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Characteristics of spray dried dahi powder with maltodextrin as an adjunct

Anjineyulu Kothakota[1*], Anil Kumar[2], Maneesh Kumar[3], Praneeth Juvvi[4], Sankar Rao[4] and Sheshrao Kautkar[4]

[1]Department of Post Harvest Process and Food Engineering, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand, India.
[2]Department of Food science and Technology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand, India.
[3]Departments of Lipid Science and Traditional Foods, CFTRI, Mysore-570 020, India
[4]College of Food Science Technology, Marathwada Agricultural University, Parbhani -431402, India

*Corresponding author: kothakotaanjanikumar23@gmail.com

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Abstract

This study investigated the effect of adding as a complementary drying aid of maltodextrin (MD) on spray drying of dahi powder. Dahi powders were prepared by curd adding with maltodextrin (MD) drying aid at 5%, 7.5%, 10, and 12.5% level before spray drying by maintaining with outlet air temperature and blower speed being 70°C and 2200 rpm, respectively. The survival rate of lactobacilli during spray drying of dahi powder were investigated such as 0.62% shows maximum at 7.5% maltodextrin (MD) drying aid. Tests were conducted to evaluate the powder properties relevant to physical, chemical and reconstituted properties of the spry dried dahi powder. Results showed addition of 7.5% maltodextrin (MD) aid could significantly increases the product yield for the spry drying process of dahi powder and the consumer acceptable also. At the same time values of lightness, wet ability, water solubility index, viscosity, bulk density, dispersibility and total solids increases with increasing the maltodextrin (MD) aid. Moisture content, acidity and hygroscopicity decreases with increasing maltodextrin (MD) aid in spry dried dahi powder but the values of pH and acidity remain constant during spry drying process by increasing maltodextrin (MD) aid. The flavour of reconstituted *dahi* samples improves as the maltodextrin content increases may be due to more acetaldehyde retention in the samples. Addition of maltodextrin (MD) aid also improves the sensory properties and overall acceptability of reconstituted spry dried dahi powder.

Highlights

- It can be concluded that maltodextrin at the level of 7.5% is most suitable level for maximum survival rate and optimal improvement in physicochemical properties, sensory attributes and overall acceptability as well.
- The optimum values of lightness, wet ability, water solubility index, viscosity ,bulk density total solids, moisture content, hygroscopicity, dispersibility, pH and acidity at 7.5% respectively
- 97.409, 270.4s, 33.46%, 38.5cp, 0.625 (g/1001cm), 19.54%, 4.2%, 97.5 (g/100 g), 97.42%, 4.35 and 0.918%.

Keywords*:* Maltodextrin, lactobacilli survival, reconstituted dahi powder, spray drying

Livestock sector plays a multi-faceted role in socio-economic development of rural households and contributes about 4.2% to the Gross Domestic Product and 25.6% to the Agricultural Gross Domestic Product in the country. Over the last three decades, livestock sector has grown at an annual rate of 7%, which is more than double the growth of the agricultural sector. Empirical evidences indicate that livestock is an important component of the agriculture system, providing an additional source of income and nutritional cover to a large section of the rural population, particularly the disadvantaged and poor households (Singh *et al.,* 2007). Dahi or curd is the most popular indigenous fermented dairy product of Indie, which is made from buffalo milk. It has a firm body and white glossy appearance, with a cream layer on top. Mixed mesophillic cultures of Lactobacillus lactis sub sp. lactis, Lactobacillus lactis sub sps. Cremorosis, Lactobacillus lactis sub sp. diacetylactis species are grown together for production of dahi. Dahi has a short shelf life, i.e., about one or two days under ambient conditions and not more than a week under refrigerated conditions (Kamruzzaman *et al.,* 2002). Besides the limited keeping quality of dahi, the maintenance and propagation of dahi culture, packaging and transport of dahi in semi solid form are other challenges faced by the dairy industry. Fermented dairy products like dahi can only be presented by keeping it at low temperature as no other method of preservation seems suitable for it. However dehydration or drying of dahi may be other potential techniques to preserve it. Among the various methods of preservation drying of food products is the most widely used process in dairy industry. The selection of drying process should be based on the important criteria of starter culture survival and sensory quality of final product in terms of colour, flavour and overall acceptability. The versatility of spray drying process and the considerable progress made through technical innovation have lead to greater flexibility to meet bio technical requirements, especially low heat treatment to avoid loss of activity (fu and chin, 2011; Silva, Freixo, Gibbs and Teixeira, 2011). The primary objective of spray drying is to preserve dairy product in a shelf stable powder form of high quality without refrigeration. Removal of moisture from dahi and conversion into powder will not only increase its shelf life but also result in reduction of packaging, transportation and storage costs because of reduction in bulk. The dahi powder can be used as a base for the formulation of health drinks, energy drinks, food fortification and nutraceuticals. In order to have health claims for such products, the survival of beneficial lactic acid bacteria is an important criterion.

The spray drying is a continuous operation in which almost any pumpable liquid can be converted into a free flowing powder. This type of drying process is commercialized for the large-scale industrial production of milk powders, instantaneous coffee and fruit juice powders, as well as for the encapsulation of functional active components (Barbosa *et al.,* 2005; Masters, 1991). Spray drying revolutionized the production of good quality fruit juice powders with low water activity feasible for easier transport and storage. Some researchers claimed that drying of fruit juice could produce the fruit powder that reconstituted rapidly to a fine product resembling the original juice (Gabas *et al.,* 2007). However Spray dried fruit juice powder has some inherent problems such as stickiness, hygroscopicity and solubility because of presence of low molecular weight sugars and acids having low glass transition temperature (Bhandari *et al.,* 1993). However most of aroma compounds and rheological characteristics of product are lost during this process. it is known that complex changes in the morphologies (size, shape, and appearance) of drops occurs during this process and that of retention of volatile compounds and protection of these materials are related to the porosity integrity of the microcapsules (perez silva *et al.,* 1997) Thus powder can stick on the walls of chamber during drying process leading to lower yield and certain operational problems. These problems can be resolved by addition of some carrier agents, like polymers and gums to the product before atomization, (Figueroa *et al.,* 2002) reported the effect of hydrocolloids on reconstitution properties of spray dried yoghurt. Along with reduction in substantial hygroscopicity of powder, polymers and gums can also be used for microencapsulation imparting protection to sensitive food components against unfavourable ambient conditions. It ultimately masks or preserves flavors and aromas, reduce the volatility and reactivity and provide additional attractiveness for the merchandising of food products (Re, 1998). However, some carrier agents protecting sensitive components like vitamin C in fruits such as camu–camu (Dib *et al.*, 2003) and to increase product stability in acerola powder recorded their potential for commercial exploitation (Righetto and Netto, 2005).

Maltodextrin is produced as a result of starch fragmentation by enzyme and acid. Maltodextrin gel can easily combine with liquid and solid fats and form as table emulsion gel. it is popular to incorporate maltodextrins as a carrier in spray drying hygroscopic powders such as fruit juice powders and infant formula. It may significantly increase glass transition temperature (*Tg*) and reduce hygroscopicity of the final product (Goula *et al.*, 2008; Kurozaw *et al.*, 2009: Tong *et al.*, 2008;). However, there has been very limited research on the properties of dahi powders using maltodextrins as a carrier. Considering the scientific facts mentioned above efforts were made to investigate the advantages of carrier or bulking agents such as maltodextrin on spray drying of fermented dairy product dahi.

Materials and Methods

Raw Materials

Double toned homogenized and pasteurized milk of brand (verka) was used for preparation of dahi milk was heated to 90°C for 15 minutes and then cooled to 42°C and then inoculated with 2% dahi starter culture and kept for incubation at 40°C for 4 h. (De, 1999). Aqueous solutions of maltodextrin were prepared by dispersing maltodextrin (dextrose equivalent (DE) 10, pH 4.7, and moisture content 5.2%) into 200 gram of hot water. The solution was mixed with 900 gram of fresh dahi using the blender. The amounts of maltodextrin dispersed into the hot water were 55, 82.5, 110 and 137.5 grams in order to provide concentration of maltodextrin content 5, 7.5, 10 and 12.5% in the final combination of hot water and dahi 1,100 gram. .

Spray drying process for dahi powder

Pilot plant Spray-dryer (S.M. Scientech, India) with a concurrent air flow was used for spray drying of dahi. The speed of blower was set at 2200 rpm for all the drying experiment. Distilled water was pumped into the dryer at a fixed flow rate and inlet temperature was (120-140°C) so that the outlet temperature achieved should be 70°C. All the parameter were selected by trial and error method in accordance with the preliminary work. The dryer was run at this condition for about 10 min before the feed was introduced. The product was collected in a pre-weighed, insulated glass bottle connected at the end of cyclone separator.

Quality determination

The color and pH of the fresh dahi were measured by "a "Minolta" color meter model CM-3500d, and a "JENCO" pH meter respectively. For the dahi powders collected from the drying experiments, the bulk density, moisture content, dispersibility, wettability, hygroscopicity and solubility were measured. Apart from that, the reconstituted samples from dahi powder were subjected to the determination of color, pH, Acidity, percentage of total solid, and viscosity. Furthermore, the sensory evaluation was carried out for the dahi reconstituted from the powders collected in two selected drying runs. Figure 3 illustrates the procedure for preparation of dahi powder and the quality determination.

Figure 1. Spray-dryer (S.M. Scientech, India)

Moisture content

The moisture content was determined by the hot air oven method using two gram of powder is taken in pre weighed Petridis and kept in oven at 105°C for 2 hrs. Thereafter, the sample was cooled in a desiccators, weighed and re-dried for 2 hrs. The process was repeated until a change in weight between the successive dryings at 2hr intervals was not more than 2 mg (Jittanit *et al.*, 2010). The weight loss after drying in the oven was used to calculate the moisture content of dahi powder and was expressed on wet basis (WB).

Hygroscopicity

Hygroscopicity was determined according to the method proposed by (Cai and Corke, 2000), with some modifications. Samples of powder (approximately 1g) were placed at 25°C in a container with NaCl saturated solution (75.29% RH). After one week, samples were weighed and hygroscopicity was expressed as gram of adsorbed moisture per 100 g dry solids (g/100 g). Dahi powder from each drying run was reconstituted with the proportion 37 g of powder per 100 g of Lukewarm distilled water (40ºC) in order to make them to be comparable with the fresh dahi.

Bulk density

The procedure described by (Al-Kahtani and Hassan, 1990) was used. Twenty grams of powder were transferred to a 100 mL graduated cylinder which was mounted on a shaker compartment of the "STUART SCIENTIFIC" water bath model SBS 30 (produced by Bibby Scientific Ltd., StaffordshireST15 OSA, UK). The shaker was set at position 100 rpm and operated for 5 minutes. The bulk density was calculated by dividing the weight of the powder by the volume occupied in the cylinder.

Solubility

To determine the solubility index, the methods of (Anderson *et al.*, 1969) was applied. Spray-dried dahi powder (2.5 g) and distilled water (30 ml) were vigorously mixed in a 50 ml centrifuge tube, incubated at 37 °C water bath for 30 min and then centrifuged for 20 min at 10,000 rpm in a centrifuge. The supernatant was carefully collected in a pre-weighed beaker and oven dried at a temperature of 103 ± 2 °C. The solubility index (%) was calculated as the percentage of dried supernatant with respect to the amount of the original 2.5 g dahi powder.

Dispersibility

Dispersibility of powder in water is the amount of dry matter, which after stirring for 15 seconds with a spoon can pass through a 210 microns sieve (Haugaard *et al.*, 1978). The 13 g dahi powder was stirred with 100 ml water at 50 °C in a beaker for 15 s. The reconstituted dahi was then filtered through a 210 micron sieve. The dry matter of filtered dahi was

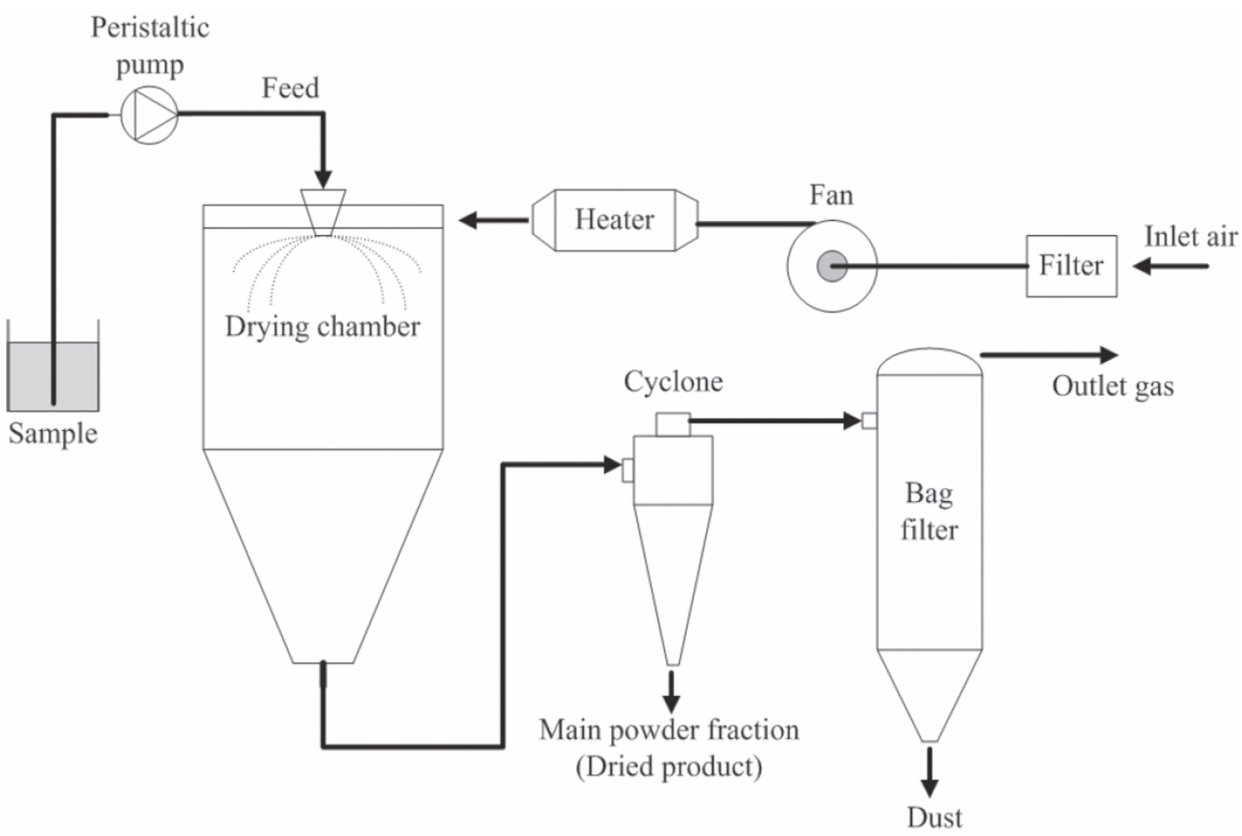

Figure 2. A schematic diagram of the spray dryer.

estimated by the method prescribed by (International Dairy Federation, 1991). The percent dispersibility was calculated using the following equation

$$V_s = \frac{(100 + 13)Sp}{13 \times Sr}$$

Where, Sp = Total solids in dahi powder (%)
Sr = Total solids in reconstituted dahi after it passes through the sieve (%)

Acidity

Acidity is defined as percentage of acid present in sample, determined as per International Dairy Federation (1991). 10gms of sample was taken in a conical flask. The volume was made to 30 ml with distilled water. 15 ml of the aliquot was taken and 2-3 drops of phenolphthalein indicator was added. Aliquot was titrated against 0.1N sodium hydroxide solution (NaOH) until the color changed to light pink and noted the titer value, or the ml, or NaOH used.

Acidity (% as lactiacid)

$$\frac{\text{Titrate value} \times 0.9 \times \text{volume made up}}{\text{Aliquont taken} \times \text{weight of sample}}$$

Total solids

Total solids in the *dahi* include the fat and the non-fat solids. Total solids in the *dahi* can be determined using hot air oven as per International (Dairy Federation 1991). Taken 2 g of Zinc oxide in a tarred aluminium box and kept the box in hot air oven at a temperature of 102 ± 2 ºC for 1 h. Dish was cooled in the desiccators. 10 g of *dahi* was taken in the dish followed by stirring with glass rod to mix zinc oxide. The dish was heated on water bath at a temperature of 90 ºC for 30 min. with frequent mixing. Then it was placed in hot air oven at 102 ± 2°C for 4 h. After cooling in desiccators, the weight of the dish was taken and the total solids were calculated as:

$$\text{Total solids (\%)} = \left[\left(\frac{m_2 - m_1}{m_1 - m_0}\right) \times 100\right] + 0.1a$$

m_0 = mass of dish including zinc oxide, g

m_1 = mass of dish including zinc oxide and *dahi* samples, g

m_2 = mass of dish including zinc oxide and dried *dahi*, g

a = mass of lactic acid, g (as obtained in acidity)

Viscosity

An aliquot of the reconstituted samples prepared by the same method applied for color determination was used to measure the viscosity using a "Brookfield" digital viscometer with the spindle no 27 (produced by Brookfield Engineering Laboratories, Inc., Middleboro, MA 02346 USA).

Enumeration of *Lactobacilli*

(International Dairy Federation, 1988) methods were used for the enumeration of Lactobacilli. (International Dairy Federation 1988) methods were used for the enumeration of Lactobacilli. Lactobacillus MRS Agar media was prepared by dissolving the specific quantity of media in distilled water followed by filtration and then filled in conical flasks. The conical flasks were cotton plugged and wrapped with aluminium foil. Sterilization was done by keeping the conical flasks in autoclave at 15 psi for 15 min. then the media was allowed to cool to 42-43 ºC. Then 1 ml serially diluted *dahi* sample was poured in Petri plate with the help of sterilized pipettes under laminar airflow bench. The agar media (10-12 ml) was added in the Petri plates and rotated, 10 times clockwise and 10 times anticlockwise to ensure proper mixing and then the media was allowed to solidify. The agar plates were incubated at 37 ºC for 72 h under anaerobic conditions. After incubation, typical colonies of bacteria were counted with the help of Quebec colony counter. The counts were averaged for three replicates and expressed as cfu/ml.

Sensory evaluation

Apart from the quality determination as previously described, the reconstituted samples were subjected to the sensory test for appearance, color, aroma, taste and overall liking perceptions. The sensory was evaluated using a 5-point hedonic scale test by 30 panellists who were the undergraduate students in the faculty.

Statistical analysis

All measured quality attributes of dahi powders and the reconstituted samples were determined in three replications. The software package of Statistica 5.5 Stat Soft^{TM} (supplied by StatSoft, Inc. Tulsa, OK 74104 USA) was used for the analysis of variance (ANOVA) and a Duncan's multiple range test in the statistical analysis.

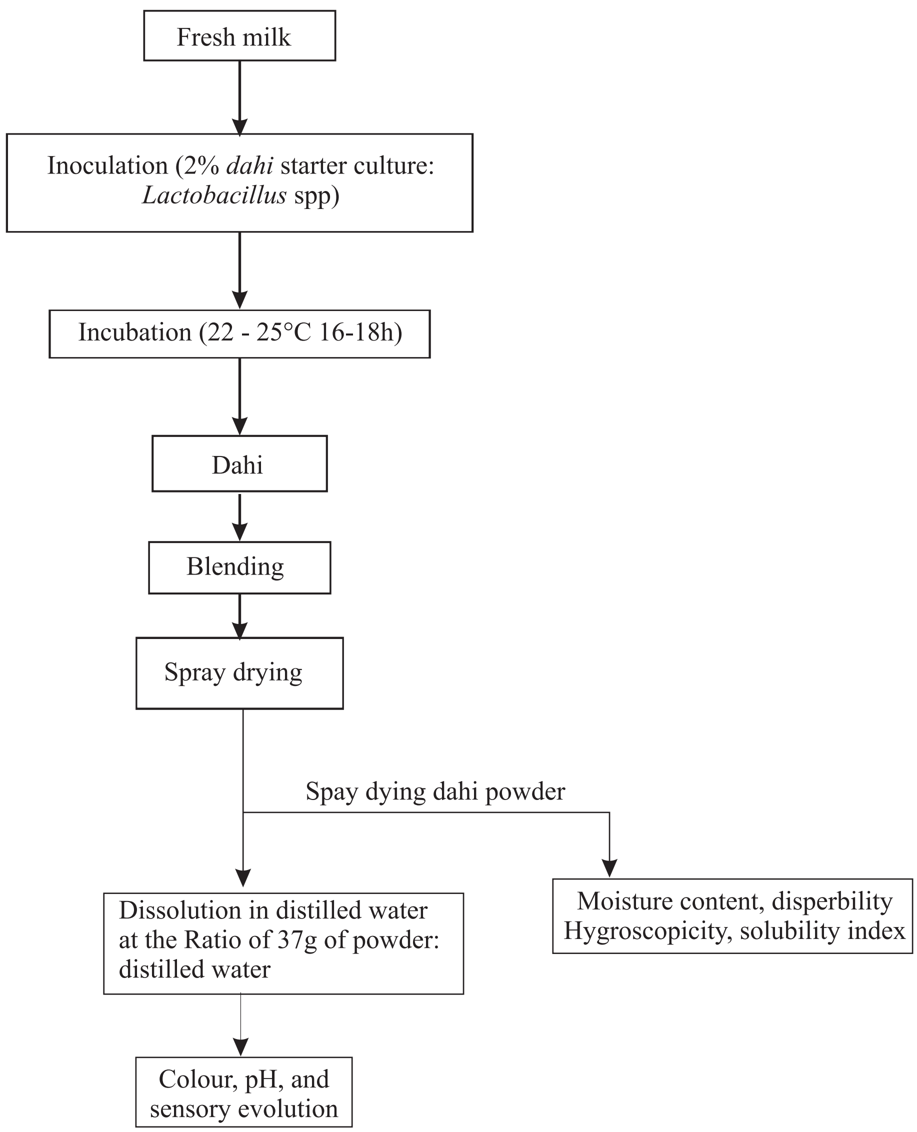

Figure 2. A schematic diagram of the experiment

Results and Discussion

Quality determination

In the initial trial *dahi* as such is directly fed in the spray drier and it was observed that some powder tends to stick inside the main chamber and the powder collected in the cyclone shows some browning reaction. As the outlet air temperature was major parameter affecting number of survivors in spray drying of plain yoghurt (Kim and Bhowmik, 1990) the parameters such as feed rate and inlet temperature are maintained so that the outlet temperature remains constant i.e.70 ^{o}C. On the basis of literature Maltodextrin was incorporated in various levels as bulking agent to facilitate the spray drying and to improve the functional and physicochemical characteristics of spray dried *dahi* powder.

Moisture content

Regarding the moisture contents of dahi powders, all specimens had moisture contents below 4% wb. They are close to the moisture contents of dried tea powders with the range of 3-5% (Sinija *et al*., 2007). The results showed that the moisture content of spray dried dahi powder by increasing concentration of maltodextrin .Similar results were observed in spray dried pineapple juice in which increase in the maltodextrin concentration resulted in decreases of the moisture content dried product. This decrease might be attributed to an increase in solids in the feed and reduced amount of free water for evaporation (Abadio, *et al*., 2004).

Hygroscopicity

Hygroscopicity is the ability of food powder to absorb moisture from high relative humidity environment. In case of fruit powder, glucose and fructose are responsible for strong interaction with the water molecule due to polar terminals present in this molecules (Haugaard, *et al.*, 1978; Slade and Levine, 1991). It is very important to study this property in case of powders as stickiness is a phenomenon frequently encountered during production and storage of dried powders. Basically the sticky behaviour of powder depends on the sugar content and temperature of the product. The fast removal of moisture during spray drying results in either a completely amorphous product or with some microcrystalline regions dispersed in the amorphous mass. The amorphous form is a non-equilibrium meta-stable state. Amorphous products also show high degree of hygroscopicity. The values in Table 1 indicate that hygroscopicity of spry dried dahi powder decreasing by increasing the concentration of maltodextrin up to 17.95(g/100g).Similar results of decrease in hygroscopicity of fruit powder with increase in maltodextrin concentration were also found in acai (Euterpe oleraceae) powder produced by spray drying (Tonon, *et al.*, 2008). The drying aids decreased the powder hygroscopicity, especially cashew tree gum (CTG), which also enhanced the powder flow ability (Germano, *et al.*, 2009).

Solubility index

Solubility of powders can be affected by many parameters such as initial compositions of the raw material to be spray-dried, the carrier agents, compressed air flow rates, and low feed rates (Bhandari *et al.*, 1993; Al-Asheh *et al.*, 2003; Goula *et al.*, 2004). The results showed that the solubility index of spray dried dahi powder without addition of maltodextrin contains 22% and then increasing concentration of maltodextrin content in dahi powder which increases the solubility index up to 48%. It means that the tamarind powder could be dissolved in water at room temperature without difficulty. Similar results were observed in spray dried ginger juice powder in which increase in solubility index with increase in maltodextrin concentration due to drying aids of Maltodextrin (Phoungchangdang and Sertwasana, 2010).

Bulk density

The bulk density is an important characteristic for the packaging design and the calculation of transportation volume.. The results showed that the increasing concentration of maltdextrin content which increases bulk density may be due to the reduction in particle size or decrease in moisture content or increase in feed concentration. The bulk density of dahi powder was in agreement with those of orange powder produced by (Chegini and Ghobadian 2005) ranging from 0.41 to 0.85 g/ml .Similar results were observed in increases in bulk density with increase in maltodextrin was observed in case of spray dried pineapple (Ananas comosus) juice powder due to the lower moisture content of the products and decrease in void spaces (Abadio *et al.*, 2004).(Goula and Adamopoulos ,2004) found a correlation between an increase in particle size and a decrease in bulk density for spray dried tomato paste. (Banat *et al.*, 2002) found bulk density to increase with increased feed concentration due to the formation of heavy, solid spheres with high density.

Table 1. Moisture content, solubility index, Hygroscopicity and Bulk Density of the spray dried dahi powder

Outlet air temperature (ºC)/blower speed (rpm)	MD content (%)	Moisture content (%)	Solubility index (%)	Hygroscopicity (g/100g)	Bulk Density (g/cm^3)
70ºC /2200	0	8.2 ± .1	22.0 ± .1	33.9 ±.3	0.444 ±.2
	5	5.0 ± .2	29.7 ±.3	21.0 ±.5	0.571 ±.4
	7.5	4.2 ± .1	33.4 ± .3	19.5 ±.4	0.625 ±.3
	10	3.8 ± .3	38.5 ±.1	18.8 ±.3	0.666 ±.5
	12.5	3.2 ±. 3	47.2 ±. 3	17.9 ±.1	0.714 ±.3

Note: rpm = rotation per minute. MD= maltdextrin
Moisture content, solubility index, bulk density and Hygroscopicity values are mean ± standard deviation.

Dispersibility

As metioned earlier the spray dried dahi powders were reconstituted with distilled water with proportion 37 g of powder per 100 g of distilled water in order to make the solutions that were similar to the fresh dahi. The results of dispersibility, color and pH determination for the solutions comparing to the fresh dahi are illustrated in Table 2. The term dispersibility refers to the dispersion of agglomerates with little stirring. “Dispersibility” describes the ease with which the powder may be distributed as single particles over the surface and throughout the bulk of the reconstituting water. Dispersibility is reduced by clump formation and is improved when the sinkability is high. The values in Table 2 indicate that dispersibility of spry dried dahi powder without addition of maltodextrin contains (96%) and then increasing concentration of maltodextrin content in dahi powder which increases the dispersibility (98%). These results are in conformation with the research of previous workers (Figueroa *et al.,* 2002).wherein they stated that the addition of hydrocolloids such has (carrageenan, xanthan gum, gellan) to the spray dried yoghurt the dispersibility will be increases.

Colour

Regarding the color, it appeared that the lightness, redness and yellowness of the solutions of spry dried dahi powder were significantly different from the fresh dahi for almost all cases. In general, the solutions had the more lightness than the fresh sample but the redness and yellowness were lower. The cause of the more lightness was due to the effect of the maltodextrin. Because of white color of maltodextrin a greater lightness of powders, represented by a higher L* value, was obtained at higher concentrations of maltodextrin. The powder without addition of maltodextrin was more redness and yellowness due to non-enzymatic browning reactions occurring during the spray drying. But this effect can be reduced by addition of maltodextrin. Similar results were also found in spray dried sweet potato powders (Grabowski *et al.*, 2006) and in pineapple juice powders (Abadio *et al.*, 2004).

PH of the Reconstituted powder

The results of color and pH determination for the solutions comparing to the fresh dahi are illustrated in Table 2. It showed that the pH of the solutions were significantly higher than those of the fresh sample. This result was unsurprising because the pH value of maltodextrin applied in this study was 4.7 while the fresh dahi pH was 4.3. Furthermore, there were only slight differences in the pH among the reconstituted specimens. If deeming the proportion total soluble solids and maltodextrin (based on dry weight), it is clear that maltodextrin contents were not very difference between powder samples. Moreover, these powders were reconstituted with distilled water before measuring pH; as a result, the effects of different proportions of juice and maltodextrin contents on the pH values were also diluted.

Wettability

The term wettability refers to the ability of agglomerates to be penetrated by the liquid. Wetting is a time controlling first step and it refers to a simple solid wetting assisted by the capillary suction of the pores in the agglomerates (Pietsch, 1999). This describes the capacity of the particles to absorb water on their surface, thus initiating reconstitution. This property depends largely on particle size. Small particles have a large value of specific area (i.e., the ratio of surface area to mass) and may not be wetted individually; Increasing particle size and/or agglomerating particles can reduce the incidence of clumping. The nature of the particle surface can also affect wettability. For example, the presence of free fat in the surface reduces wettability. The selective use of surface-active agents, such as lecithin, can sometimes improve wettability in dried powders containing fat. Results shows that wettability of sample without addition of maltodextrin was 178 s and it increases as the maltodextrin concentration increase may be due to difference in particle size.

Acidity

Acidity of reconstituted *dahi* powder without addition of maltodextrin was 0.936% and the values for acidity decreases as the maltodextrin concentration increases beyond 7.5%.According to the (Narender Raju and Dharam Pal, 2011) showed that there was increase in acidity of artificially sweetened *misti dahi* on maltodextrin addition as a bulking agent but in contrast in our study there was decrease in acidity of reconstituted *dahi* as we added the maltodextrin after incubation where as they added maltodextrin before incubation. Acidity for the sample containing 5% maltodextrin remains same as that of the sample

Table2. The Dispersibility, Colour and pH values of the spray dried dahi powder

Outlet air temperature (ºC)/blower speed (rpm)	MD content (%)	Dispersibility (%)	Colour characteristics L* a* b*			pH
70ºC /2200	0	96.2 ±.1	93.6±.4	3.2±.3	15.3±.4	4.3±.1
	5	97.4 ±.3	96.5±.4	0.57±.4	9.3±.2	4.3±.1
	7.5	97.4± .2	97.4±.1	-0.02±.1	6.8±.3	4.35±.1
	10	97.9±.1	97.6±.2	0.22±.3	7.1±.1	4.4±.2
	12.5	98.4± .2	98.3±.1	-0.1±.1	6.3±.1	4.4±.1

Note: rpm = rotation per minute, MD= maltodextrin L*, a*, b* and pH values are mean ± standard deviation.

containing 100% *dahi*.

Viscosity

Viscosity is the important rheological property in case of *dahi* and the values ranges from 800-920 Cp in freshly prepared *dahi* (Rathi *et al,* 1990). It has been reported that most of the aroma compounds and rheology (viscosity) of yoghurt are lost during spray drying process (King, 1994). Results shows that viscosity of reconstituted *dahi* without added maltodextrin was 12.5 Cp and as the maltodextrin concentration increases the viscosity of reconstituted *dahi* also increases. Highest viscosity obtained was 62 Cp for the sample containing 87.5% *dahi* and 12.5% maltodextrin. These values indicates that there is much more losses occurred in rheological properties of spray dried *dahi* powder as compared to other methods such as freeze drying in which viscosity of *dahi* ranges from 100-150 Cp (Rathi *et al,* 1990). This shows that maltodextrin concentration has significant effect on viscosity of reconstituted dahi powders ($p < 0.05$).

Total Solids (TS)

TS of *dahi* without addition of maltodextrin were 12%. The TS of reconstituted *dahi* samples increases as the maltodextrin concentration increases. Results shows that maltodextrin concentration has significant effect on TS of reconstituted *dahi* powders.

Survival Rate of lactobacilli during spray drying

As dahi used for spray drying was prepared once in bulk and then maltodextrin was added after incubation at various levels, the initial count of lactobacilli in all dahi samples was remains constant and it was 2.1×10^7cfu/ml. The parameters for spray drying of dahi samples were adjusted so that the outlet temperature remains constant i.e. at 70^{o}C. The powder from cyclone separator was collected and used for lactobacilli count. Table 1 shows colony count and survival rate for reconstituted dahi powder. The survival rate was calculated by using following formula

The survival rates for the other samples containing 5, 7.5,10 and 12.5% maltodextrin were 0.6, 0.62, 0.5 and 0.4% respectively. The samples containing 5 and 7.5% maltodextrin shows somewhat more survival rate than the sample without added maltodextrin. This may be due to encapsulating effect of maltodextrin (Oldenhof *et al.,* 2005). The survival rate for the samples containing 10 and 12.5% maltodextrin are 0.5 and 0.4% respectively, may be because of less moisture content of powder from which they were reconstituted. These results are in conformation with the research of previous workers (Kim and Bhowmik 1990).

Table 3. Survival rate, viscocity, acidity, wettability and TS test results of the solutions of spry dried dahi powders

Outlet air temperature (ºC)/blower speed (rpm)	MD content (%)	Survival Rate (%)	Viscosity (Cp)	Acidity (% lactic acid)	Wettability (s)	TS (%)
70ºC /2200	0	0.5±.2	12±.3	0.936±.3	178±.2	12.0±.3
	5	0.60±.3	25±.4	0.936±.1	230±.4	16.5±.4
	7.5	0.62±.4	38±.5	0.918±.4	270±.4	19.1±.5
	10	0.5±.5	50±.2	0.900±.6	290±.5	21.2±.3
	12.5	0.4±.5	62±.3	0.900±.3	300±.3	23.9±.4

Note: rpm = rotation per minute, MD= maltodextrin
Survival rate, Viscocity, Acidity, Wettability and TS values are mean ± standard deviation.

Sensory Evaluation

The results of sensory evolution are shown in Table 4.The sensory evaluation depicts that both drying temperature and maltodextreen content affected the characteristics of the solutions. With regards to the appearance, Mouth feel and Flavour, almost all of the solutions of maltodextrin showed higher score than the fresh dahi. The solution without maltodextrin showed average value of appearance, it may be result of non enzymatic reaction occurring during spray drying. The value for appearance increases as the concentration of maltodextrin increases due to masking effect of maltodextrin which cause extremely white in color (Vongsawasdi *et al.*, 2002). Redrying the product more whiter in term of the Flavour, The powder without maltodextrin showed average value, it may be result loss of flavour during spray drying. The value for Flavor increases as the concentration increases due to effect of maltodextrin. Similar results were obtained for increased acetaldehyde (compound responsible for flavour) retention with increase in total solids (Silva *et al.*, 1997). Regarding the Mouth feel, the value increases as the concentration of maltodextrin increases due to increasing the viscosity. The overall liking score revealed that the solutions of spry dried dahi powders produced from the feed with 7.5% maltodexrin at drying temperature 70°C were the most accepted samples.

Conclusion

Results as this study reported that the practicability of producing the spray dried dahi powders from the mixture of fresh dahi and the aqueous solutions of maltodextin by applying the spray drying method. The survival rate of lactobacilli showed maximum for the sample containing 7.5 % maltodextrin (0.62 %) in spray dried dahi powder. After reconstituting the spray dried dahi powder in the distilled water, it was found that a number of samples obtained the sensory test scores not less than the fresh counterpart in aspects of appearance, color, Flavor, Mouth feel and overall liking. Obviously, maltodextreen content had significant influence on the product quality. The fresh dahi added with maltodextrin at 7.5% and dried at 70°C achieved the highest overall liking score. The spray dried dahi powder made under this condition had the moisture content and solubility index 4.2% and 33.46% respectively. Moreover while its solution had the hygroscopicity 19.54 (g/100 g), dispersibility 97.5%, pH 4.35 and lightness 97.409.These results are useful for the dahi powder producers and researchers.

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Table 4. The sensory test results of the solutions of spry dried dahi powders

Outlet air temperature (°C)/blower speed (rpm)	MD content (%)	Score (maximum = 9.0)			
		appearance	Flavour	Mouth feel	Overall Acceptability
70°C /2200	0	4.9±.1	6.4±.1	5.7±.3	7.6±.1
	5	7.0±.2	7.0±.1	6.6±.1	7.7±.5
	7.5	8.4±.1	7.7±.3	8.2±.4	8.1±.1
	10	8.5±.2	8.2±.2	8.2±.1	8.3±.1
	12.5	8.5±.3	8.2±.2	8.3±.1	7.8±.3

Note: rpm = rotation per minute. MD= maltodextrin
Sensory score values are mean ± standard deviation.

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