Supercritical CO_2 Drying of Berries

E. Sánchez [a], M.D.A. Saldaña[a,*]

[a]*Department of Agricultural, Food and Nutritional Sciences, University of Alberta, Edmonton, T6G 2P5, Canada*
**Corresponding author: marleny.saldana@ualberta.ca*

1. Introduction

Among the berries, strawberry is a rich source of anthocyanins and therefore has high antioxidant activity[1]. However, strawberry has an extremely short shelf life due to its high sensitivity to microorganisms, resulting in softening, water loss and browning, limiting its further use in other products and shortening its shelf life. Currently, drying methods used to extend the shelf life of strawberries include hot-air drying, microwave drying, and freeze drying. However, these methods offer various drawbacks.

Supercritical CO_2 drying has proven to be a feasible alternative[2,3] that can be exploited at mild temperatures, preserving the original properties of fruits and decreasing the microbial load. Also, the removal of moisture from foods reduces the weight and the volume to facilitate transport and storage. Therefore, the use of supercritical CO_2 as a drying technique of berries is a promising alternative to increase the product shelf life, but more research is needed to deal with challenges associated with this drying process. Also, information for drying fruits and vegetables is still at the initial stages. Therefore, the main objective of this ongoing study was to determine the effect of supercritical CO_2 drying conditions, temperature, pressure and time, on the physical properties of the dried fruits and moisture removal efficiency. In addition, data obtained using supercritical CO_2 drying for strawberries were compared with conventional drying, including oven air drying and freeze drying.

2. Materials and Methods

Fresh strawberries were purchased from the local supermarket (Superstore, Edmonton, AB, Canada). A knife was used to cut cylindrical pieces (d=2.0 cm and h=0.5 cm) from the middle of the fruit. A supercritical CO_2 drying equipment was used mainly composed of a syringe pump (ISCO 260D), a 90 mL high pressure vessel, CO_2 tank, water bath, electrical heaters, and a micrometering valve (Figure 1).

For the experiments, one cylindrical strawberry piece was placed on a sintered porous filter inside the vessel, then the compressed CO_2 pre-heated to the desired temperature (40, 60 or 100 °C) using an electrical resistance passes through the vessel. Once the temperature and pressure (120 bar) were reached, the micrometering valve was regulated achieving a constant flow rate of ~1 L/min (at STP). At the end of each drying experiment, the micrometering valve was slowly opened to allow depressurization at a constant rate of 5 bar/min. The moisture content as a function of time was calculated from the total initial moisture content and the mass loss during drying.

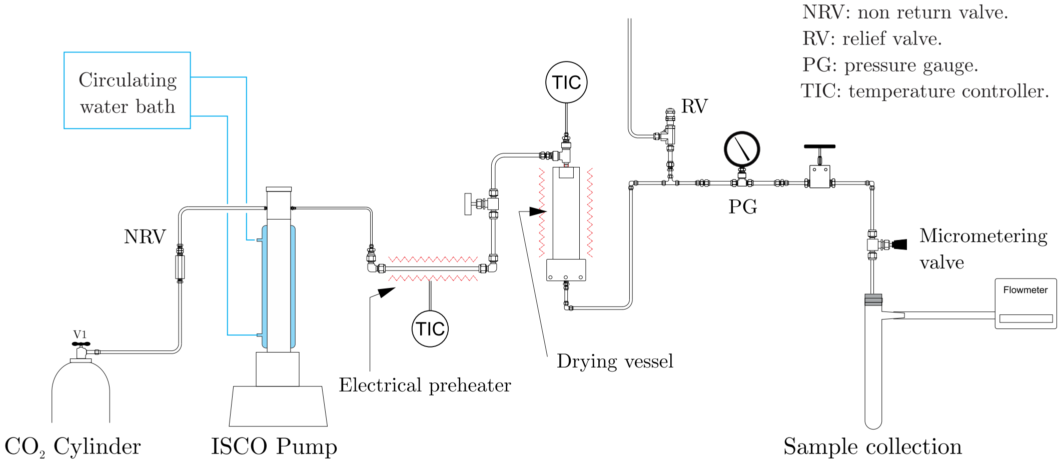

Figure 1. Schematic of the experimental SC-CO_2 drying system.

3. Results and discussion

Figure 2 illustrates the effect of temperature on supercritical CO_2 moisture removal efficiency at 40-100 °C and 120 bar. Higher moisture removal at comparable times was achieved by increasing the temperature due to the increment of water solubility in compressed CO_2 with temperature[4,5], 98% of water removal was achieved in 5 h at 60 °C and 120 bar. In addition, higher rates of moisture removal were observed for 60 and 100 °C compared to 40 °C. Within 3h of supercritical CO_2 drying, the moisture removal efficiencies were 98, 90 and 60% for 100, 60 and 40 °C, respectively.

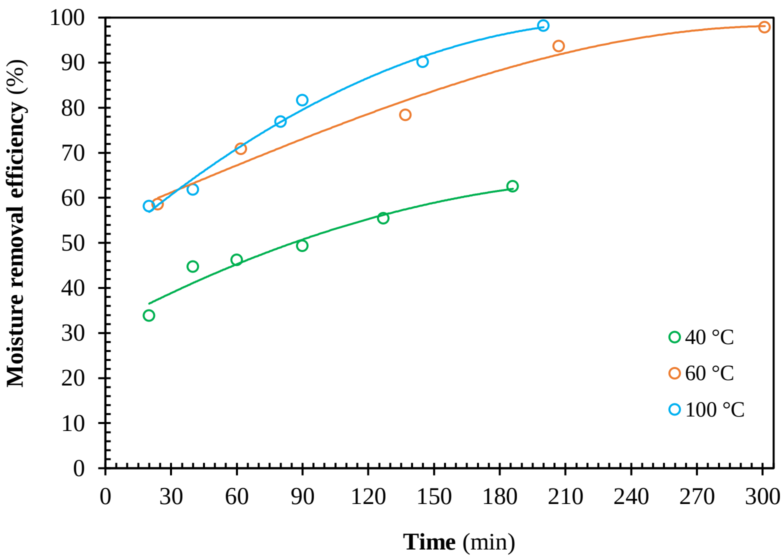

Figure 2. Moisture removal efficiency from strawberry as a function of time at different temperatures and 120 bar.

Figure 3 shows some pictures that illustrates the effect of the type of drying on the physical aspect of the strawberry. Shrinkage percentage and texture were the most affected physical properties during drying. Dried strawberry obtained using supercritical CO_2 was crunchy meanwhile the strawberries obtained using oven and freeze drying were gummy and soft. Table 1 summarizes the operational conditions and results obtained for the three different types of drying used.

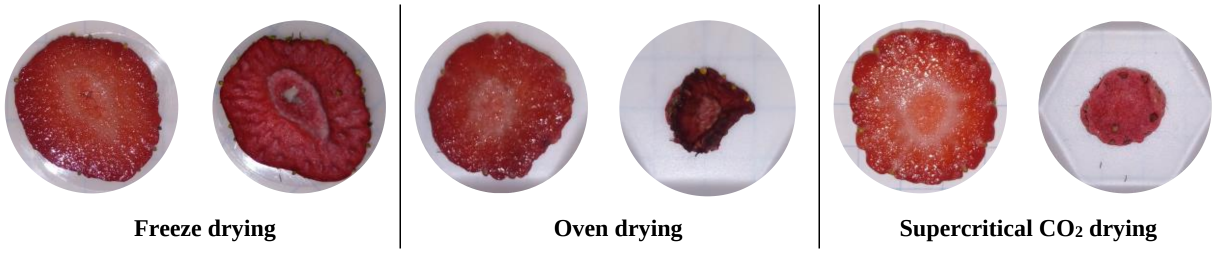

Figure 2. Comparison between three different types of drying and the effect on the physical aspects of strawberries.

Table 1. Operational conditions and results for drying of strawberries.

	Freeze drying	Oven drying	Supercritical CO_2 drying
Temperature	-25 °C	40 °C	60 °C
Pressure	0.05 mbar	1 bar	120 bar
Time	48 h	24 h	5 h
Initial moisture (%)	88.7	89.5	87.8
Shrinkage (%)	11	73	69

4. Conclusions

Supercritical CO_2 drying successfully removed 98% of the initial water content at 60°C/5h or 100°C/3h 30min. This drying process is a promising and competitive technique applicable to berries regarding time and energy consumption. In addition, some physical properties such as texture and color of the dried strawberries were better with supercritical CO_2 drying than the ones obtained with the other two air-drying techniques.

Acknowledgement: This study was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC, #04371-2019).

References

1. J. Gamboa-Santos, *et al.*, *Food Chemistry*, *161*, **2014**, *40–46*.
2. I. Djekic, *et al.*, *LWT - Food Science and Technology*, *94*, **2018**, *64–72*.
3. Z.K. Brown, *et al.*, *Innovative Food Science and Emerging Technologies*, 9, **2008**, *280–289*.
4. A. N. Sabirzyanov, *et al.*, *High Temperature*, 40 (2), **2002**, 203−206.
5. M. B. King, *et al.*, *Journal of Supercritical Fluids*, **1992**, 5, 296−302.