evapeos®: The Green Future of Instant Coffee

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Introduction

Coffee can be presented in different forms: brewed coffee, coffee pod or instant coffee. Our study focuses here on instant coffee.

Sartori Kato, who had already invented soluble tea in 1899, also invented instant coffee. It is a useful product as it enables time to be saved and its preparation is easy. Two methods exist for its production: the more ancient one is spray drying, the second one is most recent, appearing in 1965, and it is more respectful towards the product: it is freeze-drying. This coffee is essentially produced from Robusta beans.

In the production of instant coffee there is a step of concentration of the coffee extract. This step is delicate, as it has to be done under mild conditions in order not to alter the product by destroying the flavors. However, today it is mainly done by evaporation at high temperature.

evapeos® could be the key solution to this problem. It is a process including a membrane technology, which permits to concentrate vegetal and biological products. The low temperature conditions of evapeos® allow **preservation of the flavor** of the coffee extract. Moreover, **evapeos®** is a **green process**, as it has **low energy consumption.**

This process, patented by **ederna**, can, for instance, concentrate coffee extract at room temperature and pressure. These mild operating conditions guarantee **no degradation of the flavors**, and a **low consumption of energy**. It is a technology **respectful of the product and with a low environmental impact.**

The objective of this paper is to demonstrate the **benefits of evapeos® integrated in the manufacturing process of instant coffee.**

The company: ederna

ederna is a French company which has developed a proprietary process that permits vegetal and biological products to be concentrated in very mild conditions.

After several years of intensive research and development activities, the company now offers its process to testing to universities, research institutes and corporate innovation departments worldwide.

For that purpose, **ederna** offers trials in its laboratory, the renting or sale of test equipment and also the development of industrial processes along with its partner T.I.A. (for more information: www.tia.fr).

A gentle alternative to evaporation: evapeos®

Principle

evapeos® uses the principle of osmotic concentration. Water transfers across a **membrane** from the **product** to an extraction liquid, the **osmotic agent**. The transfer is done naturally, due to an activity difference between the compartments on each side of the membrane. Moreover, only water can transfer across the membrane; the other compounds remain in the product.

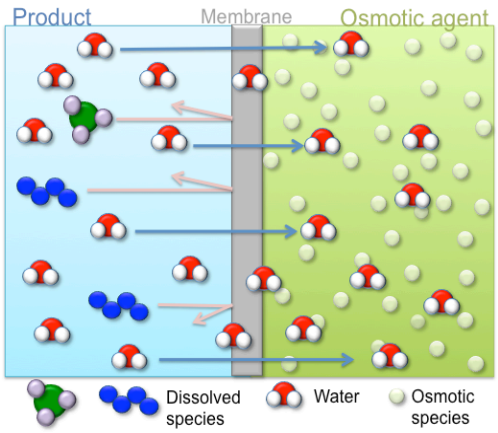

Figure 1: Osmotic concentration principle

Thanks to the osmotic principle, this concentration is performed at **ambient temperature and pressure**. Therefore, the product is concentrated under mild operating conditions and without direct contact with the osmotic agent.

Operation

Concentration using the **evapeos®** process is driven in batch or semi-batch mode. The product flows on one side of the membrane, while the osmotic agent flows on the other side. The solution is concentrated and the osmotic agent is diluted. After flowing to the membrane module the osmotic agent is regenerated continuously by Mechanical Vapor Recompression (MVR) as detailed in ***Figure 2***. **ederna** recommends the use of an MVR to lower the energy consumption of the operation but virtually any evaporation equipment could be used.

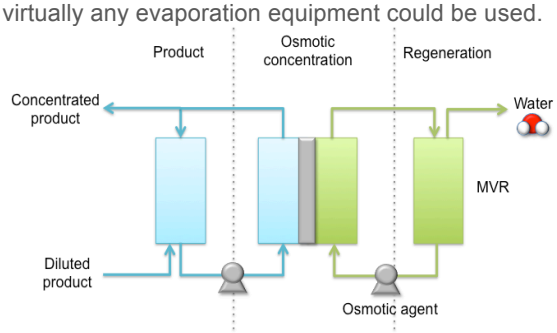

Figure 2: Description of the evapeos® process

Instant coffee manufacturing process

To obtain instant coffee there are different steps. The coffee beans have to be roasted, to develop all the flavors, and then the coffee is extracted with hot water. The diluted coffee obtained has to be concentrated. There can be first a step of pre-concentration with reverse osmosis then a step of concentration with evaporation. Usually a thin film evaporator can is used for this purpose. At the end the concentrated coffee is freeze-dried or spray dried.

evapeos® could be easily integrated in the instant coffee concentration process, replacing the thin film evaporator. It permits to obtain a high quality product, consuming less energy.

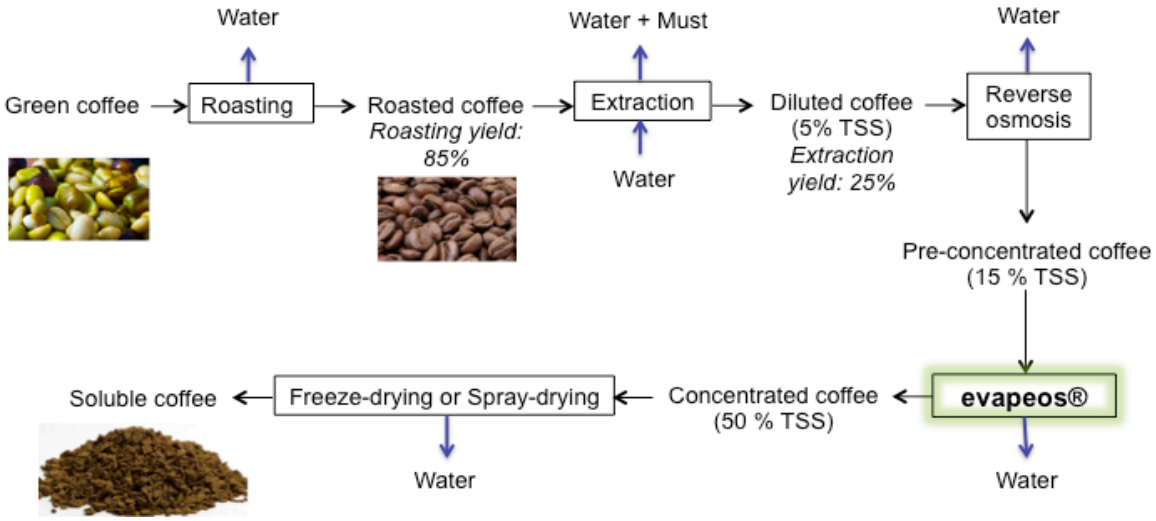

Figure 3: Possible integration of evapeos® in the instant coffee manufacturing process

Experiments: Coffee concentration assays

Coffee concentration experiments with the **evapeos®** process were carried out in the laboratory in order to validate the technical feasibility of the operation and to collect data for the technical-economic evaluation. A preliminary concentration was made by reverse osmosis.

Equipment

For the purpose of this experiment an **ederna** Lab Unit was used. It is an easy-to-use laboratory device designed to test the **evapeos®** process with a membrane technology with a specific area of 0.5 m^2.

Figure 4: Picture of ederna Lab Unit

The initial volume solution of coffee to be concentrated was 10 L. The coffee solution was prepared by grinding coffee beans. Coffee was then extracted by adding hot water (1L for 100g of coffee).

The solution obtained was then filtered. The initial concentration was 5% TSS. After reverse osmosis the concentration reached was 15% TSS*.

**TSS = Total soluble solids*

Results

A concentration from 15% TSS to 50% TSS was reached for a coffee solution at 20°C using the **evapeos®** process. The evolution of the flow and the concentration are shown in the chart below:

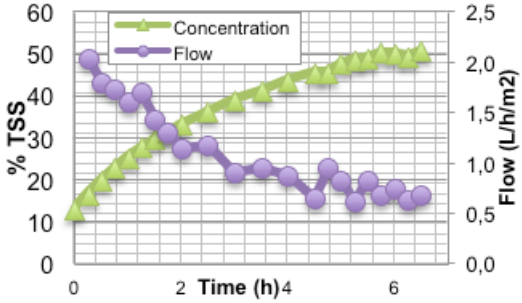

Figure 5: Evolution of concentration and flow

Sensory analysis showed that it was clear that most of the coffee flavors were not affected by the concentration process. A product with a **good quality was obtained.**

Experimental results are detailed in the following table:

Table 1: Experimental data

Maximum pressure	2 bars
Temperature	18 – 22°C
Initial sample volume	10 L
Initial coffee concentration	15 % TSS
Final coffee concentration	50 % TSS
Operating time	6.5 h

Optimization of instant coffee manufacturing

Based on the experimental concentration results and on economic data a study was carried out to quantify the benefits of incorporating the **evapeos®** process into the soluble coffee manufacturing process.

Aim of the study

This study was conducted in order to compare two instant coffee production processes: in both processes, coffee is ground then extracted with hot water before being concentrated and at the end is spray dried or freeze-dried.

Two processes were compared:
Unit 1 "without evapeos®": the diluted solution was concentrated by reverse osmosis then by a **thin film evaporator**. This technology has the advantage of a very short residence time. Therefore it does not have the time to deteriorate the product. However, it needs a lot of energy, so it is more expensive to operate.

Unit 2 "with evapeos®": the diluted solution was concentrated by reverse osmosis to 15% TSS, then by the **evapeos®** process to 50% TSS.

Hypothesis

- Both units were equipped with a reverse osmosis unit able to pre-concentrate the coffee.
- **evapeos®** unit is equipped with a membrane surface of 550 m^2.

Method

1. Determination of the quantities to be treated in each step for unit 1, according to the annual production.
2. Estimation of annual costs (including the investment amortization, maintenance, energy consumption and consumables), for both processes.

Energy data

The energy consumption of a thin film evaporator – an estimate based on data from literature - is **16,400,000 kWh/year**, whereas we estimated a consumption of **315,000 kWh/year** for **evapeos®**.

Based on the literature below:
https://repository.tamu.edu/bitstream/handle/1969.1/94591/ESL-IE-83-04-06.pdf?sequence=1
http://www.spx.com/en/assets/pdf/Evaporator_Handbook_10003_01_08_2008_US.pdf

Results

Unit 2, which includes **evapeos®** technology, has an energy consumption which would be 98% lower than unit 1 each year. Annual costs would be reduced by more than 30%.

NB: The steps leading to the dilute solution of 15%TSS are not taken into account in the estimations.

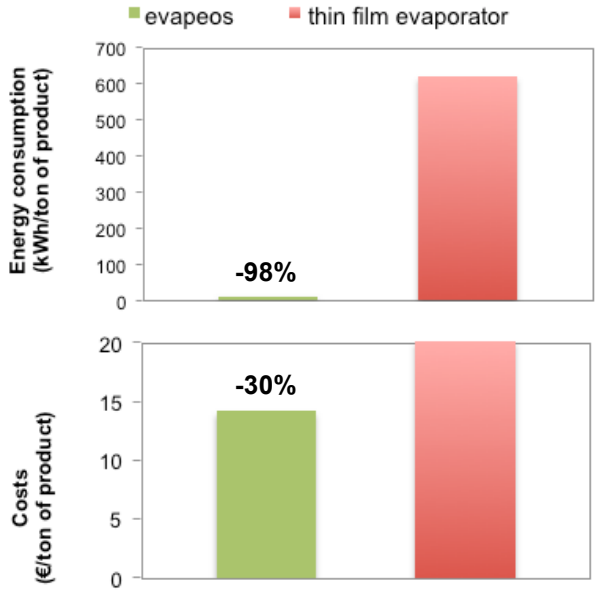

Figure 6: Energy consumption and costs

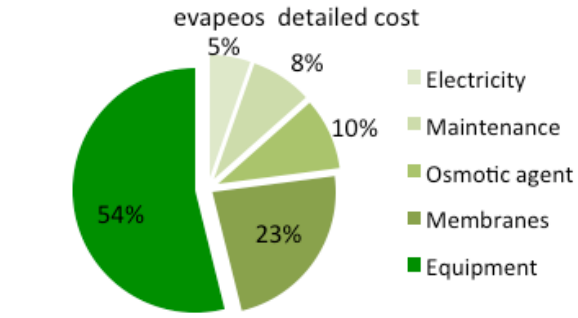

Figure 7: evapeos detailed cost

Though the **evapeos®** process would require a more substantial investment and the use of consumables (membranes, osmotic agent), it would consume far less energy than the standard process. This key point explains why costs could be significantly reduced. The estimation of the cost distribution for the **evapeos®** process is detailed in the pie chart. In the chart below there is the estimated evolution of the cumulated costs of both processes. After five years, **evapeos®** would be 30% less expensive than the thin film evaporator.

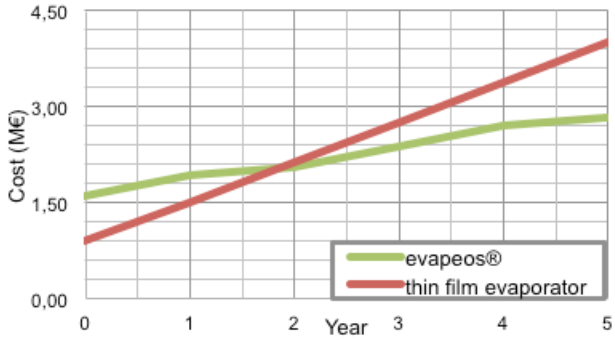

Figure 8: Evolution of processes costs over a five year course

Conclusion

The **evapeos®** process could easily be incorporated into instant coffee manufacturing. Its technical performance and low energy consumption would make this possible. Moreover, this process can be operated under mild conditions of temperature and pressure, permitting **preservation of all of the flavors of the coffee as well as preservation of the environment.**

Its low operating cost and gentle operating conditions would make it the ideal process to concentrate diluted coffee for instant coffee production.

evapeos® can also be used for a large number of other applications: concentration of fruit and vegetable juices or dairy products, in order to develop new food and beverage ingredients as well as functional ingredients for the nutrition, health and cosmetics markets.

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