPE. Consequently it is harder, tougher and less flexible but still easy to process and easy to form. HDPE containers have excellent moisture barrier qualities, chemical inertness, rigidity and tensile and impact strength. Hence they are popular for large and small general food applications (e.g. bottles for milk, juice, and water or bags for groceries and rubbish).

Polypropylene (PP): PP is a highly crystalline, thermoplastic polymer which is a good water vapour barrier but a poor gas barrier. Polypropylene is the lowest density polymer used widely for commercial packaging (density range 0.900 g/cm³ to 0.910 g/cm³). Oriented polypropylene (OPP) has been uniformly stretched during manufacture to orient the polymer chain so as to give a clear glossy film with good optical properties and a high tensile strength and puncture resistance. It has moderate permeability to moisture, gases and odours, which is not affected by changes in humidity. Biaxially-oriented polypropylene (BOPP) has similar properties to OPP but is much stronger. PP can be moulded to produce rigid containers (e.g. yoghurt tubs or frozen food packages). Foamed PP is used to provide the structural properties in laminates for modified atmosphere packaging (MAP) thermoformed base trays, where it is combined with an EVOH (ethylene-vinyl alcohol) barrier and a PE heat-sealing layer. Packaging made from this material is excellent for holding products that require high temperatures. PP melts at approximately 170°C so it can be used as a container for microwaving low-fat food products. It should not be used for microwaving fatty foods, where temperatures in excess of its melting point could be reached.

Polystyrene (PS): PS is an amorphous polymer with clear, hard and brittle properties and with a relatively low melting point. It can be mono-extruded, co-extruded with other plastics, injection moulded, or foamed to produce a range of products. It may be oriented to improve its barrier properties. PS, which has a density of 1.05 g/cm³, is widely used in foamed compositions (expanded PS or EPS) to make lightweight, heat-insulated products, such as cups and moulded dunnage, or used as cushioning to protect food products. Polystyrene is a low-cost, low-strength plastic that, in foamed form, is used as a cushioning and tray material for variety of foodstuffs like throw-away cups and tubs, takeaway food packaging and cushioning in packaging to prevent breakages. Foamed PS has recently been used as a structural layer for pre-formed MAP base tray applications. The high gas permeability of foamed PS requires the material to be laminated to a plastic such as EVOH that provides the required gas barrier properties.

Polyvinyl chloride (PVC): The polymer, density 1.2 g/cm³, has no effective crystallinity and is, therefore, described as an amorphous polymer. It contains the chlorine atom that produces a mix of very different polymer properties. It is permeable to gas and water and resistant to chemicals and acid. PVC has a relatively low softening temperature and good processing properties. A major drawback is that PVC is very susceptible to heat degradation, producing fumes of hydrochloric acid and alteration of the polymer colour (white to dun to black). PVC does not have a good environmental image and therefore it is not allowed by some private organic labels.

Polyesters: Polyethylene terephthalate (PET) has a density of 0.910 g/cm³ and is used for rigid products. It is widely used in stretch blow moulding to produce bottles with a very high clarity and good gas (oxygen and carbon dioxide) barrier properties. It is ideal for food and drink packaging as it contains some of the characteristics found in glass. Because of its high melting point it is suitable for processes that require high temperatures or for reheating in a microwave. PET as a crystalline material (CPET) has poorer optical properties but improved heat resistance melting at temperatures in excess of 270°C. PET has excellent packaging-related properties – it has clarity, high tensile strength and is an adequate barrier to gas. It is very popular for general food containers, tray packs and carbonated beverages. CPET is used for dual ovenable pre-formed base trays where its high temperature resistance makes it an ideal container for microwave and convection oven cooking.

Polycarbonates: Polycarbonates (PCs) are polyesters of unstable carbonic acid and have carbonate linkages. PCs in food packaging are used as components of multilayer co-extrusions and co-injection moulding to provide transparency and high strength to containers which undergo hot filling or hot processing after filling (e.g. refillable water bottles and sterilizable baby bottles).

Polyamides: PAs provide mechanical strength and gas barrier properties. In general they are highly permeable to water vapour. PA films have excellent thermal stability (they can withstand up to 1400°C).

Ethylene-vinyl acetate (EVA): EVA is a random co-polymer whose properties depend on its vinyl acetate content and molecular weight. The absence of leach-able plasticizers favours its use for some food applications. It is used in stretch films and cling-wraps.

Ethylene-vinyl alcohol (EVOH): EVOH co-polymers are highly crystalline in nature. It is a good barrier to contaminants like gases, smells and solvents. EVOH is used as a barrier layer in food packaging.

Laminates and co-extrusions: It is possible to combine layers of plastic for rigid packaging by co-extrusion or by lamination in the case of plastic films. Lamination involves bonding together two or more plastics or bonding plastic to another material such as paper or aluminium. Bonding can be achieved by use of water-, solvent-, or solid-based adhesives. In co-extrusion, two or more layers of molten plastics are combined. Because co-extrusion and lamination combine multiple materials, recycling is complicated. However, combining materials results in enhanced barrier properties and minimized weight.

Packaging shape and design with plastics: For details of the manufacturing process of plastic food packaging see the PACKit manual. According to the kind of plastic used and the manufacturing process, plastic can be used for firm rigid packaging containers as well as for flexible films. Table 10 provides a summary of manufacturing processes.

Table 10. Summary of container manufacturing processes

Process	Summary
Extrusion blow moulding (EBM)	Hollow containers are mostly extrusion blow moulded (typically for containers from 0.2 litre bottles to 250 litres or larger). Smaller containers are normally produced by injection blow moulding, a process also used for most PET bottles, as it provides a better appearance. Very large containers, with complex shapes and low production runs, are usually produced by rotational moulding. Bottles and jars can be from PET, HDPE, LDPE, and PP. The bottles of largest volume are formed by blow moulding polyethylene grades with densities in the range of 0.958 to 0.961 g/cm ³ , as these offer an excellent balance of stiffness and environmental stress crack resistance (ESCR).
Injection stretch blow moulding (ISBM)	A refinement of blow moulding, ISBM produces a container with improved gas barrier and accurate neck finish. This makes it suitable for carbonated drink bottles and jars in PET and Polyethylene naphthalate (PEN). Virtually all beverage bottles made in PET use this technique.
Injection moulding	Used to form rigid containers or pre-forms for PET. Involves an extruder-like barrel forcing melted plastic under pressure into a mould in the form either of the finished plastics package (e.g. a crate) or into an intermediate plastics packaging material such as the PET pre-form (the most common use of injection moulding for intermediates in plastics packaging). For solid products, this process gives the high accuracy required for intricate mouldings, such as closures, fitments, crates and pallets, in HDPE and PP.
Vacuum forming	Using sheet material, the process gives a lower cost alternative for many foodstuffs (e.g. trays, pots, lids) in PET, PVC, PS, Acrylonitrile butadiene styrene (ABS) and high-impact polystyrene (HIPS).

Process	Summary
Thermoforming	Whereby a sheet of thermoplastic material is placed over a single- or multi-cavity mould, then clamped in place and heated to its softening point. At this point, a vacuum pulls through small holes in the mould, or air pressure is applied from above the sheet, and/or a male mould (plug) is lowered to force the sheet into the female mould. The shaped sheet is cooled and removed for further use – either as is for biscuit trays, or as moulded blisters for blister packs. Thermoformed trays, tubs and lidded cups are used as consumer packages for food products. Trays can also be used as retail packages for fruit. Complete, deep frozen meals are packed on thermoformed trays, which can be heated in microwave ovens. Foamed polystyrene is used for making vegetable trays. PP competes with polystyrene for similar applications. The PP raw material price is usually slightly lower than that of PS – and it has a lower density, meaning more packs per kg – but it takes longer to process on the thermoforming line. Crystalline PET can be used for meal trays. It can tolerate deep freezing, and, in contrast to aluminium, can be micro waved directly. The cover film is also made from PET, which makes sealing relatively straightforward.

Figure 12. Examples of plastic packs



High performance PET film and microwaveable punnets



Micro-ovenable punnets



PP pots with detachable labels to allow Separation of materials (for recycling purposes)



Labelled PET jars (Injection-blow moulded) for Honey from Kenya

4. Packaging with glass

Glass for the packaging of food products is almost invariably soda lime. Soda lime glass is made from sand (silica, SiO_2), sodium carbonate (washing soda, Na_2SO_4) and calcium carbonate (limestone, CaCO_3). The sand introduces iron oxide (Fe_2O_3), which gives an apparently colourless glass a distinctive green tint when viewed edge-on. It may also introduce some aluminium oxide (alumina, Al_2O_3), which increases the durability of the glass. If dolomite is used as a raw material instead of limestone, then the glass will contain magnesium oxide (MgO) as well as calcium oxide (CaO).

Recycled broken glass (cullet) is also used in glass manufacture. It is strong and durable and can be recycled many times without losing strength. The molten glass can be formed into a container by a number of different techniques, but they all have in common the need for a mould to determine the final shape. All glass containers need to be annealed (toughened by heating and slow cooling) before they can be used as packaging. Because glass is odourless and chemically inert with virtually all food products, it has several advantages for food-packaging applications: it is impermeable to gases and vapours, so it maintains product freshness for a long period of time without affecting taste or flavour. The ability to withstand high processing temperatures makes glass useful for heat sterilization.

Below is a list of the main properties of glass.

Density: Soda-lime-silica glasses used for packaging all have a density of around 2.5 g/cc (2.5 kg/m³). Density is not normally a critical part of the container specification but is important as a control feature.

Thermal expansion: Glass expands when it is heated however if stress levels are excessive, the glass will break. Shape and thickness also affect the vulnerability of the glass to breakage, as does whether or not it has a coating. This is a well-known danger and packers/fillers must take precautions against it happening on filling lines, beyond the permissible limits, in which case the lot of packaging must be rejected.

Durability: The durability of a glass is determined by its ability to withstand the chemical actions of internal and external gases, liquids and solids. Glass, by its very nature, is durable, but under specific circumstances it may be attacked by water vapour in the atmosphere and by highly alkaline solutions. It is also attacked by hydrofluoric and phosphoric acids. Durability is controlled by the chemical composition of the glass.

Optical properties: Glass is usually transparent. Most clear glass appears 100% transparent, and even highly coloured glasses can be seen through. The transparency of glass allows consumers to see the product, yet variations in glass colour can protect light-sensitive contents.

Container production: Originally, containers and all other glass objects were produced by hand. Today, with the exception of those made for a few specialist applications, all glass containers are made by machine.

4.1. Glass for organic food

Glass is used in rigid packaging form. Glass is inert, does not taint foodstuffs or affect taste, is impervious to gasses, has transparency and is liked by consumers. It is a trusted and environmentally friendly packaging material because of its recyclability.

The following shapes might be used for organic food:

Bottles: More than 75% of the glass used for packaging is in the form of bottles. In packaging for retail consumer markets, the 750 ml bottle for wines and spirits is most common but 250, 330 and 500 ml bottles for beers and designer spirit-based carbonated drinks come a close second.

Figure 13. Examples of glass bottles



A range of filled glass containers



Tinted glass bottles

All carbonated drinks bottles are round, to distribute gas pressure evenly. Flavoured oils, vinegars and premium oils, such as organic olive oil, are traditionally packed in glass containers. Fruit juices, especially fresh juices and those with a premium image, are often packed in glass.

Jars: Jars are glass containers with all the characteristics of bottles but with different proportions. As already mentioned, the distinction can be blurred and may depend on the perception of the contents and the tradition of the market rather than dimensions. Many vegetables and fruits are packed into glass jars all over the world. In many places the glass jar rivals the tin can as a packaging medium.

Figure 14. Examples of jars



A range of empty jars

Filled glass jars

Traditional sauces and pickles based on acetic acid have been packaged in jars for many years and standard 275 g jars are a good packaging option for asparagus and mushrooms. The real growth area for this sector has been in cooking sauces of the kind used for pasta and rice dishes. This has been extended to other areas like ready meals.

There is a strong design element to the jars for the purposes of branding and differentiation and there have been significant technical advances as many of the jars have to carry two separate products. There is no standard size of container for this sector of the market due to the complexity of the product mix. A small jar of chilli paste may weigh 50 g and a cooking sauce may weigh 500 g, with any and every size in between. A high percentage of jams and preserves such as marmalade and lemon curd are packed in glass jars. Common sizes of jar in this sector are 225 g and 450 g but many producers now supply individual servings to the catering trade in 25 g jars. Small jars have captured some of the luxury or specialist market in this sector, with 25 g and 50 g versions.

Points to consider:

- Use glass with recycled content where possible and prefer glass containers which can be washed and reused.
- There are two disadvantages of glass: its heavy weight, which increases the energy consumption and transportation cost as well as its brittleness and susceptibility to breakage from minimal pressure, impact, or thermal shock.
- Packaging made from glass can be easily sterilized, reducing the need for product preservatives.

5. Packaging with metals

Packaging made from steel or aluminium offers a combination of excellent physical protection and barrier properties, formability and decorative potential. Metal packaging also contains a significant amount of recycled scrap material and can be recycled many times without loss of quality. This means less environmental impact from producing the materials, as fewer raw materials, such as bauxite, need to be extracted. The infrastructure for recycling metals is well established in most developed countries. However, the mining of raw materials and the fabrication of metal require large amounts of energy, and produces air, land and water pollution.

Steel, usually coated with tin and known as tinplate (hence the misnomer, tin can), is by far the most common metal used in the manufacture of heat processed food cans. Tinplate is available in a number of standard tin coatings to provide steel with some corrosion resistance. The choice of tin coating depends on the application of the package.

Electrolytic tinplate (often designated ETP) has completely replaced hot dip tinplate as a packaging material because of the cost savings associated with thinner tin coatings.

Blackplate, uncoated mild steel, has been considered for the manufacture of food cans but is suitable only for a very limited range of products, even when fully lacquered. This is because it readily rusts and generally has poor chemical resistance.

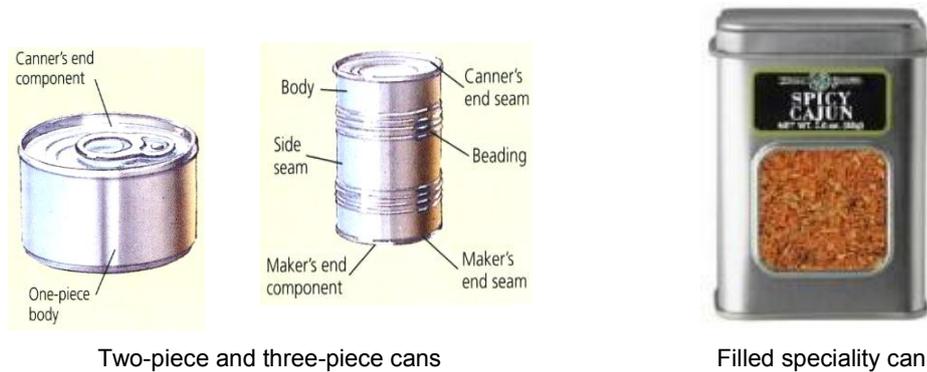
Tin-free steel (TFS – also known as electrolytic chromium coated steel or **ECCS**) has found fairly wide usage, typical examples being draw-redraw containers and fixed (non-easy open) ends for processed food cans. The tin has been replaced by other non-rusting metals, such as chromium, or the base steel may be given special rust-inhibiting treatment called “passivation”. These types of metals, termed tin-free, are used because of their lower cost. The inside, and often outside, of the can is further protected against rusting, pitting, or reaction with the food by a thin layer of non-rusting metal and a baked-on resin. Additional lacquers avoid corrosion and provide an inert barrier between the metal and the food product. Commonly used lacquers are materials in the epoxy phenolic and oleoresinous groups and vinyl resins. There have sometimes been problems, with the migration of epoxy derivatives such as BADGE (bisphenol-A, diglycidyl ether) out of lacquers and plasticizer out of the compound of twist-off caps. Especially problematic are small packaging sizes and fatty food as pesto so special migration tests have to be performed.

5.1. Steel cans

A wide range of can sizes exist, with capacities between 71 ml and 10,200 ml. However, most foods are packed into cylindrical cans with a capacity of 140 ml to 900 ml. Standard diameters are 52 mm, 65 mm, 73 mm, 84 mm, 99 mm, 127 mm and 105 mm. Can sizes are always expressed as *Diameter x Height*, e.g. 99 mm x 105 mm for a 900g jam. Tinplate can be formed into any shape but for food and beverage are divided into two basic types based on method of construction:

Three-piece 'sanitary' cans are comprised of a cylindrical body and two end-pieces. These are seamed cans, either welded or soldered. However, the use of solders is declining in favour of welding. Three-piece welded cans, still prominent in food packaging, are made from rectangular blanks cut from tinplate or electroplated steel. They are delivered to the canner with the top of the can open ('open top' can) so that the food product can be put inside. The top sections (canner's end) are supplied separately to be attached by the canner. They are used to seal heat-sterilized foods hermetically and also for powders, syrups and cooking oils that are not heat-treated. Corrugations (beading or ribs) on the open top can contribute to its strength and has allowed substantial wall thickness reductions.

Two-piece cans are made from one single body and one can end-piece that is applied afterwards. Two-piece cans are less likely to have flaws and can be made to withstand higher forces while using less metal. Soldered cans and three-piece cans have been giving way to two-piece welded cans as the industry modernizes its manufacturing lines. Two methods of forming are used — **drawing and ironing** (D&I in the United States, DWI in the European Union) and **draw and redraw** (DRD). Both processes provide a lighter weight container without a side seam, i.e. a two-piece construction and separate top. DWI cans are sealed with an aluminium easy-open pour aperture end. They are used in the beer, soft drink, flavoured wine, fruit juice and processed foods industries.

Figure 15. Two-piece and three-piece cans and speciality steel cans

Two-piece and three-piece cans

Filled speciality can

5.2. Aluminium

Aluminium is used as primary structural package material in both can and foil forms. Aluminium is a lightweight, silvery white metal derived from bauxite. Besides providing an excellent barrier to moisture, air, odours, light and microorganisms, aluminium has good flexibility and surface resilience. The main disadvantages of aluminium are its high cost compared to other metals and its inability to be welded, which renders it useful only for making seamless containers. Aluminium, both as cans and foils, is protected with organic coatings of natural and synthetic polymers.

5.2.1. Aluminium foil

Foil is produced by a cold reduction process in which pure aluminium (purity greater than 99.4%) is passed through rollers to reduce its thickness and annealed to give dead fold properties (where material will keep its shape once folded). Foil more than 15 μm (0.015 mm) thick is totally impermeable to moisture, gases, light and microorganisms. The thinnest foil used for packaging can be 6 μm , normally 8 μm or 9 μm thick are used for flexible laminates. These very thin foils contain minute perforations (visible if the foil is placed over a light in a darkened room) that will allow traces of moisture and gases to pass through. Aluminium foil is widely used for wraps 9 μm (0.009 mm), and thicker foils for bottle caps 50 μm (0.05 mm) and trays for frozen and ready meals (0.05 mm-0.1 mm). Foil is also used as the barrier material in laminated films and aluminium is used to metalize flexible films.

5.2.2. Aluminium cans

Cans are the most common rigid containers used for packaging and preserving food. While almost any food, including dried goods, can be canned, the most common applications are for fruit juices, fruit in syrup, tomatoes, and vegetables. Decorative cans are also used for organic spices and proprietary blends and herbs for traditional looks with contemporary style. Rigid aluminium containers have mostly good resistance to corrosion but they require a lacquering for acidic (with a pH level less than or equal to 4.5) or salty (containing more than 2% salt) foodstuffs and beverages. Therefore, avoid also packing of red coloured fruits, e.g. fruit salad and fruit cocktail packs, where corrosion has also led to bleaching. Disadvantages are that they are weaker than tinplate and more expensive.

Figure 16. Packaging applications with aluminium

Aluminium foil trays

Cans and closures

5.3. Lacquers and coatings for cans

The principal reasons for varnishing the inside of metal cans, whether steel or aluminium is to prevent or avoid changes in taste or other chemical reactions that may result from the dissolving of small amounts of metal in the product; discolouration of the product, chemical reaction between the metal and the product that may lead to corrosion, perforation or formation of hydrogen within the can; and discolouration of the inside of steel cans by tin or iron sulphide, arising especially from contact with meat, fish and some vegetables such as maize.

In general, foodstuffs may be divided into three main groups in terms of their effects on metal cans (see table 11). For details on types of lacquers, see PACKit.

Table 11. Internal coating requirements for metal cans

Sulphur-containing organic products	Pulses, peas, lima beans, brussels sprouts, cauliflower, tuna, sardines, tripe, crustaceans, shellfish, snails, and various prepared dishes containing them.
Less aggressive organic products	Fruits not containing anthocyanins, salad products, juices and jams, tomatoes, french beans, celery hearts, endive, spinach, pickled beetroot, beans or fish in tomato sauce, and pickled cauliflower.
Aggressive acidic organic products	Fruits and vegetables containing anthocyanins (red cherries, strawberries, red currants, plums, beetroot and red cabbage in vinegar, etc.) and fruits and fruit juices not containing anthocyanins such as oranges and grapefruit.

In terms of packaging with metals, below are a number of points to consider:

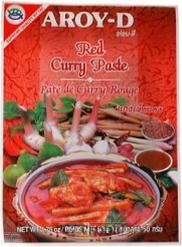
- Metals with recycled content should be preferred where possible.
- Ribbed steel cans are lighter and stronger than conventional steel cans.
- Internal coatings and lacquers normally need to be used where the metal is in contact with food in order to prevent corrosion. Uncoated cans may be used for some foodstuffs such as dry powder and some fruits.
- Migration tests have to be performed.

6. Flexible packaging

Flexible packaging incorporates the good properties of each material (paper/plastics/aluminium) to create a tailor made packaging solutions for a product. Some of the ways in which flexible films are manufactured and used are shown in table 12. As the name suggests, such structures are formed in thin film/sheet/foil form. Films can be converted into an infinite variety of bags for organic food retailing and packaging, including: shopping bags, sacks wrappers, cooking pouches, frozen food pouches and wrapping and laminating film. Cling-, shrink- and stretch-wrap films are also typical ways that flexible films are used.

Table 12. Flexible packaging films and their uses

<p>Monolayer</p> 	<p>This process uses a single polymer at the point of extrusion to blow the film. The most common plastic materials used for packaging are PE and PP. LLDPE film is used for making plastic bags and for wrapping articles. Its advantages are good moisture protection, heat sealability, fairly low price and availability. LDPE film is never totally clear but it is transparent, so products can be seen through it. It has a smooth, soft surface, and is reasonably tough. With appropriate additive (10%-12% EVA [ethyl-vinyl acetate]) it tolerates temperatures from approximately -70°C to +70°C. HDPE is also used for making bags. It has better resistance against moisture and fats than LDPE but is also more expensive. It also tolerates higher temperatures than PE-LD, up to +100°C, which makes it more difficult to seal by heat. HDPE, with a “milky” look is less transparent than LDPE but is stiffer and stronger. LDPE and HDPE are usually well accepted also from the environmental point of view, as they are fairly easy to recycle. Simple wrapping can extend the shelf life while retaining the quality of fresh vegetables by many days.</p>
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<p>Co-extrusion</p> 	<p>A process that combines layers of two or more plastics together at the point of extrusion to blow the film. Multiple extruders can be used to feed the annular die, and often films can be produced of three layers, or sometimes as many as seven layers. In these instances process control is very critical.</p> <p>The different layers provide special characteristics, such as heat sealability, improved gas or moisture-barrier properties, better print surface, etc. Such combinations may be cheaper to produce via this technique than through subsequent or on-line lamination. A large number of layers (e.g. seven) often include "tie-layers", materials which simply act as an interlayer adhesive to bond the previous layer to the next. Coextruded films used for packaging spices to protect them against loss of aroma and ingress of moisture.</p>
<p>Lamination/adhesive bonding</p>  	<p>A process that combines two or more films of plastics together with the use of adhesives or the tie layer which could be plastic. Plastics are also used as coatings and in laminations with other materials, such as paper and paperboard, and aluminium foil, to extend the range of properties that can be achieved. In the laminated structure each film contributes in terms of its properties such as OTR (oxygen transmission rate), MVTR (moisture vapour transmission rate), light barrier qualities, seal strength, clarity, printability etc.</p> <p>High-performance films are typically used in food and speciality packaging. Most are composed of a multi-layer structure and include barrier materials such as EVOH (ethylene vinyl alcohol copolymer), nylon, aluminium foil, HDPE and OPP (oriented polypropylene). All-polyethylene structures may include combinations such as LDPE/LLDPE/LDPE, used in liquid packaging. Polyethylene resins are typically incorporated into the sealant portion of the structure, or used as a toughness layer buried in the structure. High-performance films are often used to package fresh produce, liquids, dry foods, and frozen foods. Most of these are packaged using form, fill, or seal equipment. Other applications include pre-made pouches for bag-in-box applications, clarity films for bread bags, and lamination films.</p>
<p>Foil laminates</p> 	<p>Thin aluminium foil is not particularly strong and is frequently laminated to stronger material to reinforce it. The cheapest reinforcing material is paper and laminates of foil and paper are widely used in packaging. Films also used for reinforcing foil are cellulose film, polyester, nylon (polyamide), PE and PP. These films, in addition to providing strength, protect the foil against mechanical damage. They also block any perforations in the foil. Two-ply laminates are generally used for small pouches or sachets where the packs are subjected to less handling. Typical constructions for pouches are:</p> <ul style="list-style-type: none"> - Paper/ foil/ heat-seal coating or film - Foil/ paper/ heat-seal coating or film - Polyester/ foil/ polyester <p>Picture shows a precooked and retorted rice dish in a flexible pack with secondary paper carton.</p>
<p>Metallisation</p> 	<p>This is a process of depositing a microscopically thin but uniform layer of aluminium onto a plastic film surface, by means of a sophisticated process known as 'vacuum deposition'. The resultant barrier material, generally based on a polyester or PP film, has properties comparable with aluminium foil, but is less costly. Metallized films are effectively opaque, and have an exceptionally high surface shine, which enhances the appearance of graphics printed on or over them.</p>
<p>Coating</p> 	<p>Several types of coating process are available to apply plastic coatings by extrusion, deposition from either solvent or aqueous mixtures or by vacuum deposition. For example, coating a plastic (e.g. PP or PET) with aluminium (metallization) can improve the gas and vapour barrier properties and enhance the visual appearance of the material.</p> <p>Pastry product wrapped with polyvinylidene chloride (PVdC) film courtesy of Swiss Baker is shown in the picture.</p>

<p>Weaving</p> 	<p>Woven PP sacks with or without liners can be used for flour, cocoa, nuts and dry mixes. Polyethylene liners sewn into the top closure provide a strong, moisture-resistant pack which withstands the rigours of handling inherent in production and transportation for markets. The fabric for sacks and FIBCs (flexible intermediate bulk containers) is produced by extruding PP into long tapes or filaments, which are then woven, using traditional fabric technology, into either circular or flat form. The product is then baled.</p> <p>Sacks are most likely to be made from circular woven fabric, thus reducing the amount of stitching needed to produce the final article. FIBCs commonly contain up to one ton of products and require special handling equipment for filling and discharging. The woven PP can be coated with PP or PE film for moisture barrier and sift proofing.</p>
<p>Stretch wrapping</p> 	<p>In stretch wrapping, a thin film is tightly wound around the product, often in several layers, so that when the wrap is completed, the stretched film tries to return to its original size, thereby holding the product or group of products tightly in place. The wrapping can be done manually or with special equipment ranging from small portable devices to sophisticated automatic machines. Stretch wrapping is often more economical than shrink wrapping, because there is no need for heating. Investment costs for equipment are lower and the same equipment can be used for wrapping varying sizes and shapes of products without changes. PE-LD film is one of the options.</p>
<p>Shrink wrapping</p> 	<p>In shrink wrapping, a specially treated film is loosely wrapped around the product(s) and then shrunk with heat to form a tight package. For the application of heat, a variety of equipment is available ranging from small hand-held blowers (even hair-dryers have been used for this purpose) to big heating tunnels. PE-LD is one of the polymers/blends used for shrink wrapping. A pack of six bottles in a half carton and shrink wrapped reduces the cost and amount of secondary packaging.</p>
<p>Flexible nets for fresh products</p> 	<p>Plastic and textile nets, incorporating display labels and often including a handle feature, are much used for packing some fruits and vegetables. Fresh products selected for net packaging must be sufficiently damage-resistant to survive the lack of protection that arises with this method. Sacks and nets of various descriptions, sizes and materials are in widespread use for root crops, such as sweet potatoes, yams, and carrots, and for some citrus fruits.</p> <p>Sacks may be woven from natural fibres or more frequently today from synthetic materials such as PE and PP. Sacks are perhaps the cheapest kind of packaging available. They are difficult to clean and so are generally regarded as single-use packs, produced as finished, filled bags on form-fill-seal units, and made from net tubing. The flexibility of sacks means that they offer no support for the produce and do not protect it from top loads when stacked. Filling of net packages can be accomplished automatically when dedicated to a particular size, for example the 5 kg net bag for oranges. The nets must have a mesh size adequate to allow proper ventilation of the produce.</p>

The success of flexible plastics in the packaging of foodstuffs is due to their relatively low cost, good barrier properties against moisture and gases and wet and dry strength, and the facts that they are heat sealable to prevent leakage of contents, add little weight to the product, are suitable for printing, suitable for high-speed filling, easy to handle and convenient for the manufacturer, retailer and consumer. They also fit closely to the shape of the food, thereby wasting little space during storage and distribution.

7. Bioplastics

Some biodegradable and compostable materials are available but caution should be used when choosing them to package food. In India, the BIS Standard IS/ISO 17088:2008 and in the European Union, standard EN 13432 certify the compostability of certain biodegradable plastic however, these standards are not meant to certify that the materials are safe to use in contact with food, drinking water or pharmaceuticals.

Compostable plastics are too expensive for everyday use and it can actually be difficult in practice to compost the plastic in question. The plastic is not suitable for home-composting and, as it is difficult to separate compostable plastics from other plastics, many industrial composters do not want plastic of any kind in their feedstock. The limitations of compostable plastics prevent their large-scale use at the moment.

Meanwhile, conventional-structural materials continue to be used in the packaging of organic products. Various materials are discussed below:

Biodegradable materials: Made from corn, PLA (Polylactic acid) – based packaging is ideal for cold-fill or ambient-temperature applications such as fresh-cut produce, whole fruit, salads, bakery goods, fresh juice, fresh dairy beverages and still water. It can be physically recycled, industrially composted, incinerated, chemically converted or disposed of with other waste streams to make organic salad see-through punnets and clam-shell containers.

Biodegradable/compostable plastics: These plastics undergo degradation by biological process during composting to yield CO₂, water, inorganic compounds and biomass at rate consistent with other known compostable material and leave no visible, distinguishable or toxic residue. Biodegradable plastics made with bio-based polymers have been available for many years. Their high cost, however, has meant they have never replaced traditional non-degradable plastics in the mass market. There are several kinds of degradable plastics such as: biodegradable, compostable, hydro-biodegradable, photodegradable and bioerodable. ISO 17088:2008 defines the standard and specification for compostable plastics. Some PLA based materials are available and used for packaging of food products. Point to consider: The raw materials of bioplastics are mostly agronomic products such as maize, sugar cane, soya, etc. In most of the cases they are GMO-plants. For organic products and packaging any use of GMO is not allowed and GMO-free bioplastics can be very expensive.

8. Other materials

8.1. Wood

Timber is one of the earliest packaging materials and still remains useful. Being a natural material, it is not very uniform in its physical characteristics, therefore, it is necessary to select and treat it in a manner that will make it useful as a packaging material.

All woods fall into two general categories: 'soft' woods, which come from coniferous or needle-bearing trees and 'hard' woods, which come from deciduous broad-leaf trees (the wood from 'soft' wood trees is not necessarily softer than that from 'hard' wood trees).

The performance of wooden packs is influenced by the moisture content¹⁰. As wood dries, most of its strength properties are increased at a moisture content of 25%-30%. Wood material dried to approximately 12% moisture content may be twice as strong in bending as green material, which may have moisture content as high as 250%. If the timber is kiln-dried to 5%, its bending strength may be tripled. Wood used for packaging purposes is usually of a low grade, containing defects, some of which seriously affect the strength properties important in packaging construction. These defects should be kept within reasonable tolerances. Miscellaneous defects include bark still present in the timber, cupping, bowing and twisting, case hardening, collapse, discolouration, decay and insect attack or infestation. Further information can be obtained from the PACKit module Wood.

Specific to wood packaging there is an international fumigation/heat treatment regulation ISPM 15 which must be carefully examined by organic food exporters. In 2003 an international decision was made to exempt thin (up to 6mm) softwood and hardwood from the need for heat treatment or other sterilisation when exporting to requirements of ISPM 15. This is a major concession which is undergoing verification on a country-by-country basis. Traditional methods of stapled construction can continue, but care will have to be taken to ensure that new regulations concerning the absence of chemicals and heavy metals are met.

¹⁰ The moisture content is the mass of water in the wood expressed as the percentage of the mass of the dry wood (dry weight).

Wooden packaging applications for organic products: Some applications include: trays and punnets, cases and crates, storage boxes for vegetables and, commonly, pallets. As the volume of pallets manufactured has increased, new methods have been found for faster pallet production that still maintains quality. For more details, see ISO 15629:2002: Pallets for materials handling – Quality of fasteners for assembly of new and repair of used, flat wooden pallets.

8.2. Jute and cotton bags

The advantages of jute bags are that they allow products to breathe during handling and transport, and are relatively easily available at moderate prices. Their disadvantage is that they tend to absorb moisture when in contact with container walls, thus permitting the development of moulds and toxins. Meanwhile, other stored products, insects, particles or rodents may contaminate their fibres, because of their relatively open weave, and further contaminate the product within. In addition, numerous foods have been contaminated by mineral oil from jute bags.

Jute bags are made with fibres softened and rendered elastic for spinning by treatment with mineral oil. When foodstuffs are packed into the jute bags, the oil migrates into the foodstuff. To limit the effects of these disadvantages, containers need to be adequately ventilated and inner sacks of woven polyethylene or polypropylene may be used.

Textile sacks or bales made of cotton, sisal or jute are the types of packaging most widely used for the export of spices and dried herbs from developing countries even when some countries (the European Spice Association has a strongly negative point of view regarding the use of textile sacks and bags for export packaging of spice and dry herbs) do not prefer it. This type of export package is of great importance for the economies of developing countries but is ill-suited to the packaging and transport requirements of industrialized markets when the gross weight (filled with the product) is high.

In dry herbs and spice packaging, jute sacks, generally called 'gunny bags', have a number of good qualities: they take up little space and need no special protection when they are empty (though they should be kept dry); they are relatively light, adding little to the cost of transport; they can be sized to facilitate handling by one person and are quite resistant to rough handling; and they can be easily and effectively closed (a simple hand-stitching operation, provided it is well done). All the above qualities makes them particularly appropriate for use in developing countries, where spice producers have access to abundant low-cost labour, which can compensate for the absence of mechanical handling equipment and the often-inconvenient layout and location of the traditional, small-scale premises where spices are often handled. It is not uncommon to see spice sacks being carried on people's backs from stores that are inaccessible to any sort of wheeled handling device, and loaded onto trucks in the street.

Annex I Common paper grades used in packaging

Paper grades	Characteristics and usage
Kraft paper (70-225 g/m ²)	Used for multi-wall bags and sacks where exceptional strength is needed. Extensible kraft paper can absorb energy at sudden rates of strain. Examples of food applications: large sacks, with a capacity of 25-50 kg, for powdered or granular products such as flour and grain.
Natural (unbleached) krafts	Have good mechanical properties. Precise standards have been set for machine-glazed versions of such papers. Examples of their use include large sacks for fruit and small sacks for fruit and vegetables.
Bleached glazed krafts (32-64 g/m ²)	Are shiny on both sides. These papers provide an excellent surface for printing. Examples of use include bags for coffee, flour and other dry grocery products.
Glassine (40-50 g/m ²)	Transparent and moisture-repellent. Examples of use include wrapping for flowers and sandwich bags.
Crystallized cellophane papers. (40-50 g/m ²)	Derivatives of glassine but are not as strong or as transparent as glassine itself. Examples of use include protective and decorative trimmings and covers for trays of fruit and vegetables.
Greaseproof and similar papers 950-64 g/m ²)	Good barriers against fats, a property that can be modified to suit user and product requirements. They provide a good barrier against permeation by moisture, odours and blood serum. Vegetable parchment papers have exceptional barrier properties against moisture. Examples of use include wrappings for butter, cheese and coffee.
Thin papers (16-32 g/m ²)	Usually machine-glazed. Examples of applications include bags for bakery and confectionery and their incorporation into multi-material packages for a variety of foodstuffs.
Papers for impermeable containers (160-280 g/m ²)	Normally laminated with extruded polyethylene and other impermeable films. These composite materials are used for cartons for milk, fruit juice, chocolate drinks, etc.

Annex II General classification of plastics in food packaging

Plastics for packaging	
Grouping	Commonly used plastics
Polyolefins. These refer to the family of plastics based on ethylene and propylene. The term “alkene” is used for hydrocarbon containing a carbon-carbon double bond e.g. ethylene and propylene.	LDPE, LLDPE, HDPE, PP, Metallocenes
Polycarbonates (PCs). These are polyesters of unstable carbonic acid and have carbonate linkages. PCs in food packaging are used as components of multilayer co-extrusions and co-injection moulding to provide transparency and high strength to containers which undergo hot filling or hot processing after filling.	
Substituted olefins. The simplest substituted olefins are those in which each ethylene group has a single substitution; these monomers are called vinyl compounds. Di-substituted monomers with two substituents on the one carbon are called vinylidene.	PVC, PVdC, PS
Polyamides. PAs are generally linear made from monomers with amine and carboxyl acid functional groups resulting in amide linkages in the main polymer chain that provides mechanical strength and barrier properties. In general they are highly permeable to water vapour, PA films have excellent thermal stability (can withstand up to 1400 C, Nylon (originally brand name of DuPont) are differentiated by the numbers based on resin manufacture. Generally Nylon 6, Nylon 6.6 and Nylon 11 find their use in food applications.	
Copolymers of ethylene. The polymers can be classified as either copolymers or homopolymers if the molecular percentage of the comonomer is less than 10%.	EVA, EVOH, EAA, Ionomers
Polyester. These are based on carbon-oxygen-carbon links where one of the carbons is part of a carbonyl group and are formed by the process of condensation polymerization. In this process, two molecules are joined together through the elimination of a smaller molecule (typically H ₂ O) whose atoms derive from both the parent molecules.	PET, PEN, Co-Polyesters
Expanded polystyrene (EPS). EPS is produced from GPPS by expanding PS beads, using low boiling hydrocarbon as a blowing agent. Due to heating, beads are formed with a much larger diameter than the original cellular structure. After conditioning, a shaping step including a second expansion and melting together of the beads takes place. EPS has high mechanical strength in relation to its extreme low density (approx. 0.006 kg/m ³). Applications include food containers, trays, cups, egg packages, insulation material, fruit and vegetable cases and cushioning materials.	

Chapter 7 Associated materials, technologies and their use

1. Associated materials, adhesives, etc.

Adhesives are used for bonding of different layers in flexible packaging laminates. Solvent based adhesives should be avoided since they tend to produce off flavours in the food contained within. It is advisable to use epoxy food grade or the two component systems.

The following adhesives are used for CFB manufacturing:

- Starch is the dominant natural adhesive used. Additives may be used to improve the performance of the bond – for example to improve adhesion or to increase water resistance. Starch may also be used in the sealing of packages, and in seaming and forming bags and sacks, as it adheres excellently to paper and is heat-resistant. It is also easy to use, easy to clean and inexpensive. The negative aspects of starch include its relatively slow bond formation, poor water resistance and limited or no adhesion to coatings and plastics.
- Synthetic water-borne adhesives are resin emulsions and usually include water-soluble colloids and may be further compounded by the addition of plasticizers, fillers, defoamers, preservatives, etc. They may be very water insensitive for immersion resistance or very water sensitive to promote easy clean up, and their fast set facilitates high production speeds with good economy. The use of copolymers has meant the utility of these emulsion systems has increased. The largest areas of use for vinyl emulsions are in carton sealing and the formation of the manufacturer's joint.
- Hot melts have thermoplastic polymer as their base. The copolymers have a good balance of molten stability, adhesion and toughness over a broad temperature range. Their advantages include the mechanism of bond formation by simple cooling and solidification, fast setting, and the wideness of the range of polymers and modifiers that can be used to formulate adhesives for almost any surface. They are generally safe and judged acceptable from an environmental point of view. Their disadvantages include the rapid loss of strength at elevated temperatures.

The choice of adhesive depends on cost, productivity, specific use requirements and environmental considerations. Water-borne and hot melt adhesives dominate the use of adhesives in packaging, as solvent-borne adhesives must be used with great care because of their volatile organic emissions.

2. Printing, labelling, decoration and techniques¹¹

Operations like printing, labelling, decoration and sleeving primarily refer to activities intended to promote sales as well as meet legal requirements relating to safety of the consumer, the transport operation and environment protection.

Bear the following guidelines in mind when planning your printing:

- **General design factors:** Create graphics which are simple and effective in conveying the distinct features of the organic food. Minimize the amount of material you are using and find environmentally friendly materials for your labelling. For example, use water based inks, consider how easy labels and caps/closures are to remove in the recycling process.
- **General technical factors:** Which printing or labelling methods are suitable for the form, characteristics and surface texture of the packaging material? For instance, is the packaging material plastic, card, paper, corrugated fibreboard or foil? Are there environmental regulations that influence the choice of material? Which printing methods are available? Does the printer have the

¹¹ For detailed information on printing and decoration processes and techniques, please refer to Packaging Information Kit, PACKit Cross cutting Module-printing (International Trade Centre), available at: <http://www.intracen.org/about/e-shop/>.

expertise as well as the equipment to reproduce your design requirements such as the number of colours, the precision of colour registration or the need to print photographs?

- **General commercial factors:** How much is to be printed? Economies of scale will dictate various forms of printing. Are there quality requirements? Are quality control measures in place? Where is the manufacturing and packaging site? Are there supplier approval requirements driven either by company policy or an external certification process?

2.1. Special ink and coating requirements for organic product packages

Inks and coatings will vary not only with the process used but also according to the properties dictated by the end use of the printed product. Inks for laminate and plastic film packages are also required to withstand the heat-sealing temperatures that are often required to close them:

- Ideally, water-based inks are used for printing on the packs for organic food. Such inks are available for flexo and gravure printing on many materials. Wherever possible epoxy based inks could also be used even though a bit expensive.
- Certain inks are affected by light and by contact with other agents; some of the brightest and most light-stable inks are derived from heavy metals such as lead, mercury, cadmium and chromium and so are no longer acceptable for printing applications. Some of the organic inks that have replaced them are not as light-stable and are particularly susceptible to the UV radiation that is nowadays used to cure varnishes. Therefore collect information and discuss your specific requirements with the printer about the brilliancy and colour stability of your inks and specify the use of your package and the expose to sunlight. Magenta and yellow tend to fade faster than black and cyan.
- Caution is required in the selection of ink components, especially if there is a possibility of contact between them and packaged foodstuffs. Carbon black, the standard black ink pigment, is produced from petrochemicals and mineral oils. This has been known to migrate from the paper it is printed on to carton packaging. These inks and coatings have a major environmental impact because of the problems faced in the generation and disposal of printed-packaging waste and the emission of volatile organic compounds (VOCs) arising from organic solvents.
- Rub (abrasion) resistance is an important requirement for packaging printing. Offset litho prints a thinner layer than direct letterpress or gravure and this thinner layer should be more rub-resistant. On the other hand, litho ink needs to be more vibrant because of its thinness and to print a strong colour the proportions of varnish to colour may not be high enough to ensure rub-resistance. Inks for printing on outer surface must have a good abrasion resistance especially when product is packaged in the powder form.
- The pressure built up in a rewind reel of printed work will almost certainly produce 'set off', if slow-drying inks are used. Ink suppliers identify the correct grades to meet your specific requirements.

3. Caps, closures and lids

The term 'closures' refers to caps and lids. A closure is an access-and-seal device. Although seemingly a small component of any package, it plays a vital role. Poor design can lead to leakages, poor permeability can spoil the product and poor choice of cap wadding can lead to the migration of unwanted chemicals into the food product. However, these problems can be avoided by bearing in mind a few simple facts.

Automatic filling and capping productions lines often feature:

- **In-line cappers** which work on the direct cap pick-off principle: the bottles are held by travelling belts while another set of belts, operating sometimes on the top of the cap and sometimes on the skirt, spin the cap home.
- **Rotary cappers** which hold the containers individually while rotating chucks screw home the caps until a pre-programmed torque (tightness) is reached.

- **Roll-on capping** which can also incorporate a pilfer-proof device so the action of removing the rolled-on cap breaks a series of perforations and leaves a tell-tale ring on the bottle neck.
- **Corking and plugging** machines which are similar in construction to rotary cappers, the corks or plugs being fed from an unscrambling hopper to a chuck via a transfer arm or disc.
- **The crown cork (or cap)**, for soft drinks and beer bottles on filling lines.

There has been increasing demand for speciality closures, particularly for convenience in use, dispensing, tamper-proofing and child-resistant systems. There are some 12 classifications of tamperproof closures, from film wrappers or shrink seals around the neck and a closing seal for the container which needs to be removed to obtain the product, to blister packs and sealed cartons. Such closures may be useful for certain premium products for security.

4. Packaging machines

Automated production is an essential part of any packaging line, providing volume and consistency. Many countries have also included containers and food handling systems under the FCM definition in their regulations. Commonly used packaging machinery is shown in table 13.

Table 13. Packaging machinery

Machine type	Description of operation
*Filling and dosing machines	Packaging machines that measure out a product from bulk by volume, level in a container, mass or number.
Closing machines	Packaging machines which seal or close filled packages.
Labelling, decorating and coding machines	Packaging machines that apply labels, decoration or codes and other markings to packages.
*Cleaning, sterilizing, cooling and drying machines	Machines that clean, sterilize, cool or dry containers or filled packages.
*Fill and seal machines	Packaging machines that combine the functions of filling and closing in one machine. There are a great variety of machines combining the functions of filling machines and closing machines.
Inspection machines	Packaging machines that inspect products, packages or packaging components, for a particular attribute (e.g. colour, size or mass) and reject items that fall outside pre-set values.
Container and component handling machines	Packaging machines that arrange dispense or accumulate packages or packaging components.
*Form, fill and seal machines	Packaging machines that form, fill and seal a package.
Carton erecting, carton closing and cartoning machines	Packaging machines that erect and close, or erect, fill and close carton blanks or folded and side seam sealed cartons.
Wrapping machines	Packaging machines that wrap a flexible packaging material (e.g. paper, aluminium or plastic film) around a product or groups of products.
Group or transit packaging machines	Packaging machines that group together products for transit purposes. Group packages include cases, trays, crates and carton board sleeves.
Pallet forming, dismantling and securing machines	Packaging machines which form, dismantle or secure pallets and other loading units.

* Will come into contact with food and therefore need careful consideration.

Special considerations related to packaging machines

When making packaging orders, bear in mind the kind of packaging machine that will be used.

- Some kinds of packaging material or laminate also tend to cause stoppages, breakdowns and wastages in the printing machines.
- Flexible pack sealing quality depends on the type and thickness of packaging material being used, ambient conditions such as humidity and the degree of risk of contamination with the product.
- Machines used in the food-processing sector also need to meet certain regulations. For instance, European Council directive 89/392/EEC has laid down basic health and safety requirements.

Chapter 8 Product processing and packaging technologies¹²

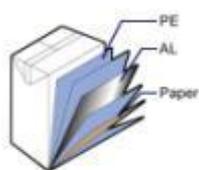
Advances in packaging technology promise to be very valuable for organic food producers.

Heating/canning/sterilising: Some products are preserved by sterilisation once they are in their packages. The pH of the product determines the thermal processing conditions – if the pH is greater than 4.5: 60-90 minutes processing at 121°C; if the pH is less than 4.5: mild heat treatment for 20 minutes.

Appropriate packaging for this kind of processing includes:

- **Two- or three-piece tin can:** Canned fruits and vegetables must have the correct internal lacquer (enamel) applied to avoid corrosion of the tinplate and migration risks;
- **Glass containers:** Cylindrical, wide-mouth glass jars are commonly used with either a twist-off or pry-off cap made from mild steel or aluminium coated with a suitable lining material;
- **Retortable pouches:** Made from laminates of plastic film generally with an aluminium central layer, these are often used for the packaging of fruit and vegetables which have been heat-sterilized.

Figure 17. Some technology options



Aseptic carton



Bulk cashew kernels pack



Bulk aseptic package for spices



Microwave oven-friendly punnets



Aseptic bag in aseptic box



Retortable pouch in carton

Pasteurization: Pasteurization preserves foods through the inactivation of enzymes and the destruction of relatively heat-sensitive microorganisms. It causes minimal changes to the taste, smell or nutritional value of a food. Pasteurized products are short shelf-life products and are packed in clean pouches, mono-film structures, glass or plastic containers.

Hot fill or hot pack: The terms hot fill and hot pack refer to the packing of previously pasteurized or sterilized foods, while still hot, into clean but not necessarily sterile containers, under clean but not

¹² For detailed information on metals, please refer to Processed Food – *The Integrated Export Packaging Information Kit*, PACKit Product Module (International Trade Centre), available at: <http://www.intracen.org/about/e-shop/>.

necessarily aseptic conditions. Hot filling is not the same as aseptic packaging. Hot filling is achieved by passing the liquid product through a heat exchanger and then filling at about 70°C. The closure is then applied. Any microbiological contamination on the inner surfaces of the bottle and the closure is destroyed by the hot liquid, and adequate sterility is obtained without heating the container thereby a better shelf life.

It is crucial to test your packaging to make sure it is suitable for these processes and will not migrate into your product during hot filling, pasteurisation or sterilisation.

Figure 18. Filling of hot organic marmalade



Aseptic packaging: Aseptically packaged products require the sterilization of the product and packaging, the maintenance of sterile surroundings while forming and filling the pack and finally the production of packages that are sealed efficiently to prevent any re-infection. Aseptically packed products offer a very long shelf life at ambient temperatures.

A range of aseptic packaging options are available:

- **Aseptic bag-in-box:** This often features a flexible, fully sealed, gas-barrier bag with inside E-flute or B-flute printed corrugated container, with a handle, a closure and a tap through which the contents are dispensed. Bag-in-box packaging offers many advantages including convenience of carriage, storage and use – but at a price. These packs are often used as bulk packs for wines and juices.
- **Aseptic glass containers:** With aseptically packaged glass containers, the jars are filled at ambient temperature and then closed under vacuum. Since no heat treatment is given to the container after capping, the vacuum level achieved on the capping machine will be maintained throughout the shelf-life of the container. However, sterility of the glass container has to be ensured.

Low temperature preservation: Low temperatures slow down the degradation of food. Low temperature categories include chilled foods where the package only has to survive a few days before the consumer uses it, and frozen or canned foods where the pack may have to offer protection to the food for up to three years. Low-temperature technologies are used for fruit (such as strawberries, raspberries, blackcurrants) either whole, pureed or as juice concentrates; vegetables (including peas, green beans, sweet corn, spinach, sprouts and potatoes) and prepared foods.

Modified atmosphere packaging: Modified atmosphere packaging (MAP) is a process by which the shelf-life of a fresh or processed product is increased significantly by enclosing it in an atmosphere that slows down the growth of microbial organisms. One such process involves the removal of oxygen and replacing it with carbon dioxide.

Figure 20 compares the condition of bananas in ordinary packaging and in MAP bags after 6, 9 and 12 days.

Figure 19. Delayed ripening by use of ethylene gas over 6, 9 and 12 days



Note: Bottom row shows MAP flexible bags

Packaging gases such as E290 carbon dioxide, E938 argon, E939 helium, E941 nitrogen and E948 oxygen are allowed under European Commission regulation EU-VO 889/2008 for organic products; their use has to be stated on the label.

Vacuum packaging: Vacuum packaging is a means of improving the quality of food during its natural life rather than a means of increasing its shelf life. Vacuum packaging can be used to protect a variety of produce including canned foods, nuts, spices and tea. Rigid packages, evacuated after filling, closing and sealing, retain their shape. Flexible packages assume the shape of the food when they are filled, evacuated, closed and sealed. They become 'skin packs' that take up minimum space.

Intelligent packaging: According to the European food quality directive 2004/1935/EC, 'intelligent food-contact materials and articles' means equipment which monitors the condition of packaged food or the environment surrounding it. An example would be equipment to monitor the temperature of food to ensure that chilled storage had not been disrupted.

Irradiation – not recommended: Irradiation exposes food to [ionizing radiation](#) to destroy [microorganisms](#), [bacteria](#), [viruses](#), or [insects](#) that might be present in food. However, irradiation is used by conventional food products and cannot be used¹³ for food products grown organically. Accordingly, the use of irradiation for packaging is limited.

Microwave heating: Appropriate packaging for food which will be heated in microwave ovens include: glass, ceramics, plastics and paper which do not absorb radio-frequency energy so microwaves pass through them without making them hot. The most commonly used materials are made of plastics that do not deform or char when exposed to temperatures over 100°C. Packages should be flat and not too deep (less than 5 cm).

¹³ 'See Codex Alimentarius – Organically Produced Food': <http://www.fao.org/docrep/005/y2772e/y2772e00.htm>.

Chapter 9 Packaging for transport and distribution¹⁴

Each transport mode has its own requirements regarding package strength and resilience. If several modes of transport are used for export, all of the packaging (including primary, secondary and transport packaging) must be designed to endure the toughest stages of the distribution chain.

If goods are normally handled mechanically at the main trans-shipment points, the packages should be arranged to make this possible. The dimensions of unit loads should be chosen to suit both the modes of transport and the handling equipment at the destination. Many modes of transport also have their own package-marking requirements to ensure that packs are correctly handled and safely delivered.

Particular product groups, including organic and perishable foods such as fresh fruit and vegetables, have specific marking needs. Individual countries often have their own requirements in addition to the internationally accepted markings.

1. Integration with transport and supply chain components

Unitising and optimising loads and pallets: The unit load concept involves securing individual packages together so that the single unit can be safely and efficiently loaded, transported, stored and delivered. Pallets – often shrink-wrapped (except for fresh produce), and designed to match the dimensions of containers – eliminate the multiple handling of individual packs and thus boost efficiency and slash costs.

Points to consider:

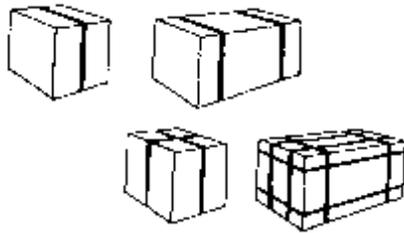
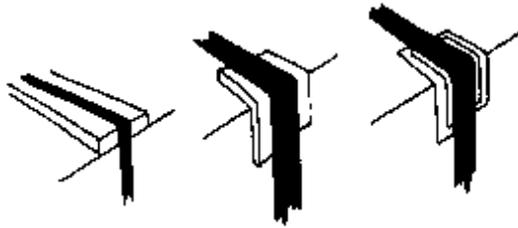
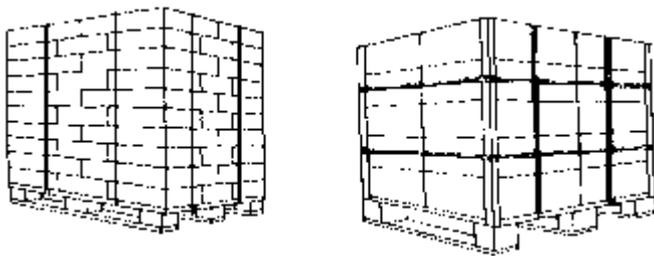
- Packaging has to be designed to suit the pallet and fit in with any height restrictions in the distribution system.
- Individual packages have to be able to be locked together to form a stable unit load.
- Packaging has to be appropriate for plastic and metal strapping used for closing and securing transport packages and unit loads. The most common plastic strapping used for fibreboard boxes is 13 mm wide polypropylene (PP) strapping with a thickness of 0.5 to 0.9 mm.
- Unit loads themselves have to be able to be immobilized during transport.
- Payloads are limited by the capacity of each pallet and also by portability considerations. Make sure you choose pallet types commonly used in international trade¹⁵ so that they correspond to the various types of container, cargo ship compartment, truck, fork-lift truck, etc. which will be used during distribution. With the exception of fresh fruit and vegetables transported by airfreight, European importers categorically require that merchandise be transported using the pallet system. All costs arising from repackaging the produce and loading it onto pallets are charged to exporters.

Pallets for sea transport may not exceed a total height of 2.05 m, to allow for transportation by truck and warehousing in intermediary depots. Standard sizes include:

- ISO pallet size of 1200x1000 mm, also called the sea pallet. This size is mostly used all over the world including France and Netherlands. It offers better stacking stability and efficiency with larger surface area and greater height.
- European pallet size of 800x1200 mm, used in some parts of Europe.
- Standard Grocery Manufacturers Association (GMA) pallet, 1219 x 1016 mm (48 by 40 inches), used in the United States.

¹⁴ For detailed information on transportation and distribution, refer to 'Transport – The Integrated Export Packaging Information Kit', PACKit Cross Cutting Module (ITC), available at: <http://www.intracen.org/about/e-shop/>.

¹⁵ For detailed information on pallets please refer to 'Fresh Fruit and Vegetables – The Integrated Export Packaging Information Kit', PACKit Product Module (ITC), available at: <http://www.intracen.org/about/e-shop/>.

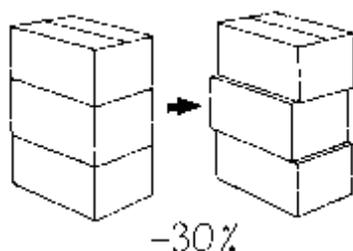
Figure 20. Positioning of strapping on the boxes**Figure 21. Protection of edges****Figure 22. Use of strapping to fix unit loads on pallets**

Stretch wrapping: Stretch wrapping wherever feasible is used to secure the pallet loads. A good stretch wrap has three wrappings each with 40% overlap. 50 mm extension of three overlaps over bottom (down the pallet) and over the top of the load provides extra security. The added top wraps provide extra security at the point in the load most likely to move.

Tension net: The net system has a similar effect to stretch film, but allows ventilation; it is therefore the preferred system for products such as fruit and vegetables where ventilation is necessary.

Stacking: When corrugated fibreboard boxes are stacked on top of each other, the stacking should be carefully and correctly done. Corners are the strongest parts of the boxes, and the ability to bear loads decreases between the corners. Therefore, a straight column stack is the best scheme in relation to compression strength. However, even a 12.5 mm out of line stacking results in a reduction of 30% in stacking strength (see figure 23). The same is true for a box that overhangs the pallet base. When boxes are stacked in a bonded block mode, stacking strength can be reduced by up to 50%.

Figure 23. How one box which is 22.5 mm out of line reduces the stacking strength by one-third



Containerisation:¹⁶ Arranging international freight is a crucial part of the distribution process for food producers. Hazards can be avoided to a great extent through containerization. Containerization cuts loading and unloading times, improves security and reduces cargo damage during handling and transit. Marine containers offer several ways of carrying your produce: as a full container load (FCL) or less than a container load (LCL) when the cargo should be placed in a box or on pallets of standard size.

Follow these guidelines for the safe transport of your organic produce:

- Before organic food is loaded onto a container, it should be inspected for cleanliness. Prepare monitoring and pest-management plans.
- Remember that the use of many insecticides, pesticides and repellents is not allowed around organic products. Ensure no direct or indirect fumigation activity is undertaken unless authorized.
- Typically the container is lined with cardboard to prevent cartons from shifting during transport. This cardboard can absorb moisture and other contaminants. Ensure just-in-time (JIT) packaging supplies are stored in hygienic conditions.
- Some packaging materials require particular storage conditions; if these conditions are not available at the location where packaging takes place, change your packaging materials.

Marking and coding for shipping and handling:¹⁷ Labelling requirements specific to organic products are covered in chapter 3. But the most important aspect during transport, storage and delivery is the separation of organic products from non-organic products. Therefore organic products need clear labelling not only on primary packaging but also on secondary and transport packaging. Batch numbers are also important to track consignments.

These are some marking and coding guidelines for transport and handling:

- **Product Information marks:** Such information might include: name and address of packer and/or dispatcher (or code mark), nature of produce, variety of produce (or commercial type), batch number, country of origin, trade name, class of quality, size, weight, numbered units. See figure 24 for an example.

¹⁶ For detailed information on containerization please refer to Paper and Board – The Integrated Export Packaging Information Kit, PACKit Materials Module (International Trade Centre), available at: <http://www.intracen.org/about/e-shop/>.

¹⁷ For detailed information on pallets please refer to Fresh Fruit and Vegetables – The Integrated Export Packaging Information Kit, PACKit Product Module (International Trade Centre), available at: <http://www.intracen.org/about/e-shop/>.

Figure 24. A design for the correct labelling of avocados



- **Shipping marks:** Information necessary to deliver the package to its correct destination includes the initials or abbreviated name of the buyer, reference numbers as agreed by importers and exporters, the destination, and package numbers and/or the total numbers of packages in the shipment.
- **Handling marks:** Internationally recognized handling marks should be used in pictorial form, i.e. the graphic symbols in ISO 780:1997 Packaging – pictorial marking for handling of goods. The use of handling marks does not guarantee that the packages will be correctly handled but it does increase the chances. If handling marks are not used when they are needed, insurance will not cover losses caused by incorrect handling.
- Marking of transport packages must be:
 - Legible – characters must be big enough and coloured in sufficient contrast to the background.
 - Durable – inks used should be waterproof, permanent and resistant to humidity, sunlight and friction.
 - Visible – marks should be placed on at least two sides of the package.
 - Communicative – text should be as short as possible and use pictorial marks.

2. Identifying hazards and finding solutions

Most damage to produce occurs during warehousing, transport and handling and is caused by compression, shock and vibration. Packaging should protect your product during transport and distribution.

Transport packaging must correspond with systems used in warehousing and storage, the loading and unloading of freight containers and transport vehicles, associated inventory management systems, and the in-house operations of the end-user – its unpacking and disposal systems.

Common hazards and ways to protect against them are shown in table 14.

Table 14. Hazards and solutions during transportation and distribution

Environment hazard and reason	Effect on packages and product	Recommendations
Heat: Direct exposure to sun, high ambient temperatures, proximity to boilers	Melting, spoilage including taste deterioration, bleeding, blistering, peeling, fusing, discolouration etc.	- Temperature extremes in distribution must be avoided particularly some plastics may become soft/stiff at high temperatures and brittle at low temperatures. Transport packaging materials of most concern are cushioning foams and stretch wrapping. - Define the transport and storage temperature of your goods and communicate these recommendations to your distributor.
Cold: Unheated aircraft, ships holds, cold climate	Cracking, freezing, brittleness etc.	

Environment hazard and reason	Effect on packages and product	Recommendations
Water/water vapour: Rain during transit, handling or storage. Condensation, bilge- and seawater. Water vapour transmission in or out of the product. Condensation occurs inside an inter modal container when the temperature drops, and water forms on the ceiling and walls	Dissolution, dilution, separation, rust, corrosion, staining, print smudging and discolouration, lumping, blocking, pitting, mouldering of product etc. In humid conditions especially paper packaging is affected	- Pack at the correct humidity and temperature conditions.
Vibration: Bumpy roads, poor rail joints, tarred air strips, bad suspension and out-of-balance wheels etc.	Bruising of fresh products, damage to packaging etc.	- Use well-maintained transportation and stick to speed restrictions. - Test packaged transport loads to simulated vibration conditions. - Choose compression and skid-proofed packaging systems.
Static and dynamic compression: Different stack loads during storage and transportation, careless warehouse stacking and bracing. Railway shunting, stack resonance, collisions with other packages on conveyors or chutes, etc.	Crushing and bursting of packaging and product; deformation of packaging	- Subject transport packs to stack load and compression tests. - Use proper box specifications to avoid effect of moisture on compression. - Choose a transport or distribution company which is certified under logistic standards such as IFS or BRC.
Piercing, snagging, puncturing: Hooks, projections, misuse of handling equipment, poor handling methods, shifting cargo during handling and transportation	Broken or damaged packaging.	- Ensure proper design (e.g. your cardboard boxes are strong enough). - Follow standard operating procedures for loading/handling.
Cracking or deformation: Improper pallet size or loading, uneven support, uneven lifting, rough handling	Crushing and bursting of packaging and product; deformation of packaging	- Use proper pallets and packaging.
Low pressure: High elevations, unpressurized aircraft holds	Build-up of pressure differential across the packs; bursting of packaging	- Use proper vents and closures. - Design for pressure differentials.
Light: Direct exposure to sunlight	Light affects print shades, markings; degrades package materials	- Use UV coating and varnishes, polymers with UV stabilizers etc. - Use lightproof tertiary packaging (e.g. paper carton).
Biological microorganisms, fungus, moulds, insects, rodents	Degraded pack appearance and functions Product degradation	- Maintain clean conditions. - Use well-sealed pallets through stretch/shrink films. - Don't use anti-fungal/insects/rodent sprays and pesticides, which are not permitted in organic regulation. - Use an integrated pest management scheme.
Contamination: Dust, grit, sand and other external materials. Rusty metal work, leakage of adjacent products	Product damage Degraded performance and appearance	- Palletize and unitize with stretch/shrink films. - Use clean storage and distribution facilities.

Testing of product fragility/susceptibility: The determination of what constitutes unacceptable physical damage to products is often complex and subjective and depends on the type of product. For instance, on an apple bruising is considered damage but the intensity of bruising that determines whether the apple is damaged is more subjective. It is advisable to lay down quality parameters in line with importers' requirements or existing regulations. In a damage-boundary analysis, the product without its package is fastened to a shock machine table. Testing is started at a low velocity and then increased gradually until

damage occurs. Products usually have different fragility levels in each orientation, so testing must be done in all three directions. Damage caused by transportation vibration most frequently occurs on the surface of the product in the form of abrasion. Testing should also be undertaken with packaging in place. Packages containing products should pass drop tests and stack load tests.

3. Point of sale and display requirements

A modern food distribution system demands a consistent product quality and uniformity in package sizes and quantity or weight per pack. It always pays to understand and meet the requirements of attractive display, at point of sale.

Figure 25 Organic products on a retailer's shelf



Shelf-life and stock-rotation estimate: The package size must be such that the retailer can sell unit packs of the product and at the same time maintain a reasonable stock level consistent with its shelf life. Therefore portion pack, multi-pack and portion sizes must be governed by stock rotation estimates and consumer habits.

Shelf space and storage space limitations: As most retailers lack sufficient storage space and as suppliers need efficient and cost-effective dispatch of products from the packing stations or wholesale markets to the retailers, close attention should be paid to choice of the best size of the individual package.

Point-of-sale display: Foodstuffs can be presented to the consumer in many ways. A common and economic practice for fresh products that are not pre-packed is to display them in the transport package received from the supplier and country of origin. This type of presentation is often used by greengrocers to show off exclusive and exotic produce including organic products. In these situations it is crucial to use an attractively designed transport package displaying the produce to best advantage. The produce should be fully visible and of clean and tidy appearance.

When fresh produce is presented unpacked and loose for self-service selection by the shopper or for sale by the piece, organic identification through a tag, sticker or package band is a better branding technique than relying on the branding on packaging where performance remains the main criterion (see figure 26).

Figure 26. Point of sales display and identification of organic fresh food



Chapter 10 Packaging selection and sourcing through examples

1. General considerations – packaging selection and sourcing

The first step in the packaging procurement process is to decide what is needed from your supplier. The best way to do this is to create a written specification using internationally accepted definitions.

The four principal purposes of the specification should be to:

- Ensure that the package is technically adequate for the product;
- Avoid technical and commercial misunderstandings;
- Serve as a basis for possible damage claims;
- Permit comparative bidding from competing potential suppliers.

Technical specifications: These should start with the type of pack required (plastic, glass, wood, flexible, CFB etc.) and include a description of the product to be packed; requirements for its protection against mechanical and atmospheric damage and migration; package design; weight/volume or quantity of the items to be packed per unit package; raw material grade and its physical characteristics; package construction and dimensions including tolerances; graphic design and printing conditions; quantity of packages required per week/month/year; delivery of the packages including their packing, price and terms of payment including the shipping terms; and quality control aspects including inspection procedure and classification of defects and finally procedures for claims of defects.

Quality guidelines: The decision to buy a certain type of packaging material requires very careful consideration of the design and quality of the package. It may not, however, be necessary to purchase the best quality material if a lower-quality but cheaper material will fulfil all the requirements. If, for example, a thinner film will provide all the protection needed for a particular application, it is a waste of money to buy a thicker one. One must nonetheless consider the possible consequences of appearing to be too cheap. Complaints from customers, for instance, might be more costly than the initial provision of an adequate package. One must also bear in mind the effect of lower quality material on the use of the packaging machine – will the material actually run on the available equipment?

Selection of suppliers: When purchasing materials, the reputation of the supplier is all-important: will they deliver on time, will they meet specifications, can they provide technical support and perhaps design assistance? For major purchases it is a worthwhile exercise to obtain several quotes from various suppliers. This means, of course, that a standardized specification is necessary. The lowest price is not always the best price, as the purchaser must consider a number of other factors, including the reliability and support issues mentioned above.

Purchasing packaging materials from a supplier in your own country can be in principle the best option, as it means having to deal with fewer concerns about, for example, trade restrictions (both tariff and non-tariff); preferential bilateral trade conditions; the cost of freight; the language of technical instruction materials and bag markings (operators of machinery are not always fluent in foreign languages, even if the management is); and exchange rate fluctuations. Local suppliers may also be willing to provide smaller quantities of materials, whilst foreign suppliers will usually require larger orders. However, none of these concerns should be restrictive: the flow of packaging materials across borders is very common indeed and national monopolies should no longer be considered the only sources of materials.

2. Costs of packaging solutions

Once investment is made in the development of packaging and organic products value realization gets better, especially in a niche market. Having said that, the following is a list of issues to be looked into to optimize the packaging costs:

- In the case of exports from developing countries, packaging and distribution costs will often amount to more than the costs of organic food production. Such products, while common and inexpensive in the country of origin, may be considered rare and exotic in the target market.

- To promote products successfully, expenditure on packaging and distribution should reflect their perceived value at the point of sale, not their production costs.
- Packaging costs should always be calculated as the total costs of the packaging operation and related activities, including costs of damage and loss attributable to package defects, not just the price of packages or packaging materials. Total packaging costs include costs of procurement and storage; packaging equipment investment; packaging operations including personnel costs; related transport and distribution costs; and the costs of packaging-related losses and insurance for them.
- It should be borne in mind that the lowest-cost packaging is not always the most economical overall. On the contrary, the cheapest available packages may be of inferior quality, leading to packaging-line breakdowns and product damage during transportation, with consequent increases in total distribution costs.
- The first consideration in choosing a package and its constituent materials should always be its quality and performance. Packaging should be of the optimum quality for the task, not the best quality in an absolute sense.
- The continuous availability of the selected packaging may also be an important cost factor. To avoid expensive surprises arising from delivery delays, the reliability of suppliers should be investigated before placing orders.

It should be stressed that besides cost evaluation, packaging alternatives should be carefully compared on the basis of how well they meet all the technical requirements of the product and the distribution chain. When the alternatives have been analysed and the optimum one chosen, the planning phase can be considered complete and implementation – including detailed design and specification – can commence. Choice is often a compromise but should always meet the basic functional requirements as determined by initial market research.

3. Design approach for consumer and bulk packaging for ground cumin seeds

Product Features: Exported spices must be top quality, so packaging must protect its key qualities such as its smell, flavour, and appearance over the products expected shelf life. In addition, packaging must protect the spice from insect infestation and contamination. There are different requirements for whole and ground spice. Ground cumin is highly sensitive to climate as it loses volatile oils at higher temperatures. Under humid conditions, it loses free-flow properties and is also becomes vulnerable to microbial contamination. The spice is in the form of powder with agreed moisture content by weight of say 6%.

Packaging should:

- Resist oils and fats;*
- Abide by the food regulations of the export markets;
- Protect the product from seepage and spoilage;*
- Protect against physical-chemical and microbial spoilage due to temperature, humidity, light and oxygen;*
- Prevent loss of volatile oils, aroma and flavour;*
- Protect against pick up of foreign odours;*
- Be economical and competitive;
- Allow the printing of attractive graphics.*

The importance of attributes will vary according to whether the packaging is primary, secondary or tertiary (consumer, institutional or transport). Attributes marked with * will have greater relevance for the consumer

packs. Printing and graphics are less important than functional qualities for institutional packs. Bulk or shipping containers need to be stronger to be road-worthy.

Testing the shelf life of produce in different kinds of packaging: A shelf-life study has to be undertaken to test the effectiveness of various consumer packaging options. As an example, table 15 includes the shelf life information and loss of volatile oils of ground cumin seeds at accelerated storage conditions (92% relative humidity, 380°C) in different kinds of pack.

Table 15. Shelf life of ground spice (cumin seeds) in different packs

Type of consumer pack (net quantity)	Shelf life; caking and lumping (days)	% loss (volatile oils at the end of shelf life)
Flexible (LDPE) 200 g (100 g)	70	75
Flexible laminate metallized polyester 12μ/15 g LDPE (100 g)	120-150	30
Soda lime glass container – colourless, clear, flint glass, with aluminium cap	Excellent with minimum loss of volatile oils	
Tin plate can with a tagger and snap fit lid	Excellent with minimum loss of volatile oils	

Note: Sample values to explain the design procedure

Different options for consumer packs: Choose your pack according to shelf life, cost and marketing appeal. Flexible metallized laminate, glass containers and metal containers, each to contain 100 g of spice are selected as possible options. The next step is to lay down the specifications for each and make selection on the basis of costing for each:

- **Specifications for flexible laminates:** The structure should be metallized polyester 12μ/150 g LDPE. (100 g) with inner layer as LDPE. Inner contact layer should be a food-grade material with good sealing properties (metallocene grade is preferred). Metal deposition should be specified as 2-4 OD (unit for metal deposition). Plastic film or plastic granules should come with food-compatibility certificates.
- **Specifications for metal and glass containers** (see table 16).

Table 16. Metal and glass consumer packs (representative specification details for 100 g)

Metal pack specifications	Glass pack specifications
Material of construction: tin plate prime	Soda lime glass, colourless, clear, flint glass, free from cracks, pin holes, gas bubbles and blisters
Tin coating inside/outside-E-25	
Thickness of Tin Plate-up to 250 g 0.20 mm(nominal)	Brimful capacity 105+/- 5ml
Lacquer internal – gold lacquered (ensure no salt added),external-as per print requirement	
Construction: shape as per exporters requirement round/rectangle; seaming-all dry seams, double seaming	Neck finish – a)38/46/53 mm RO type as per IS 7511-1971
Type of closure-friction or the lever lid	
Tagger-optional (for friction lid and lever lid closure) but for other (metal/non-metal) type of closures RTL tagger of aluminium should be used	Weight 160+/- 3 g/m ²
Labels-printed attractive wrap round labels	
Capacity of container for 100 g – 223 ml (volume calculated based on powder bulk density of 0.48 to 0.50 giving 3% ullage)	Closure-38/46/53 mm dis ROPP caps as per IS 8353-19779 with 1.66 mm thick pad) No insert
Aluminium foil tagger and snap fit lid	

Selection of direct bulk packs: Market practice (gather the same from the importer or other reliable sources) is to use direct bulk packs in 25 kg, 40 kg, 50 kg and 70 kg sizes.

Representative specifications for a 25 kg bulk bag are shown in table 17.

Table 17. Specifications for a 25 kg bulk bag

Plastic woven bag	Kraft paper sac
HDPE (high density polyethylene) woven flat or HDPE/PP (polypropylene) woven circular fabric with optional loose liner bag of 40/50 or 70 kg	a) 5ply sack kraft paper with loose liner bag 25-50 kg and 70 kg b) Paper reinforced with woven HDPE fabric bag 25-50 kg and 70 kg
Denier 1000	Grammage and individual plies (g/m ²)-80/80/80/80/80+/-4 g/m ² per ply
Ends/dm 50 +/-5 Picks/dm 50+/-5	Tensile strength (N/15mm) of individual ply (min).MD 75,CD 50
Breaking load (kilogram force (kgf)) warp-way 85+/-5, Weft-way 85 +/-5	Elongation-% at break of individual ply (max) MD 2.5, CD 4.5
Seam strength (kgf) bottom 39+/-2 Side 35+/-2	Tear factor of individual ply (min) MD 100, CD 120
Stitching shall be 10 mm from the edge. The number of stitches per 10 cm shall be between 9 and 11	Tea-J/m ² of individual ply MD 137, CD 68 (in case extensible sack kraft is used)
	Porosity (gurley) sec/100 ml of individual ply(max) 20
	Instead of using a loose liner bag, the inner ply of the paper sack could also be laminated with LDPE.

The consumer pack must be suitable to be packed in the shipping container, which will usually be a corrugated box.

Organic labelling and graphics will have to be designed for the particular markets and the applicable regulations on organic declaration.

4. Packaging for fresh organic pineapples

Product features: Pineapple is categorized as a tropical and subtropical fruit. Standards are applicable, for example those issued by: EUREPGAP (EUREP's 'Good Agricultural Practice'), United Nations Economic Commission for Europe (UN-ECE), Organisation for Economic Co-operation and Development (OECD), the Codex Alimentarius Commission, and the Common Agricultural Policy (CAP is the standard for EUREPGAP certification). These standards are primarily used to determine size, quality tolerances and presentation (including uniformity) which are relevant when determining packaging specifications.

Pack size and weight usually are governed by the market practice or the demands from the importer. This has to be optimized with the pallet size and transportation mode. Let's assume there is a need to pack six pineapples in a pack allowing for each pineapple to weigh between 5 to 7 kg.

Packaging attributes: The packaging should protect the product from the external environment and may have to deal with impact, pressure, compression and vibration or different temperature and moisture conditions. In addition, it should facilitate distribution, inform end-users about the product, and market the product.

The most often used containers are corrugated fibreboard boxes, which serve as a consumer display box as well as transport containers. These may need internal fitments to further protect the fruit.

The transport packaging needs to protect the pineapples from rough handling and be able to withstand a stacking height of up to 2.5 m. It needs to be able to survive high humidity, which is occasionally present

during transport. The transport packaging should also have ventilation holes to allow air to circulate around the produce in the inner packaging and maintain temperature.

Corrugated fibreboard box specifications: To test the suitability of the packaging, it should undergo tests to simulate the effects of stacking, vibration, dropping and impact during transport. Conditions could be accelerated to get quick results.

Typical specifications are shown in table 18.

Table 18. Specifications for sourcing of a CFB box for export of fresh pineapples

Box style	Style 1	Style 2	Style 3	Style 4
Capacity of bulk pack (approx. number)	5-7 kg (6)	5-7 kg (6)	5-7 kg (6)	5-7 kg (6)
Construction material	Corrugated fibreboard	Corrugated fibreboard	Corrugated fibreboard	Corrugated fibreboard
External dimensions (mm)	400 x 300 x 200	400 x 300 x 200	400 x 300 x 200	400 x 300 x 200
Style of box	RSC (0201)	Telescopic (0300)	Telescopic (0306)	Telescopic (0312)
Number of plies	3	Lid-3 Tray-3	Lid-3 Tray-3	Lid-3 Tray-3
Type of flutes	B (narrow)	Lid-B (narrow) Tray-B (narrow)	Lid-B (narrow) Tray-B (narrow)	Lid-B (narrow) Tray-B (narrow)
Grammage (g/m ²) outer to inner (indicative)	250/150/150	Lid-250/150/150 Tray-250/150/150	Lid-250/150/150 Tray-250/150/150	Lid-250/150/150 Tray-250/150/150
Burst factor of paper (kraft) minimum	2	20	20	20
Bursting strength of board (kg/cm ²) minimum	11	Lid/tray-11	Lid/tray-11	Lid/tray-11
Compression strength of box (kgf) minimum	350	350	350	350
Cobb (30 minutes) g/m ² maximum	60	60	60	60
Number of ventilation holes	14	14	14	14
Hole diameter (mm) and position				
• Two sides each	2	2	2	2
• Two ends each	1	1	1	1
• Top and bottom each	4	4	4	4

Use only starch-based adhesives for corrugated fibreboard construction and hot melts for box construction. Paper used in construction of boxes should meet the specified heavy-metal limits and should carry a certificate to that effect. Boxes or the paper used for manufacturing should not be subjected to chemical treatment or fumigation.

Additional Notes:

Health and safety in paper and board packages: Materials and products must be manufactured in compliance with good manufacturing practices so that, under their normal or foreseeable conditions of use,

they do not transfer their constituents to foodstuffs in quantities which could endanger human health or spoil the foodstuffs or damage their taste or smell.

If sold loose, each pineapple should have a tag to identify that it is organically grown (as shown in figure 26).

An exporter wanting to enter the world of organically-grown produce should feel comfortable with the ethos and nature of this business. To understand the sector, it is recommended that exporters study bio-outlets, bio-importers and those supermarket chains introducing their own eco-labels.

Appendix Further resources

- ITC, 'Product Carbon Footprinting Standards in the Agri-food Sector', 2012, available online at: <http://www.intracen.org/Product-Carbon-Footprinting-Standards-in-the-Agri-Food-Sector/>.
- ITC. 'Export Quality Management – A Guide for Small and Medium-Sized Exporters,' second edition, 2011.
- Websites of eco-labelling systems and marks:
 - Global Ecolabelling Network: <http://www.globalecolabelling.net/>
 - Green Seal (United States): <http://www.greenseal.org/>
 - Blue Angel (Germany): <http://www.blauer-engel.de/en/index.php>
 - Nordic Swan (Nordic countries): <http://www.svanen.se/en/>
 - Eco Mark (Japan): <http://www.ecomark.jp/english/>
 - Ecomark (India): http://www.cpcb.nic.in/ecomark_logo.php
 - EcoLogo (Canada): <http://www.environmentalchoice.com/en/>
 - EU Ecolabel: <http://ec.europa.eu/environment/ecolabel/>
- For information and support on food sustainability requirements, see: <http://www.theconsumergoodsforum.com/>.
- Sagar Shejwalkar and Prasad Balan Iyer 'Twelve principles of green packaging,' DEStech Publications, Centre for Green Technology / Department of General Engineering, Institute of Chemical Technology, Mumbai, India.
- Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers,' ECR, available online at: http://www.europen.be/download_protected_file.php?file=186.
- A number of standardization efforts are being carried out with regards to biodegradable plastics. The biodegradability of these materials needed to be demonstrated in appropriate waste management infrastructures (like composting where biodegradation can occur). Standards that have been developed or are under development include:
 - ASTM Standards (United States):
 - D883 Standard Terminology Relating to Plastics;
 - D5338 Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions, Incorporating Thermophilic Temperatures;
 - D6002 Standard Guide for Assessing the Compostability of Environmentally Degradable Plastics;
 - D6400 Standard Test Specification for Labelling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities;
 - D6691 Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium.
 - The European Commission (EC) has mandated the development of Standards for Biodegradable Packaging Materials. This is under the jurisdiction of CEN TC 261(packaging)/SC4 (packaging & environment)/WG2(degradability & compostability). The Standard (EN 13432) is very similar to the ASTM D6002, except that it has pass/fail specifications built into it. In Germany, for biodegradable plastics to be accepted in compost operations and satisfy the DSD requirement, the plastic will have to pass the DIN 54900.

- ISO 14000 series of standards provides specifications and guidelines for various environmental management disciplines, including environmental management system (EMS), environmental performance, environmental auditing, environmental labelling and life cycle assessments. The most popular of the ISO 14000 series of standards is ISO 14001: Environmental Management Systems – Specification with Guidance for Use. Other standards of interest include:
 - o **ISO 14020** – Environmental labels and declarations – General principles;
 - o **ISO 14031** – Environmental management – Environmental performance evaluation – Guidelines;
 - o **ISO 14041** – Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis;
 - o **ISO 14042** – Environmental management – Life cycle assessment – Life cycle impact assessment;
 - o **ISO 14855** – Determination of the ultimate aerobic biodegradability and disintegration of plastic materials under controlled composting conditions – Method by analysis of evolved carbon dioxide – Part 1: General method;
 - o **ISO 14852** – Determination of the ultimate aerobic biodegradability of plastics materials in an aqueous medium – Method by analysis of evolved carbon dioxide.



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The International Trade Centre (ITC) is the joint agency of the World Trade Organization and the United Nations.