Journal of Dairy Research (2018) **85** 243–246. © *Hannah Dairy Research Foundation 2018*
doi:10.1017/S0022029918000225

Characterisation of mango flavoured curd powder developed using spray drying technique

Akash Basu and Kathirvelpillai A Athmaselvi*

Department of Food Process Engineering, School of Bioengineering, SRM University, Kattankulathur 603203, India

Received 9 March 2017; accepted for publication 2 April 2018

This research communication describes the production of flavoured (Mango) curd powder. The mango flavoured curd powder was developed in two different temperatures (150 °C and 170 °C) in various ratios with one control curd sample. The final powder was obtained in high quality which can be used directly or as an ingredient. The percentage of lactic acid in the developed powder showed the healthy amount of probiotic present in it. The physical properties and probiotic growth of the mango flavoured curd powder, developed by spray drying technique, have been evaluated in this article. Various properties were analysed, including moisture content, water activity, dispersibility, bulk and tapped density, porosity, particle morphology, colour analysis, pH, functional group identification using FTIR, identification of the pure culture and % of lactic acid for 3 different Curd and Mango ratios (1:0·5, 1:1, 0·5:1), respectively with one control curd sample. The lactobacillus strain found in this newly developed flavoured powder was *Lactobacillus curieae*. Lactic acid percentage showed the powder to contain appropriate and healthy amount of probiotic and significant flavour. Future studies are focused on storage studies of the produced powder.

Keywords: Spray drying, dairy, flavoured curd powder, % lactic acid.

Spray drying is suitable for mango flavoured curd powder due to its very short time of heat association and the high evaporation rate, which gives high quality, stable, functional and low moisture content products (Koc et al. 2011). Dairy based powder like curd powder can be used to prepare many products like ice cream, instant drinks, thick creams etc. A dried flavoured curd powder also will be highly desirable due to its long shelf life and flavour (mango) and requires comparatively low transportation cost and capacity of storage (Koc et al. 2014). Mango (*Mangifera indica*) is an important fruit in Asia and around the world. Nutritional importance of mango is mainly due to carotenes and other bioactive compounds (Wilson et al. 2012).

The aim of the present work was to produce self stable mango flavoured curd powder using spray drying technique and to study various parameters such as, reconstitution properties (dispersibility), morphological properties (appearance and particle shape), bulk and tapped density, microbial growth, % lactic acid, moisture content, water activity, Colour and pH of the developed powder. The two spray drying temperatures (150 °C and 170 °C) were selected based on a spray drying system which has been characterised for yogurt at various combinations of inlet air, outlet air temperatures or feed rate, atomisation speed and feed temperature (Kim & Bhowmik, 1990; Koc et al. 2010).

*For correspondence; e-mail: athmaphd@gmail.com

Material & methods

Materials

Mango flavoured curd powder was used in this study which was obtained by spray drying in a tall type spray drier under 2 different temperatures (150 °C and 170 °C) and 3 different curd and mango ratio (1:0·5, 1:1, 0·5:1) with curd sample as control. The curd was prepared from pasteurised, double toned, homogenised milk (fat 1·5%, SNF 9·0%). The spray drying condition for flavoured curd powder production (inlet air temperature of 150 °C and 170 °C, outlet air temperature of 80 ± 10 °C and 105 ± 10 °C, respectively and feed temperature of 15 ± 5 °C) was targeting the maximum survival ratio of lactic acid bacteria, utmost overall sensory attributes, minimum colour change and acceptable moisture content. Besides, all the physical and biochemical properties were measured carefully.

https://doi.org/10.1017/S0022029918000225 Published online by Cambridge University Press

Analytical methods

Moisture content. Moisture contents of flavoured curd powder were determined gravimetrically by oven drying at 105 °C for 3 h.

$$MC = \frac{\text{Intial Weight} - \text{Final Weight}}{\text{Final Weight}} \times 100\%$$

Water activity (a_w). The water activity was determined using a water activity meter (LabSwift-aw; Novasina, SRM University, India).

Dispersibility. Dispersibility measurements of flavoured curd powder were performed in water by little stirring and the time of dispersion was noted down.

Bulk density and tapped density. The bulk density (ρ_b) of the flavoured curd powder was determined by taking the weight of the powder and the corresponding volume. For the tapped density (ρ_t), the cylinder was tapped strenuously by hand until no further change in volume took place (Nijdam & Langrish, 2005).

Porosity. The porosity (ϵ) of the powder samples was evaluated using the relationship between the tapped (ρ_t) and bulk (ρ_b) densities of the powders (Nijdam & Langrish, 2005):

$$\epsilon = \frac{\rho_t - \rho_b}{\rho_t}$$

Particle morphology. The morphological properties of flavoured curd powder (the appearance and the particle shape) identified by using images which are taken *via* a scanning electron microscope (SEM, FESEM–NRC, India).

Colour analysis. The colour of mango flavoured curd powder was measured using a Hunter Lab Colour quest XE-Hunter colour meter based on L* (black to white), a* (red to green), and b* (yellow to blue) values (Behboudi-Jobbehdar et al. 2013).

pH. pH of mango flavoured curd powder was determined after reconstitution using pH meter (Chegini et al. 2014).

Functional group identification. FTIR is done to identify the functional groups present in the mango flavoured curd powder (Mitali & Baruah, 2011).

Identification of the pure culture. Isolated pure culture on MRS agar petri plates was recognised with the help of biochemical tests like endospore test and catalase test.

% Lactic acid. Acidity is indicated as per cent lactic acid. Since 1 ml of 0·1 N lactic acid carries 0·009 g of lactic acid, the number of ml. of 0·1 N NaOH needed to neutralise the lactic acid in the sample, multiplied by 0·009 will produce the quantity of lactic acid (grams) in the sample, when the result is divided by weight of sample and multiplied by 100 the per cent lactic acid will be obtained. Phenolphthalein indicator is used and colour changed to pink which remained constant for 10–15 s. The titration is completed within 20 s.

$$\%\,\text{Lacti acid} = \frac{\text{No of ml of } 0\cdot1\,\text{N NaOH solution required for nutrilization} \times 0\cdot009}{\text{Weight of Sample}} \times 100$$

(Weight of sample = Volume of sample × specific gravity).

Statistical analysis. All measurements were made in triplicate and results are expressed as mean ± standard deviation. The analysis of variance (ANOVA) at a confidence level of 95% was performed. All the results that were obtained were analysed using IBM SPSS Statistics 20·0 software (SRM University, India).

Results and discussion

As reported in Table 1 the moisture content of the fresh curd sample was determined as 8·58% (150 °C) and 3·51% (170 °C) wet basis. The moisture content (%, wet basis) of mango flavoured curd powders obtained at the 2 spray drying conditions with 3 different ratios (1:0·5, 1:1, 0·5:1) are also shown in Table 1, where it is observed that samples with more amount of curd have higher amount of moisture content and water activity. The moisture content as well as water activity decreased with higher inlet temperature. For yogurt powder moisture content varies from 3·98% to 7·17% based on different inlet and outlet temperature (Koc et al. 2014). From Table 1 it can be obtained the reconstitution property (dispersibility) ($P < 0\cdot05$) was higher with higher inlet and outlet temperature. The dispersibility of flavoured curd powder is affected by the outlet air temperature, but the trend of this effect cannot be figured out clearly (Koc et al. 2014). Bulk and tapped density decreased with higher inlet and outlet temperature but porosity increased, hence there was an inverse proportionality between the two characteristics. Spray-dried products are usually non-homogeneous. Milk powder which is dried in low temperature provides relatively high bulk density due to lower porosity, whereas milk powder dried in high temperature gives low bulk density because of porous individual particles (Nijdam & Langrish, 2005).

The scanning electron microscopy images of yoghurt powder, produced at 2 different spray drying condition and 4 different ratios, are given in Fig. 1 with a level of magnification of 800× to 4000×. The first four pictures were for 150 °C sample 1:0·5, 1:1, 0·5:1 and control curd sample,

https://doi.org/10.1017/S0022029918000225 Published online by Cambridge University Press

Table 1. Physical & Chemical Properties (mean ± SD) of spray dried curd and mango flavoured curd powder

Sample	Moisture content (%)	Water activity (a_w)	Dispersibility (s)	Bulk density (gm/cm^3)	True density (gm/cm^3)	Porosity (%)	pH	% Lactic acid
Curd (150 °C)	8·58 ± 0·103	0·316 ± 0·0015	52 ± 1*	0·33 ± 0·015	0·45 ± 0·015	26·67 ± 0·252	4·28 ± 0·012	1·039 ± 0·0045
MC 1:0·5 (150 °C)	13·62 ± 0·086	0·397 ± 0·0015	54 ± 1*	0·35 ± 0·0058	0·48 ± 0·01	27·08 ± 1·281	4·37 ± 0·015	0·497 ± 0·002
MC1:1 (150 °C)	11·16 ± 0·061	0·387 ± 0·0006	56 ± 0·577*	0·38 ± 0·01	0·51 ± 0·0058	25·49 ± 1·193	4·55 ± 0·015	0·334 ± 0·0015
MC 0·5:1 (150 °C)	6·35 ± 0·118	0·366 ± 0·001	59 ± 0·577*	0·42 ± 0·015	0·53 ± 0·015	20·75 ± 0·431	4·39 ± 0·025	0·303 ± 0·0026
Curd (170 °C)	3·51 ± 0·001	0·204 ± 0·0031	79 ± 1*	0·31 ± 0·02	0·43 ± 0·01	27·91 ± 0·351	4·29 ± 0·015	1·02 ± 0·082
MC 1:0·5 (170 °C)	6·34 ± 0·125	0·257 ± 0·001	82 ± 2*	0·32 ± 0·027	0·45 ± 0·015	28·89 ± 0·318	4·44 ± 0·015	0·457 ± 0·0021
MC 1:1 (170 °C)	4·19 ± 0·092	0·242 ± 0·0021	85 ± 1·528*	0·35 ± 0·01	0·47 ± 0·01	25·53 ± 0·707	4·72 ± 0·012	0·316 ± 0·0026
MC 0·5:1 (170 °C)	2·10 ± 0·085	0·216 ± 0·0015	88 ± 1·528*	0·39 ± 0·0058	0·50 ± 0·02	22 ± 0·262	4·65 ± 0·023	0·277 ± 0·002

*$P < 0·05$

respectively. The other four pictures were for 170 °C as the above stated order of ratios.

The pH was increased with higher inlet and outlet temperature samples. Some circumstances led to an increase in the density of the concentrated liquid samples, which resulted in an increase in the pH values (Chegini et al. 2014). Sample with equal ratio of curd and mango had higher pH than the rest of the samples. Curd sample had a greater amount of lactic acid than flavoured sample powders. Lactic acid percentage decreased with higher inlet and outlet temperature. In previous experiment on yogurt-ice cream mix the percentage of lactic acid was found to be between 0·60 and 0·63 (Layusa et al. 2013). The colour analysis showed that the curd sample was white in colour and all the other three ratios were yellow in colour (reported in online Supplementary Tables S1 and S2). All the flavored sample powders had a lower luminosity (L*) and higher yellow colour intensity (b*) compared to the curd-only sample. The luminosity (L*) decreased and intensity of yellow colour (b*) and intensity of red colour (a*) was increased with higher inlet temperature.

The FTIR results showed that with different inlet spray drying temperature and ratios the functional groups present in the sample powder changed (reported in online Supplementary Table S3). In both the cases ratio of mango 0·5: curd 1 had the almost similar functional group against control curd sample (online Supplementary Figs. S1–S8). The number of functional groups decreased with higher inlet temperature. Alkanes were present as same number in flavoured curd powder at both 150 °C and 170 °C inlet temperature. From the result we can see alkenes groups were not present in only curd sample at both 150 °C and 170 °C inlet temperature.

To identify the lactobacillus strain present in the curd powder we obtained an almost-complete 16S rRNA gene amplification with primer combinations 27F and 1492R. The phylogeny tree S9 (reported in Supplementary Fig. S9) shows the strain present in the sample is *Lactobacillus_curieae* which is a gram-positive, non-motile, facultative anaerobic, non-spore-forming, rod-shaped bacteria which did not exhibit catalase activity (Lei et al. 2013).

Conclusion

The newly developed final product mango flavoured curd powder possesses good flavour and colour. A fine particle powder was obtained with higher spray drying temperature. The bulk and tapped densities of sample curd powder are an indication that sample powders have fair porosity. Flavoured curd powders have moderate-poor flowability due to their small particle size. With respect to morphology, the sample powders particles were mostly spherical and showed a crater-like structure. For purposes of understanding the particle formation process, predicting product quality and evaluating the behaviour of spray-dried mango

https://doi.org/10.1017/S0022029918000225 Published online by Cambridge University Press

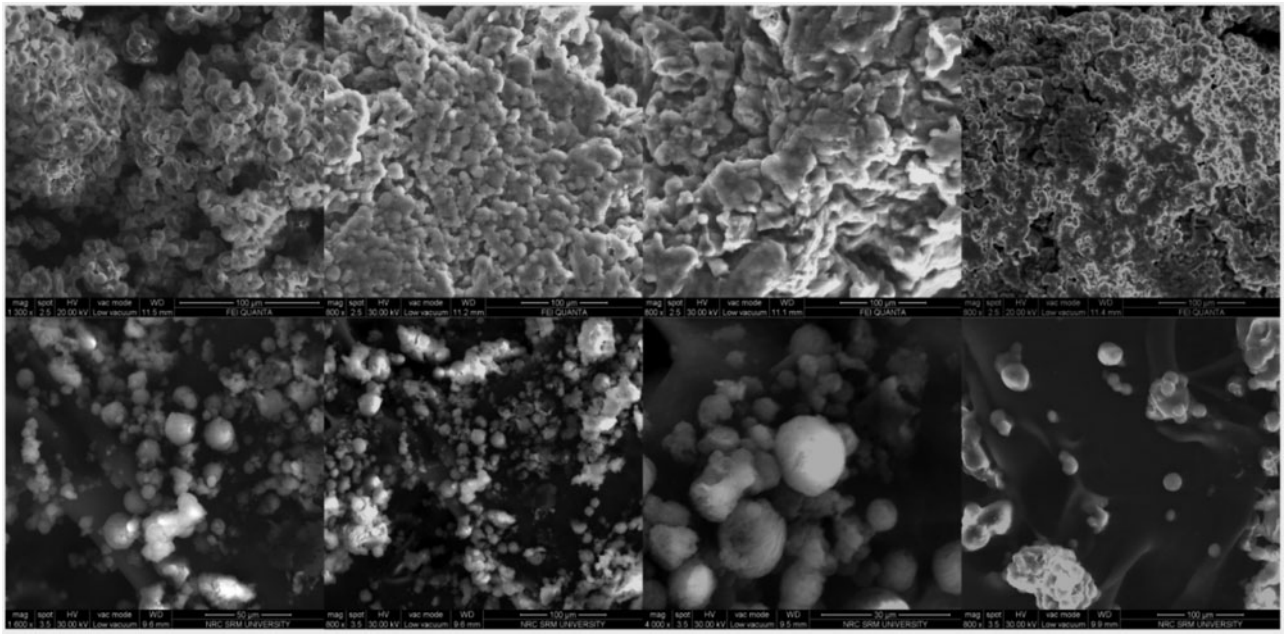


Fig. 1. The scanning electron microscopy images of Mango flavoured curd powder, produced at the optimum spray drying condition (inlet air temperature of 150 °C & 170 °C, outlet air temperature of 80 ± 10 °C & 105 ± 10 °C and feed temperature of 15 ± 5 °C)

flavoured curd powder during reconstitution, this information will provide a helpful approach. Also the lactobacillus strain (*Lactobacillus_curieae)* was found, which potentially makes this powder healthy and probiotic.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S0022029918000225

References

Behboudi-Jobbehdar S, Soukoulis C, Yonekura L & Fisk I 2013 Optimization of spray-drying process conditions for the production of maximally viable microencapsulated L. acidophilus NCIMB 701748. *Drying Technology* **31** 1274–1283

Chegini G, HamidiSepehr A, Dizaji MF & Mirnezami SV 2014 Study of physical and chemical properties of spray drying whey powder. *International Journal of Recycling of Organic Waste in Agriculture* **3** 1–7

Kim SS & Bhowmik SR 1990 Survival of lactic acid bacteria during spray drying of plain yoghurt. *Journal of Food Science* **55** 1008–1010

Koc B, Sakin M, Balkir P & Kaymak-Ertekin F 2010 Spray drying of yoghurt: optimization of process conditions for improving viability and other quality attributes. *Drying Technology* **28** 495–507

Koc M, Koc B, Susyal G, Sakin-Yılmazer M, Kaymak-Ertekin F & Bagdatlıoglu N 2011 Functional and physicochemical properties of whole egg powder:effect of spray drying conditions. *Journal of Food Science and Technology* **48** 141–149

Koc B, Sakin-Yılmazer M, Kaymak-Ertekin F & Balkır P 2014 Physical properties of yoghurt powder produced by spray drying. *Journal of Food Science and Technology* **51** 1377–1383

Layusa DRC, Barraquion VL, Dizon EI, Elegado FB & Sevilla CC 2013 Optimization of spray drying parameters for yogurt-Ice cream Mix. *Philippine Agricultural Scientist* **96** 392–403

Lei X, Sun G, Xie J & Wei D 2013 Lactobacillus curieae sp. Nov., isolated from stinky tofu brine. *International Journal of Systematic and Evolutionary Microbiology* **63** 2501–2505

Mitali K & Baruah GD 2011 On the nature of vibrational bands in the FTIR spectra of medicinal plant leaves. *Scholars Research Library Archives of Applied Science Research* **3** 214–221

Nijdam JJ & Langrish TAG 2005 An investigation of milk powders produced by a laboratory-scale spray dryer. *Drying Technology* **23** 1043–1056

Wilson RA, Kadam WM, Chadha S, Grewel MK & Sharma M 2012 Foam Mat drying characteristics of mango pulp. *International Journal of Food Science and Nutrition Engineering* **2** 63–69

https://doi.org/10.1017/S0022029918000225 Published online by Cambridge University Press