"Superheated Steam-based process for low energy and high quality drying of food and food residues"

Project executive summary

The STEAMDRY project aims at offering to the European food producers and food processing industries an efficient and sustainable solution to dry their products and maintain their quality.

To realize this, STEAMDRY has focused on three main technological objectives:

- **New Dryer using Superheated Steam + low pressure technology**

Adaptation of conventional direct dryer using superheated steam and low pressure technology. Using low pressured steam as heating medium will decrease the energy intake while improving the final product quality (low temperature drying). Besides, the dryer will have high efficiency, thanks to the reuse of the extra steam generated for liquid evaporation along with the reuse of any thermal energy to heat up the steam.

- **Steam cleaning system**

In STEAMDRY, steam is the heating medium in both drying and evaporation, which means that the drying plant can save energy by reusing the hot steam in both processes. However, during the drying, the steam collects dust, particles and solids from the raw materials. Removing the dust and particles from the steam decreases the needs for maintenance (clogging/blocking) and allows the proper reuse of the steam in the evaporator, thus decreasing the energy intake of the overall process.

- **Food quality multi-sensor and process control**

Development of a specific optical fibre multi-sensor to monitor in real-time several volatile aroma compounds (VOCs) released by the foods in the steam while drying. This multi-sensor integrated in the overall process control, allows an efficient real-time control of the food quality status.

The different exhaustive tests run for the verification of the implemented system were useful to validate and demonstrate that the selected approach is not only valid for high quality food drying, but also provided results even better than targeted, which makes this technology very promising for its industrialization.

Project context and main objectives

The EU market for processed foods is changing: there is now an increasing demand by consumers for foods that have undergone fewer changes during processing, foods that resemble more to the original raw materials with high nutritive values, flavor and a "natural" image. Exhaustive food processing (high temperature and time) is generally linked to a loss of nutrients and sensory characteristics. To compensate, food producers add, in most cases, artificial ingredients not just to ensure shelf life but also palatability.

Consumers have become aware of the risks triggered by the consumption of these synthetic compounds present in a majority of packaged foods in supermarkets. These include allergies, sensitivities or chemical sensitivities among others. In addition, many of these foods lack the nutrients they originally have on a raw

state prior to processing. As a consequence consumers are demanding healthier, clean label foods. This is being confirmed by consumer trend analyses made by different market research companies like Innova Market Insights which state that “clean label has become industry standard” (source: foodnavigator.com, report July 2015). A need for a more gentle, subtle, processing of foods to improve nutrient profile and taste while minimizing artificial additives in foods is thus required.

For the food machinery SMEs, today is the time to respond to these changes and enable the dried food industry to recover their competitiveness. The STEAMDRY project gathers 4 SMEs (HRS, Arnold & Partner, Avenisense and Fiordelisi) which aims at developing a new drying plant to allow food producers and food processing SMEs to dry their foods with efficiency, high quality and sustainability, thanks to:

- ✓ Innovative drying technology, using superheated steam at low pressure, ensuring efficiency through better heat transfer and a better quality of product due to lower temperature.
- ✓ Two-step cleaning system to remove the dust/particles from the extra steam and allow its reuse in the upstream process, reducing the energy bill.
- ✓ New optical multi-sensor integrated in the process control, to monitor the food drying quality along with the energy balance of the system.

The STEAMDRY process will enable the food processing market to recover their competitiveness via the production of high quality dried products, with lower process impact on energy environment.

Tomato ripening and drying at different stages

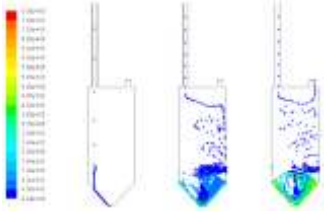
Main S&T results/foregrounds

The overall objective of the STEAMDRY project is to offer to the European food producers and food processing industries an efficient and sustainable solution to dry their products and maintain their quality. In order to achieve this goal, the Consortium partners have developed the following innovative components:

New Dryer using Superheated Steam + low pressure technology

A new drier has being designed and constructed using superheated steam and low pressure technology. Dryer has high efficiency, as extra steam will be reused for liquid evaporation and also thermal energy will be reused to heat up the steam. The design, construction, instrumentation and commissioning of a prototype of the Low Pressure Superheated Steam Drying (LPSSD) system has been done. The dryer is fully instrumented and monitored using computer based data logging systems to facilitate full characterization of the processes involved and provide data for the validation of numerical simulations and process optimization.

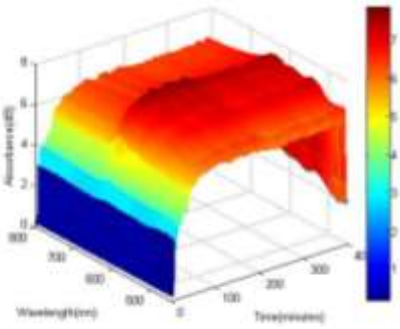
Clean Steam technology



A robust 2-step cleaning system has been designed and implemented to remove solids, dust and particles from the dirty steam produced by the evaporation of the feedstock moisture. In the first step, the dirty steam is cleaned in a “shower” reactor by the liquid feed coming to the plant. The resulting fluid, loaded with solids and dusts, is then injected in a lower temperature vessel: it results a flash reaction from the sudden temperature drop, producing clean steam that can be reuse in the upstream evaporator, saving up to 15% of the process energy just because of this reason. This decreases the needs for maintenance and allow the proper reuse of the steam in the dryer (also decrease of energy intake).

Food quality multi-sensor and process control

The drying process quality has to be controlled by the odour emitted by the foods before, during and after the process. A reliable optical fibre sensing system to detect and measure in real-time multiple volatile aroma (VOCs) present in the steam during the drying process has been designed and built. This system, located in the dryer steam outlet, measures the main evaporated aromas using multiplexing and a specific signal processing strategy. Based on this sensor and the feedback loop on the operation parameters, the overall process control ensures both high final product quality and optimized energy consumption (overall reduction of up to 60%).



The main advantages and benefits achieved with the creation of STEAMDRY system are:

- ✓ Up to 60% overall power and time reduction in food drying processes.
- ✓ Heat reuse to save additional power.
- ✓ Decreasing maintenance time and costs by including a self-cleaning unit.
- ✓ Efficient real-time control of the drying process.
- ✓ Less odour generation by working under vacuum.
- ✓ Over 80% nutrients retention.
- ✓ Germs hygiene indications 60 times cleaner than in equivalent standard drying processes.
- ✓ No nutritional loses with relation to standard drying processes.
- ✓ 99.7% particles removal.

STEAMDRY Food drying system main advantages

Attending to the main results described above, the STEAMDRY solution has contributed to achieve an Integrated and Cost-Effective solution to dry fruits and vegetables by**:**

- ✓ Increasing in final product quality: retention of nutrients, vitamins and aroma;
- ✓ Reducing microbiological activity in the final product;
- ✓ Reducing in energy consumption: the new dryer with higher drying rates + the reuse of steam for evaporation + reuse of the local available thermal energy enabling to reduce the total energy use;
- ✓ Reducing maintenance costs;
- ✓ Respecting the EU environmental policies and directives: low odour generation and CO2 emissions.

Potential impact and use and dissemination activities performed

The STEAMDRY project is directed at the European dried food producers and food processing SMEs which needs energy efficient and eco-friendly processes to produce dried food while retaining their color, appearance, nutritional and sensorial qualities.

The European food and drink market, with a 2011 turnover of €956 billion, weighs at the largest manufacturing sector in Europe. This industry counts more than 274,000 companies, 99.1% being small or medium sized (SMEs). Within the sector, the dried food (fruits & vegetables), with more than 1,500 SMEs, represents a market of €8 billion, where €3.5 billion are for the consumption, representing 1.8 million of tonnes (2008). According to PRODCOM, the European production of dried fruits and vegetables reaches 1.9 billion with more than 550 thousand tonnes (2008). Italy, Spain and France are the main producers: they produce mainly dried onions, potatoes, carrots and tomatoes (vegetables) and dried grapes, dates, figs and prunes (fruits). Other main markets are the UK, Germany, Poland and Greece.

There is a significant decline in global EU market of dried products (fruit and vegetables). The European Commission, as explained by its Vice-President Günter Verheugen in 2007, needs to adjust and adapt to consumers' evolving and more sophisticated preferences. With an increasing demand for healthier quality products, STEAMDRY drying plant follows this statement with the production of high quality healthy dried food. STEAMDRY process allows the retention of nutrients, vitamins and flavor as opposed to common extended solutions. In addition, it is a much more sustainable process with lower energy consumption. Such technology will enhance the future of the vital EU food industry, providing a competitive strength against competitive regions producing dried products (Africa, Asia).

The creation of the new STEAMDRY system, represents, therefore, a great business opportunity by providing the above market with the proposed solution. The Consortium is much aware of this fact and is planning a strategy to scale up the system and take it to real production.

The Consortium has carried out a sales forecast (European and Worldwide) of economic benefits for the SMEs of the sector considering a sound market penetration on the EU market of around 1% within the first 4 years of exploitation. This penetration will be consolidated by the active dissemination via the dried food processing SME Fiordelisi and the SME Arnold & Partners. From year 5, STEAMDRY will penetrate the US and Asian markets, which will enormously multiply the market size.

Being also aware of the importance of all the dissemination activities for the final success of the STEAMDRY solution, all the different SMEs in the STEAMDRY consortium (HRS Exchangers, AVENISENSE, APAG and the end user FIORDELISI), together with all the RTD members (INSPIRALIA, BRUNEL University and FPTP) have closely collaborated in their development and the completion of the associated tasks.

To reach the intended awareness level, dissemination has been supported by communication materials, including a demonstration video which can be visited at https://www.youtube.com/watch?v=Yk_nkzA2WWs , internet presence (including STEAMDRY website update as well as each partner website update to continuously provide the latest information), articles, posters, press releases and international fair presence.

Consortium members

Partner	Short name	Country
HRS HEAT EXCHANGERS	HRS	Spain
ARNOLD & PARTNER AG	APAG	Switzerland
AVENISENSE SAS	AVENI	France
FIORDELISI SRL	FIORDE	Italy
TECNOLOGIAS AVANZADAS INSPIRALIA S.L.	INSP	Spain
BRUNEL UNIVERSITY	BRUNEL	UK
FONDAZIONE PARCO TECNOLOGICO PADANO	FPTP	Italy

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