Jordi Saldo

“Thanks to food processing technologies these products have longer lifespans, which favours their consumption and increases their safety, and there is a growing tendency to keep processing”

Jordi Saldo lectures at the Department of Animal Science at the Autonomous University of Barcelona and is Director of the Special Research Centre Food Technology Plant (CERPTA) at the same university. He has taught at the Polytechnic University of Catalonia and has been Visiting Researcher at the University of Guelph in Ontario.

Food Packaging. Too Many Waste Containers or Less Food Waste?

Food waste is high all over the world, but one characteristic of industrialised societies is that most of this waste is generated by end consumers. Among the strategies followed to reduce it we should mention better conditions of food preservation and packaging. One new initiative is the use of intelligent labels that inform consumers of the state of preservation of each container, enabling them to make wiser choices.

Hundreds of millions of tons of food are wasted every day in the European Union. The Food and Agriculture Organization of the United Nations (FAO) informs that the global waste of food amounts to one third of the entire world food production. As stated by the European Commission, food loss is high in all regions of the world, although food distribution varies according to economic development. In developing countries, 40% of losses are produced after harvesting and during processing. In industrialised countries, 40% of the food that is lost is rejected during the stages of its commercialisation and final consumption. Food that is produced and not consumed means a great loss of resources. At present, its production would still suffice to adequately feed the entire world population if it were appropriately distributed. However, with a population that is still growing, the pressures on agricultural land will increase and resources will be limited. As regards production, food loss is due to imbalances between supply and demand, and to products that are rejected because they do not meet the aesthetic standards (weight, size, shape and appearance) desired by distributors. Premature harvests in developing countries lead to nutritional and economic losses, and to products being spoilt if the appropriate storage infrastructure isn’t used. In industrialised countries, the idea that rejecting a product is cheaper than reusing or recycling it also favours waste.

The commercialisation of processed and packaged products reduces the amount of refuse generated in homes. All inedible parts are removed in factories, and this makes their treatment more efficient, as they can be used to obtain functional ingredients (from pectins to antioxidants) for animal food, compost or energy production from waste (bio-fermentation).

We can measure the cost of producing food that is not eventually consumed thanks to the carbon footprint. The more work that has gone into the food that will not be consumed, the greater the impact of

1 *Global Food Losses and Food Waste.* Extent, Causes and Prevention, 2011 [online], Food and Agriculture Organization of the United Nations. [Accessed: 10 March 2015]. Available at: http://www.fao.org/docrep/014/mb060e/mb060e.pdf.

the loss. Every ton of food discarded during the production phase is the equivalent of 2.4 tons of CO_2, including its treatment as waste. If it is discarded during the distribution phase, the impact rises to 2.8 tons of CO2. But if the food is rejected during the commercialisation and domestic consumption phases, it amounts to 3.2 and 3.8 tons of CO_2, respectively. When the waste is produced during the final consumption phase, the environmental cost of the waste increases by 50%.

Up to 40% of the fresh fish, meat and poultry, up to 51% of the dairy produce and fruit, and up to 44% of the vegetables purchased by a typical American family is thrown away. It is thought that around two thirds of discarded products are wasted because they aren't consumed at the right time.[2] Any tool that will help prolong the lifespan of processed food will also help reduce the problem of food loss.

There are many reasons why food is discarded in the final consumption phase.[3] In rich countries, consumers expect to find a wide range of goods on the shelves in food stores, and it is precisely because of the great number of products on display that in some cases their sell-by date expires before they have been sold. Food storage conditions in the markets of underdeveloped countries also contribute to the deterioration of a large proportion of foodstuffs before they can be consumed. In developed countries, a certain perception of abundance prompts consumers to throw food away in their homes and parts of the portions they are served in restaurants.

The loss of processed foods and food waste during the consumption phase can be reduced by acts directed at collective awareness-raising and at promoting better management, good practices of preservation and preparation and also thanks to technological improvements. Recent campaigns for raising awareness consist in preparing smaller portion sizes to be consumed by individual eaters. The prepared food that isn't consumed in domestic kitchens and restaurants can be re-used, a practice that used to be widespread. Better shopping planning would help reduce the number of products that cannot be consumed before they are spoilt.

"It is thought that around two thirds of discarded products are wasted because they aren't consumed at the right time. Any tool that will help prolong the lifespan of processed food will also help reduce the problem of food loss"

Thanks to food processing technologies these products have longer lifespans, which favours their consumption and increases their safety, and there is a growing tendency to keep processing to a minimum in order to preserve the nutritional and sensory qualities of food. In the third quarter of the twentieth century, heat treatment was applied for the continuous sterilisation of liquid food. Known as UHT, or Ultra High Temperature, the process is very short and preserves the properties of the original product better than sterilisation in autoclaves. The process required aseptic packaging systems in flexible containers, formed by multiple layers, each of which has a different function (waterproofing, providing rigidity and a barrier against gases and light) that help preserve the product stabilised by heat. Today, several new transformation technologies have emerged to help economise or minimise the effect of heating to obtain products that preserve the qualities of freshness even longer. Among these new technological treatments of food we should mention high pressure, a system in which the product, previously packed in flexible material, is placed in a resistant container to which water is added and pressure is increased. This isostatic pressure (that is uniform in all directions) neither deforms the product nor changes its composition, but it can affect some macromolecules such as starches and proteins. In this way, the aroma and nutritional value are preserved without changing the colour in the case of fruit and vegetables, though destroying micro-organisms. Food is stabilised by pressure treatment and can be preserved refrigerated in pasteurised form. Pressure treatment is applied instantly and uniformly to the entire product, regardless of its shape or size. As the food is packed before the treatment there is no risk of recontamination. Espuña was the pioneering firm for treating meat products with this technology in Europe, used to improve the preservation of sliced cured ham. Gradually, other producers of meat (Campofrío, Noel), fruit juices and many other food articles have begun to use the same technology.

Packaging protects processed and raw food, extending their lifespan while preserving their freshness and nutritional value, as well as helping distribute products in portions that facilitate their consumption. All these functions, in spite of introducing the use of additional packaging materials, help reduce food loss and end up protecting environmental and economic resources.[4]

Packaging serves different functions, many of which are useful for preserving food. The offer of materials in bulk is attractive to consumers because of the reduction in price and in the packaging it entails, although one of its disadvantages is the fact that the amount of product purchased is greater than the quantity that can be consumed while it remains fresh. The commercialisation of food in small portions reduces the loss of product but increases waste packaging material. When consumption units are reduced (as in many homes inhabited by one or two people) food has to be commercialised in smaller portions, in keeping with actual needs.

The balance can be found in an improvement in the conditions of preservation that will enable the product to remain fresh for longer. The temperature used for preservation is a critical parameter and is the most important single variable in deciding on a product's lifespan. In the case of packed fresh meat, the lifespan could be up to three weeks if preserved at 4ºC, as producers do, until the moment of consumption. Unfortunately, during the process of distribution temperature may reach 8º or more and in ten days the product can rot. Fruit and green vegetables can suffer excessive ripening if they are not kept refrigerated. The breaking of the cold chain, albeit for a short period of time, leads to deterioration processes in which products lose their qualities and may even prove unsafe for consumption.

As well as facilitating the commercialisation of food in convenient-sized portions, containers provide a barrier effect to avoid contact with contaminating micro-organisms and preserve the moisture content of food products, preventing fruit and green vegetables from withering and other foods from drying up. The containers of low-moisture products also limit contact with oxygen and with moisture, which could lead to their rotting earlier.

Inside the food container it is possible to maintain a favourable atmosphere for food preservation. Modified Atmosphere Packaging (MAP) is a widely accepted food preservation technique which, combined with refrigeration storage, guarantees that the products can be safely consumed during a longer period of time. There is an optimal combination of gases for preserving each kind of food, although

2 American Institute for Packaging and the Environment. *Reducing fresh food waste: The role of packaging* [en línea]. [Consulta: 10 marzo 2015]. Disponible en: http://ameripen.org/wp-content/uploads/Reducing-Fresh-Food-Waste-Final.pdf.

3 European Commission. *Preparatory Study on Food Waste Across Eu 27* [en línea]. European Commission: octubre de 2010, vol. 33, DOI:10.2779/85947. Disponible en: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf.environment/eussd/pdf/bio_foodwaste_report.pdf

4 Parfitt, J., Barthel, M. & Macnaughton, S. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 365, 3065–3081 (2010).

carbon dioxide is the most common. A high CO_2 content helps prevent the growth of micro-organisms and extends the lifespan of products packed in protective atmospheres. As CO_2 is highly soluble and can be lost through diffusion through the packaging material, plastics capable of retaining carbon dioxide are desirable, although technologically advanced plastics are more difficult to recycle because they are usually combined in multilayers. Before plastics can be recycled they must be separated according to their chemical composition.

"Not many consumers perceive the role packets and containers play in reducing waste, and associate them more specifically with food safety issues"

Other special plastics based on metallocene catalysts are used for packing salads and other fresh vegetable products. Such foodstuffs have to be preserved crisp until the moment they are consumed, which is why their metabolism is reduced to ensure they retain their composition. This is achieved by lowering the storage temperature and altering the atmosphere inside the container to delay the respiration of the product, for which the concentration of carbon dioxide should be maintained between 5% and 10%. The gas is emitted by the respiring plant and can be concentrated within the packet and yet, at the same time, the plant requires enough oxygen to stay alive. A balance is achieved between the respiration rate of the plant, consuming oxygen and producing carbon dioxide, and the permeability of the packet, that regulates its interaction with the exterior. Traditional plastics don't allow enough oxygen through or else are lacking in carbon dioxide, which explains why prepared fruit and vegetables, known as fourth generation products, didn't appear on the market until these new plastics were developed. The alternative is to use perforated layers in a proportion that matches the respiration of food.

Not many consumers perceive the role packets and containers play in reducing waste, and associate them more specifically with food safety issues. They also think that discarded packets are a worse environmental hazard than food loss, and generally believe that food products with minimum or no packaging have a lower environmental impact. And yet consumers often behave contrary to their beliefs, for at least half of them put the foodstuffs into different containers or packets as soon as they get home.

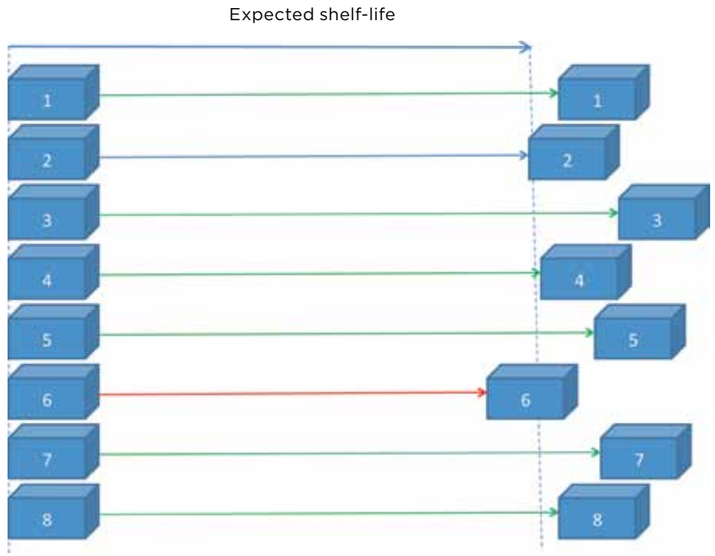
A debate concerning expiry dates and best before dates was recently held in Europe. The case of yoghourts illustrates the problem of how to inform consumers correctly of the lifespan of products, how to store them and when to throw them away. Products in which pathogenic micro-organisms cannot develop are marked with a best before date, before which the food will still have the sensory properties foreseen by the manufacturer and expected by the consumer. Products with a shorter lifespan are marked with an expiry or a use by date, for the possibility of micro-organisms developing and thus consumers being taken ill is not entirely ruled out; this date is printed by the manufacturer before the product leaves the factory, and it is thought that all the units in the batches will be stored under the same conditions. The use by date is usually conservative, and the possibility that the conditions of distribution and storage have been at some point less than optimal is contemplated in order to determine it. As a result of the variability of products and of their storage conditions, many (most) packaged foods reach their expiry date and are still fit for consumption (image 1). Yet, the fact that consumers are unable to know how long these products will last past this date prompts them to throw them away. A smart labelling system

explaining whether foodstuffs are fit for consumption according to changes in their properties could also help reduce the volume of waste. Several research groups are currently working to develop such systems, varying the information on the label in keeping with the changes in the food qualities, and legislation will no doubt adjust accordingly so that in future expiry dates may be marked differently.

Some labels record the changes in temperature suffered by food products over time, and can therefore register their thermal history. Such Time-Temperature Integrators (TTI) are usually based on enzymatic reactions monitored by the label and revealed by a change in colour. Consumers can recognise such colour changes and reject a product before its use by date if it happens to have been stored under inadequate temperature conditions. The speed of colour changes is adjusted to match the alterations the packaged product could suffer. There are several alternatives on the market, some of which are presented in image 2.

As shown in image 3, the labels are activated by consumers, who must be sure they understand the information offered by the changes in colour or by a comparative example, otherwise the message may prove confusing and there is a risk that the product will be thrown away due to an excess of precautionary measures.

▼ 1. Most packaged foods are still in good condition by the time they reach their shelf-life date. A smart label informing of the changes in the properties of products according to their containers would enable food to be consumed safely after the expiry date in use today (examples 3, 5 and 7). It would also allow food that for one reason or other had been spoilt before the date foreseen to be thrown away (example 6), thus improving food safety.



Developments that use the changes in actual products or analogous samples are exemplified by the design that won the UK James Dyson Award in 2014,[5] a prize devised to inspire young designers. The idea developed by Solveiga Pakstaite consists in using gelatine as a material that replaces the actual food integrated in the food package. The gelatine, encapsulated in the label, suffers similar changes to those suffered by the food in question, like a bump that reveals how the food inside the packet is gradually altered (image 4). Furthermore, this design enables blind people to read the label, which can be adapted by changing the concentration of gelatine to match the expected lifespan of the article.

As well as informing of the containers' thermal history, another kind of smart label reacts to chemical compounds released by the packaged food itself. One example of this is Ripesense®, a system that is integrated in fruit packages to inform of the degree of ripening of the fruit pieces, in this case by changing colour (image 5). The company launched the product in 2004, and since then it has gradually strengthened its presence in different markets. This smart labelling system also reacts to ethylene, a gas produced by fruit during its ripening process, and can reduce food waste in homes that results from buying without bearing in mind the actual consumption needs. This specific fruit packaging improves its preservation as it prevents excessive handling by consumers typically trying to establish the degree of ripeness of the product.

Besides being able to be measured, ethylene can be controlled. In many types of fruit it is the ethylene itself that induces ripening. Absorbers are integrated in the containers to make sure the fruit doesn't ripen too early. Such containers with functions that improve food storage are known as active packages.

The most popular of active packages are those that can absorb oxygen. Fungi and mould need oxy-

▲ 2. On the left (eO)®, developed by French company Cryolog. On the right, Fresh-Check®, one of the oldest companies in the field.

▲ 3. The VisaLab label distinguishes between the inactivated state, in which the product is fit for consumption, and the activated state, when it is not deemed safe. <http://vitsab.com/index.php/tti-label/>

"A smart labelling system explaining whether foodstuffs are fit for consumption according to changes in their properties could also help reduce the volume of waste"

5 James Dyson Foundation. Bump Mark, a bio-reactive food expiry label [en línea]. [Consulta: 3 febrero 2015]. Disponible en: http://www.jamesdysonaward.org/projects/bump-mark-bio-reactive-food-expiry-label/.

▲ 4. As indicated by its name, the Bump Mark reveals the changes suffered by the food by swelling underneath the label. The moment the contents are definitively spoilt will depend upon storage conditions, which explains why food in different packets belonging to the same batch may decay at different times.<http://www.jamesdysonaward.org/wp-content/uploads/2014/07/usr-449-img-1404477517-10eec-536x356.jpg>

▲ 5. The Ripesense® label changes from red to yellow as the fruit inside the container ripens. This knowledge enables consumers to make better informed shopping decisions according to their anticipated food requirements.<http://www.ripesense.com/gal/read_sensor.html>

gen to develop. The oxidation of some of the components of the food may limit their lifespan. Oxygen absorbers can be introduced in the form of tiny bags inside the container, as in some cured meats, pasta or pastries. Their function is to eliminate the gas that could have remained inside when the container was closed, or to gradually absorb all that which could slowly have penetrated by diffusion.

Other alternative presentations are labels integrated in the actual packaging material. The main suppliers of oxygen absorbing bags are Multisorb (FreshPax®) and Mitsubishi (AgeLess®). More recently a polymer has been developed (EMCM, by Chevron Phillips) that is able to absorb the oxygen itself. Other solutions consist of particles of absorbing materials dispersed inside the plastic, which can be used to make sheets and containers that integrate this function.

Antimicrobial containers are even more recent developments, as the first European regulations on the matter didn't appear until 2009.[6] In this case, the packaging material contains a product (in the form of trapped particles) that can be released very slowly towards the foodstuff to control the possible development of micro-organisms.

All these different strategies can help reduce food waste. Most of them include a correct use of packaging systems. Despite the fact that packaging materials aren't consumed and may end up as refuse material, in a global assessment we must value them positively, for the significant reduction in food waste they entail is much higher than their environmental impact.

6 Commission Regulation (EC) No 450/2009 of 29 May 2009 on active and intelligent materials and articles intended to come into contact with food [en línea]. [Consulta: 10 marzo 2015] Disponible en http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0450.