# Perspective for market up-take

Thermal processing of foods is a major technology used to increase shelf-life and maintain food safety with a reasonable processing cost. Traditionally, food safety and palatability issues require the use of thermal processes for modulation of food raw materials during food processing at industrial and household levels (*van Boekel et al., 2010*). Some disadvantages of conventional thermal processing technologies are well known, particularly in products where the organoleptic quality need to resemble those of the unprocessed one. There are for example chemical reactions leading to off flavours, destruction of thermolabile nutrients, and other losses of product quality such as textual and colour changes. Conventional thermal food processing produces both desired Maillard reactions products to confer taste and aroma to foods, as well as undesired PCs. The PROMETHEUS project investigated the feasibility of application of alternative technologies to reduce the formation of PCs. Alternative and new processing technologies are necessary to offer chemically and microbiologically safe foods, retaining the sensory and nutritional quality of fresh ingredients, and finally to improve the convenience of processed foods to consumer expectations (*Jaeger et al., 2010*). Two novel technologies such as ohmic heating and high pressure processing have revealed as successful for scaling up .The PROMETHEUS project aimed to map out the main limits and advantages of the selected alternative technologies for reduction of targeted PCs in baby food purees and canned fish, in terms of

a. microbial stability
b. nutritional quality and content of process contaminants
c. technical feasibility, cost effectiveness, and consumer acceptance

**a. Microbial stability**

Assessment of food safety in terms of microbial stability of the product to prevent food spoilage is the first mandatory step for any scaling up process, including any novel technology. Sterilization guarantees the absence of pathogenic and food spoilage bacteria capable of growing in food products under non-refrigerated conditions of storage and distribution.

Ohmic heating of baby food puree. The mechanisms of microbial inactivation in baby food puree treated by ohmic heating are exclusively thermal in nature. The effect of storage on baby food puree samples was carried out over 6 months and evaluated in a stable low acid product using a standardized method (NF V 08-408). Results confirmed that all baby food purees produced at pilot scale were stable at 37°C and 55°C where ohmic heating mets the expectatives for maintaining microbial safety during shelf-life.

High pressure processing of fish. A precise evaluation of microbial inactivation for high pressure processing is needed since it is not possible to assume that the most heat-resistant spores are also the most baroresistant. High pressure processing inactivates microorganisms by interrupting cellular functions responsible for reproduction and survival. Although pressure levels in the range of 400–800 MPa inactivate the vegetative forms of pathogenic and spoilage bacteria, the inactivation of bacterial spores by pressure alone is not assured. Alternatives such as PATP (pressure assisted thermal processing), termed HPTS (High pressure thermal sterilization), can inactivate bacterial spores since it is based on the combined application of high pressure and high temperature, typically in excess of 600 MPa and 100 °C. Feasibility of this alternative technology has been compared with conventional retorting.

The results of the storage trials revealed that HPTS did not produce a stable product for tuna in brine. For sardine in olive oil and tuna in sunflower oil, HPTS treatments were effective for microbial inactivation, and 110 °C/600 MPa for 6.53 min.

**b. Nutritional quality and process contaminants**

Impact of the alternative technologies on the main quality parameters have been evaluated for baby food puree and canned fish including after shelf-life.

Ohmic heating of baby food puree.

Infant nutritional requirements are increased after an age of four months, and breastfeeding alone is not enough to covering these needs. Complementary foods are needed to provide a suitable energy and nutrient intake. Purees, with their soft texture play an important role in infant nutrition.

Sugars, protein, fat, carotenoids, total polyphenols, vitamin content were evaluated in the baby food purees produced in the project. In addition, the reduction in the levels of targeted PCs (furan and HMF) recorded at lab/pilot-plant level was confirmed during scaling up.

For some samples studied we observe a better preservation of carotenoids and polyphenols content after sterilization by ohmic heating than after retorting.

No significant differences in sugars, fat, protein, vitamin C, and fatty acids profile were detected when comparing ohmic heating sterilization and conventional retort sterilization for equivalent sterilization values. However, there was a significant decrease in total amino acids content (36.6 % as compared with unprocessed sample) and essential amino acids including arginine and histidine during retort sterilization. On the contrary, baby food puree treated by ohmic heating did not show differences in essential and non-essential amino acids content as compared with unheated control. Ohmic heating applied to baby food purees has a significant protective effect on the destruction of essential amino acids as compared with the conventional sterilization process for baby food puree.

In regards to PCs, ohmic heating was an effective strategy for the reduction of HMF and furan formation both in vegetables mix and in chicken mix. The concentration of HMF and furan in ohmic treated samples was always significantly lower than the retorted counterpart. Levels of HMF and furan did not change during the storage at room temperature of the baby food puree.

High pressure processing of fish.

The consumption of fish is particularly recommended because of the contribution of fatty acids, where an important part of the fish consumed is in the form of canned fish. Recently in Europe, canned fish preparations accounted for around 20-30% of total seafood consumption. Some of the most commonly canned fish are tuna and sardines, together with albacore, and salmon. Tuna and sardines are represent a great percentage of the total amount of blue fish capture. Only around 35% is sold fresh whereas the rest is destined for making preserves. Tuna is canned in edible oils, in brine, in water, and in various sauces. Sardines are canned in many different ways, including packing in olive or sunflower oil, water or difference sauces.

The major difficulty encountered in the project for the canned fish production is the seasonality of the raw material. This phenomenon is observed within all species but it is more significant for fat fish during spawning period or migration. Variations of composition mainly affect water and fat fractions, since these components may represent around 80% of the composition of the flesh.

Nutritional quality assessment was focused on the fat and fatty acid profiles. The individual fatty acids were classified by saturated, monounsaturated, polyunsaturated, as well as the sum of EPA and DHA for tuna in brine, tuna in sunflower and sardines in oil treated by HPP. No significant differences were observed in the fatty acids profile of fish regardless of the extent of the process and type of treatment.

In regards to PCs, 3MCPD and esters were not detected in alternative and canned samples. But furan content was significantly reduced after high pressure thermal sterilization compared with conventional retorting for sardine in olive oil.

**c. Technical feasibility for scaling up, cost effectiveness, and consumer acceptance.**

From the industrial side, replacing conventional technologies with one of the alternative technologies applied in the project is a decision that must be approached carefully where many variables should be considered. In the case of novel technologies, the added value to the product (improved quality, safety, and shelf-life) should be balanced with the beneficial effect on other important issues, such as packaging, transportation, storage, insurance, labour costs, or consumer convenience, among others. It is not the aim of the project to carry out a prospective study of the market.

However, it has been identified a number of limitations/beneficial technical features of the alternatives technologies for implementation at industrial scale as summarized in tables 4 and 5.

Table 4. Assessment of limitations vs benefits of the ohmic heating.

| Ohmic heating | |
|---|---|
| **Limitations** | **Benefits** |
| • Food must be easy to be pump at a constant flow<br>• The electrical conductivity of the food must be comprise between 0.01 S/m and 10 S/m to allow the electric current to pass through and heat the food.<br>• Potential disruption in the current flow by presence of air in the food<br>• Feasibility depends on the food matrix, where sterilization by steam injection is still more efficient for liquid products. | • The process is able to heat materials very rapidly and uniformly with reduction of the cooking time<br>• The limited fouling rate will allow the equipment to remain operational for longer<br>• High energy efficiency where almost 100% of the electrical energy is converted into heat<br>• Feasibility to adapt aseptic fillers to large flow rates from the ohmic heaters<br>• Highly effective for foods with particles<br>• Operational costs are comparable to those for freezing and retorting of low-acid products |

Table 5. Assessment of limitations vs benefits of the high pressure processing.

| High pressure processing | |
|---|---|
| **Limitations** | **Benefits** |
| • Product should be vacuum-packed to reduce the pressurization time<br>• No commercial high pressure thermal sterilization unit is currently available, although there is an available system operating with a large vessel capacity (55 L)<br>• Initial high cost of the installation | • Technically is very simple to scale up since high pressure processing effects are independent of the equipment and product geometry and size<br>• Design of high pressure units is not restricted to spatial considerations as they can be vertical or horizontal |

Alternative food technologies could create some level of consumer concern because consumers are in some cases unaware of the processes applied to foods. Thus, effective communication regarding their benefits is essential for the successful marketing of novel and conventional technology

processed foods. Current consumers' expectations are linked to food products that provide convenience, variety, adequate shelf-life, low caloric content, reasonable cost, and environmental soundness.

In general, ohmic heating and high pressure thermal sterilization are mature technologies with feasibility for scaling up and not adverse response from consumers to be implemented in the European market. However, the initial high investment required for the high pressure thermal sterilization installation could be balanced in production of gourmet-like or tailored-made foods. Applications of ohmic heating for baby foods and high pressure thermal sterilization to canned fish not only fit important consumers' demands concerning to high quality foods with naturalness characteristics, maintaining nutritional value and shelf-life (microbial stability) but also in terms of reducing the levels of processing contaminants.

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