

TECHNOLOGY WATCH REPORT



New packaging solutions for fresh foods



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Overview of innovation and tendencies in Smart Packaging

Consumer life style changes are bringing about a demand for fresh foods of animal and vegetable origin with longer **storage times**, packaged in disposable **containers that are open or transparent** or which can be easily resealed, that guarantee the **nutritional value** of food with natural ingredients and minimise **environmental impact**.

Subjected to considerable pressure to reduce the volume of the material used in containers and packaging to confront the progressive emphasis on sustainability, food packaging companies strive to find a balance between **investing in innovation and maintaining price levels**. They seek solutions related to **flexible containers** with biodegradable, easily recyclable packaging materials that are compatible with the trend towards **high performance and high protection** materials that save costs throughout the value chain and enable **freedom of design** and fast printing.

The development of **minimum additive treatments** is yet another constant. Over the last few decades, technologies based on **protective atmospheres** have been used to package and extend the shelf-life of numerous fresh or minimally processed foods.

These technologies include vacuum packs, consisting of eliminating any air inside the packaging, as well as packaging in modified atmospheres consisting of eliminating air from inside the packaging and injecting a gas or mixture of gases to preserve the food.

In this context of constant innovation, **active containers** are also becoming increasingly relevant. These food/packaging/environment systems act in conjunction to maintain -or even improve- the healthiness, organoleptic properties and quality of the packaged food **by incorporating a system of active agents** that contribute to inhibiting oxidation, the growth of micro-organisms, eliminate ethylene, control moisture, taste and odour.

“One of the most interesting tendencies in product packaging is so-called smart packaging associated with an increase of the industrial productivity, the guarantee of food safety and reduction of wastage”

But one of the most interesting tendencies in the field of packaging high-value products is so-called **smart packaging** associated with an increase of industrial productivity, the guarantee of food safety and reduction of wastage.

Intelligent packaging, more specifically, has become a field of active research on **advanced incorporated in the containers**, with multiple practical advantages:

- Information about the properties of fresh food such as moisture content, temperature, or other properties that are important for ideal consumption.
- Indicators of microbial contamination, time or temperature abuse, deterioration due to the oxygen produced during storage, or other packaging responses to external

environmental factors.

- Informative labelling about storage periods or racking systems that enable tracing products along the supply chain.

The **Frost & Sullivan** report “Advances in Smart Packaging (Technical Insights) Next Gen Packaging to Improve Monitoring and Traceability” indicates some smart packaging **innovations and tendencies**.

- The **competitive strategy** of smart packaging includes factors such as added value, increased safety, process optimisation, application diversity and niche requirements. The growth of the smart container market depends on adopting one or more competitive strategies to satisfy the demands of end-users and packaging companies.
- The growth of the smart container market over the next few years will also depend on the solutions found for **package tolerance to the environment** (influence of inhibitors, moisture, aqueous agents, contaminants), as well as of process optimisation through **minimising wastage**.
- Some active research projects developed on a **commercial scale** in the food industry, apart from those already mentioned, are: carbon dioxide scavengers; ethanol emitters; preservative releasers; moisture absorbers; breathable materials; gas volatiles indicators.
- Other technologies developed are **thermochromic inks** that change colour on exposure to heat and **photochromic inks** that react on exposure to light.
- Developments of integrated systems include **oxygen scavenging** labels such as Freshmax and incorporation of oxygen scavengers in closure seal liners like Smartcap.
- There are also air fresheners that release **aromatic aerosols** when the built-in sensor in the product packaging detects movement.
- The ageing of the population and society's increased awareness of the quality and reliability of consumer goods have driven the development of smart containers in these market segments. Consumers are also more interested in having **information about the product they are buying**.
- Developments in **electronic technology** include materials and processes with the potential to create packages that provide data readable by digital devices.
- The new forms of communication associated with the generalisation of smart phones and social networks have encouraged the use of **electronic labels and RFID** to improve stock purchasing, product replacement and the adjustment of **unit prices**.
- The tendency for smart packaging to be associated with an increase in the **price of the product** could impede development of these technologies. In addition to this challenge, consideration must be given to the potential **difficulties of recycling** some smart packaging.
- Another challenge is increased **consumer awareness**. This means that **producers** must face the possibility of consumers becoming “hyperactive” and reject any food with a minimum change of colour indicating its degree of freshness.

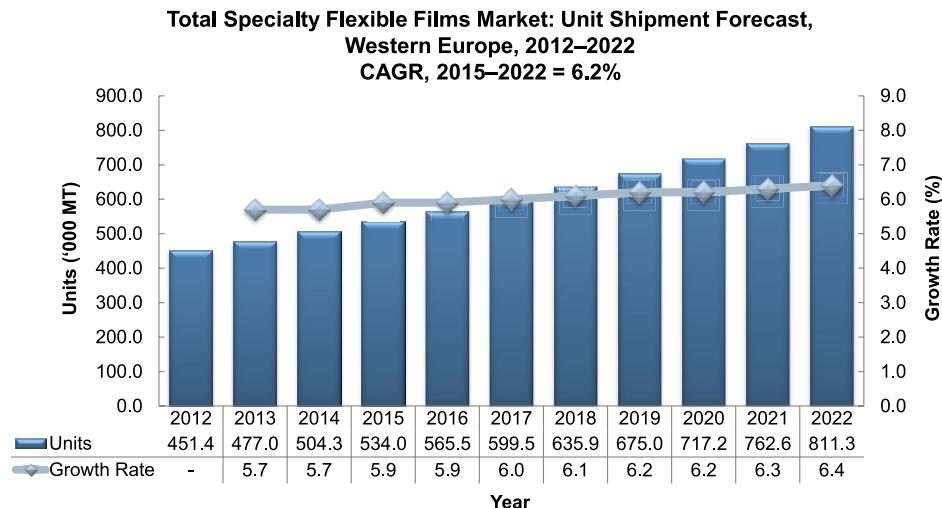
- Development of the smart container market is heavily dependent on the **regulatory framework**; regulatory authorities influence sectors making use of smart containers. Government organisations are mainly focussed on promising technologies and aid commercialisation through regulations in favour of adopting a particular technology.
- As this technology is still embryonic, it is the **universities that are leading the design and development of components for smart packaging**.

With a growing interest in adopting various market and competitive strategies, smart packaging technologies have the potential to expand and respond to any increase in food producer demands as well as the legal actions of end users. We are dealing with an established **area of RDI with predictions of high dynamism**, but we must bear in mind that the acceptance of new technologies by consumers is closely related to their perception of food safety, and will, depend on marketing campaigns that show that a fresh product is just as good, if not better, than in conventional formats. It is undeniable that costs will also play an important role in their commercial success.

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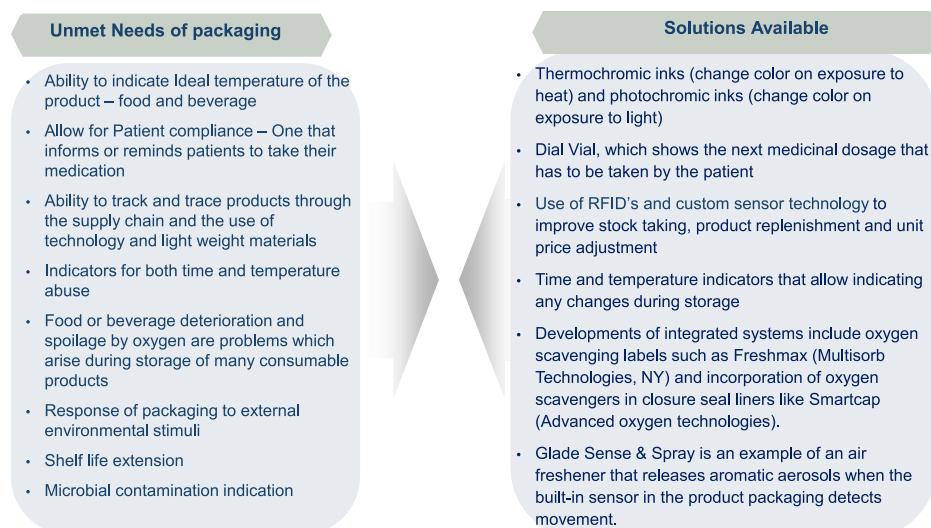
Food containers: Key infographics on a dynamic market

2.1. Prospective evolution of the plastic film market for food packaging (units) in Western Europe



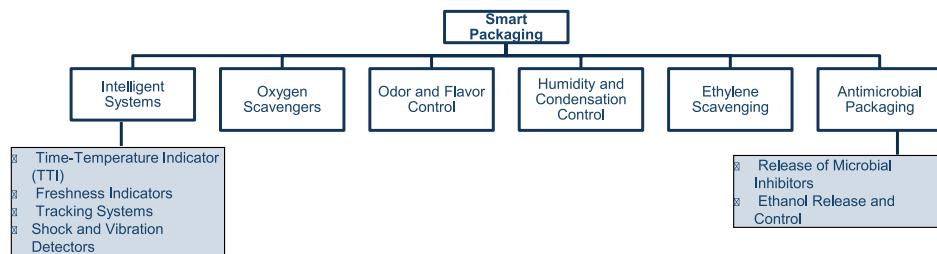
Source: Frost & Sullivan (2016). Analysis of the Western Europe Specialty Flexible Films in Food and Pharmaceutical Packaging Market. Adaptation to Convenient Foods Drives Market Growth

2.2. Applications for smart packaging



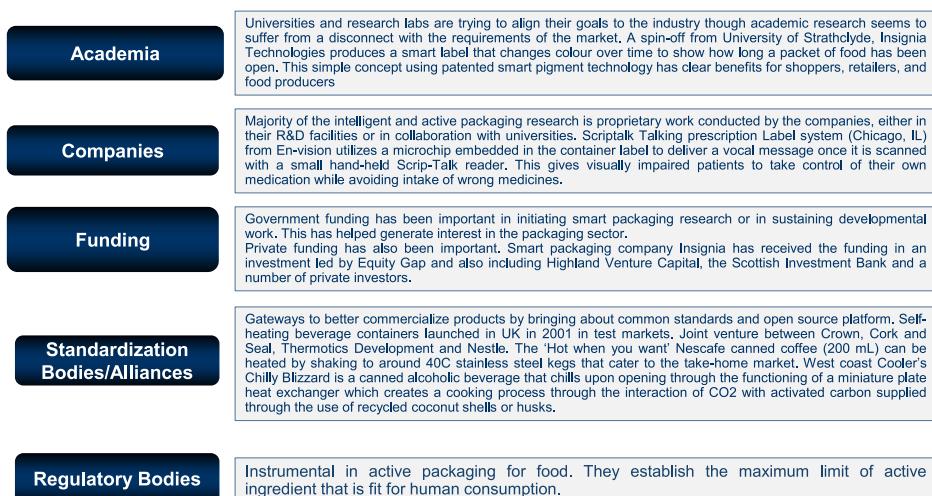
Source: Frost & Sullivan (2014). Advances in Smart Packaging (Technical Insights). Next Gen Packaging to Improve Monitoring and Traceability

2.3. Technologies associated with smart packaging



Source: Frost & Sullivan (2014). Advances in Smart Packaging (Technical Insights). Next Gen Packaging to Improve Monitoring and Traceability

2.4. Innovation ecosystem in smart packaging



Source: Frost & Sullivan (2014). Advances in Smart Packaging (Technical Insights). Next Gen Packaging to Improve Monitoring and Traceability

2.5. R&D&I case study 1 Temperature-monitoring shelf life indicator for food products

 Unmet Needs	 Technology Solution
<ul style="list-style-type: none"> Shelf life is the length of time food can be stored before perishing and becoming inedible. The expiration date is a guideline to the shelf life based on normal temperature and handling exposure. However, the expiration date does not guarantee the safety of the food item. Often the quality of the food item is determined more by the temperature or the conditions in which the food is exposed versus the conventional expiry dates put on the packaging. Smart food packaging systems with indicators and sensors can give information about the product quality, depending on the prevailing surrounding conditions during storage. 	<ul style="list-style-type: none"> Understanding the need for a smart packaging solution, Keep-it Technologies® AS has developed the Keep-it® shelf life indicator, which can constantly monitor the temperature to which the product has been exposed. It gives real-time information of the actual shelf life and the durability of the perishable food product by giving information about the number of days remaining before the food is spoiled. It helps give consumers a clear picture of whether the product has been kept at the right temperature throughout the entire supply chain. Keep-it® does not improve the food quality, it prevents consumption of stale or spoiled food. The indicator is made up of simple standard packaging plastic. It does not contain any harmful or hazardous chemical indicators. If products are stored in warm place, indicators move rapidly, if placed in cold, it moves slowly. Keep-it® is attached to the package in the last step of production. By monitoring the temperature, it tracks the food freshness from stores to consumer's shopping bag and refrigerator. Keep-it® advantages include avoiding food wastage, saving money, and protecting the environment.
 Innovation Attributes	 Commercialization Success
<p>The content of the indicator can be designed depending on the products packaged. For example, fish products will have a 4-degree centigrade, 12-day shelf life. However, in comparison, vegetables have slightly more than 4 degrees centigrade and almost 2 weeks shelf-life. Keep-it® can be modified depending on the food item stored.</p>	<p>By 2016, 22 million Keep-it Technologies® indicators were sold. It is used by REMA 1000 (a multi-national supermarket chain), kolonial.no (food delivery), Marine Harvest (one of the largest seafood companies), and other seafood and meat companies, such as Fiskcentralen AS, SALMAR, Nortura, Norsk Kylling AS, and Norsk Sjømat.</p>

Source: Frost & Sullivan (2017). Innovations in Food Packaging, Food Color, Gold Processing, and Coffee Supply Chain – Industrial Bioprocessing TechVision Opportunity Engine (TOE)

2.6. R&D&I case study 2 Edible food packaging made from milk protein

 Industry Needs	 Technology Solution
<ul style="list-style-type: none"> Many foods, such as meat, cheese, and bread, come in plastic packages. These plastic packages contain harmful chemicals that leach from the packaging and contaminate the food. This non-recyclable, non-biodegradable plastic packaging is not environment friendly. Tons of packaging waste generated each year does not degrade easily. Another disadvantage of the plastic packages is that they are not very effective in preventing food spoilage. 	<ul style="list-style-type: none"> Researchers at the U.S. Department of Agriculture are developing an all natural, bio-degradable, sustainable packaging film made of the milk protein casein. These milk-based edible packages have small pores, preventing oxygen from entering the packages. Currently available starch-based edible packages are more porous, allowing oxygen to enter the package. The researchers initiated the process by using pure casein for packages. The resulting packages were strong, effective, and powerful oxygen blockers. However, they were difficult to handle and quickly dissolve in water. Later, the researchers improved the process by incorporating citrus pectin into the blend. This made the packages even stronger, as well as more resistant to humidity and high temperatures.
 Innovation Attributes	 Applications
<p>The casein protein-based films are 500 times better than plastic packages in keeping oxygen out of the package; thereby, preventing food spoilage during the entire food supply chain.</p>	<p>The packaging can be used to pack single-serve food items, such as single cheese sticks or candy, in plastic pouches and wraps, which usually consumes a lot of plastic packaging.</p> <p>This casein solution can be sprayed onto food, such as cereal flakes, to retain the crunch in milk. It is a healthier alternative to the commonly used sugar coating on cereals used to prevent losing crunch.</p> <p>It can also be used as a safe alternate to the toxic perflourinated lamination on the paper and cardboard foodboxes to prevent grease from staining the package. Casein coating sprayed on the packages to serve as a lamination step for paper or cardboard food boxes or plastic pouches is a safe and environment friendly alternative.</p>

Source: Frost & Sullivan (2017). Innovations in Food Packaging, Food Color, Gold Processing, and Coffee Supply Chain – Industrial Bioprocessing TechVision Opportunity Engine (TOE)

2.7. R&D&I case study 3 Inhibition of bacteria and fungi growth in packaging for fresh fruit and vegetables

 Industry Trends	 Technology Solution
<p>According to the US Department of Agriculture (USDA), each year approximately 25 billion pounds of post-harvest fruits and vegetables get wasted. Energy, money and effort put into harvesting are also wasted, resulting in huge economic losses. The USDA also states that in 2015, 42.2 million people lived in food-insecure households in United States. These challenges of food insecurity and wastage can be handled only by reducing such wastages.</p>	<ul style="list-style-type: none"> Hazel Technologies has developed innovative solutions to mitigate the waste and improve the efficiency of supply chain in an eco-friendly and sustainable manner. They are aimed to reduce waste in the agricultural supply chain. For ethylene sensitive food items such as honeydew, papaya, guava, kiwi, avocado, berries or most of the tropical food produce, the company has developed carton inserts which extend the lifetime of fresh fruits and vegetables. It keeps them fresh, firm, reduces scald and retains color, thereby improving customer experience. Hazel Technologies has two technology solutions, FruitBrite™ and Berrybrite™. They are explained below: <p>FruitBrite: This carton insert extends the shelf life of ethylene sensitive produce such as fruits (apples, bananas, fig, kiwi, lychee, mango, peach, plum) and vegetables (tomato, onions, lettuce, kale, broccoli). It is effective for both whole fruits and vegetables or fresh cuts. It retains higher post storage quality.</p> <p>Berrybrite: This is a proprietary clamshell insert that increases the shelf life of berries (strawberries, raspberries, blueberries, blackberries, and grapes).</p>
 Innovation Attributes	 Funding Aspect
<ul style="list-style-type: none"> FruitBrite uses 1-methylcyclopropene (1-MCP) technology. This is structurally similar to plant hormone ethylene used for ripening. 1-MCP is a synthetic plant growth regulator. The shelf life of the produce is increased by reducing its respiration rate and increasing its resistance to ethylene. 	<ul style="list-style-type: none"> BerryBrite contains a mixture of controlled dose of a natural essential oils that inhibit the growth of bacteria, fungi, and molds in stored berries. It increases shelf life by three times, reduces disease and rot by up to 90%, and improves post-harvest firmness.

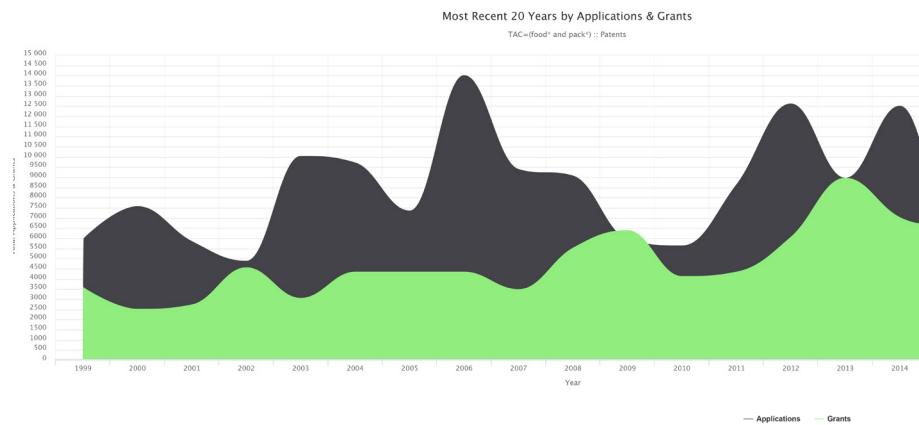
Source: Frost & Sullivan (2017). Innovations in Agriculture, Sugar Production, Food Preservation and Packaging, and Bacterial Fermentation – Industrial Bioprocessing TechVision Opportunity Engine

3

Patent analysis

3.1. Evolution of patents applied for and granted

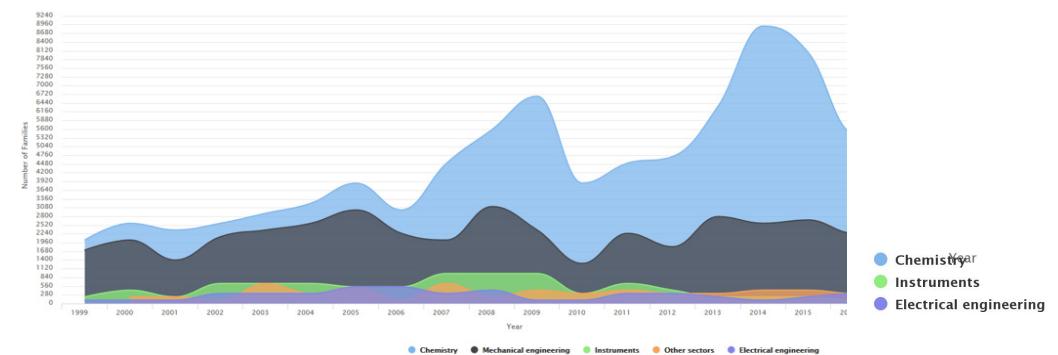
An analysis of the patents applied for and granted over that last few decades reveals the growing tendency. On average in this area of knowledge, 51.87% of patents applied for are granted.



Source: PatBase. Query: June 2018

3.2. Technological sector of the patents applied for

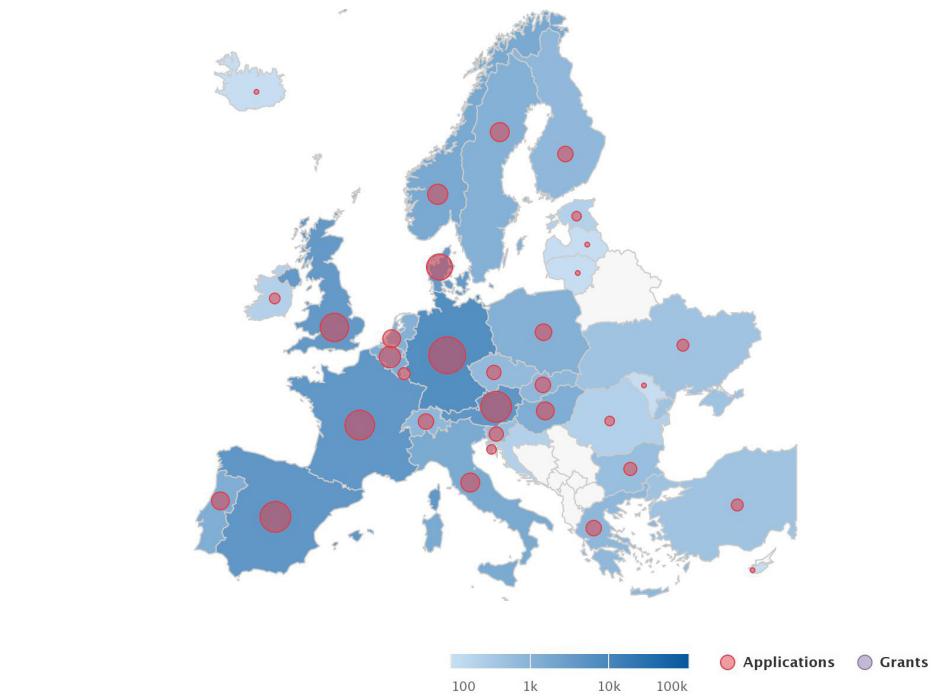
The technologies most involved in patents applied for in the field of fresh food packaging are in the following fields: chemistry, mechanical engineering, instruments and electronic engineering.



Source: PatBase. Query: June 2018

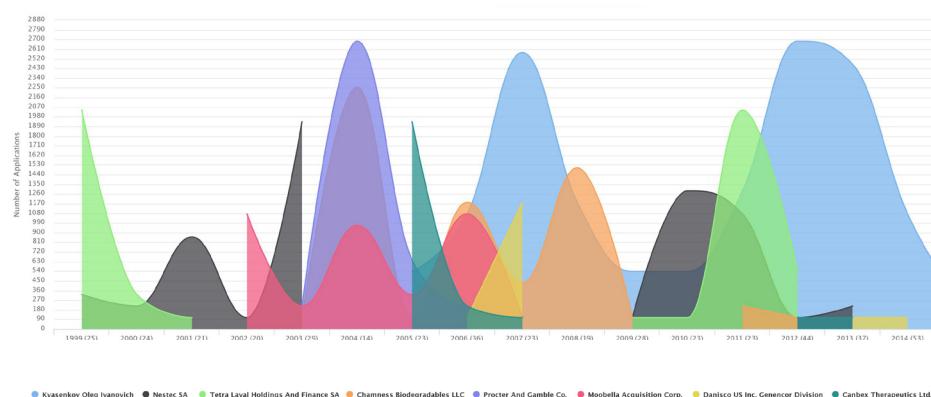
3.3. Territorial location of patents: Europe holds first place among the continent where more patents are applied for

Europe is the key continent in world-wide patents related to Smart Packaging, the countries with the highest number of applications being, in this order, Germany, Spain and Austria. Behind Europe, in second place, is North-America.



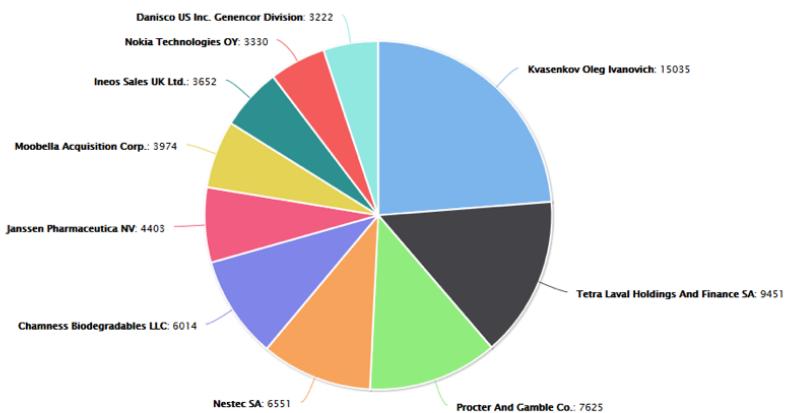
3.4. Most active patent applicants over the last 20 years

The graph shows the eight most active applicant organisations over the last 20 years, as well as the periods in which these applications were concentrated.



3.5. Who applies for most patents? The most active applicants

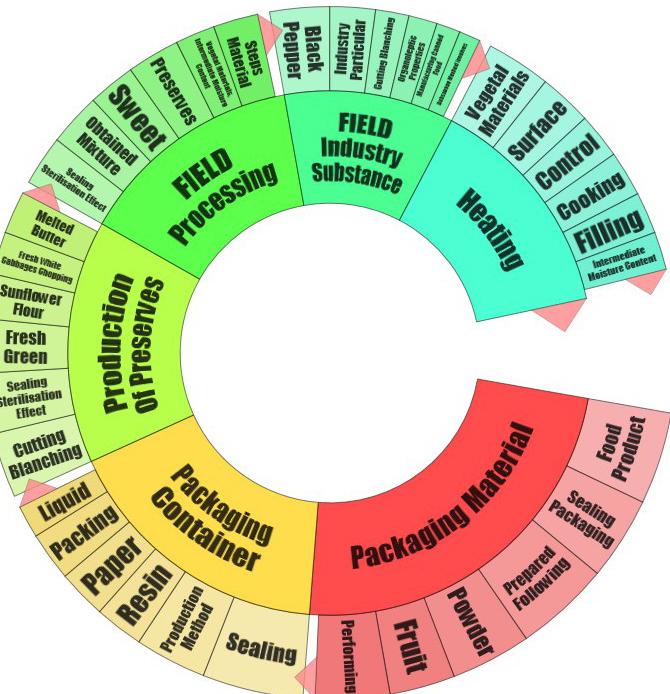
The ten most active bodies (companies, institutions or people) filing patent applications, including the number of applications for each one.



Font: PatBase. Consulta: Juny 2018.

3.6. Anàlisi de paraules clau

The main keywords associated with patent applications in the field of study are: packaging material; packaging container; production conservation; processed; industrial substance and heat.



Font: PatBase. Consulta: Juny 2018.

3.7. METHODOLOGICAL APPENDIX

The data provided in the “Patent analysis” section refers to a study carried out on a sample of 225,948 patent applications in the field of new packaging for fresh foods (Smart Food packaging and Intelligent Food packaging), and focussed on world-wide activity over the last twenty years, with greater emphasis on Europe.

84,731	50,796	225,948	288,770
Patent family	Family of patents granted	Applications	Publications
Total number of families in this set of results	Total number of families with publications granted with this set of results	Applications with this result	Publications within this result

Font: PatBase. Consulta: Juny 2018.

Within the industrial sector, the field of knowledge related to smart packaging of fresh foods is multidisciplinary and transversal, but may be divided into more specific sub-areas. As a result, the criterion applied to query operations in the drafting of this report has been as wide as possible.

Patent documents are classified in different international classification systems to simplify searches; the most often used being the International Patent Classification (IPC). Pursuant to this nomenclature, obtaining the sample for this report considered the inclusion, among others, of the following indexes:

- A23L3/00: Preservation of foods or foodstuffs, in general, e.g. pasteurising, sterilising, specially adapted for foods or foodstuffs (preserving foods or foodstuffs in association with packaging).
- A23L3/00: Foods Or Foodstuffs; Their Preparation Or Treatment
- G01N 33/02: Investigating or analysing materials by food.
- A23L5/00: Preparation or treatment of foods or foodstuffs, in general; Food or foodstuffs obtained thereby; Materials therefor (preservation thereof in general)
- A23L19/00: Products from fruits or vegetables; Preparation or treatment thereof.
- B65D81/34: Containers for packaging foodstuffs intended to be cooked or heated within the package
- A23L33/00: Modifying nutritive qualities of foods; Dietetic products; Preparation or treatment thereof.
- A23L5/00: Preparation or treatment of foods or foodstuffs, in general; Food or foodstuffs obtained thereby; Materials therefor
- B65D77/00: Packages formed by enclosing articles or materials in preformed containers, e.g. boxes, cartons, sacks or bags

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