

NEW PROCESS FOR THE PRODUCTION OF PERMEATE POWDERS WITHOUT SPRAY DRYER

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Abstract:

An innovative process scheme for the production of dairy permeate powders was tested at the pilot scale. It includes: (i) overconcentration of the permeate concentrate from 60 to 80% w/w dry matter (DM) content; (ii) granulation of the overconcentrate with powder up to 88% DM; and (iii) drying of the granules up to 97% DM.

The quality of the resulting powder was comparable to a standard powder produced using conventional technologies. Furthermore, considering energy required for water removal, the new process led to significant savings: they were estimated in the range of 10.7 to 23.5% and up to 32% when taking into account the whole production process or the drying step alone, respectively.

Keywords: dairy powder; sustainable technology; permeate; drying

Introduction

For the production of dairy powders, the energy required for spray-drying is considerably in excess to that required for evaporation [1]. Moreover, the increasing viscosity due to the increasing dry matter content limits the performances of the falling-film evaporators as well as the spraying systems to a concentration at about 60% w/w DM.

One way to reduce the energy cost of the process is to replace the spray-dryer by specific equipment able to handle highly viscous concentrates. This alternative way was applied in the new process scheme. Its feasibility was tested at the pilot scale and the properties of the resulting powders were compared to a standard powder produced using conventional technologies. The energy-efficiency of the new process was evaluated too with regard to the energy required for water removal.

Materials and Methods

As for conventional technologies, the new process implies vacuum evaporation of liquid permeate from 5.5 to approximately 60% w/w DM in a multiple-effect evaporator, followed by batch crystallization at a controlled temperature (25-30°C) for 4 to 12 hours. The concentrate is then subjected to a three-step process:

- i) Overconcentration of the concentrate from 60 to 80% w/w DM;
- ii) Granulation of the highly viscous overconcentrate with recycled powder i.e. powder produced during a previous production cycle - the granulation leads to the formation of granules at 88% DM;
- iii) Final drying of the granules up to 97% DM and subsequent cooling. Powders are sieved and stored.

The specific feature of this process is that the same technology, a thin-film horizontal rotary evaporator, is used for the three steps. But the configuration of the device (feeding systems, air circulation...) and the operating conditions (feed flowrate, air temperature...) are adapted depending of the processing step.

The process scheme was applied experimentally to a liquid permeate that was first concentrated up to 58.5% w/w DM in a falling-evaporator. The properties of the permeate powders were then determined and the energy efficiency of the process was evaluated theoretically in term of energy required for water removal and according to a methodology adapted from Schuck et al. (2015) [1].

Results and discussion

The properties of the experimental permeate powder produced using the new process were closed to those of a standard powder produced using conventional technologies with regard to rehydration properties, flowability, floodability and densities (Table 1). The sole difference concerned particle size distribution since the particles of the experimental powder are larger than those of a standard powder. These results might be inherent to granulation step.

Permeate powder	a_w (25 °C)	Dry matter (w/w %)	Crystallization ratio (%)	True density ($\text{kg}\cdot\text{m}^{-3}$)	Bulk density ($\text{kg}\cdot\text{m}^{-3}$)	Tapped density ($\text{kg}\cdot\text{m}^{-3}$)
Experimental	0.37	3.6	70	1554	527	616
Standard	0.23	2.2	86	1513	528	637

Permeate powder	d(0,5) (μm)	Flowability (-)	Floodability (-)	Solubility (%)	Dispersibility (%)	Wettability (s)
Experimental	200	78	50	>99.5	96	2
Standard	125	70	53	>99.5	97	14

Table 1: Properties of the experimental and standard powders

The new process led to significant energy savings, from 10.7 to 23.5% depending of the configuration of the evaporator (Table 2). The estimation is based on the basis of the energy required for water removal, which means that investments and operating costs are not taken into account.

Total energy consumption ($\text{kJ}\cdot\text{kg}^{-1}$ powder)	New process	Conventional process	Energy savings (%) using the new process
Six-stage evaporator	8,996	10,067	10.7
Two-stage MVR evaporator	3,513	4,594	23.5

Table 2: comparison of the energy consumption of the whole process for the production of 1,701 $\text{kg}\cdot\text{h}^{-1}$ of permeate powder at 97% DM from 30,000 $\text{kg}\cdot\text{h}^{-1}$ of liquid permeate at 5.5% DM

Conclusions

The feasibility of an innovative process for the production of permeate powders was validated at the pilot scale. More works are required to optimize the operating conditions and to include the investments and operating costs in the determination of energy costs.

References

- [1] Schuck, P., Jeantet, R., Tanguy, G., Mejean, S., Gac, A., Lefebvre, T., Labussiere, E., Martineau, C. (2015) Energy Consumption in the Processing of Dairy and Feed Powders by Evaporation and Drying. *Drying Technology*, 33, 176–184. doi:10.1080/07373937.2014.942913