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Spray Dried Fermented Milk Products

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A B S T R A C T

Fermented milk products are perishable in nature. They possess lot many health benefits due to probiotic nature. Most of the fermented dairy products are available in liquid form that is highly perishable in nature. Spray drying technology presents a better, convenient and affordable method for preserving such products by enhancing their storability and making them shelf stable from a week to several months. The technology convert fermented milk products into powder form, which are stable, probiotic, easy to use, easy to transport, and is appropriate for solicitations in the food sector. The overall demand for probiotic dried fermented dairy products has improved in perspective of promptly developing market, corroborating the requirement for their significant production. Only a few spray dried fermented milk powders like Srikhand, Kefir, Yoghurt, Bifidus milk and cheese are reported, therefore, this review specifically provide a state of knowledge on the preparation of spray dried fermented milk powder.

Introduction

Lactic acid bacteria is prominently used to ferment food chiefly milk since time immemorial, which have occasioned to produce cultured dairy products with distinctive flavour which makes them divergent from core food (Amadoro *et al.*, 2018). Along with the conservation and modification of nutrients of milk, fermentation complies the consumer with live and active probiotic cultures, when taken in passable amount confer health benefits (FAO/WHO, 2002). But these functional foods are highly perishable in nature (Shiby and Mishra, 2013). Their perishability is attributed to high production of lactic acid (Hati *et al.*, 2019) which creates an acidic environment. Shelf life extension of most dairy products is done through pasteurization and chemical preservatives which affect viability of probiotics. Generally fermented milk products are stored in the refrigerator to extend their shelf life. Moreover, they also require refrigeration during transportation thereby increasing cost which may be costly especially to those in rural communities.

As a way of dealing with perishability of these products and reducing cost due to transport, spray drying has been employed in the drying of fermented milk products to make powders, which can be stored for longer periods at ambient temperatures (Costa *et al.*, 2015). The dehydration of these products helps in stabilizing them for storage and later use (Schuck, 2016). Spray drying is preferred in dairy industry because of its less operational costs and more output (Wirjantoro and Phianmongkhol, 2009; Koc *et al.*, 2014). It is a process through which liquid state of food is converted into solid state (powder), by spraying the liquid feed through nozzle or atomizer into a hot dried chamber (Friesen *et al.*, 2019). This method causes minimal structural and functional changes in dairy food products (Gabites *et al.*, 2010; Kumar *et al.*, 2018). Masses of literature is available on spray dried milk powder, but very scarce compilation is available on spray dried fermented milk products like Srikhand, Kefir, Yoghurt, Bifidus milk and cheese powder (Fig. 1). This review offers update with specific reference to the spray dried fermented dairy products.

Spray drying of fermented milk products

Spray drying is used to dehydrate dairy products and its process conditions are directly associated with the production costs and value of the final product (Santos *et al.*, 2018). Some researchers have recorded the success of spray dried fermented milk products (Kothakota *et al.*, 2014, De, 1980). Inlet temperature, outlet temperature and speed of drying are crucial factors for continuous production of probiotic fermented dairy products (Gharsallaoui *et al.*, 2007).

Srikhand powder

Srikhand is a semi-soft dairy product prepared commonly from buffalo milk Anagnostopoulos and Tsaltas, 2019; Tamang *et al.*, 2020). During its preparation, the curd is drained, and then the solid mass obtained is called *chakka*. It is mixed with an adequate amount of sugar to obtain srikhand (Narayanan and Lingam 2013). In the process of making spray dried powder, the srikhand go through pre-treatment stages which involve homogenization and concentration. Mahajan *et al.*, (1979) reported on spray dried srikhand powder in which homogenized slurry was adjusted to 35 percent total solid and spray dried at pre-determined inlet air temperature and outlet temperature i.e. 180-200°C and 100°C respectively. Storability of this powder is appraised over three months provided the product is packed in hermetically sealed containers.

Kefir powder

Kefir is fermented dairy product of North Caucasus Mountain, Eastern Europe and Russia produced chiefly from cow or sheep milk. Kefir milk is prepared by inoculating milk with kefir grains. These grains comprise of bacteria and yeast in a synergetic matrix. The following species of LAB and yeast which forms up the matrix: *Acetobacter*, *Kluyveromyces marxianus*, *Lactobacillus*, *Leuconostoc*, *Lactococcus* and *Saccharomyces* respectively (Anonymous 2009). An inlet air temperature, outlet temperature and feed temperature (171°C, 60.5°C and 15°C) were noted as most favourable for yoghurt powder (Koc *et al.*, 2010) with respect to the survival probiotics; color, moisture and overall acceptability of powder. Atalar and Dervisoglu (2015), modelled and optimized spray drying of Kefir by means of response surface methodology and produced supreme quality powder as spray dried powder.

If feed temperature, pump rate and inlet air temperature was in a range of 4–30°C, 120-180°C and 20–40% respectively, then maximum survival rates of probiotics, decreased moisture content of kefir powder was obtained. After spray drying the maximum survival rate was observed in *Lactococci* 8.51×10^3, *Lactobacilli* 9.54×10^2 and *Leuconostoc* 3.23×10^2. Teijeiro *et al.*, (2018) described the effect of alteration in carriers during spray drying of traditional kefir. They observed a fewer viable count when kefir was dehydrated without carriers. Whereas, 9 log CFU/g survival of LAB by using a carrier named skim milk however, when carrier medium was whey permeate then 8 log CFU/g LAB and 4 log CFU/g yeast was obtained. In kefir powder when skim milk was used as carrier, then maximum probiotics survival was simulated under GI conditions and retained stable for minimum 60 days at 4 °C. It was concluded that spray drying is an appropriate methodology to prepare kefir powder.

Yogurt powder

Yoghurt, similar to Indian curd prepared from whole milk. It is obtained after fermentation by two specific strains: *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The best spray dried optimized condition for yoghurt preparation was 15°C feed temperature, 171°C inlet air temperature and 60.5°C outlet temperature, respectively (Koc *et al.,* 2010). Spray drying of *Chakka* (strained yoghurt) was reported by De and Patel (1989) who used 190ºC and 95ºC as inlet and outlet temperatures respectively. Prior spray drying yoghurt is churned to obtain a uniform mass followed by adjustment of the total soluble sugars (Kim and Bhowmik, 1995). According to Seshamamba *et al.,* (2016) yoghurt with 25% TSS yield a high amount of powder and that when reconstituted there is little difference between the fresh and reconstituted yoghurt. Basu and Athmaselvi (2018) developed spray dried curd powder with mango flavour. They observed that in high inlet temperature powder still had some viable count of probiotic microorganism and furthermore concluded if the particle size of powder is small then it results in poor flowability of powder. For preparation of sweetened yogurt powder inlet temperature of spray drier: 140–180°C, rate of feed 0.3–0.6 L/h and atomizers' pressure 500–1000 kPa was studied (Seth *et al.*, 2017a).

Yogurt powder exhibited negative correlation in reference to solubility and dispersibility with variations in inlet temperatures of spray drier and atomizers' pressure. Rate of feed of yogurt expressively affected the solubility of yogurt powder while, as the inlet temperature was raised simultaneously an increase in wetting time of powder was observed. A decrease in flow property and water activity of sweetened yogurt powder as inlet air temperature of spray drier and atomizers' pressure increased whereas, water activity increased with gradually increase in rate of feed. Under optimal conditions of spray drying (inlet air temperature 148°C, feed rate 0.54 L/h, and atomization pressure 898 kPa), Seth *et al.*, (2019) confirmed that a practically fair quality shelf-stable sweetened yoghurt powder can be manufactured. By spray drying a commercial drinkable yogurt with low water activity and total bacterial count of 8.48–8.90 log cfu/g was produced by Bater *et al.*, 2019. In spray-dried yoghurt *S. thermophilus* showed better survival than *Lactobacillus bulgaricus* (Bielecka and Majkowska, 2000).

Bifidus milk powder

Bifidus milk is a product of milk fermentation by probiotic strain *Bifidobacterium bifidum* (BB). Selvamuthukumaran and Shukla (2016) supplemented milk with gelatin, mono-sodium glutamate and skim milk powder for increasing the concentration to desired levels (slurry) for manufacturing spray dried bifidus milk powder. Bifidus milk was spray dried with 175°C inlet and 65°C outlet air temperatures, respectively. The viable count of probiotic microorganism during spray drying was maximum when the inlet spray driers' temperature, bifidus milk concentration and inlet air pressure in spray drier chamber was 164°C, 25.62% of 2.5 kg/cm^2 respectively. Bifidus milk powder was shelf stable up to four months when stored under room temperature, with good overall acceptability after reconstitution to form bifidus milk.

Cheese powder

Lab scale spray driers were used for the manufacturing of cheese powder (Pisecky, 2005; Erbay and Koca, 2019). Gardiner *et al.,* (2002) spray-dried probiotic milk powder at inlet and outlet temperatures of 175°C and 68°C with probiotic survival (84.5%). Further they manufactured cheddar cheese by using this powder, having 1×10^9 cfu g^{-1} of *Lb. paracasei* NFBC 338 Rif^r without adversely affecting the cheese quality. A successful trial was performed with pre-determined atomizers' pressure, inlet temperature and outlet temperature of spray drier chamber (354 kPa, 174°C and 68°C) to prepare cheese powder. Powder was observed to have bulk density (252 kg/m^3), fat (40.7%), non-enzymatic browning (0.123 OD) and solubility index (82.7%), respectively (Erbay *et al.,* 2015). Erbay and Koca (2019), prepared cheese powder by incorporation of maltodextrin and whey to improve its physical properties. A decrease in volatile fatty acid was estimated during formulation of emulsion (9%) and was highest after spray drying process (53.5%). Sweet whey powder added to Danbo cheese prior spray drying resulted better solubility, small particle size and faster wettability properties (Da Silva *et al.,* 2018).

Challenges

Spray drying of fermented milk products is tedious task due to its acidic pH, which results adhesiveness in driers' chamber and makes difficulty in recovery of powder. Another drawback of spray drying fermented milk products is that products lose the key flavour components such as diacetyl in curd and acetaldehyde in yogurt. Spray drying process hinge on material concentration, feed rate, nozzle pressure, inlet and outlet air temperature which play a crucial role in probiotics' viability and cellular damage occurred due to thermal and dehydration stress during drying (Fu and Chen, 2011; Seth *et al.,* 2017b). Survival rate of lactic acid bacteria is one of the major challenges to get probiotic dairy powder along with pleasant sensory characteristics.

In conclusion, spray drying method provides suitable and agreeable method to commercially manufacture fermented milk powders with lower cost, easy availability, easy to store, handle, transport and convenient to use. Powders available throughout year may be used in varied food preparations like an instant beverage and functional foods. For commercial utility of spray drying technology further research will be focused on standardization of the spray drying conditions for specific fermented milk products to retain their original nutritive, probiotic and sensorial characteristics.

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