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NANO SPRAY DRYING OF BIOACTIVE FOOD INGREDIENTS

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Abstract

Nano spray drying is a process for converting liquid substances into a dried submicron powder. Encapsulated bioactive food ingredients (e.g. vitamins, minerals, antioxidants, amino acids, peptides, enzymes, oils, plant extracts) improve protection, ensure stability, increase shelf life and enable controlled release. This study provides an up-to-date overview of the research work on nano spray drying of bioactive food ingredients.

***Keywords**: nano spray drying, encapsulation, bioactive, food, particles*

1. Introduction

Bioactive food ingredients from natural sources promote health and well-being thanks to their biological activity (Jafari, 2017). In many cases, it is necessary to encapsulate bioactives for better protection (e.g. oxidation, degradation), taste masking, gastrointestinal stability or improved storage. Spray drying is the most common drying and encapsulation technology for bioactive substances in the food industry (Celli et al., 2015; Fang and Bhandari, 2017). In view of the rapid progress of nanoencapsulation technologies, nano spray drying offers the opportunity to improve the formulation and release of bioactive food ingredients.
This paper explains the concept of nano spray drying, the influence of process parameters on powder properties and provides an overview of applications for the formulation and encapsulation of various bioactive food ingredients.

2. Material and method

The laboratory Nano Spray Dryer B-90, introduced in 2009, expands the spectrum of achievable particle size to the nanoscale (Arpagaus et al. 2018, 2017). The implemented vibrating mesh atomizer, the laminar drying process and the electrostatic particle collector enable the production of ultrafine submicron powders with narrow size distributions, high encapsulation efficiency and yield. Small powder quantities of a few grams can be processed in R&D works that provide data for feasibilty tests and further scale-up.

3. Results and discussion

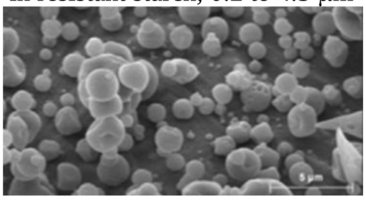
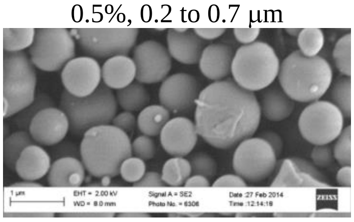
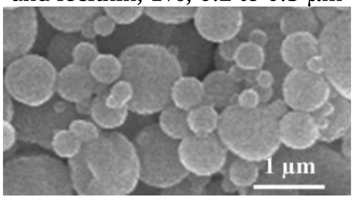
The feasibility of encapsulating bioactive food ingredients in submicron particles by nano spray drying has been demonstrated in various studies. Table 1 illustrates a selection of SEM images of such nano spray dried particles. Various vitamins, such as vitamin B_{12} (Oliveira et al., 2013), vitamin E as nanoemulsion (Li et al., 2010) or folic acid (vitamin B_9) (Pérez-Masiá et al., 2015), and others were encapsulated by nano spray drying in natural rubber, modified starch, maltodextrin, whey protein or sodium alginate as wall materials.
Another research focus is on nano spray dried polyphenols from natural sources. The feasibility of encapsulating curcumin, which is a widely used food colorant and antioxidant, in submicron chitosan and albumin particles has been demonstrated by O'Toole et al. (2012)

and Jain (2014). Nearly spherical and smooth particles were achieved with controlled release over several hours. Further examples are nano spray dried aqueous extracts from guava leaf (Camarena-Tello et al., 2018) or resveratrol, a natural phenol from berries (Dimer et al., 2015). Kyriakoudi & Tsimidou (2018) encapsulated aqueous saffron extracts in maltodextrin. Spherical particles were obtained with increased thermal and gastrointestinal stability.

Hu et al. (2016), for example, nano spray dried antimicrobial eugenol oil nanoemulsions (~100 nm) with gum arabic and lecithin and obtained ultrafine spherical powders of less than 500 nm. The dried powders showed excellent redispersibility in water and could be used as food preservatives.

The optimal nano spray drying conditions are within 90 to 120°C inlet and 40 to 60°C outlet temperature with an air flow rate of 130 to 150 L/min. Submicron particles are achieved at solid concentrations of 0.1 to 1% w/v and a nozzle mesh size of 4 µm.

Table 1. Examples of nano spray dried and encapsulated bioactive food ingredients.

Folic acid (Vitamin B_9) in resistant starch, 0.2 to 4.5 µm	Curcumin in albumin, 0.5%, 0.2 to 0.7 µm	Eugenol oil nanoemulsion in gum arabic and lecithin, 1%, 0.2 to 0.5 µm
		
(Pérez-Masiá et al., 2015)	(Jain, 2014)	(Hu et al., 2016)

4. Conclusions

The review shows that nano spray drying is an efficient processing technology for the formation of submicron powders loaded with various bioactive food ingredients (e.g. vitamins, polyphenols, extracts, nanoemulsions). The results open up further perspectives for the application of nano spray drying in food technology.

5. References

Arpagaus, C., Collenberg, A., Rütti, D., Assadpour, E., Jafari, S.M., 2018. Nano spray drying for encapsulation of pharmaceuticals. Int. J. Pharm. 546, 194–214.

Arpagaus, C., John, P., Collenberg, A., Rütti, D., 2017. Chapter 10: Nanocapsules formation by nano spray drying. In: Jafari, S.M. (Ed.), Nanoencapsulation Technologies for the Food and Nutraceutical Industries. Elsevier Inc., pp. 346–401.

Camarena-Tello, J., Martínez-Flores, H., Garnica-Romo, M., Padilla-Ramírez, J., Saavedra-Molina, A., Alvarez-Cortes, O., Bartolomé-Camacho, M., Rodiles-López, J., 2018. Quantification of Phenolic Compounds and In Vitro Radical Scavenging Abilities with Leaf Extracts from Two Varieties of Psidium guajava L. Antioxidants 7, 34.

Celli, G.B., Ghanem, A., Brooks, M.S.-L., 2015. Bioactive Encapsulated Powders for Functional Foods—a Review of Methods and Current Limitations. Food Bioprocess Technol. 8, 1825–1837.

Dimer, F., Ortiz, M., Pohlmann, A.R., Guterres, S.S., 2015. Inhalable resveratrol microparticles produced by vibrational atomization spray drying for treating pulmonary arterial hypertension. J. Drug Deliv. Sci. Technol. 29, 152–158.

Fang, Z., Bhandari, B., 2017. Spray Drying of Bioactives, Engineering Foods for Bioactives Srability and Delivery, Food Engineering Series. Springer New York, New York, NY.

Hu, Q., Gerhard, H., Upadhyaya, I., Venkitanarayanan, K., Luo, Y., 2016. Antimicrobial eugenol nanoemulsion prepared by gum arabic and lecithin and evaluation of drying technologies. Int. J. Biol. Macromol. 87, 130–140.

Jafari, M., 2017. Nanoencapsulation of Food Bioactive Ingredients - Principles and Applications. Elsevier.

Jain, I., 2014. Crosslinking albumin for drug release from spray dried particles, Master Thesis, Electronic Thesis and Dissertations, Paper 674. University of Louisville, USA.

Kyriakoudi, A., Tsimidou, M.Z., 2018. Properties of encapsulated saffron extracts in maltodextrin using the Büchi B-90 nano spray-dryer. Food Chem. 266, 458–465.

Li, X., Anton, N., Arpagaus, C., Belleteix, F., Vandamme, T.F., 2010. Nanoparticles by spray drying using innovative new technology: The Büchi Nano Spray Dryer B-90. J. Control. Release 147, 304–310.

O'Toole, M.G., Henderson, R.M., Soucy, P.A., Fasciotto, B.H., Hoblitzell, P.J., Keynton, R.S., Ehringer, W.D., Gobin, A.S., 2012. Curcumin Encapsulation in Submicrometer Spray-Dried Chitosan/Tween 20 Particles. Biomacromolecules 13, 2309–2314.

Oliveira, A.M., Guimarães, K.L., Cerize, N.N., Tunussi, A.S., Poço, J.G., 2013. Nano Spray Drying as an Innovative Technology for Encapsulating Hydrophilic Active Pharmaceutical Ingredients (API). J. Nanomed. Nanotechnol. 4, 1–6.

Pérez-Masiá, R., López-Nicolás, R., Periago, M.J., Ros, G., Lagaron, J.M., López-Rubio, A., 2015. Encapsulation of folic acid in food hydrocolloids through nanospray drying and electrospraying for nutraceutical applications. Food Chem. 168, 124–133.