

PACKAGING MATERIALS

6. PAPER AND BOARD FOR FOOD PACKAGING APPLICATIONS



REPORT

Prepared under the responsibility of the
ILSI Europe Packaging Material Task Force

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By Delphine Ottenio , Jean-Yves Escabasse, Barry Podd

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CONTENTS

INTRODUCTION	5
WHAT IS PAPER AND BOARD?	6
MANUFACTURE OF PAPER AND BOARD	7
BASIC CHEMISTRY	11
PAPER & BOARD AND FOOD PACKAGING APPLICATIONS	15
REGULATORY	16
SAFETY	18
ENVIRONMENTAL ASPECTS	20
GENERAL CONCLUSIONS	23
REFERENCES	24

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INTRODUCTION

Paper and board is the oldest and most versatile packaging materials available on the market today.

It is a paradoxical material: it can be permanent or transient, delicate or strong, cheap or expensive, in abundance or scarce. It can be preserved in a museum or thrown away... It is made and used by the millions of tonnes or may be so rare that only a few tonnes of hand-made paper are produced in a year.

Paper and board, alone or associated with other materials, has been used in food packaging or food contact for many years. A particular effort for adaptation to the environmental concerns and the users' needs was made at the same time as the use of paper and board was increasing. Paper and board is indeed an essential part of our lives and satisfies many human needs. We use it to store and communicate information (newspapers, books, documents and writing paper), for cultural and artistic purposes, to transport and protect goods (packaging, sacks, liquid packaging board), for personal hygiene (tissues, napkins, nappies, etc.) and in medicine (hospital uses).

In 2002, the Confederation of European Paper Industries (CEPI) member countries produced 90 million tonnes of paper and board, 39 million tonnes of pulp, and used 43 million tonnes of recovered paper.

During the same year, the CEPI member countries produced:

- 21 million tonnes of case materials,
- 7.9 million tonnes of carton boards,
- 4.2 million tonnes of other paper for packaging,
- 3.6 million tonnes of wrappings.

The use of recovered paper and board by sector is:

- 19.2 million tonnes of recovered paper used in "case materials sector",
- 3.7 million tonnes of recovered paper used in "carton boards sector",
- 4.4 million tonnes of recovered paper used in "other paper for packaging and wrappings sector".

WHAT IS PAPER AND BOARD?

Paper and board is made from cellulose fibres, which are obtained from trees, recovered papers and annual plant fibres like cereal straws. The industry was at one time based almost entirely on softwoods such as spruce, pine, larch, fir and cedar. Nowadays, hardwoods such as birch, aspen and other hardwoods occurring in temperate climates are used as an ideal raw material for processing into fluting for corrugated cases as well as printing and writing papers, whilst eucalyptus, originally occurring only in Australia and New Zealand, has been successfully cultivated in other warm climates (e.g. South America, Spain and Portugal and even Southern France) as raw material for high-quality pulp suitable for a wide range of papers. Nevertheless, softwoods provide longer fibres (average 3 mm compared with 1 mm for hardwoods) and continue to be used for papers requiring the highest strength characteristics.

Chemically pure cellulose consists of long, ribbon-like molecules made up of smaller glucose units. The glucose units are formed from atoms of carbon, hydrogen and oxygen. These molecules are held together side-to-side by hydrogen bonds to form "sheets", which in turn are stacked together in tightly packed layers to form "microfibrils". The microfibrils group themselves in bundles, and groups of these bundles form the paper fibre. Paper is generally called board when it is heavier than 224 ⁽³⁾ grammes per square metre.

The demands placed on the form of paper and board vary widely with the intended end-use but some are common to all grades, i.e., the paper must be strong enough to fulfil its technical function and also be able to be printed upon in a way that makes it attractive to the consumer.

Paper and board can be used in contact with food in very different ways, either directly or indirectly, and either alone or laminated with other materials such as plastic or metal foil. In the latter case, so-called "functional barriers" are aimed at suppressing any substance transfer between food and the base paper material. The subject of functional barriers in itself would deserve a long presentation, and will not be treated in detail here.

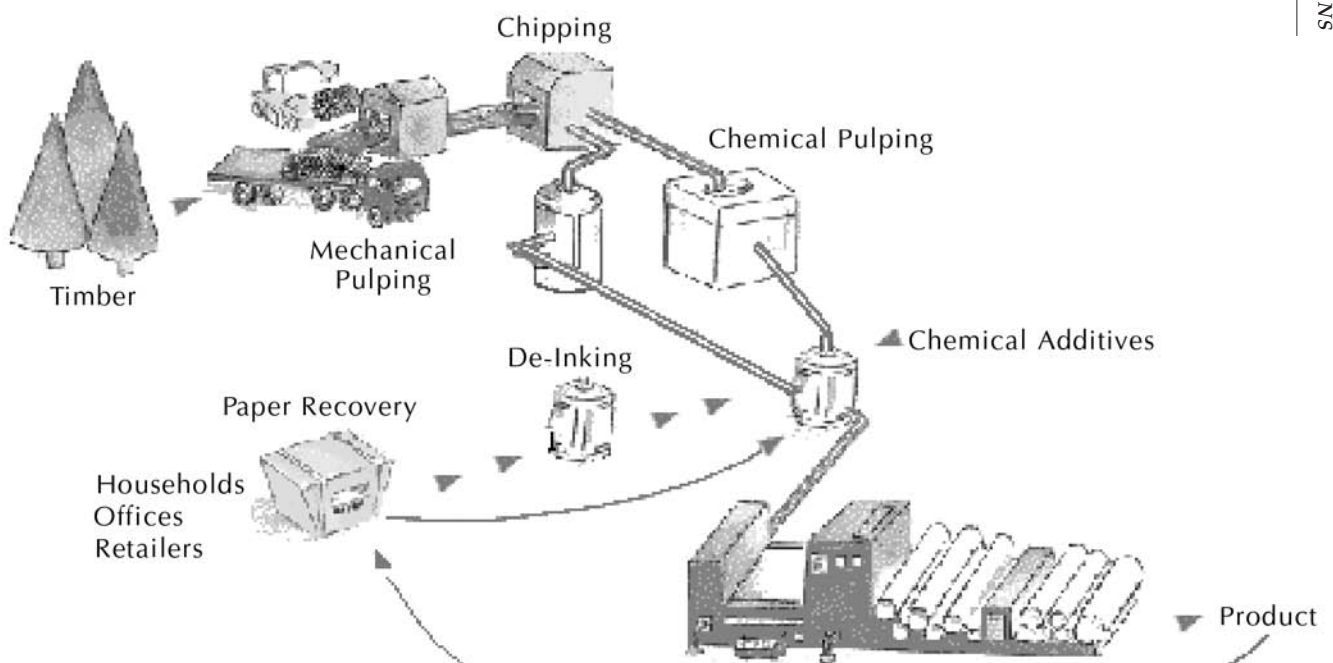
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MANUFACTURE OF PAPER AND BOARD

Paper and board has a long history, beginning with the ancient Chinese (pulp was made from old rags, peels and nets reduced to mush from which paper was manufactured) and continuing to the present day. While hand-made methods dominated for thousands of years, paper production became industrialised during the 19th century: the first machine to manufacture paper continuously was invented by the Frenchman Louis-Nicolas Robert in 1799. Originally intended purely for writing and printing purposes, a wide variety of paper grades and uses are now available to the consumer. Each paper or board grade is produced on equipment tailored for this particular grade and mill. Production processes are optimised for each grade. There are many variables: raw material composition (mixture of chemical softwood and hardwood pulp, mechanical pulp, recovered paper, fillers, pigments, additives, etc.), machine size (width, speed), type of production equipment, and automation level.

Paper and board production (Figure 1) involves two steps. First, the fibres need to be produced. This is done in a pulp mill where pulp is produced using chemical or/and mechanical processes. Pulp production can be integrated with paper production, or the pulp can be produced in a separate pulp mill. The paper itself is then produced on a paper machine from a mixture of fibres (which can be primary or recycled fibres), chemicals and additives.

Figure 1: Simplified scheme of production process

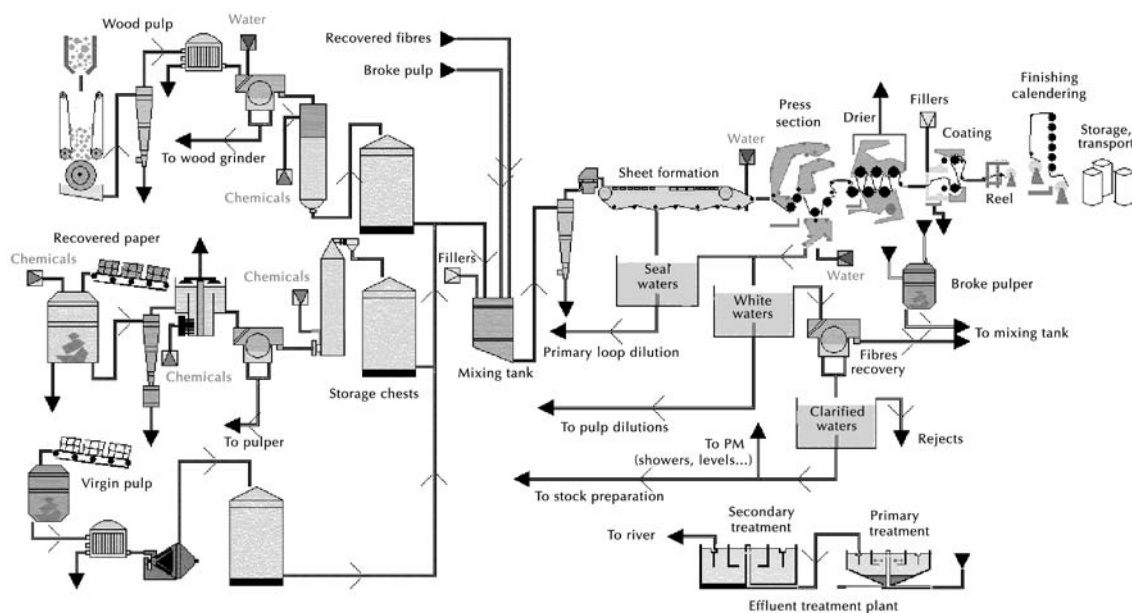


All paper and board machines are based on a similar basic process. There are seven distinct sections: head box, wire section (wet end), press section, drier section, size press, calender and reel-up.

Figure 2 presents the different stages of the manufacture of paper and board (except for tissue papers):

- **The preparation and the cleansing of the pulp:** this untwists the fibres. Beating is a mechanical treatment intended for swelling, fibrillating and shortening the fibres. The result is a better sheet formation and the development of paper's mechanical properties.
- **Before of the paper machine:** the pulp is purified, diluted and air bubbles are eliminated.
- **The wet-end part:** raw material fibres and chemicals (and 99% of the water) are pumped to the headbox, which feeds the stock evenly onto the wire section. This is a woven plastic mesh conveyor belt that can be 35 metres long and up to 10 metres wide. As the paper stock flows from the head box onto the wire, the water drains away through the mesh leaving tiny fibres as a mat on top of the mesh. The paper machine can travel at speeds of up to 2000 m/minute and by the time the paper stock has travelled half way down the wire, a high percentage of water has drained away. By the time the thin mat of fibres has reached the end of the wire section, it has become a sheet of paper, although very moist and of little strength.
- **The press section:** this consists of a number of sets of felts and heavy cylinders through which the moist paper web passes. More water is squeezed out to felts and drawn away by suction. Pressure binds the fibres together and consolidates the web.
- **Dryer:** this consists of a large number of steam-heated drying cylinders which have a temperature of slightly over 100°C. Synthetic drier fabrics carry the paper web round the cylinders until the paper is dry.
- **Coating:** part way down the bank of drying cylinders is the size press, where a solution of water and starch can be added in order to improve the surface for printing purposes. Instead of sizer, a coater can be used to produce coated papers. Coating covers the fibrous surface with a smooth coat of pigments and binding agents.
- **Finishing:** at the end of the drying process, the sheet is smoothed using an "ironing" method, which consists of hot polished iron rollers mounted in pairs with synthetic material rollers, one above the other (calenders or softcalenders). This also helps to consolidate, polish and glaze the surface of the paper: the characteristics of the surface of the sheet are improved.
- **Shipping:** still travelling at very high speeds, the paper comes off the machine ready for reeling up into large reels (also called parent reels), which can be cut or slit into smaller ones, according to customer requirements. These large reels are produced and changed without any interruption of the production process.
- **Quality control:** sensors and computers verify parameters such as the production speed, the pressure, and the resistance at every step of the process to ensure that the paper or board is of a consistently high quality. Moreover, for food contact applications, microbiological, chemical and organoleptical controls have to be carried out.

Figure 2: Overall paper process



A board machine often has several formation devices in the wet end (headboxes and wires) producing a multi-ply sheet, combined on the forming table and press. Basis weight of the boards can be as high as 500 g/sq.m, whereas the printing and writing papers are usually 40-120 g/sq.m. Paper and board machines are each different – the size of the production capacity and technology varies. Each one is tailored to the specification of the paper mill.

Recovered paper and board

Recovered paper is an important raw material in terms of volume and utilisation for the paper industry in many countries. The recycling of paper is an example of sustainable use of resources. Although recycling is both economically and ecologically sound, recovered paper cannot be used in all paper grades.

Broadly speaking, the final production process for recycled paper is the same as the process used for paper made from primary fibres. The main difference is that recovered paper fibres have already been used, so that non-fibre material, originating from previous uses, will have to be removed.

The major steps in the recycling process are:

- **Collection and Transportation:** recovered paper is sorted, graded, formed into bales and delivered to a paper mill.
- **Repulping and Screening:** having reached the paper mill, recovered paper is mixed with water and chemicals, which separates the paper into individual fibres.
- **Cleaning:** following pulping, the pulp mix is diluted with water and passes through a system of centrifugal cleaning equipment and screens: the pulp is filtered and screened through a number of cycles to make it more suitable for papermaking. This is done to remove large contaminants like wood, plastic, stones, glass and paper clips, along with small contaminants like string, glue and other sticky materials: pulp is cleaned in a large spinning cylinder and the heavy contaminants move to the outside of the cylinder and are removed.

- **De-inking:** for certain uses (e.g. for the production of graphic, sanitary and domestic papers but rarely for manufacture of packaging materials) and for certain types of recovered papers (e.g. newspapers and magazines), the fibres have to be de-inked. The de-inking process can be carried out by flotation, with or without washing, with or without kneading, with or without bleaching.
 - Flotation involves the pulp being fed into a large vat called a flotation cell. Soapy chemicals are added to help the ink separate from the pulp. Air bubbles are blown into the mixture. The ink attaches to the bubbles and rises to the top. The inky bubbles are then skimmed off, leaving the pulp ink-free.
 - During kneading the pulp fibres are rubbed against each other, further loosening the inks, while chemicals are added to begin the bleaching process.
 - Bleaching the pulp counters any yellowing effect sometimes seen in paper containing wood fibres like those used for newspaper. The fibres are soaked in chemicals for about three hours in a storage chest. The pulp that went into the bleaching process grey and dirty in appearance comes out much whiter and cleaner.
 - Optionally, more de-inking/washing/kneading/bleaching loops are implemented. If coloured paper is present in the recovered paper furnish, colour stripping may have to be carried out. The pulp is then washed, pressed, kneaded and placed in the decolourization chest. A chemical is added to remove any colours that might tint the pulp. Subsequently, the pulp is washed again to remove any remaining ink particles, fillers or other contaminants.

The finished recycled pulp is now ready to be made into paper and is either sent on a mile-long conveyor to the mill for papermaking, or is formed into sheets of pulp for shipment and sale. Depending on the grade of paper being produced, quantities of virgin pulp from sustainable sources may be added. Some papers, such as newsprint and corrugated materials, can be made from almost 100% recycled paper. Once the paper is used, it can be recycled and the process starts again. Individual fibres will gradually be degraded in the process so a continuous addition of new fibres is necessary to sustain the recycling cycle.

There are different grades of recovered paper and board to satisfy the needs of different producers according to strict specifications.

More than 50 grades of recovered paper and board are defined in the European List of Standard Grades of Recovered Paper and Board (EN 643).

They can be described as follows:

- **Low grades** (mixed papers, old corrugated containers, board, etc.) constitute the main part of the recovered paper consumed. These are used to produce secondary packaging papers and boards, and are not intended to be in direct contact with food
- **De-inking grades** (newspapers and magazines, graphic papers, etc.) are usually also considered as low grades because they need extensive recycling treatments. These are for graphic and sanitary papers.
- **High grades** (scraps, sheets, print offcuts, etc.) require little or no cleaning. They can be used for the production of any paper product as pulp substitute. They may therefore be suitable for food contact packaging.

BASIC CHEMISTRY

The raw materials used in the manufacture of paper and board

Paper and board is manufactured from natural fibres of unbleached or bleached cellulose obtained from plants (primary fibres) or obtained from recovered paper and board (recycled fibres). The paper's characteristics depend on the composition and the treatment of the pulp used. The various treatments carried out determine the aspect of the surface of the paper (e.g. opacity, colour, thickness, weight).

Pulp based on primary fibres is obtained through the separation of fibres from each other and the lignin which is binding them together, while degrading them as little as possible. Four main types of pulp can be distinguished according to the process applied to separate the fibres and the yield of separated fibres:

- Mechanical, thermo-mechanical and chemico-thermo-mechanical pulp (yield higher than 90%). These pulps are used in the newspaper and magazine industry, and in folding box board manufacture.
- Chemico-mechanical pulp (yield between 80 and 90%).
- Semi-chemical pulp (yield between 70 and 80%).
- Chemical pulp (yield between 45 and 55%).

Recovered papers come from merchants who use collection systems. They may be subject to several treatments designed for recovered papers before being passed to the paper machine. These could include: special pulping, de-inking and/or bleaching if necessary, hot dispersion, washing, oxygen or ozone treatment if necessary, and enzymatic treatment.

Whatever the source, the pulp is passed to a reslushing unit (pulper) where it is mixed with up to 100 times its weight of water and subjected to violent agitation intended to produce a suspension of individual fibres in water. At this, and subsequent stages, auxiliary chemicals, additives and fillers may be added.

For the manufacture of paper and board, different mixtures of mechanical and chemical pulps and recycled fibres may be used, depending on end use, and ranging from 100% virgin pulp to 100% recycled fibres. Pulp is supplied directly from forestry and pulping operations. It is delivered to the paper mill in a dry state in stand-alone mills or in a wet state in integrated mills.

Chemical additives used in paper and board manufacture

The additional technical demands (mechanical strength, optical properties) placed on the paper and board are normally obtained through the use of chemical additives which are combined with the fibrous raw materials. The additives can also be applied after paper production – e.g. onto the paper surface. In this case, the process is called "coating". The amount required to achieve the technical effect is very small, i.e., for most additives significantly less than 1% by weight of the paper.

The chemical additives used by the paper industry fall into the following general categories:

- **Functional additives:** these are used to either improve or change the properties of the paper and they are designed so that they are retained in the paper. Typical examples are sizing agents, wet and dry strength resins, softeners, dyes and pigments. The use of these additives is not universal and depends on the required type of paper or board.

Sizing agents can be used to make the paper slightly hydrophobic, which in turn makes it possible to print the paper effectively. Originally they were called engine sizes because they were added to the paper before it was formed but now surface sizing agents are deposited on the surface of the paper after it has been formed. Typically the “engine” sizes used are based on rosin, alkyl ketene dimer or alkenyl succinic anhydride while those added to the surface are polymeric materials based on either styrene or polyurethane. The rosin-based sizing agents are primarily based on tall-oil rosin, which is a by-product of the Pulp Industry. Alkyl ketene dimer is made from fatty acids of animal or plant origin. Alkenyl succinic anhydride is a synthetic material derived from the oil industry. The styrene- and polyurethane-based surface sizing agents are also made from synthetic materials derived from the oil industry. Normally, the rosin-based sizing agents are used under mildly acid conditions while the other products are used under neutral or mildly alkaline conditions. The development of the neutral/alkaline based sizing agents was critical commercially as it permitted the use of calcium carbonate as a pigment as well as china clay.

Wet strength resins are used to make the paper strong while it is wet. Wet strength resins are polymers based on urea-formaldehyde, melamine-formaldehyde or polyamide resins crosslinked with epichlorohydrin. The formaldehyde-based resins are most effective under mildly acid conditions while the epichlorohydrin-based resins are normally used under neutral or mildly alkaline conditions. The development of the neutral/alkaline based wet strength resins was critical to the production of soft, absorbent grades of paper.

Dry strength resins are not only based on natural products such as starch and carboxymethylcellulose but also synthetic materials, such as polyacrylamide. The use of polyacrylamide is not restricted to functional additives such as the dry strength resins.

Colourants are usually of synthetic origin. They are seldom used in paper and board for food contact, and if such is the case, are subject to particular requirements.

Fluorescent whitening agents (FWAs) are also synthetic chemicals. Their function is to absorb ultra-violet rays in daylight and restore it into visible, blue light, thus increasing the brightness of paper and board. Only certain FWAs are permitted in paper and board for food contact.

Fillers usually consist of clay, calcium carbonate or even titanium dioxide and are added to modify the optical properties (in particular opacity) of the paper and board or as a fibre substitute.

- **Process chemicals or Processing aids:** these are used to improve the efficiency of the paper making process and they are designed so that they are not intended to be retained in the paper. Therefore the potential for migration to the food is minimal. Typical examples are defoamers, biocides, felt cleaners and deposit control agents. Paper and board production involves high sheering and steering, favouring the occurrence of foam in chests and circuits. Foam is detrimental to production efficiency and air bubbles may cause defects in the finished products. **Defoamers** are used to prevent its formation. To produce paper and board, large volumes of water are used. Circuit closure involves soluble material concentration in process water. Microbiological degradation is avoided by **biocides** and precipitation on felts and in circuit walls by **felt cleaners** and **deposit control agents**.
- There is also an intermediate group of products that are retained in the paper but are designed to improve the efficiency of the paper-making process. Typical examples are retention aids and drainage aids. Sheet formation involves swift dewatering of low consistency pulp suspension. **Retention aids** are meant to assist in retaining fines and fillers in the wet web, while **drainage aids** increase dewatering speed.

The main challenge facing the papermaker is retaining the chemical additives in the paper so that they can perform their intended technical function. This challenge is the main reason why the contaminants and by-products present in the additives supplied to the paper industry do not end up in the paper. They are mostly soluble in water and therefore remain in the process water during filtration. They can also be evaporated with the steam in the dryer section of the paper machine. There are often limitations placed on the amount of the chemical additives as well as limitations on the by-products and residual monomers present in the polymeric products that can be found in the paper. These values are set by the Regulatory Authorities and, as often as not, are based on toxicological data available for each of the individual substances.

The basic chemistry of the chemical additives is broad, some additives are made from natural products, and others from synthetic chemicals. Some are polymeric while others are monomeric.

The chemical additives are either soluble or readily dispersible in water. This property is important because the papermaking process is an aqueous process that allows the chemical additives to be added directly to the papermaking process without further modification.

Migration under conditions of use

Migration is a major factor in regulating the safety and the quality of packaged food. Migration of chemicals from packaging materials can have an impact both on food safety and on food quality. This is recognised in the European Framework Directive 89/109/EEC, Article 2, which states that: "Materials and articles must be manufactured in compliance with good manufacturing practice so that, under their normal or foreseeable conditions of use, they do not transfer their constituents into foodstuffs in quantities which could:

- Endanger human health.
- Bring about an unacceptable change in the composition of the foodstuffs or a deterioration in the organoleptic characteristics thereof."

Chemical migration is a diffusion process that is subject to both kinetic and thermodynamic control. The diffusion process is influenced by:

- Temperature: migration increases with increased temperature of contact.
- Time: migration is higher for contact of long duration.
- Thickness of the material.
- Nature of the material and amount of migrant in the material: migration decreases with substances of higher molecular weight in the packaging material.
- Type of food.

The conditions of use of paper and board for food packaging range from short contact time (less than 1 day) at temperatures from 5°C up to 150°C, for example packaged sandwiches or baker's ware, to long contact time (more than 1 day) at temperatures from -20°C to 40°C, for example frozen foods or chocolate. The characterization of inertness varies according to the nature of food, the temperature and the duration of contact, the specific use and conditions of use.

Although migration risk may vary between different dry foodstuffs and different wet or fatty foodstuffs, only two types of contacts are conventionally considered: dry and non fatty contact on the one hand, and wet and/or fatty contact on the other.

Presently, in contrast to what is the case for plastic materials, few analyses of paper and board materials intended to come into contact with foodstuffs take into account the product's foreseeable use conditions (short or long contact time with foodstuffs).

For some years, research work has been undertaken to assess the migration phenomena from paper and board materials to foodstuffs.

In France, the study "Interactions de matériaux cellulosiques et plastiques enduits avec les simulants gras" was based on an analysis of the interactions between packaging material and food, and showed that:

- Migration depends on contact time between packaging material and food.
- Migration is limited for coated materials in foreseeable use conditions.
- Migration test is not necessary for materials intended for short contact time (less than 1 week).

In Europe, the PIRA study (Investigation of migration from paper and board into food – Development of methods for rapid testing, published in August 2000) was based on:

- The migration analysis of DiIsoPropylNaphthalenes (DIPNs), Di-n-Butyl Phthalate and DiIsoButyl Phthalate, from paper and board materials intended to come into contact with foodstuffs (including "tissue papers").
- The choice of a food simulant to develop a method for rapid testing. This simulant had to represent dry and non-fatty foods, dry 'fatty foods', such as pastry and cake, and pizza (at higher temperatures for short contact times).

Test operating conditions for short contact time were:

- For tissue papers (industrial wipes, kitchen towels and napkins): 40°C for 24 hours and 100°C for 30 minutes.
- For corrugated boards (pizza packaging): 150°C for half an hour.

Migration tests were carried out with Tenax and a semi-solid simulant, on one or several specific foods (rice, flour and icing sugar, cake, pizza) according to the nature of the paper and board sample. The PIRA study concluded that:

- Tenax was a suitable food simulant in all cases studied.
- Migration of studied chemicals from tissue papers was very low or not detectable even when substances with a high propensity for migration were present; this was probably because of the short exposure times to food.
- In the case of short contact and high temperature application of corrugated boards (pizza), chemicals studied could migrate at low level but Tenax overestimates migration to pizza base when tested under comparable conditions.

Even though it is generally accepted that specific migration is extremely low with paper and board, proving compliance through analysing a heterogeneous medium such as paper and board presents a significant challenge that should not be underestimated.

PAPER & BOARD AND FOOD PACKAGING APPLICATIONS

Paper and board comes in a variety of forms:

- **Paper packaging:** natural or bleached, rubbed, coated or associated with other materials, paper can be found in the shape of bags e.g. for fruits and vegetables, vegetal parchment paper.
- **Folding box board:** often referred to as cartonboard, it may be single or multi-ply, wood-coloured or grey, coated or non-coated, and it can present various properties like barrier to grease, humidity, gas and it can be found in the shape of pastry boxes or container. It is mainly used in cartons for consumer products such as frozen food and for liquid containers.
- **Corrugated board:** brown and white, of low grammage or high density, resistant to bursting, to humidity or to compression, it can be found in different shapes such as showcases for use in stores, or small boxes for mass-market products. Corrugated cases constitute the highest volume of paper and board for food contact applications.

For food contact applications, the package has to be strong enough to protect the food. It may in certain cases be printed to ensure its attractiveness to the consumer because it is part of the food delivery system. To a limited extent, some barrier properties are expected, to protect the food against degradation by the external environment. Specific barrier properties may be obtained with dedicated chemical treatments or through lamination with other materials such as metal or plastic.

There has been a significant increase in the use of paper and board packaging in the past 50 years for many reasons.

- It is robust and adaptable – corrugated board can be used to protect delicate porcelain or large electrical items, but also delicate fruits and vegetables.
- It is practical – cartons can be delivered flat to the packager, reducing space and thus transport costs.
- It is easily recycled.
- It is made from renewable materials, recovered paper and wood pulp.

REGULATORY

The key idea of the Framework Directive 89/109/EEC, “on the approximation of the laws of the member states relating to the materials and articles intended to come into contact with foodstuffs”, is the “inertness principle” (described in the chapter “Migration under conditions of use”). However, no purity criteria are given.

Manufacturers of materials and articles intended to come into contact with foodstuffs are liable for ensuring the suitability of their products and the consumers’ safety. The manufacturers must also ensure that the materials comply with the current legislation in the country of use.

Paper and board, alone or associated with other materials, has been used in food packaging or food contact for a long time. However, not all countries have specific regulations on paper and board materials intended to come into contact with foodstuffs but just general regulations on materials (plastic, glass, metal) for food contact. Various differences in legislation concerning materials for food contact exist and the manufacturer has to determine the destination of his product in order to define the analyses required to prove the suitability of the paper and board material intended to come into contact with foodstuffs. So, in the absence of specific Community legislation on paper and board for food contact, the Council of Europe’s Committee of Experts on Materials Coming into Contact with Food has prepared a resolution on papers and boards intended to come into contact with foods, Resolution AP (2002)/1. Its publication does not mean that the European work in this field is now complete, as there are still a number of outstanding items that need to be addressed. The resolution does not have a legal status but Member States may take it as the basis for their national legislation. In practice the National Recommendations and Regulations apply in the following countries: Belgium, Finland, France, Germany, Italy and The Netherlands. In the absence of fully harmonized EU legislation, the principle of "mutual recognition" may be relied upon to ensure that materials and articles that comply with the regulation in place in one Member State may freely circulate in the other parts of the EU unless there is a notification by a clause of safeguard from danger.

The Resolution is supported by 5 technical documents:

- **Technical document n°1:** List of substances used in the manufacture of paper and board intended to come into contact with foodstuffs.
- **Technical document n°2:** Test conditions and methods of analysis for paper and board intended to come into contact with foodstuffs.
- **Technical document n°3:** Guidelines on paper and board, made from recycled fibres, intended to come into contact with foodstuffs.

These Guidelines are recommendations for manufacturers and users, intended to offer practical advice relevant to the safety of the end product. They are intended to assist paper and board manufacturers in reviewing their own quality systems. They will be amended in the future in accordance with developments in processing of recovered paper, improvements in analytical techniques, and increased knowledge of the toxicology of chemical substances.

- **Technical document n°4:** Good Manufacturing Practice (GMP) for paper and board intended to come into contact with foodstuffs.

GMP is a fundamental part of quality control and product safety assurance. Basic elements of GMP include availability of production manuals and instructions, compliance with specified quality requirements for raw materials, appropriate storage and handling conditions, the application of processes to avoid or remove contamination, specifications for end product testing, and information to ensure traceability and to maintain production records.

- **Technical document n°5:** Practical guide for users of Resolution AP 2002/1 on paper and board intended to come into contact with foodstuffs.

Tissue paper products (e.g. kitchen towels and napkins) are not intended to come into contact with food and are excluded from Resolution AP 2002/1. These multipurpose products, which may come briefly and occasionally in contact with food, are covered by specific guidelines.

According to the Resolution, paper and board intended to come into contact with foodstuffs has to comply with:

- Maximum permitted quantity of residual substance (QM) or Specific Migration Level (SML) restrictions (chemical restrictions): indeed, based on toxicological studies, migration of specific food packaging components into food is limited.

QM is the Maximum permitted Quantity of the substance in the finished material or product expressed as mg per dm² of the surface in contact with foodstuffs.

SML is the Specific Migration Limit, i.e. the maximum permitted concentration of a given substance into food or food simulants migrating from the material or article, and it is expressed in mg (of substance)/kg (of food or food simulant).

- Microbiological restrictions for aqueous/fatty foodstuffs.
- Organoleptic restrictions.

In order to avoid off-flavour problems, i.e. unacceptable modification of foodstuff flavour, tests on the end product are recommended under defined conditions. Presence and transfer of substances from paper and board causing off-flavour will strongly depend on fibrous composition, chemicals added, contact type (dry, wet, fatty foodstuffs) and contact conditions (duration and temperature). Several methods, some of them standardised, are available for testing organoleptic inertness of paper and board, which take those parameters into account. A panel of experts gathered in Ispra in 1997 has discussed this issue, and it has been recognised that it should not become the object of further regulation, since non-complying materials will easily be detected and discarded from the retail market.

SAFETY

Microbiology

Microorganisms are of concern for all packaging materials, including glass, plastics and metals. Paper, being made of natural cellulosic fibres with processes involving large amounts of water, could be particularly exposed to microbiological problems.

The conclusions given by a panel of experts in microbiology (Jouve, 1999) show that:

- Concerning risk assessment, the quantity and quality of germs in packaging material should be lower than in the packed food.
- All food types do not present the same requirements in terms of the microbiological quality of the packaging (for example, aseptic wet and liquid foods are sensitive).
- Particularly, the microbiological load of package quality for dry foods is less critical than for wet foods, so dry foodstuffs do not need particular requirements.
- Barrier properties of the package to prevent migration of microorganisms should be taken into consideration.

In a publication presented at the 1st European workshop on paper and board intended to come into contact with foodstuffs, it is specified that recycled materials, including those based on very contaminated materials, can be decontaminated if adapted processes of recycling are set up (Proceedings of the first European Workshop on Paper and Board in Food Contact Applications, October 1997, published by the European Commission Joint Research Centre). In the final report of this workshop, it is underlined that paper and board constitutes only one small part in terms of total potential for the microbiological contamination of food, the principal elements being manufacturing machines and equipment. Therefore, microbiological control of paper and board is addressed during production and conversion operations, through Hazard Analysis Critical Control Point systems, which are part of Good Manufacturing Practice. In another study (Suominen *et al.* 1997), various types of paper and board were studied. It was shown that the presence of nutrients in paper and board did not contribute to the mobility of micro-organisms within the fibre network. No transfer of micro-organisms from the paper material was observed. It was also shown that packaging boards for liquid food were not colonized by bacteria, and this even after 90 days of direct exposure to liquid food and moisture.

Chemical contaminants and safety assessment

Today, we can note a divergence in the methods of risk assessment between different countries, and even within the same country. There are no validated harmonised testing methods for the safety assessment of paper and board intended for food contact. Currently a European project (Biosafepaper, <http://www.uku.fi/biosafepaper>) is being carried out to investigate possible testing methods. In contrast to plastics, ceramics and regenerated cellulose there is, as yet, no specific Directive for paper and board intended for food contact. The Resolution on Paper and Board states that “the use of chemical or toxicological screening tests for possible unknown toxic substances should be evaluated and should be recommended in the future”. However, at present the implementation of chemical screening tests for unknown substances might not be feasible. Furthermore, the current knowledge about the applicability of toxicological screening tests for

paper and board is insufficient, but it should be noted that studies to establish the validity of these tests for paper and board are in progress. Consequently, the paper and board manufacturers are concerned about providing high safety standards for their products and wish to reduce the gaps in the existing legislation. They therefore intend to develop new methodologies for migration and toxicological testing of their products using realistic tests based on end use applications.

It is recognised that comprehensive chemical analyses of food contact materials may not be feasible. Only so-called “screening tests” may be performed, while substances of safety concern may go undetected. Moreover, the toxicological interpretation of the results of chemical analyses remains impossible due to the number of substances present, the lack of adequate toxicological information on each substance, and substance interaction. It is therefore advisable to set-up overall evaluation tests using biological parameters to investigate the safety of materials.

Toxicological tests are used to identify potential chemical risks present in food, water, pharmaceuticals, etc. The harmful effects of chemicals may be acute or chronic depending on the nature and concentration of the contaminants. It is recognised that acute poisonings from packaging are unlikely; therefore investigations focus on chronic effects, such as carcinogenicity, which could be attributed to long-term low dosage exposure and are more difficult to detect.

Instead of time-consuming and costly chemical analyses, several short-term tests have recently been introduced in order to directly evaluate both the acute and chronic toxic effects of samples. However, the validation of these tests for the assessment of packaging materials still has to be done.

Appropriate simulation procedures representing conditions of use, types of food, temperature and duration, should be developed in order to provide paper extracts for toxicological evaluation. This involves the selection of appropriate food simulants, and knowledge of the kinetics of substance transfer from materials. Toxicity tests should be relevant to food safety and, in particular, their results should be consistent with current knowledge of food contaminants.

The European project Biosafepaper develops, validates and intercalibrates a battery of short-term biological tests for the safety assessment of paper and board intended for food contact. The developed methods are tuned to help the European paper industry reduce the contents of unwanted substances in packaging materials based on renewable resources; and the final aim of this project is to create a basis for scientifically sound recommendations for a harmonised risk evaluation and product testing and to increase the confidence of consumers in the will and ability of European industries to continue to provide safe food contact materials.

ENVIRONMENTAL ASPECTS

Paper is a natural product manufactured from a natural and renewable raw material, wood and plants. The advantage of paper is that it is recyclable and biodegradable.

Directive EC/94/62

The Directive EC/94/62 gives essential requirements for packaging and packaging waste in order to harmonize national measures and to reduce the environmental impact of packaging and packaging waste. The essential requirements are the following:

- Prevention by reduction at source in terms of weight, volume and minimization of heavy metals and dangerous substances contained in the packaging materials.
- Promotion of reuse in order to increase the number of rotations of the packaging material (for the same use).
- Promotion of final recovery by at least one of the following ways:
 - Recycling (favoured)
 - Energy recovery by incineration
 - Organic recovery through composting and biodegradation.

Heavy metals

According to EC Directive EC/94/62, Member States shall ensure that the sum of the concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components shall not exceed 100 ppm by weight five years after 30th June 2001.

For the time being, packaging shall also contain less than 100 ppm by weight of the four heavy metals already mentioned.

In the case of papers and boards packaging, chromium may come from additives used during paper and board production and lead and cadmium may come from inks and colourings used for printing.

In paper and board packaging, actual figures observed for the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium are much lower than 100 ppm. Most often those concentration levels are even lower than the detection threshold of the method used.

Collected data on different types of papers and boards showed that the concentration of the four heavy metals are most often lower than 1 ppm. For recycled fibres corrugated box, lead, cadmium, mercury and chromium, the cumulated concentration remains well below 100 ppm.

Dangerous substances

Packaging shall be so manufactured that the presence of noxious and other hazardous substances is minimized in emissions, e.g. ash or leachate when the material is discarded, incinerated or dumped.

Prevention by reduction at source

Packaging shall be so manufactured that the packaging volume and weight be limited to the minimally necessary amount, considering safety, hygiene and acceptance.

Reusable nature of packaging

Packaging shall be designed, produced and commercialised in such a way as to permit its reuse, as many times as possible.

Recoverable nature of packaging

Packaging shall be designed, produced and commercialised in such a way as to permit its recovery in at least one way.

Material recycling

Packaging must be manufactured in such a way as to enable the recycling of a certain percentage by weight of the materials used.

Energy recovery

To allow energy recovery, packaging shall be combustible and have a sufficient inferior calorific value in order to provide a calorific gain in the energy recovery process.

Organic recovery through composting and biodegradation

Packaging waste shall not hinder composting process activity and shall decompose according to physical, thermal or biological actions into carbon dioxide, biomass and water. Packaging shall disintegrate quickly too.

Cellulose and hemicellulose contained in papers and boards are fast biodegradable products. Lignin is biodegraded more slowly by microorganisms because of its structure. Treatments added during the production of papers and boards may have different effects on the rate and kinetics of biodegradation. For example, starch coating treatment may increase biodegradation kinetics whereas wet strength treatment may have an opposite effect. Nevertheless, papers and boards packaging are biodegradable products and do not hinder composting process activity.

Moreover adding cellulosic packaging to traditionally composted products may improve compost structure and has no negative or inhibition effect on plant germination and growth.

Key figures for papers and boards*Recycling*

Recycled pulp comes from recycled papers and boards after use, from which contaminants (e.g. plastics, staples, inks, metals) are removed by a succession of elementary treatments (i.e. screening). Recycled pulp is then used singly or mixed with primary fibres. All types of papers and boards can be produced with such a mix of primary and recycled fibres. By recycling, fibres can be used several times over in the life cycle of papers and boards.

Recycling of papers and boards increased a lot during the 90's. At the end of the 90's, the collection of papers and boards had increased by 70% in comparison to the situation in 1990. The recycling rate has risen from 38.8% in 1990 to 48.7% in 1999. An objective of a recycling rate of 56% for 2005 has been established by the signatories of the "European Declaration on Paper Recovery", which means an increase of 25% in the collection efficiency, considering the increasing consumption of papers and boards throughout Europe.

In fact, the present percentage of recycled fibres on total fibre use varies widely within the different European countries:

- Spain: 81%
- The Netherlands: 77%
- The United Kingdom: 66%
- Germany: 61%
- Romania: 43%
- Italy: 54%
- France: nearly 50%

In packaging materials, the rate of use of recycled fibres is very high and tends to increase further, as it has done steadily over the past ten years. The proportion of recycled fibres varies according to the quality of paper produced. For example, corrugated papers commonly use 90% of recovered papers and boards.

Energy recovery

Papers and boards packaging have most often an organic material content higher than 50% and they usually have a minimum inferior calorific value much larger than 5 MJ/kg. This is why they are considered as allowing energy recovery.

The table below shows values of calorific gain for two different products commonly used for food contact application:

Criteria	Unit	Paper	Cardboard
Cellulose	% Dry basis	80%	66%
Inert filler	% Dry basis	20%	11%
Lignin	% Dry basis	0%	23%
Moisture content	% Wet basis	3%	7%
Net calorific value: Qnet (*)	MJ/kg	12.4	15.3
Required energy: Ha (*)	MJ/kg	6.4	7.6
Calorific gain: Qnet – Ha (*)	MJ/kg	6	7.7
Ash	% Wet basis	19%	10%

(*) as defined in the EN13431 standard

However, as papers and boards are materials that can be efficiently recycled, material recycling should be promoted and be given a higher priority than energy recovery.

Considering the increasing attention being devoted to climate policy, the incineration of used papers is less environmentally friendly than its reuse. A logical step would be that incineration is only used, once the recovered paper no longer can be processed by the paper and board industry.

GENERAL CONCLUSIONS

Paper and board is a very versatile material. It is produced from cellulosic, naturally renewable fibres. It is therefore considered as an environmentally friendly material, being easily recycled, composted or incinerated after use. It may be used in food packaging applications within a wide range of grammages, being designed as wrapping paper, folding box board or corrugated board, for direct or indirect contact, i.e. as primary, secondary or tertiary packaging. Other paper grades, such as tissue paper, may be used in occasional contact with foodstuffs.

When paper and board is intended, or likely, to come into contact with food, manufacturers follow relevant and acknowledged regulations and guidelines to design manufacturing processes and recipes, and ensure consumer safety.

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