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Effect of homogenization parameters on selected physical properties of lemon aroma powder

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ABSTRACT

The aim of this study was to examine the relationship between homogenization parameters of lemon aroma emulsion and selected physical properties of obtained powders. Emulsion was prepared in a high shear homogenizer (10 min, 24,000 rpm) or a two-stage pressure homogenizer (30_10 or 60_20 MPa). A 30% emulsion of maltodextrin and Arabic gum in the ratio 7:1 by mass in water and aroma was prepared. The addition of lemon aroma was 2, 6 and 10% (w/w). It was found that in emulsions an increase of aroma addition caused an increase in diameter from 2.4 to 4 μm for Ultra Turrax high shear homogenization and did not change the diameter size for pressure homogenization. For pressure homogenization similar viscosity values were observed. A different effect was observed for high shear homogenization (31–40 mPa s). Increase in aroma addition caused an increase in viscosity. Moreover, a similar diameter of the aroma phase after reconstitution of emulsion from powder (0.7–1.3 μm) was observed. In powders with an increasing amount of aroma, regardless of homogenization method, an increase in porosity, spread of particle size and total colour differences and also a decrease in loose bulk density, solubility and lightness were observed. The lowest apparent density of powders was found for an emulsion containing 6% aroma. The shape of powder particles did not differ from themselves.

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Keywords: Microencapsulation; Spray drying; Emulsion; Food powder; Microstructure; Homogenization

1. Introduction

The main purpose of microencapsulation of aroma is isolation of the core material, e.g. from light, humidity, heat and oxygen. In addition microencapsulation prevents losses of volatiles and after the process we can control the release rate at which the core material leaves the microcapsule (Frascareli et al., 2012; Hogan et al., 2001; Lee and Rosenberg, 2001). In this way, reactive, sensitive or volatile agents (vitamins, flavours, plant extracts, etc.) can be turned into stable forms (Gouin, 2004; Loksuwan, 2007). As the most frequent microencapsulation method of volatile substances, spray drying is used, not only in the laboratory but also in the food industry (Jafari et al., 2008; Neethirajan and Jayas, 2011; Sarkar et al., 2013). This method is flexible, quite cheap, relatively sensitive to the substances and produces powders with good quality (Frascareli et al., 2012; Desai and Park, 2005; Janiszewska and Witrowa-Rajchert, 2009). The process involves four stages: preparation of a dispersion or emulsion, homogenization of the dispersion, atomization of the feed emulsion and dehydration of the atomized particles (Petrovic et al., 2010). Physical and chemical properties of microcapsules, which can determine their future application, depend on various factors such as the amount and properties of the wall material and core substance, the homogenization method and parameters of spray drying (Hogan et al., 2001).

Walton and Mumford (1999) classified the materials used as carriers in three categories: agglomerate, skin-forming and crystalline structures. The authors found that the type of applied material can induce an oval or round shape with varied surface structure. The most commonly used materials for microencapsulation in the food industry are materials of

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skin-forming type (e.g. maltodextrin, milk proteins). Also, due to its good emulsification properties and ability to creation a strong impermeable film around droplets for microencapsulation of aromas Arabic gum is used (Soottitantawat et al., 2003; Wandrey et al., 2010). One carrier cannot provide good protection, which is why a mixture of them is usually used. A mixture of maltodextrin and Arabic gum can create generally good protection after spray drying (Frascareli et al., 2012; Janiszewska and Witrowa-Rajchert, 2009).

Important in the drying process is the viscosity of the emulsion, which can be created by different links of core and carrier material. Emulsion viscosity depends on the kind and amount of core material and the method of homogenization. An increase in core material concentration caused an increase of the emulsion viscosity (Janiszewska and Witrowa-Rajchert, 2009; Jinapong et al., 2008; Soottitantawat et al., 2003; Wandrey et al., 2010). The addition of carrier (such as maltodextrin, gum or starches) to the feed emulsion is important in the spray drying process, due to its influence on the physical properties and stability of the food powders. The most commonly used concentration of core material is 25–40% because of acceptable viscosity which also supports creation of droplets during spraying (Janiszewska and Witrowa-Rajchert, 2009; Tonon et al., 2008; Zuidam and Heinrich, 2010). Moreover, stability of the emulsion is necessary, not only in research but also in industrial drying. Disadvantages of spray drying are mainly connected with process scale-up. The drying conditions, emulsion stability and viscosity and its transfer to the spray disc are the most important challenges to solve (Zuidam and Heinrich, 2010). Emulsion stability and viscosity can be created by homogenization parameters, core and carrier proportion as well as carrier type (Janiszewska and Witrowa-Rajchert, 2009; Tonon et al., 2008). Furthermore, emulsion preparation is a critical point for the microencapsulation efficiency by the spray drying method. This emulsion must be stable through the whole process of microencapsulation (Thies, 2004) including short-term storage before the process, as well as transportation to the spray disc and the whole drying time. The stability of the emulsion can be improved by forming an emulsion with uniform and small droplets of the dispersed phase (below 2 μm) (Risch and Reineccius, 1988). The droplet size of the emulsion can be reduced by increasing the pressure and the time of homogenization (McClements et al., 2007). But a too intense homogenization process can increase the size of the emulsion droplets (Floury et al., 2003; Jafari et al., 2007). In addition, the stable emulsion should have a suitable viscosity (Thies, 2004; Rosenberg et al., 1990) because emulsions of high viscosity can block the spray-disc and form large droplets, which are usually not sufficiently dried. Too low viscosity causes diffusion of essential oil droplets towards the surface of the dried particles, which can decrease the efficiency of the microencapsulation (Rosenberg et al., 1990). The optimal viscosity of the emulsion should be selected in each case, taking into account the type and characteristics of the spraying device. During homogenization, the interface between the oil and water is disrupted, causing the liquids to blend together. Various mixing heads can be attached to high speed mixers to reduce droplet size by generating intense disruptive forces. Food emulsions containing a varied size distribution of droplets are referred to as polydisperse (Capela et al., 2007). The type and parameters of the homogenizer also caused changes in properties of the obtained emulsion, which affects the physical properties of powders (Frascareli et al., 2012; Risch and Reineccius, 1988). However, for the flavour microencapsulation this relation is not fully tested.

The hygroscopicity and size of particles cause problems in industrial driers. As stated by Adamiec et al. (2006), deposition of a powder on the chamber wall and pipes is possible. The deposition maybe due to changes of material properties after it has been sprayed. This problem can be solved by changing operating parameters of drying, but it is not always possible. Additionally, knowledge of physical properties of the emulsion that affect physical properties of the powder particles is useful. Viscosity, solid content and droplet size influence such parameters of powders as moisture content, bulk density, apparent density, porosity, and solubility (Finney et al., 2002; Abadio et al., 2004; Fernandes et al., 2013). Some relationships are known, such as the following: the higher diameter size of droplets the lower encapsulation efficiency (Risch and Reineccius, 1988; Soottitantawat et al., 2003; Turchiuli et al., 2014); higher viscosity can lead to greater particle production with higher moisture content (Finney et al., 2002; Turchiuli et al., 2014); depending on the core material we can obtain different porosity of powders, which is important in transport and storage (Fernandes et al., 2013; Janiszewska and Witrowa-Rajchert, 2009).

To verify these observations and to solve problems with future storage of microcapsules of lemon aroma, the aim of the study was to examine the relationship between homogenization parameters of lemon aroma emulsion and selected physical properties of powders after the spray drying process. The scope of the study included: (a) testing the influence of different types of homogenization on viscosity, diameter and stability of the emulsion, (b) drying emulsions in the same conditions, (c) testing physical properties of obtained lemon aroma microcapsules, and (d) correlation of physical properties of the emulsion and powder.

2. Materials and methods

2.1. *Emulsion preparation*

Materials used in experiments were lemon aroma (330–402 lemon aroma without terpenes, aroma in oil phase, from company "JAR" Jaskólski Aromaty) (Warsaw, Poland) and as carriers low-crystalized maltodextrin DE = 10 (MD) (Roquette, Freres, France), Arabic gum type 4639 (AG) (Jaskólski S.A, Germany).

Thirty percent solutions of carriers in the proportion maltodextrin to Arabic gum 7:1 were prepared. To these solutions aroma was added. The addition of lemon aroma was 2, 6 and 10% (w/w). The solution of a mixture of maltodextrin and Arabic gum without aroma was prepared and kept for 24 h to allow Arabic gum hydration. After that time the aroma was added. To create pre-emulsions all mixtures were homogenized in a high shear homogenization Ultra Turrax Model T25 basic high shear homogenizer (UT-HSH) (IKA, Works Inc., Wilmington, NC, USA) for 10 min at 12,000 rpm. Pre-emulsions were then homogenized in different ways. One was homogenized by UT-HSH for 10 min at 24,000 rpm, another in a two-stage pressure homogenizer Panda (HP) (GEA Niro Soavi, Parma, Italy), at pressures on the first level 30 or 60 MPa and on the second 10 or 20 MPa, according to Dłużewska and Leszczyński (2005). The temperature of pre-emulsions was 20 °C. Emulsions after UT-HSH homogenization had the same temperature. The value of temperatures of emulsions after HP homogenization were in range of 23–25 °C.