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ROADMAP LOW SHEAR EXTRUSION (LS-EXTRUSION)

i³ FOOD

New treatments for better food

THE I³-FOOD CONSORTIUM

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Erdbär Gmbh
www.frechefreunde.de

Foodcase International Bv
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Entex Rust & Mitschke GmbH
www.entex.de

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DMK Eis Gmbh
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THE I³-FOOD PROJECT

The i³-food project achieves an optimum process control, leading to application of three food processing technologies under real life operating conditions. This is done by demonstrating and piloting in a near to operational environment of applicable validation systems for each technology. We are defining a scientific and cutting edge strategy for overcoming the market barriers ensuring a fast and wide market uptake. Finally, our multidisciplinary endeavor is connecting and amplifying the EU strengths in advanced technology research. This project is supported by the Horizon 2020 EU Research and Innovation programme.

Novel food processing technologies have been further developed in recent years and decades. Although technical advantages have been made in terms of time savings, energy savings, extending of shelf life for retailers and 'ready to use' products, the implementation of these technologies in industrial food production is often still rather limited. The reasons for that are manifold and vary from low acceptance or rejection by consumers (e.g. ionizing radiation of food), to non-open market access or lack of knowledge and information among food producers on how to integrate novel technologies. An applicable validation system for integrating these technologies one by one based on a generally approach is missing. Taking the risk and investing in an improvement of their processing lines is one of the main hurdles for the industry, especially for small and medium-sized enterprises (SME) in food processing. There is neither the time nor the resources available that are needed for the implementation of new non-standard processes.

The overall objective of i³-food is the implementation of three prioritized innovative food processing technologies by validation of optimum process control under industrial conditions.

Three technologies prioritized in i³-food are:

- Pulsed Electric Field preservation (PEF-P) of liquid food products (e.g. fruit juices or smoothies)
- High Pressure Thermal Sterilization (HPTS) for ready-to-eat-meals
- Low Shear Extrusion of cold food products (ice cream).

A connatural set of both, technical (missing online sensors) and process-conditioned bottlenecks exists, which hinders their uptake by industry and into the market.

Therefore, optimum process control will be achieved in i³-food leading to application under real life operating conditions by demonstrating and piloting in a near to operational environment of applicable validation systems, for each technology.

For rapid and easy market penetration an analysis of the innovation environment and identification of opportunities have been performed, leading to roadmaps for market uptake (one roadmap per technology). This integrated approach is providing maximal synergies in between the three afore-mentioned technologies. The summary of one roadmap is shown in this brochure.

TECHNOLOGY OF LOW SHEAR EXTRUSION OF ICE CREAM

Extrusion is a processing technology widely used for food production of products like pasta, flips or breakfast cereals for many years. In the food industry, mostly single and twin screw extruders have been used as standard tools for already about 80 years. These extruders consist of one or two large, rotating screws fitted in barrels.

Both types of extruders, single and twin screw, have certain advantages and disadvantages. In processing of sensitive products, monitoring of parameters such as temperature regime and shear rate is of great importance, but almost impossible. This could lead to inhomogeneous product temperatures and thus quality. In addition, single screw extruders have poor mixing ability which requires a pre-mixing of raw materials.

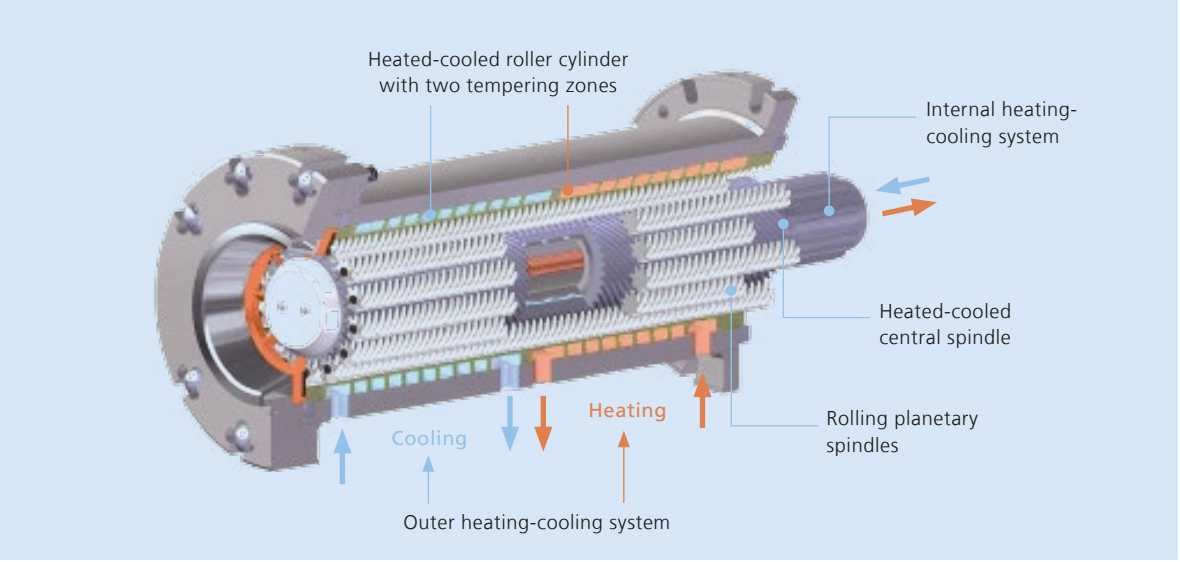
Planetary gear extruders are relatively new in food processing. Among one of the first applications of such an extruder was in processing of chocolate. However, its application to process food products at low and sub-zero temperatures (temperature down to –14 °C are beyond state-of-the-art.

The planetary gear extruder has a modular design with a central spindle which runs through all modules. Each module consists of a variable amount of planetary spindles which are arranged around the central spindle. At the rotation of the central spindle, the planetary spindles are rolling with the central spindle. Tempering of the product (cooling or heating) can be realized by a double jacket and a tempered central spindle.

During the extrusion, a single screw conveys the product to the processing section. There, the food material is taken by the spindle teeth of the planetary spindles, the central spindle and the barrel. The product is rolled over and conveyed forwards in helical path. This repeated rolling out and stretching to thin layers creates a large surface area with high heat transfer rates between the double jacket and the tempered central spindle, resulting in more accurate temperature transfer during the process. Thanks to this accurate and controllable processing conditions and low shear forces acting on the product, planetary extruders open new possibilities for extrusion in different temperature ranges.

In the i³-food project, a planetary roller extruder is used for production of ice cream and sensors for regulation and optimized monitoring of processing conditions were investigated. After the freezing step in a scraped surface heat exchanger, the aerated ice cream is pumped in the extruder for continuous and simultaneous ‘rolling’ and cooling in order to enhance the portion of small ice crystals. Afterwards, the ice cream is filled in suitable packages and cooled down to a storage temperature below –20 °C.

Due to the cooling down of the ice cream from a freezer outlet temperature of about –5 °C to an extruder outlet temperature of –2 to –18 °C less time and energy is needed compared to traditional ice cream production for the following cooling tunnel. The rolling out in a shear field of the extruder results



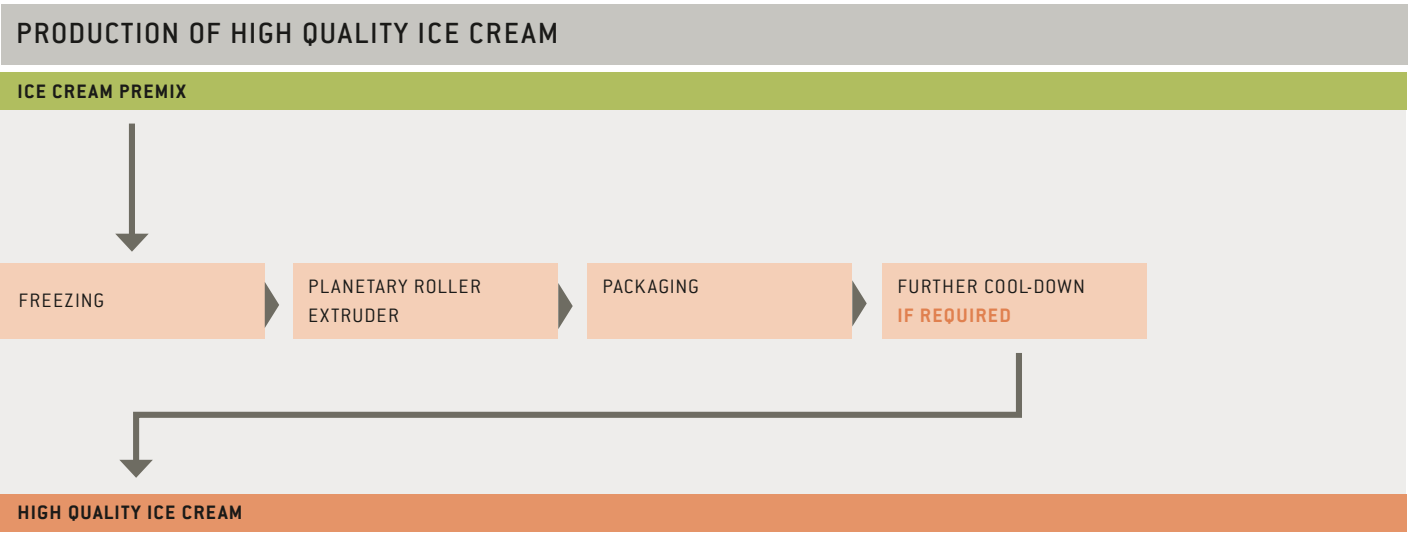
Configuration of a module in a planetary roller extruder (ENTEX, 2012)

in formation of very small ice crystals and thus their growth during storage is slowed down. Using this technology high quality ice cream with small ice crystals and a creamy mouthfeel could be achieved.

One of the objectives of the i³-Food project for low shear extrusion is the development and validation of sensors needed for continuous process control and monitoring, to ensure product quality. Besides existing temperature and pressure sensors in the extruder, in-line measurement of overrun, as one of the main processing parameter is investigated.

Ice cream overrun refers to the amount of air in the ice cream. It describes the increase of the volume of aerated ice cream in comparison to the ice cream before aerating (ice cream premix) and could be determined based on the density of premix and aerated ice cream. For in-line determination of density during manufacturing process, a straight tube Coriolis mass flowmeter is used.

The temperature, pressure and density sensors enable continuous control and monitoring of product and process parameters and ensure stable process, which will result in ice cream with improved distribution of ice crystals and enhanced creaminess. It is also elaborated as part of the HACCP concept considered in the project.



ROADMAP LOW SHEAR EXTRUSION (LS-EXTRUSION)

TIME ▶ 2017 | PREDICTABLE | 2020 | FORE

DRIVERS & BARRIERS

MARKET

- **M-D1:** Consumer acceptance is not an issue
- **M-B1:** Investment & cost of the final ice cream
- **M-D2:** Tolerance towa temperature fluctuatio longer shelf life
- **M-B2:** Lack of demonstrators for S-M companies
- **M-D3:** High food terms of cream str mouth feeling
- **M-B3:** Well-trained personnel
- **M-D4:** Flexibility of application
- **M-** ha

TECHNOLOGY

- **T-D2:** High quality (high viscosity, small crystals, low overrun)
- **T-D4:** Large added particles possible
- **T-** →
- **T-B1:** Insufficient process measuring and control
- **T-B4:** Lack of product samples
- **T-**
- **T-B2:** Not many experts
- **T-D5:** Possibility to make oth
- **T-B3:** Complex equipment
- **T-D7:** High throughput
- **T-D1:** Very good characteristics for producing and cooling ice cream
- **T-D3:** Easy implementation into the ice production process
- **T-B6:** Complet ice cream proc
- **T-B5:** Insufficient configuration (integration and interaction of different devices)

POLICY

- **P-D2:** Savings of energy
- **P-B1:** Patent only for single and twin screw extruder
- **P-D1:** Not Novel Food
- **P-D3:** No seperate labe

MEASURES

INDUSTRY

- Promote measuring and control benefits (T-B1)
- To try different options for the implementation (T-B3, T-B8)
- Specific training (M-B3, T-B2)
- To enlarge the app cations (T-B4, T-B5, T-B8, T-B10)

RESEARCH

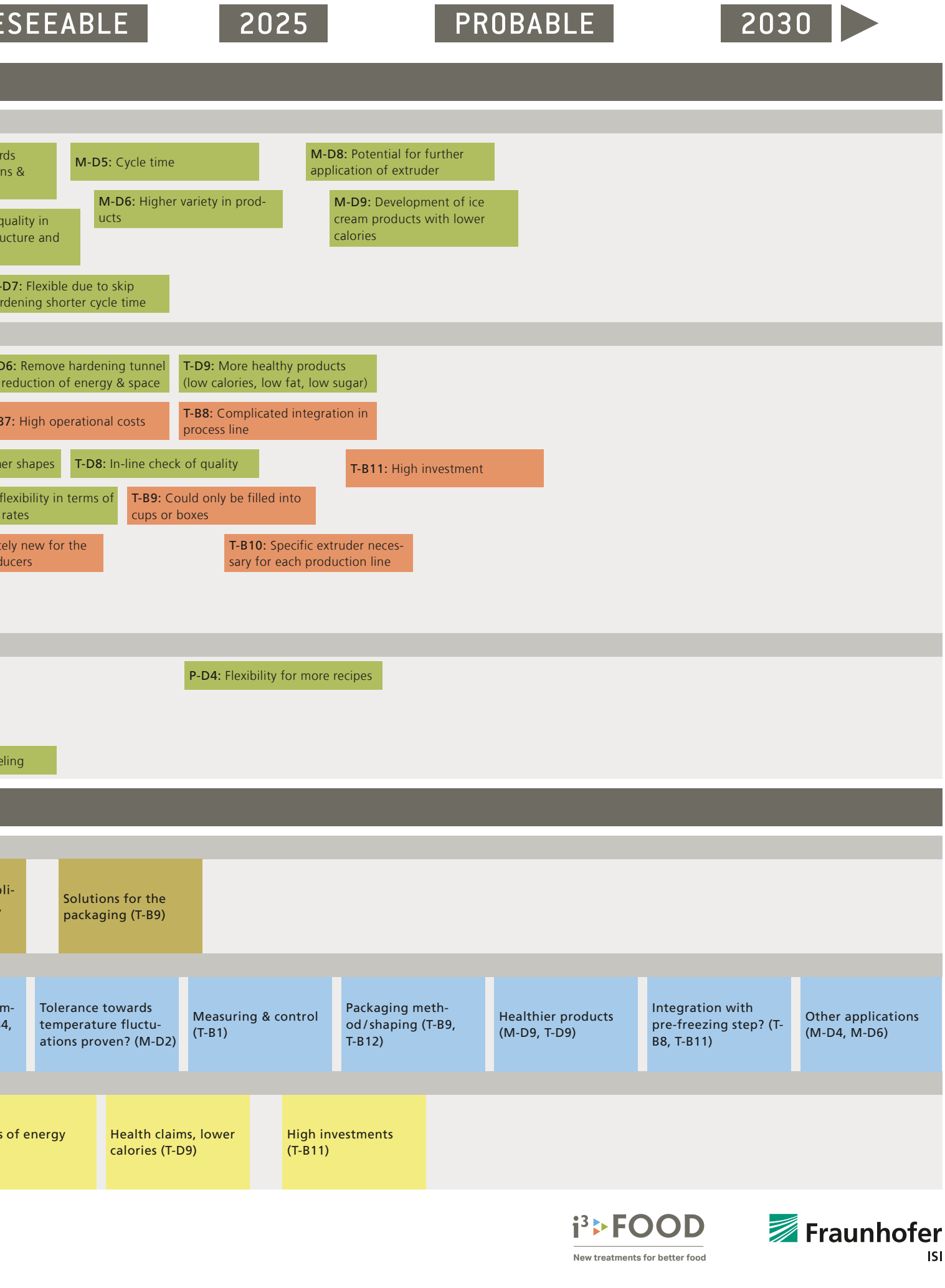
- Economic/sustainability analyses (P-D2)
- Size & costs of this process step are high and require proven benefits / great potential (T-B6, T-B7, T-B11)
- Integration in process line (T-B1, T-B3, T-B5, M-B3)
- Better quality: consumer tests (M-D3, M-D9, T-D1)
- Lack of product sa ples/pilot line (T-B M-B2)

POLICY

- IPR/patent situation (P-B1)
- Savings (P-D2)

■ Driver
■ Barrier
(M-Measures) adressed Driver/Barrier

MARKET LAYER includes Customers, Competitors, Users
TECHNOLOGY LAYER includes Features, Processes, Costs, Performance
POLICY LAYER includes Regulation, Legislation, Investment, Funding



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FOOD VALUE CHAIN AND POSSIBLE MEASURES

For a deeper understanding of the opportunities and hurdles of the technology, the food value chain for LS-Extrusion was investigated. A schematic picture is shown in the figure below.

Possible measures to address drivers and barriers are shown in the roadmap. These items show options for industry, research and policy stakeholders to improve and foster a faster market uptake of the technology. These measures are described briefly in the following paragraphs:

INDUSTRY DIMENSION

- **Promote measuring and control benefits**
  To implement new measures and control to win the trust of the process and to warranty the (homogenous) quality in the final product. The measures and control system are available in the technology. That is a very good advantage for its promotion.

- **Try different options for the implementation**
  Difficulties to change current processes and to introduce the LS-Extrusion. But the advantages of the technology are recognized, so industry must get informed.

- **Specific training**
  A specific training is required to manage and to set up the technology. Industry has to invest in training for the employees. Technology has a big portfolio of applications (chewing gum, chocolate, cereals, ice cream) so the time to train specialists depends on different products to work.

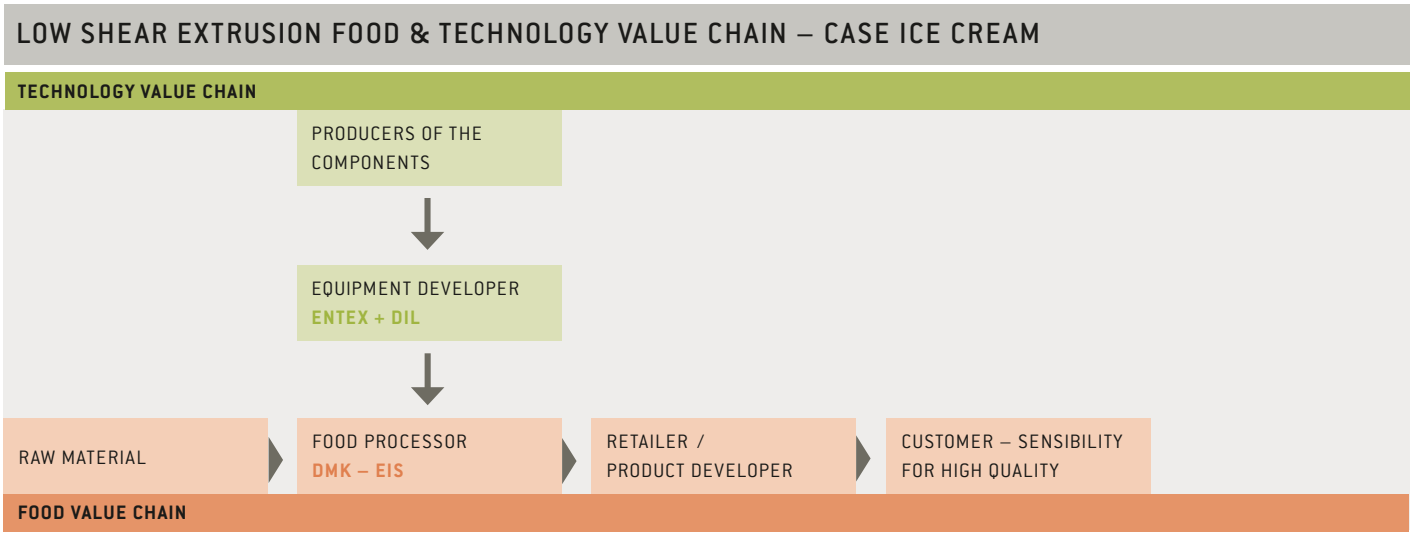
- **To enlarge the applications**
  Difficulties to promote the technology only in the ice cream sectors. Need to develop new applications (chewing gum, chocolate, cereals/grains, etc.) to promote the advantages of the technology.

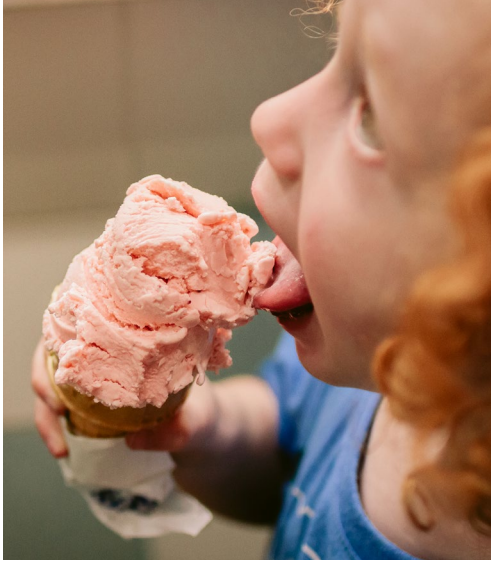
- **Solutions for the packaging**
  Few options for packaging exist, at the moment packaging only possible in boxes. New options for shaping and packaging are required. Economic analysis should be done.

RESEARCH DIMENSION

- **Economic/sustainability analyses**
  There is a need to clarify these issues and to remove the cooling tunnel.

- **Size & costs of this process step**
  They are high and require proven benefits/great potential Economic costs (300,000 Euros) vs. product quality should be considered.





- **Integration in process line**
  Clarify, perhaps simplify, all CCPs in place for entire line?

- **Better quality**
  Consumer tests should be carried out.

- **Lack of product samples / pilot line**
  Possible at DIL exists in pilot scale to test new recipies. Provide pilot line at external company.

- **Tolerance towards temperature fluctuations proven?**
  Is the crystal size distribution changing over the storage time? Shelf life studies should be carried out.

- **Measuring & control**
  Develop measuring and control to prove efficiency as well as quality.

- **Packaging method / shaping**
  The –12 °C results in harder product should be compared to conventional product method (–4 °C); avoid cooling temperature or develop or adjust new packaging.

- **Healthier products**
  With less sugar it is most complicated to keep mouth feel and other aspects acceptable. Sugar reduction is possible with new technology.

- **Integrate with pre-freezing step?**
  Are there possibilities to simplify the process? Incorporate / keep air in extruder.

- **Other applications**
  Enhance field of applications: Tolling equipment (logistically possible for ice cream, perhaps easier for other products?).

POLICY DIMENSION

- **IPR / Patent situation**
  Lack of information about patent situation. There is only a patent for single-screw and twin-screw extruders for ice cream extrusion, there is no patent for planetary roller extruder.

- **Savings of energy**
  Dissemination of the information about the savings of energy of this technology. More environmental friendliness could be claimed.

- **Health claims, lower calories**
  Science-based claims for boosting the driver should be developed.

- **High investments**
  Special taxes, financial supports as well as bonuses should be implemented.

ROADMAPPING METHODOLOGY

Roadmaps are increasingly used as a management technique for supporting innovation, strategy, and policy at firm, sector, national and international levels. Throughout its long history the roadmapping approach has evolved, firms and other organizations have adapted the concept to address their particular needs and the changing business context. Roadmaps provide decision-makers from business, science and politics with a structured overview of market developments and framework conditions, such as drivers and barriers, along with information on relevant products, technologies, and competences representing state of knowledge and their corresponding relationships.

The outcomes of a roadmapping process are graphical representations of these objects along the timeline, which links the current development trends to the future. Furthermore, roadmaps include measures and activities to address the relationships between market developments and technologies. The most important benefits of roadmapping processes are:

- The roadmap is an ideal form to display a lot of complex and interrelated information in a single picture.
- Certain patterns of interpretation are typical and unique for a roadmap. If inconsistencies are detected solutions can be discussed directly, thus 'hot topics' and 'blind spots' become visible. All these interpretations allow to define actions and to design a strategy accordingly.
- Roadmaps support strategic communication within and between firms and organizations, and the inherent flexibility of the method, which can be readily customized.

For this project, an approach of a roadmapping process was conducted based on workshops with consortium members and technology as well as marketing experts from the involved industry partners. The experts discussed assumptions about market demands and further relevant developments as well as identified opportunities and barriers and their future developments. Finally, they identified the most important measures to enable a successful market penetration. This was done in two steps:

SCOPING WORKSHOPS

- Assessment of the opportunities and barriers as well as gaps or further requirements.
- Identification of the most relevant technology applications, which are not yet obvious but could possibly occur in the future.

ROADMAPPING WORKSHOPS

- Assumptions about the future development of market demands and further relevant developments.
- Identification of the most important measures to enable a successful market penetration of the technologies.

ROADMAPPING METHODOLOGY

SCOPING WORKSHOPS

- Assessment of the opportunities and barriers as well as gaps or further requirements
- Identification of the most relevant technology applications, which are not yet obvious but could possibly occur in the future

OBJECTIVE:

REACHING A CONSESUS ON THE CRUCIAL FRAME CONDITIONS THAT HAVE TO BE CONSIDERED IN THE ROADMAPS IN ORDER TO ENABLE A SUCCESSFUL MARKET PENETRATION

ROADMAPPING WORKSHOPS

- Assumptions about the future development of market demands and further relevant developments
- Identification of the most important measures to enable a successful market penetration of the technologies

OBJECTIVE:

ENSURING A COMMON UNDERSTANDING AS A BASIS FOR A STRAIGHT IMPLEMENTATION OF THE IDENTIFIED MARKET UPTAKE STRATEGIES

ROADMAPS

PULSED ELECTRIC FIELD PRESERVATION (PEF-P) OF LIQUID FOOD PRODUCTS

HIGH PRESSURE THERMAL STERILIZATION (HPTS) OR PRESSURE ASSISTED THERMAL STERILIZATION (PATS)

LOW SHEAR EXTRUSION OF COLD FOOD PRODUCTS (LS-EXTRUSION)

IMPRINT

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