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INFLUENCE OF DRYING TECHNIQUES ON THE PRODUCT YIELD AND PHYSICAL PROPERTIES OF *Citrus unishu* PEEL DRY EXTRACTS

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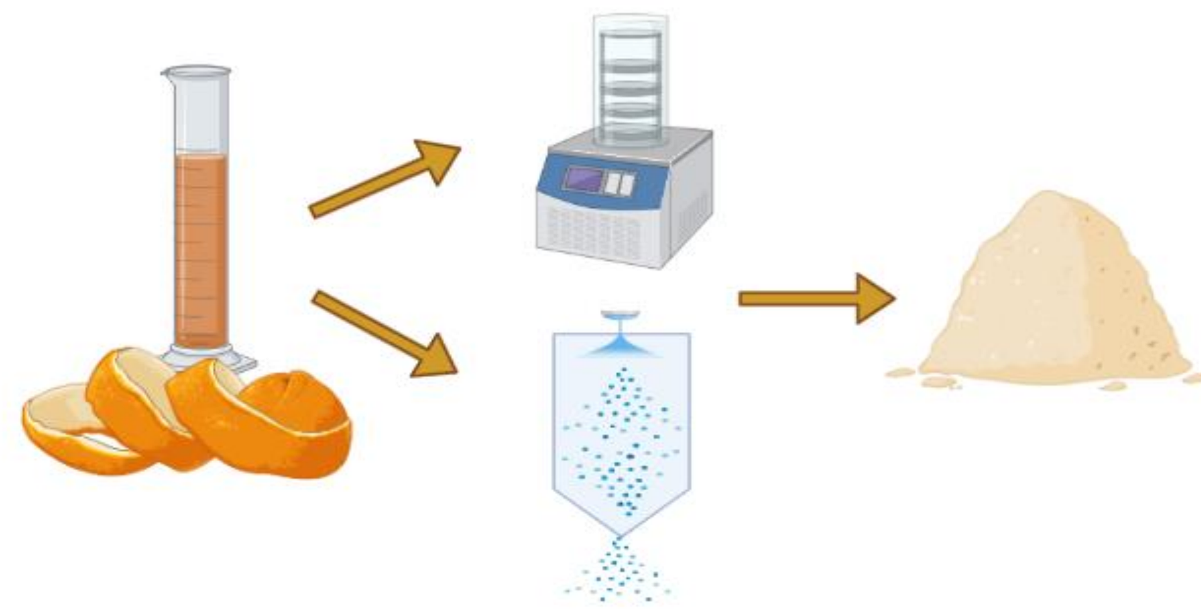


INTRODUCTION

The citrus peel make the largest amount of total produced citrus by-products, and they can be utilized for different purposes due to their bioactive compounds content. Under-exploitation of by-products and waste leads to finance losses and environmental pollution. Using spray drying and freeze drying processes, extracted bioactive compounds from food wastes and by-products can be transferred into powder form, and returned to the food chain. Those two techniques showed as convenient, energy efficient and time-saving processes, where a liquid is directly transformed into stable powder, which can be stored for a prolonged time or easily incorporated into other products. The product yield and physical properties of citrus peel dry extract, developed by two drying techniques: freeze drying and spray drying were investigated. Maltodextrin and Arabic gum were tested for their ability to serve as carriers for citrus peel extract. Obtained powders were evaluated for their moisture content, flow, solubility and color properties.

MATERIALS

Samples (whole citrus fruits, satsuma mandarin, Citrus unishu, medium late variety Kuno) were obtained from family farm OPG Pačić. Citrus fruits were grown and harvested in the Metković, Neretva Valley, Croatia in the season 2021/2022. After harvesting, the peel was removed and stored at -80 °C. Before extraction peel was dried, grounded at a laboratory mill and sieved. Citrus peel extracts were produced by ultrasonic-assisted extraction with 70% ethanol as a solvent. Carriers (maltodextrin and Arabic gum) were added to feed in the amount of 100% compared to the dry matter of the extract.

METHODS

Spray drying

The feed flow rate was adjusted to 4 ml/min, the airflow rate was 283 L/h and the temperature of drying was 120 °C. Microcapsules were separated using a high-performance cyclone and collected in the collecting chamber, weighted and stored until further analysis

Freeze drying

Before freeze drying, the feed was frozen on -80 °C, to improve heat transfer. After the preparation procedure, feeds were freeze-dried on the Alpha LCS Plus system. The procedure was taken for 48 h and the pressure during the main drying was 0.250 mbar. Prepared powders were collected and stored until further analysis.

RESULTS

Table 1 Product yield and visual appearance of citrus peel dry extracts obtained using spray drying and freeze drying

No	Samples	Process efficiency (%)	Moisture content (%)	ΔE	Whiteness index
1	CP raw	-	4.53 ± 0.029	0	53.18± 0.030
2	CP+MD+SD	54.87	2.26± 0.214	18.92± 1.255	68.99± 1.255
3	CP+GA+SD	51.02	4.85±0.005	20.38± 0.035	71.90± 0.035
4	CP+MD+FD	98.29	7.91± 0.014	12.57± 0.581	64.12±0.581
5	CP+GA+FD	90.29	6.51± 0.002	18.69± 0.023	76.98± 0.023

CP- citrus peel, MD- maltodextrin, SD- spray drying, FD- freeze drying, GA- gum Arabic, ΔE-total color change

Table 2 Flow properties of citrus peel dry extracts obtained using spray drying and freeze drying

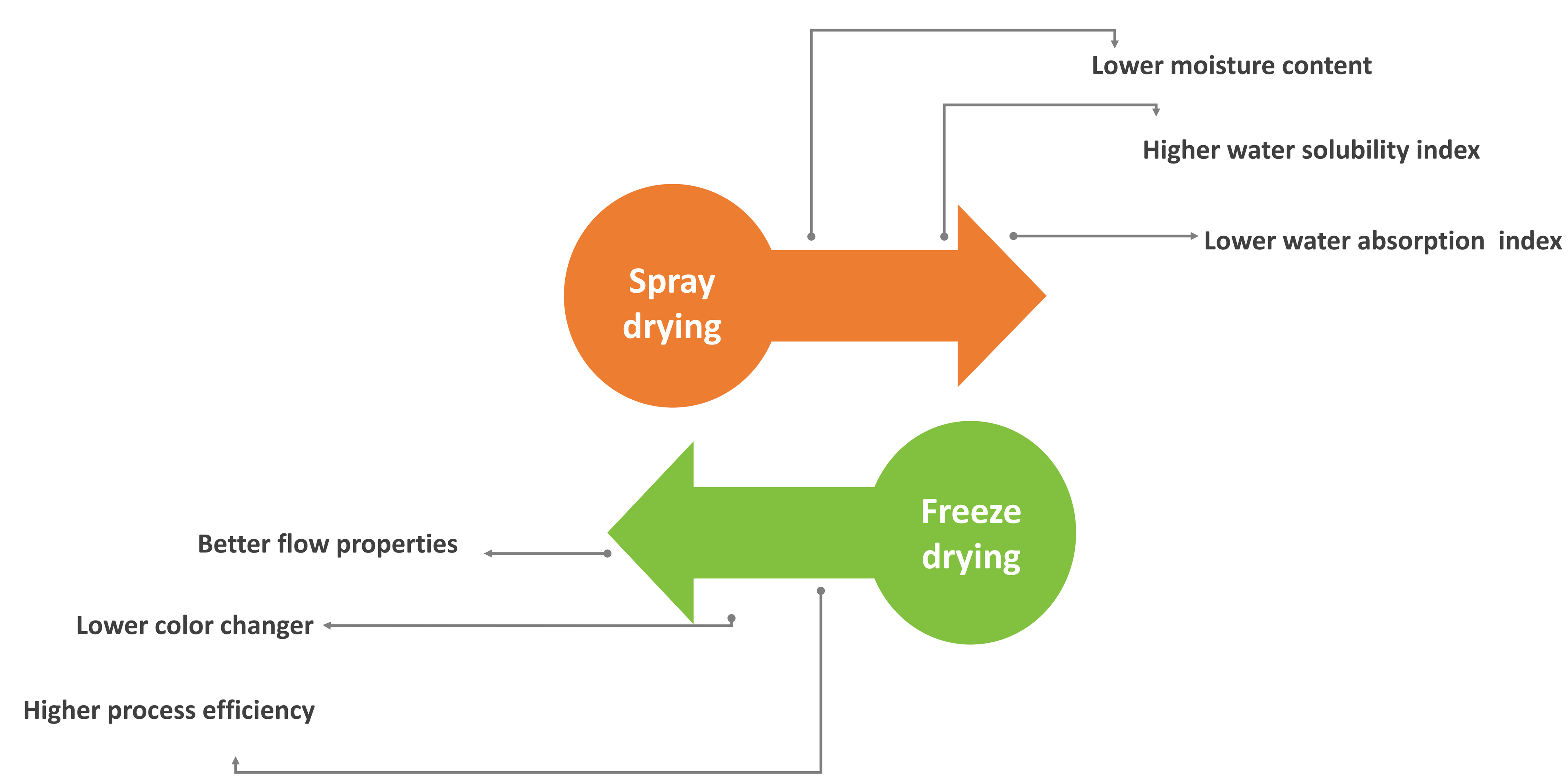
No	Samples	Bulk density (g/ml)	Haussner ratio	Carr's indeks (%)	Flow properties
1	CP raw	0.292± 0.077	1.408± 0.012	29± 0.504	Very poor/Very cohesive
2	CP+MD+SD	0.294± 0.007	1.304± 0.025	23.273± 1.486	Passable
3	CP+GA+SD	0.237± 0.001	1.246± 0.007	19.754± 0.424	Fair
4	CP+MD+FD	0.294± 0.007	1.245± 0.021	19.697± 1.339	Passable
5	CP+GA+FD	0.232± 0.003	1.259± 0.012	20.539± 0.763	Passable

CP- citrus peel, MD- maltodextrin, SD- spray drying, FD- freeze drying, GA- gum Arabic

Table 3 Solubility properties of citrus peel dry extracts obtained using spray drying and freeze drying

No	Samples	Water absorption index (WAI) [gg^{-1}]	Water solubility index (WSI) [%]	Oil absorption index (OAI) [gg^{-1}]
1	CP raw	6.614	30.586	0.296
2	CP+MD+SD	0.551	95.746	2.441
3	CP+GA+SD	0.291	99.135	2.174
4	CP+MD+FD	0.697	88.020	3.200
5	CP+GA+FD	0.589	91.817	4.185

CP- citrus peel, MD- maltodextrin, SD- spray drying, FD- freeze drying, GA- gum Arabic



CONCLUSION

Freeze drying gave high process yield (above 90%), while spray drying yield was significantly lower (around 50%). On the other hand, the moisture content of dry extracts obtained with spray drying was lower than those obtained with freeze-drying. Both drying techniques significantly improved the flow and solubility properties of citrus peel dry extracts, while color changes were lower when freeze drying was used. Obtained results also showed that maltodextrin is a better carrier choice when spray drying is used, while for freeze drying Arabic gum is more suitable. Above all, those results could be used as guidance on the practical production of functional food powders delivered from by-products like selecting a suitable drying approach and carrier choice.

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