PRACTICAL ACTION
Technology challenging poverty

FILLING AND SEALING PACKAGED FOODS

technical brief

Introduction

This Technical Brief describes the methods for filling and sealing food containers in small-scale processing. For more detailed information on packaging materials used for foods, see Technical Brief: *Packaging Materials for Foods*, and the special considerations when packaging foods in glass containers are described in Technical Brief: *Packaging Foods in Glass.*
The requirements when filling foods into containers are:

- To accurately fill the correct amount of food to prevent under-filling (a legal requirement in most countries) and to prevent product 'give-away' by overfilling.
- To avoid spillage or contamination of the sealing surface so that the container can be properly sealed.

The ability to maintain the quality of a food for the required shelf life depends mostly on adequate sealing of containers. A wide variety of closures are used to seal containers, to suit the properties of different foods and their expected shelf life. However, seals are the weakest part of containers and also suffer more frequent faults, and precautions needed to adequately seal containers are described below.

Filling

Solid foods are either in the form of large pieces (e.g. cut fruit and fish) or particles that flow like liquids (e.g. powders, rice, beans, maize etc.). At a small scale of operation, large pieces are usually packed by hand whereas powders and small particulate foods can often be filled using similar fillers to those used for liquids. These fillers are described in this Technical Brief.
Liquids can be either thin (e.g. milk, wines and juices) or thick (viscous) such as oils, pastes, creams, sauces or jams. No one type of filling machine is suitable for all types of foods and the selection of suitable equipment depends on the viscosity, temperature, particle size and foaming characteristics of the product, and the production rate required.

Filling thin liquids and particulate foods

The simplest manual filler is a jug, but this is often too slow. A simple manual filling machine for liquids is made by fitting one or more taps to the base of a large bucket or tank. The bucket should be stainless steel for filling hot acidic liquids (e.g. fruit juices) or food-grade plastic for cold filling. The taps should be 'gate-valve' types and not domestic water taps, which are more difficult to clean. In manual filling, the amount of food dispensed into the container is judged by the operator, and training is required to ensure that consistent volumes are filled into every container.
There are a variety of dispensing machines that control the volume of liquid that is filled into each container, and do not rely on the judgement of an operator. Timed gravity fillers are an economical type of volumetric filling machine, but the range of applications is limited to low-viscosity liquids that do not foam (e.g. bottled water and alcoholic spirits). The product is contained in a tank above a set of pneumatically operated valves. Each valve is independently timed to deliver precise amounts of liquid under gravity into the containers. Another type of filler is a 'dispenser' that is fitted with a 3-way valve (Fig. 1). In the first position the valve allows a cylindrical chamber to fill from a tank above. It is then moved to the second position to empty the food into a container below. The volume of food in the cylinder can be adjusted to fill different sized containers.

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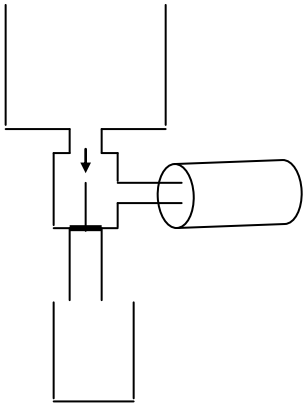
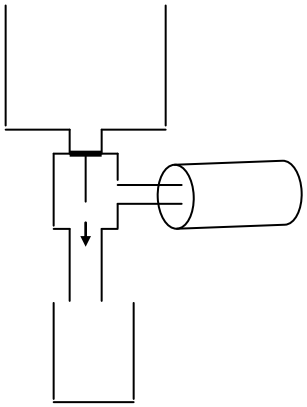
Fig. 1. Operation of liquid dispenser



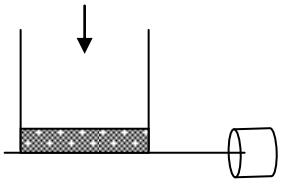
1. Filling cylinder from product tank



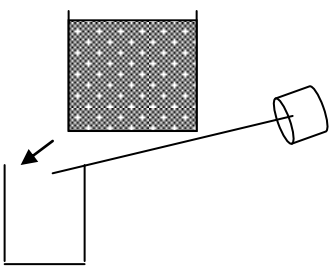
2. Emptying cylinder into container

Machines for filling powders and particulate foods have a hopper that is filled with food, and when the weight of food reaches a pre-set limit, the base of the hopper opens to drop the powder into a container below (Fig. 2). The pre-set weight can be adjusted to fill different sized containers. These machines are used to fill flour, grains and other foods that have uniform sized pieces.

Fig. 2. Filler for particulate foods



1. Filling the hopper



2. Discharging preset weight into container

Filling viscous liquids and liquids that contain particles

Because viscous liquids do not flow easily, a dispenser or piston filler is the preferred option. Dispensers are similar in operation to the equipment described in Fig. 1, but have a moving piston in the cylinder to pump viscous products into the container). This equipment is relatively low-cost but has lower production rates than piston fillers. A small gear-pump filler (Fig. 3) can be adjusted to dispense viscous liquids at volumes from 20 -999 ml and has a an anti-drip outlet that prevents food contaminating the sealing area of the container.

Fig. 3. Dispensing filler for viscous liquids
Photo from Glenvale Packaging Ltd.

A semi-automatic piston filler can either have a row of filling heads (Fig. 4), or they can be arranged in a circle as a 'carousel' filler. In operation, a piston draws product from a hopper into a cylinder and a rotary valve then changes position so that when the piston returns, the product is filled into containers. Piston fillers are relatively expensive to buy and are therefore suited to higher production volumes. This type of filler is less suitable for low-viscosity products, which can leak between the piston and cylinder.

Fig. 4. Piston filler
Photo from Inline Filling Systems Inc.

Both low- and high-viscosity liquids may contain particles of food (e.g. fruit pulps, sauces and pickles) and these are more difficult to fill because simple liquid fillers described above may become blocked by particles. For manual filling, a wide-mouthed stainless steel or plastic funnel is more suitable, and products can be pushed through the funnel using a plastic plunger. Filling machines for high-viscosity liquids and liquids that have particles use servo pumps. Each filling nozzle has a dedicated servo-controlled positive displacement pump, but the capital cost of this equipment is high compared to other types of filler.

Hermetically sealed glass jars or metal cans that are used for bottled or canned foods are not filled completely. A 'headspace' is needed above the food to form a vacuum when it cools. When filling solid foods or pastes, it is necessary to prevent air from becoming trapped in the product, which would reduce the headspace vacuum. Viscous sauces or gravies are therefore filled before solid pieces of food. This is less important with dilute brines or syrups, as air is able to escape more easily before sealing (see also Technical Briefs: *Packaging Foods in Glass* and *Canning of Foods*).

Sealing

Different types of closures for plastic and glass containers include metal or plastic caps and lids, and foil, plastic or paper covers. It is not possible in this Technical Brief to describe each of these closures in detail. In practice the selection of a package and closure depends mostly on their local availability and relative cost. The choice of packaging may therefore be a compromise between what is required and what is available/affordable, the penalty being a reduction in shelf life of the food.

Pilferage and tampering

Although total protection is not possible, tamper-resistant packaging delays entry into the package and tamper-evident packs indicate whether tampering has been attempted or has occurred. The main use of tamper resistance/evidence is for bottles, pots and jars that enable consumers to use the contents a little at a time and therefore need to be re-closable. Examples of tamper-evident or tamper-resistant closures are shown in Table 1.

Table 1. Tamper-evident / -resistant packaging

Type of packaging	Tamper-evident or tamper-resistant features
Bottles and jars (glass or plastic)	Foil or membrane seals for wide-mouthed plastic pots and bottles
	Heat-shrinkable plastic sleeves for bottle necks, or bands or wrappers placed over lids. Perforated plastic or paper strips that must be cut or torn to gain access
	Breakable rings or bridges to join a bottle cap to a lower section (the container cannot be opened without breaking the bridge or removing the ring)
	Roll-on pilfer-proof (ROPP) caps for bottles (during rolling, a tamper-evident ring in the cap locks onto the bottle neck. A seal breaks on opening and the ring drops slightly)
	A safety button in lids for heat sterilised jars (a concave section formed in the lid by the headspace vacuum becomes convex when opened)
	A breakable plastic strip that shows if a jar has been opened
Flexible films	Film must be cut or torn to gain access
	Blister or bubble packs that show if the backing material has been separated from blisters.
	Laminated plastic/foil pouches must be cut to gain access
Tubes (aluminium or plastic)	Foil membrane over tube mouth that has to be punctured to gain access
Cans	Steel or aluminium cans are inherently tamper-resistant (see also Technical Brief: *Canning of Foods*)

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Sealing plastic or glass bottles and jars

Details of sealing glass containers are given in Technical Brief: *Packaging Foods in Glass*.
Bottle and jar closures can be grouped into three categories:

1. ***Pressure seals***, used mostly for carbonated beverages. They include:
   - Screw caps.
   - Crimp-on lever-off ('crown' caps), or crimp-on screw-off steel caps. Crown caps can be sealed using the equipment shown in Fig. 5.
   - Roll-on screw-off aluminium caps. Roll-on screw caps can be fitted using a manual capper (Fig. 6) (also Roll-on-Pilfer-Proof (ROPP)) aluminium caps).
   - Cork or polyethylene stoppers.
2. ***Normal seals***, used for non-carbonated liquids (e.g. milk or wines):
   - Pre-threaded, aluminium screw caps.
   - Lug type screw twist-off steel caps. These 'Omnia' caps can be fitted using a simple manually operated capper (Fig. 7).
   - Press-on, prise-off plastic caps.
   - Push-in pull-out, or push-on pull-off caps, such as cork or synthetic stoppers. Corks can be inserted by hand after soaking overnight in clean water, or using a corking machine (Fig. 8).
3. ***Vacuum seals***, used for hermetically sealed jars:
   - Screw-on twist-off or screw-on screw-off caps.
   - Press-on prise-off, or press-on twist-off caps.
   - Crimp-on prise-off caps.

Screw caps are usually hand fitted in small-scale operations.
In each type of closure the seal is formed by pressing a cushioning material against the rim of the container. The pressure must be evenly distributed to give a uniform seal around the rim. Typically, the cushioning material is made from plastic, cork or paperboard.

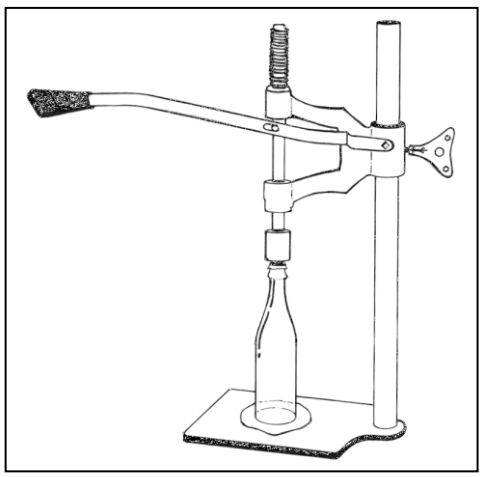


Fig. 6. Manual roll-on screw capper

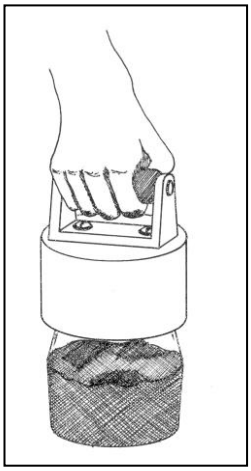
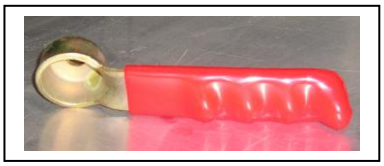


Fig. 8. Corking machine



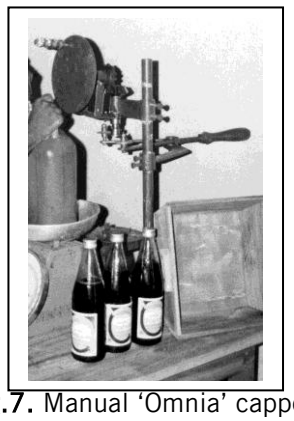


Fig.7. Manual 'Omnia' capper

Fig. 5. Different types of Crown cappers
Photo from Peter Fellows

technical brief

Plastic bottles can have a variety of closures that have a pouring spout to dispense the contents. For example, caps can have a hinged top that reveals a dispensing opening in the cap. They are used for sqeezeable bottles (e.g. for creams, oils, sauces, mustard, mayonnaise or syrups).

Pot sealers

A semi-automatic heat sealer is available for sealing film lids onto plastic pots at up to 100 pots an hour, but it is expensive and requires a source of compressed air. A cheaper and simpler sealer (Fig. 9) is available which will seal about 60 pots/hour. Alternatively an electric iron can be fitted to a suitable stand (e.g. a drill stand) and pressed down onto the surface of the pots to seal the film. Plastic trays are sealed with a plastic film or foil laminate (see Technical Brief: *Packaging Materials for Foods*) that is heat sealed to the top flanges of the tray. Narrow-necked ceramic pots may be sealed with a cork stopper covered with candle-wax or beeswax.

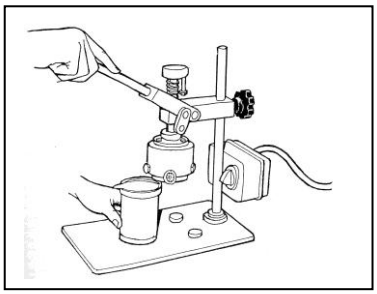


Fig. 9. Pot sealer

Wide-mouthed plastic pots and tubs or glass jars can be sealed by a range of different closures, including push-on, snap-on or clip-on lids (e.g. tubs for margarine or ice cream), and push-on or crimp-on metal or plastic caps (e.g. for nuts and snackfoods). These closures are not tamper-resistant, but containers can be fitted with tamper-evident aluminium foil or plastic membranes (e.g. yoghurt pots). Where a product is to be used over a period of time, or where additional protection is required for the membrane, a plastic clip-on lid may also be fitted to the pot. Rigid plastic or cardboard tubs for dry products can have a lid that opens so that the contents can be poured or shaken from the pack (e.g. small cardboard tubs for salt or spices). These 'disc top' closures have a plastic disc that is flipped up to reveal an opening.
Special equipment is needed to seal metal cans (see Technical Brief: *Canning of Foods*)

Sealing pouches, bags and sacks

Plastic films

Most plastic films are heat sealed but cold seals (adhesive seals) are sometimes used for heat-sensitive products (e.g. chocolate, chocolate-coated biscuits or ice cream). To seal flexible films, the two surfaces of the film are heated until they partly melt and pressure is used to fuse the films together. The strength of the seal depends on the temperature, pressure and time of sealing. Although it is possible to seal plastic bags by folding the film over a used hacksaw blade and fusing it with a flame, the quality of the seal is variable and less attractive than using an electric heat sealer. A better (and faster) option is to use an electric bar-type heat sealer (Fig. 10). If electricity is not available, it is possible to modify the sealer to heat the bar directly with a flame. A broader seal is formed with this equipment, which has better barrier properties and appearance. Sachets can be made by either buying film in the form of a tube, or by cutting the film and sealing the long side to make a tube. One end is sealed and foods are filled, before sealing the second end. It is important that foods do not stick to the inside of the pack where the seal is to made because they prevent a proper seal from forming or reduce its strength.

Fig. 10. Bar sealer for plastic film

Hot-wire sealers have a metal wire that is heated to red heat to simultaneously form a seal and cut the film, whereas a bar sealer holds the two films in place between heated jaws until the seal is formed. In the impulse sealer, films are clamped between two cold jaws. The jaws are then heated to fuse the films and they remain in place until the seal cools and sets.

Fig. 11. Band sealer for plastic film
Photo from Peter Fellows

Rotary (or band) sealers (Fig. 11) are used for higher filling speeds. They have continuous belts that pass the mouth of a sachet or bag between heated rollers, and the two sides of the film are welded together. The seal may then pass through cooling belts that clamp it until the seal sets.

Form-fill-seal (FFS) equipment

FFS equipment has different forms: vertical form-fill-seal, known as 'transwrap' or 'flow pack', and horizontal form-fill-seal known as 'pillow pack' or 'flow wrap'. The machines use a roll of film, which they form into a tube, seal one end, fill the food and then seal the other end in a continuous operation. All types of FFS equipment are very expensive, require a source of compressed air and skilled maintenance technicians, and are therefore not likely to be affordable by small-scale processors.

Shrink-wrapping and stretch-wrapping

Low-density polyethylene (see Technical Brief: *Packaging Materials for Foods*) is a film that shrinks in two directions when it is heated by either hot air or a radiant heater. Shrink-wrapped bottles, jars etc. are replacing cardboard distribution boxes in many countries (Fig. 12).

Fig. 12. Shrink-wrapped bottles and jars
Photo from Aqua Technology Inc

In stretch-wrapping, polyethylene or polyvinyl chloride film is wrapped under tension around boxes on a pallet. The equipment is simple and low-cost (Fig. 13). Shrink-wrapping can also be used to manually wrap individual pieces of food (e.g. cheese) or to form the lid of plastic trays.

Fig. 13. Stretch-wrapping cartons
Photo from Advance Lifts)

Sealing boxes and cartons

Cardboard cartons or boxes that contain packaged foods are usually sealed by either hot-melt glue, or by adhesive tape. Simple tape dispensers (Fig. 14) are available, which make carton sealing faster and more efficient.

Fig. 14. Adhesive tape dispenser

Sacks

Sacks can be sealed by hand-stitching, but more commonly in commercial operations they are sealed using an electric sack-stitcher (Fig. 15).

Fig. 15. Sack stitcher
Photo from Peter Fellows

Check-weighing and metal detection

Scales (Fig. 16) are used to ensure that fill-weights meet legal requirements and to minimise product give-away. They are tared to take account of the weight of the package and samples of products are taken from the production line to check that the net weight (i.e. the weight of product in the pack) is correct. At larger production rates, automatic check-weighers are fitted to product conveyor belts, where they weigh each pack and automatically reject those that are over/under-weight. These are however, very expensive and unlikely to be used at a small scale. Contamination with metal fragments can occur during processing as a result of wear or damage to equipment, and metal detectors are therefore an important part of quality assurance in all food processing. The basic components of a metal detector are a detection head, a conveyor that moves the products under the detection head, and a reject system that removes all packs that contain metal fragments. However, metal detectors are expensive and are often not used by small-scale processors.

Fig. 16. Check-weighing scales

Labelling of packages

Labelling options and requirements are described in Technical Brief: *Food Labelling.*

Equipment Designs

Practical Action has designs for the following hand-operated equipment: jar sealer, Crown cork bottle sealing machine and pilfer-proof capping machine. Engineering drawings are available on request.

Equipment suppliers

Note: This is a selective list of suppliers and does not imply endorsement by Practical Action. A comprehensive list of worldwide packaging suppliers and support institutions is provided by Packaging International at www.packaging-int.com/companies/

Filling and sealing equipment

- *Alvan Blanch* Chelworth Malmesbury, SN16 9SG, UK., Tel: +44 (0)1666 577333, Fax:+44 (0)1666 577339 , info@alvanblanch.co.uk , http://www.alvanblanch.co.uk
- *Aqua Technology Inc.*, San Jose, Sunnyvale, Pismo Beach, CA, USA., Tel: 1 800 4787342/1-805-773-4502, Fax: 1 805 7734409, e-mail: purewater@earthlink.net Website: http://www.aquatechnology.net/shrink_wrap.html
- *Bombay Engineering Industry* R.No.6 (Extn.), Sevantibai Bhavan, Chimatpada, Marol Naka, Andheri (East), Bombay - 400 059, India, Tel: +91 (0) 22 8369368 / 8215795, Fax: +91 (0) 22 8369368.
- *Fisher Scientific UK Ltd*. Bishop Meadow Road, Loughborough, LE11 5RG, UK., Tel: +44 (0), Fax: +44 (0) 1509 231893 1509 231166, E-mail: info@fisher.co.uk , Website: http://www.fisher.co.uk
- *Gardners Corporation*, 6 Doctors Lane, Near Gole Market, PO Box 299, New Delhi - 110001, India, Tel: +91 11 3344287 / 3363640, Fax: +91 11 3717179.
- *Glenvale Packaging Ltd.*, Unit 3, Edison Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6AH, UK., Tel: +44 1933 673677, Fax: +44 1933 676728, E-mail: info@glenvale-pkg.demon.co.uk , Website:http://www.glenvale-pkg.co.uk
- *Inline Filling Systems Inc.*, 216 Seaboard Avenue, Venice, Florida 34285, USA., Tel: +1 941 4868800, E-mail/Website: http://www.liquidfiller.com/

- ***Rank and Company*** A-95/3, Wazirpur Industrial Estate, Delhi - 110 052, India, Tel: +91 11 7456101/2/3/4, Fax: +91 11 7234126/7433905, E-mail: rank@poboxes.com .
- ***Orbit Equipments PVT. Ltd***. Block No.1, Venkat Reddy Complex, Tarbund X Roads, Secunderabad -560 009, India, Tel: +91 (0)40 2817296, Fax: +91 (0)40 2813877
- ***Technology & Equipment Developmen***t, Centre Liduta, 360 Bis Ben Van Don St., District 4, Ho Chi Minh City, Vietnam, Tel: 08 9400906, Fax: 08 9400906.

Form fill seal machines

- ***Acufil Machines*** SF.120/2, Kalapatty, Coimbatore -641 035, India, Tel: +91 (0) 422 866108/866205, Fax: +91 (0)422 572640, E-mail: gondalu@yahoo.com ,

Materials

It is not possible for small-scale producers to buy packaging or closures directly from manufacturers because the minimum order size is likely to be too large. Processors should therefore find packaging distributors/agents either locally or in neighbouring countries. However, the packaging manufacturers have information on their websites that may assist in selecting the correct types of materials. Further information on closures for glass and plastic containers is available from for example:

- *Caps for plastic bottles and glass bottles*, company information from e-Bottles, available at www.ebottles.com/showbottlefamilys.asp?type=2&mat=closures
- *Dispensing closures*, company information from Bottle Solutions, available at www.bottlesolutions.com/product/category-8c8bdd72-13dd-4069-9c21-f9e5e370e3de.aspx

References

- *Packaging Foods in Glass*, Practical Action Technical Brief
- *Canning of Foods*, Practical Action Technical Brief
- *Packaging Materials for Foods*, Technical Brief, Practical Action
- *Food Labelling*, Technical Brief, Practical Action

Further Reading

- ***A Handbook of Food Packaging***, 2nd Edition, Paine, F.A and Paine, H.Y., Blackie Academic and Professional, London, 1992.
- ***Appropriate Food Packaging***, 2nd Edn., Fellows, P.J. and Axtell, B.L., Practical Action Publishing, 2003.
- ***Environmentally-compatible Food Packaging***, Chiellini, E., Woodhead Publishing, Cambridge. 2008
- ***Flexible Food Packaging***, Hirsch, A., Van Nostrand Reinhold, New York, 1991.
- ***Food Packaging- principles and practice***, Robertson, G.L., Marcel Dekker, New York. 1993
- ***Handbook on procurement of packaging***, Ramsland, T., (J. Selin, Ed.), PRODEC, Toolonkatu 11A, 00100 Helsinki, Finland. 1989
- ***Packaging,*** Food Cycle Technology Source Book, Practical Action Publishing/UNIFEM, 1996
- ***Small-scale Food Processing: A Guide to Appropriate Equipment***, Fellows, P. and Hampton, A., Practical Action Publishing/CTA, 1992.
- ***The Packaging Regulations - implications for business***, Powell, J. and Steele, A., Chandos Publishing, Witney, Oxon., UK. 1999

Support Institutions

A comprehensive list of worldwide packaging support institutions is provided by Packaging

International at www.packaging-int.com/companies/. Further information can be obtained about local costs and availability of different types of filling and sealing equipment from the following institutions:

- ***Asian Packaging Federation***, c/o Sri Lanka Institute of Packaging, 290, D.R. Wijewardena Mawatha, Colombo 10, Sri Lanka, E-mail: slip@sltnet.lk
- ***Closure Manufacturers Association*** produces Technical Bulletins (#2: Tamper Evidence, #3: Vacuum Closures - Metal, Plastic and Composite for Various Containers, #5: Dispensing Closures, #10: Types of Closures in Relation to Glass Containers), available at http://closuremanufacturers.org/
- ***Indian Institute of Packaging***, E-2, MIDC Area, Chakala, PO Box 9432, Andheri (East), Mumbai Maharashtra 400093, India, Tel: +91 22 821 9803, Fax: +91 22 837 5302, E-mail: enquiry-iip@iip-in.com , Website: www.iip-in.com
- ***Institute of Packaging (UK)***, Willoughby House, Broad Street, Stamford, Lincolnshire, PE9 1PB, UK., Tel: +44 1780 759200, Fax: +44 1780 759220, E-mail: iop@pi2.org.uk , Website: www.pi2.org.uk
- ***Institute of Packaging Kenya***, P.O. Box 27543, Nyayo, Nairobi, Kenya, Tel: +254 2 340447, Fax: +254 2 21 9755, E-mail: sam_moturi@eankenya.com ,
- ***Instituto Peruano de Envase y Embalaje*** (IPENBAL), Av. Las Palmeras 375, Lima 1 Casilla, Peru, 1806, Tel: +51 14 704485, Fax: +51 14 400891.
- ***Packaging Industries Association of Bangladesh***, 68 Dilkusha Commercial Area, GPO Box 535, Dhaka, Bangladesh, 1000, Tel: +880 2 2372701, Fax: +880 2 833279.
- ***Union Latino Americana Del Embalage*** (ULADE), Avda. Jujuy 425, Buenos Aires, C1083AAE, Argentina, Tel: +54 1149570350, Fax: +54 1149561368, E-mail: iaenvase@infovia.com.ar , Website: www.packaging.com.ar .
- ***Zimbabwe Association of Packaging***, 17 Coventry Road, Workington, Harare, Zimbabwe, Tel: +263 4 753 800, Fax: +263 4 882 020.

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