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Production of Powdered Yoghurt by Spray Drying

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***Abstract:-* Yoghurt is a highly perishable fermented milk product that is susceptible to spoilage as a result of the over production of lactic acid and other spoliage factors. There is therfeore, need to look for methods of preserving and extending its shelf life in a more stable form. Yoghurt samples were prepared with different variations of skim milk powder with no skim milk powder, 1%, 2%, 3%, 4% and 5 % which exhibited TSS of 13.8%, 17%, 19%, 20.8%, 23.2% and 25% respectively, being kept all the other ingredients constant. The physico chemical properties like moisture content, energy content and reconstitutability, wettability and titrable acidity of yoghurt powder was estimated. Yoghurt sample with high TSS (25%) had got high amount of powder. Sensory evaluation of the reconstituted yoghurt showed that there was little difference between the fresh yoghurt and the reconstituted one.**

INTRODUCTION

Milk and milk products constitute essential dietary components for majority of population. India with annual production of more than 127.9 million tones has emerged as leading milk producing nation with per capita per day availability of 290 g in 2011-2012. Buffalo milk accounts for 57% of total milk produced in India. Ethnic dairy products account for 90% of all dairy products consumed. Many health benefits have been attributed to fermented dairy products and probiotic microorganisms. In search of better returns, the Indian dairy industry is widening its focus to include traditional milk products, and these are emerging as a new profit centers for the organized sector.

Cultured milks are products made by use of special lactic acid bacteria cultures. Yoghurt is a highly nutritious protein-rich product obtained by fermentation of milk with *S. thermophilus* and *L. bulgaricus*. According to FAO/WHO standards, yoghurt is the coagulated milk product obtained by lactic acid fermentation through the action of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in milk and milk products. The real "live" yoghurt is milk or milk product that is fermented by the true yoghurt cultures and the cultures are still active at the time of consumption (Kumar and Mishra, 2004).

The typical lactic acid bacteria in yoghurt starter culture are *Streptococcus salivaricus subsp. thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus*. The former is responsible for fermenting lactose to lactic acid whereas *L. delbrueckii subsp. bulgaricus* is responsible for flavor production, mainly in the form of acetaldehyde.

According to Mayra-Makinen and Bigret (1993) the optimum growth temperature for it is 40 ℃ to 50 ℃. In yogurt fermentation, *L. bulgaricus* is subjected to decrease environmental pH for food product preservation. Subsequently the bacterium has to survive in highly acidic gastric juice if it reaches to the small intestine in a viable state and exerts the expected beneficial effects (Henriksson *et al.,* 1999; Lee and Selminen, 1995). The proteins in milk are of excellent quality biologically and both the caseins and whey proteins (α-La and β-Lg) are well endowed with essential amino acids. One characteristic is that the proteins in yogurt are totally digestible, a feature enhanced by the fact that some degree of initial proteolysis is caused by the starter organisms themselves (Tamime and Robinson, 2000). The other pertinent characteristic is that the milk proteins in yogurt are already coagulated prior to ingestion and the "soft clot" formed in the stomach may act as a role to slow the caecal transit time of lactose, so allowing the microbial lactase to ensure that lactose-intolerant consumers do not suffer discomfort (Marteau *et al.,* 1993).

The ability of probiotics to survive in an acidic environment is important for both fermentation stability and in vivo function. Thus, acid tolerance should be considered when select potentially probiotic strains (Cui *et al.*, 2012). According to Shah and Jelen (1990), *Lactobacillus delbrueckii ssp. bulgaricus* proved to be more acid tolerant than *Streptococcus thermophilus*. Liong and Shah (2005) also reported that the most acid tolerant strains of Lactobacillus trains are *L. acidophilus* and *L. casei.* *L. bulgaricus* is commonly used together with *Streptococcus thermophilus* that they became the preferred partners for rapid milk fermentation for the production of yogurts (Delley and Germond, 2002). There are two stages involved in yogurt fermentation. In the first stage. L. bulgaricus stimulates the growth of S. thermophilus by releasing essential amino acid from casein by proteolytic activity. Meanwhile, *L. bulgaricus* grows slowly because it is microaerophilic. At the end of the first stage, the growth of *S. thermohilus* is slowed down due to the high lactic acid concentration. When *S. thermophilus* produces enough formic acid, which stimulates growth of L. bulgaricus, the second stage begins. By this symbiotic action the desirable acidity of the final yogurt can be achieved (Sandine and Elliker, 1970; Rasic and Kurmann, 1978).

Lactobacillus bulgaricus have immunological effects. It has been shown to exert host-mediated antitumor activity in mice (Ebina *et al.,* 1995). In vitro experiments have revealed the mitogenic activity of extracellular polysaccharides (EPS) produced by *L. bulgaricus* (Kitazawa *et al.,* 1998). In a study of Kitazawa *et al.* (2003), an immunostimulatory oligonucleotide was derived from L. bulgaricus NIAI B6. This strain would be a good candidate of a starter culture for the production of new functional foods as "Bio-Defense Foods".

The final product is highly acceptable to consumers because of its flavour and aroma, mainly attributed to acetaldehyde, and its texture. The shelf life of yoghurt is short, i.e., 1 day under ambient condition (25-30 ℃). Improvement of the shelf life of yoghurt can be obtained by lowering its water content by draining of whey. Another methods of drying, e.g. freeze-, spray or microwave-drying, the primary objective of which is to preserve the product in a shelf-stable powder form of high quality without the need for refrigeration. Removal of moisture from yoghurt and conversion into powder will not only increase its shelf life but also results in reduction of packaging, transportation and storage costs because of reduction in bulk. The yoghurt powder can be used as a base for the formulation of health drinks, energy drinks, food fortification, military drink and in the preparation of drinks while travelling and nutraceuticals. In order to have health claims for such products, the survival of beneficial lactic acid bacteria is an important criterion.

Spray drying is a novel technology used for the drying of food products. Therefore, an attempt has been made in this project work to develop the process technology for making yoghurt powder using spray dryer.

Yogurt powder provides longer and more stable shelf life than that of regular yogurt. Moreover, the reduced weight and bulk water of this dehydrated product decreases packaging, handling, and transportation costs. This product is very convenient for consumer to use since it can be store at ambient temperature for a long shelf life. It can also be shipped to natural calamity areas or for food aid to less fortunate countries. While the consumer can make yoghurt at home, it is a time-consuming operation requiring some skill and also need the use of refrigerator to chill and store the yogurt. However, for an instant reconstituted yogurt, consumer just needs to add water into the product and stir to mix well when they want to consume yoghurt.

Therefore, an attempt has been made to develop the process technology for making yoghurt powder using spray dryer with the following objectives.

1. Production of yoghurt using *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus.*
2. To produce yoghurt powder by using the spray dryer.
3. To assess physicochemical and microbiological analysis for yoghurt powder.
4. And sensory evaluation for reconstituted yoghurt powder.

MATERIALS AND METHODS

1. Raw Materials

Cultures of *Lactobacillus delbrueckii subsps. bulgaricus* and *Streptococcus thermophilus* were obtained from National Dairy Research Institute, Karnal. Skim milk and skim milk powder were used for yoghurt preparation. Sugar was added to impart sweetness to the yoghurt. Stabilizer i.e., sodium alginate was added to improve the consistency and to avoid ropeness and formation of whey pockets. Maltodextrin is used as a carrier durning spray drying of yoghurt. Anti-caking agent i.e., tricalcium phosphate was added to yoghurt powder to prevent caking. MRS agar is used to determine bacterial load count.

2. Preparation of Yoghurt Powder

Preparation of yoghurt

The low fat milk (0.5% fat) was warmed to 45 ºC after which skim milk powder was added,the mixture of sugar and stabilizer were added gradually to milk at a temperature of 60 ºC . The mixture was then pasteurized at 80 ºC for 5 min and then cooled rapidly to 45 ºC. It was then inoculated with 3% starter culture and incubated at 42 ºC till the exact consistency is obtained and the coagulum was cooled in a cold room overnight. Yoghurt samples with varied skim milk powder were taken for this project viz., no skim milk powder, 1%, 2%, 3%, 4% and 5%, respectively (**Table 1)** in 500 mL of skim milk and other ingredients used in preparation of yoghurt were showed in **Table 2**. TSS of these yoghurt samples were measured with refractometer (Adobe, PAL-3). The sequential steps involved in the preparation of yoghurt powder are given in **Fig 1**.

Preparation of yoghurt powder by spray dryer

The above prepared yoghurt is taken into a bowl and churned in a domestic mixer for 1 minute at high speed. Churning is done for fluidize the yoghurt. Powder was produced with a pilot plant spray dryer (M/s S.M. Scientech) with a cocurrent air flow. The speed of blower was set at 2400 rpm for all the drying. Distilled water was pumped in to the dryer to achieve the inlet/outlet temperature of 170 ºC and 65-70 ºC, respectively. The dryer was run at this condition for about 10 min before the feed was introduced. Then feed mixture of about 500 mL was introduced in spray dryer at already set conditions. The product was collected in to a polythene pouches **(Plate 1)** and were stored in a desiccator containing silica gel before analysis.

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Plate 1 Yoghurt powder in polythene pouches

Skim milk of 0.5% fat

⇩

Heat the milk till 45 °C and with or without SMP

⇩

Mixture of sugar and stabilizer was added gradually to milk at a temperature 60 °C

⇩

Mixture is heated till 80 °C for 5 min

⇩

The mixture is then cooled to 42 °C

⇩

Starter culture (3%) is added in 1:1 ratio

⇩

Incubated at 42 °C till the exact consistency is obtained

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Fig 1 Flowchart of yoghurt preparation

Table 1 Yoghurt samples with varied skim milk proportions

Ingredient	Skim Milk Powder, %					
	0	1	2	3	4	5
Skim Milk Powder (g/mL)	0	0.01	0.02	0.03	0.04	0.05

Table 2 Other constant proportions for preparation of different yoghurt samples

Ingredients	Quantity to be used
Sugar	25 g
Sodium alginate	1 g
Malto dextrins	20 g
Starter culture	3%
Tricalcium phosphate	1.5 g

3 Determination of Physico-chemical properties

Physico-chemical analysis is very much important to assess the quality of yoghurt powder and to evaluate relative changes in physical and chemical composition of final product during drying of yoghurt. The various parameters viz., moisture content, particle size distribution, loose filled bulk denisty, tapped bulk denisty, energy value, wettability, titratable acidity and lactic acid bacterial load determination were carried out by adopting standard methods.

Moisture content

Moisture content of the yoghurt powder was determined by oven drying method (AOAC, 19th Edition).

Particle size distribution analysis

Each of the different formulations of yoghurt powder samples were after spray drying analyzed for particle size distribution analysis using ASABE standard S319.3 (ASABE Standards, 2006).

Bulk denisty

A graduated cylinder 50 mL was weighted and filled with yoghurt powder sample to fill up to 50 mL graduation. This volume was considered for loose-filled bulk denisty. The cylinder was tapped for 50 times and the volume occupied by the powder after the tapping was recorded for calculating tapped bulk denisty. The ratio of the weight and the corresponding volume of the powder are reported as bulk density of dahi powder (Chevanan *et al*., 2011).

Wettability

Wettability of the powders was determined using the method of Fuchs *et al.* (2006). The powder samples (0.1 g) were sprinkled over the surface of 100 mL of distilled water at 20 ºC without agitation. The time it took until the last powder particles submerge was recorded and used for a relative comparsion of the extent of wettability between the samples.

Titratable acidity

Titratable acidity was determined by weighing 9 g of yogurt powder sample and 5 drops of phenolphthalein as indicator solution were added to the yogurt powder sample The mixtures were titrated by 0.1 N NaOH until the color changed to slight pink and persists for 30 s. Volume of NaOH used was recorded **(**Ranganna, 2004).

Calorific value

The calorific value was estimated by isothermal oxygen bomb calorimeter.

Lactic acid bacterial load

MRS agar medium was prepared for the purpose of bacterial load determination.

4. Sensory Evaluation of Reconstituted Yoghurt

Required quantity was reconstituted by dissolving 10 g of yoghurt powder in 10 g of water. Reconstituted yoghurt was stored in the cold room overnight and the evaluation done the following morning.

Reconstituted sample was compared with freshly made low fat yoghurt. Samples were assessed for colour, flavour, taste and their overall acceptability using the 9-point Hedonic scale.

Results of above experiments are presented and discussed in the next chapter i.e., Results and Discussions.

RESULTS AND DISCUSSIONS

The results of various experiments and the measured values of moisture, particle size distribution, loose-filled bulkdenisty, tapped bulkdenisty, wettability, titratable acidity, energy value and lactic acid bacterial load

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determination. The results of sensory evaluation are also presented.

1. Yoghurt Powder

The yoghurt powder was prepared using spray dryer. Speed of blower was set at 2400 rpm for all the drying. The inlet and outlet temperature of 170 ºC and 65-70 ºC, respectively were maintained during spray drying. Yoghurt samples prepared with varied skim milk powder proportions (1%, 2%, 3%, 4% and 5%) were taken which exhibited TS concentrate of 13.8%, 17%, 19%, 20.8%, 23.2% and 25%. Feed mixture of about 500 mL was given for spray drying.

Table 3 yoghurt powder obtained from different samples

SMP proportions	TSS Concentration	Fine powder(g) Obtained	Coarse powder (g) Obtained	Total
No SMP	13.8%	41.848	10.17	52.018
1%	17%	42.267	8.748	51.015
2%	19%	44.814	8.305	53.119
3%	20.8%	44.875	9.467	54.342
4%	23.2%	47.430	7.731	55.161
5%	25%	50.112	8.791	58.903

2 Physico-Chemical Properties

The physico-chemical properties of yoghurt powder like moisture content, bulk density, particle size distribution, wettability, titratable acidity, energy value determination are determined using standard procedures as stated in previous chapter and observations

Moisture content

Fig. 2 showed the variations of m.c. with same drying time for different samples of yoghurt powder. It was observed that the moisture content decreases with increase in total soluble solids concentration of yoghurt powder samples.

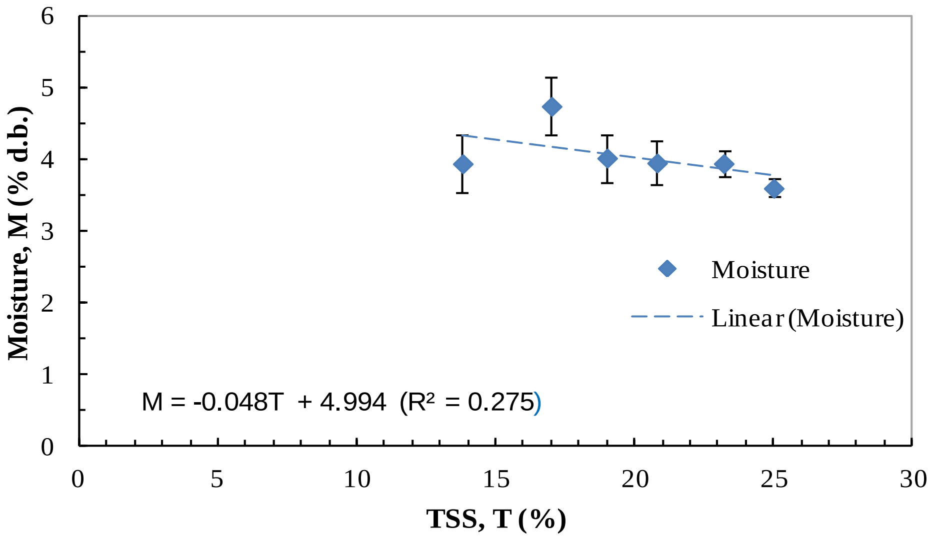

Fig. 2 Variation of moisture content of yoghurt powder for different sample

Particle size distribution

Normal distribution of different yoghurt powder samples showed dual peak on semi-logarithmic graph **(Fig. 3)**. Dual peaks indicated non-uniform distribution of particles in all the cases. All the distribution curves showed fine skewed (a tail to the right on normal scale of x-axis).

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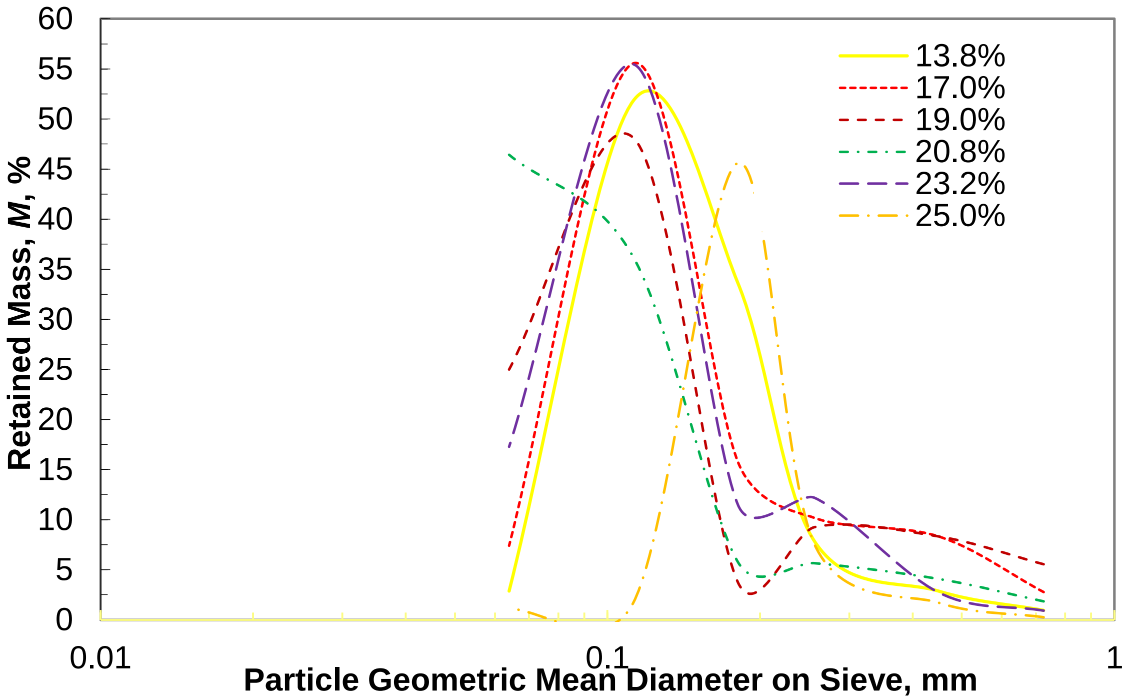

Fig. 3 Log-normal distribution of different yoghurt powder samples

Cumulative graph **(Fig. 4)** revealed step graded particle distribution. Hence, the samples analysed were of “fine skewed step-graded” materials.

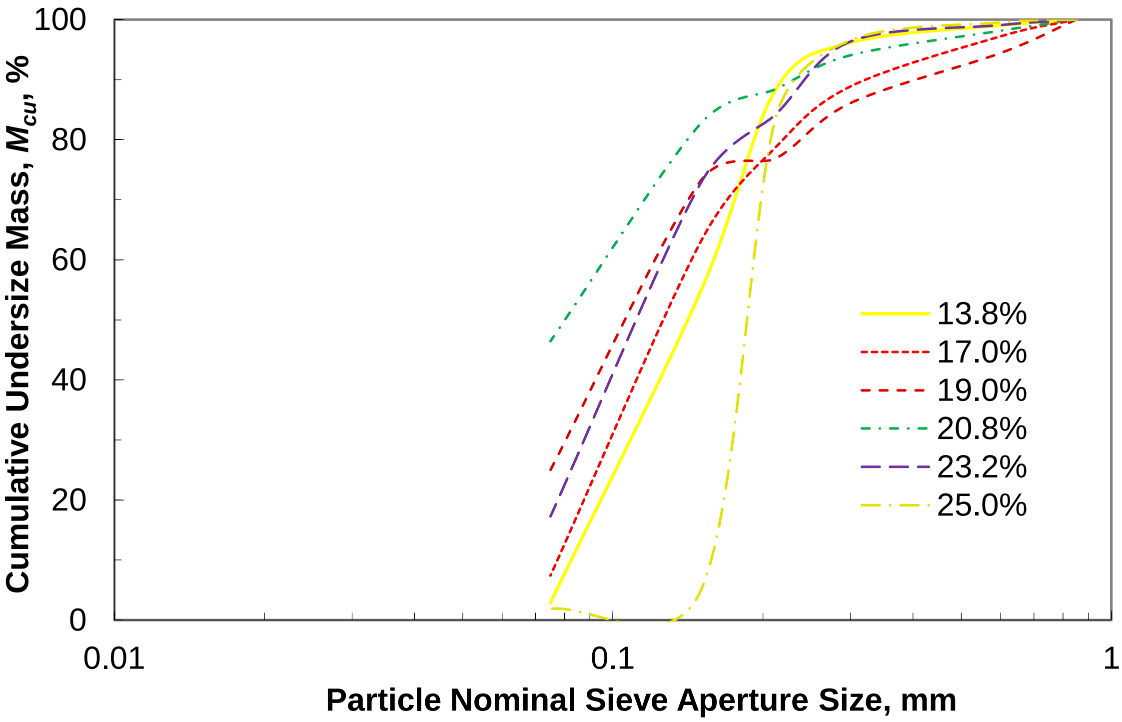

Fig. 4 Cumulative percent undersize of different yoghurt powder samples

Geometric mean diameter X_{gm}, of yoghurt powder samples of TS concentrate (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to be 0.141, 0.143, 0.128, 0.099, 0.121 and 0.186 mm, respectively. Geometric standard deviation, S_{gm} of yoghurt powder samples were found to be 1.503, 1.745, 1.989, 1.767, 1.628 and 1.311, respectively.

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Bulk denisty

a) Loose-filled bulk denisty

From the **Fig. 5** it was observed that the bulk density of the yoghurt powder increased with increase in total soluble solids concentration. Increase in bulk density may be due to the decrease in moisture content. The values of loose filled bulk density at different concentration (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to be 0.419, 0.394, 0.426 , 0.436, 0.471 and 0.483 g/cm^3, respectively.

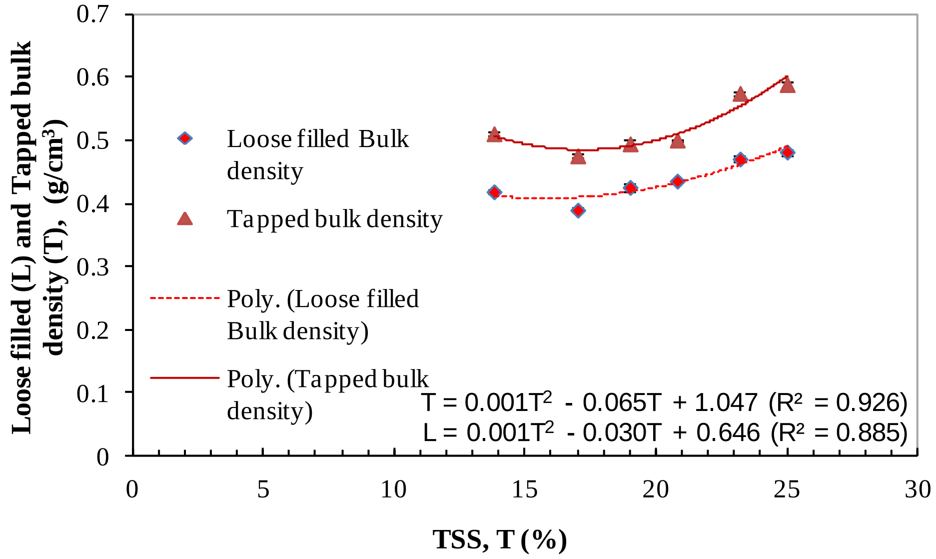

Fig. 5 Variation of loose-filled bulk denisity and tapped bulk denisty of yoghurt powder for different samples

b) Tapped bulk denisty

Values of tapped bulk density of yoghurt powder at different concentration (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) of yoghurt powder were found to be 0.511 g/cm^3, 0.476, 0.495, 0.5, 0.575 and 0.589 g/cm^3, respectively. The tapped bulk denisty of yoghurt powder samples prepared at differentconcentrations is shown in **Fig. 5**.

Wettability

The wettability of yoghurt powder at different concentration (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to 124, 132, 150, 220, 244 and 277 s, respectively. The wettability of yoghurt powder samples prepared at different concentrations is shownin **Fig. 4.5**.

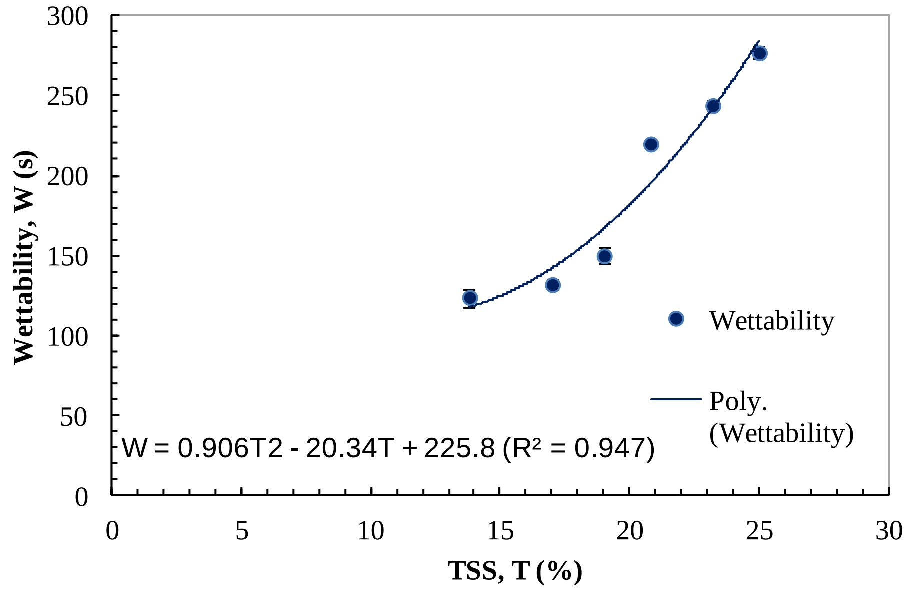

Fig. 6 Variation of wettability of yoghurt powder for different samples

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Titratable acidity

Values of titratable acidity in yoghurt powder samples at different concentrations (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to be 0.230%, 0.241%, 0.324%, 0.355%, 0.382% and 0.421% respectively. The lactic acid content in yoghurt powder was found to be present in all samples of yoghurt powder. The titratable acidity (% lactic acid) increased with increase total soluble solids concentration. The increase in lactic acid content is due to action of lactobacillus bacteria in producing lactic acid with increase in concentration of soluble solids. The lactic acid content of yoghurt powder samples prepared at different concentrations is shown in **Fig. 7**.

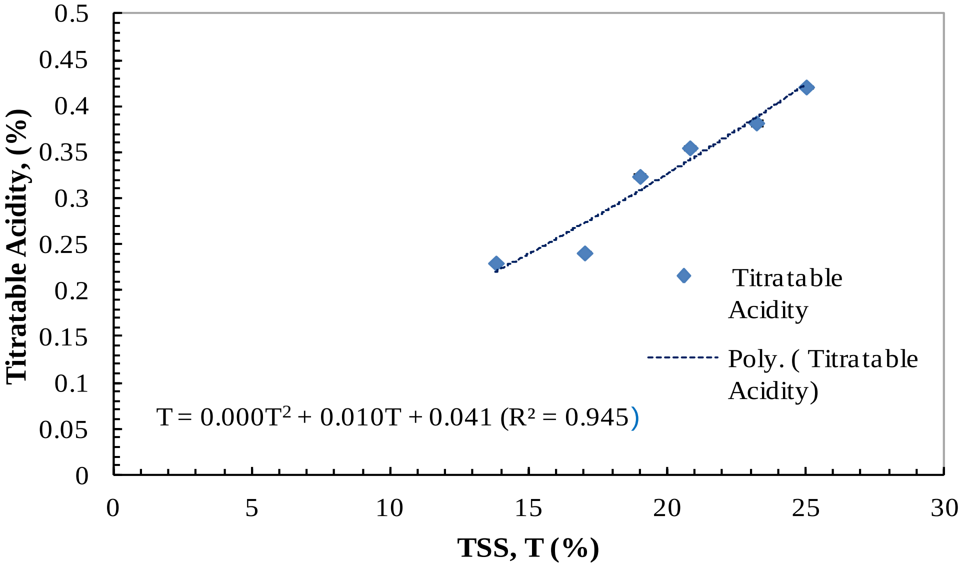

Fig. 7 Variation of titratable acidity of yoghurt powder for different samples

Calorific value for yoghurt powder

Values of calorific value in yoghurt powder samples (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to be 1.7, 2.5, 3, 3.6, 4.1 and 5 kcal/g, respectively. Calorific value of yoghurt powder samples prepared at different concentrations is shown in **Fig. 8**.

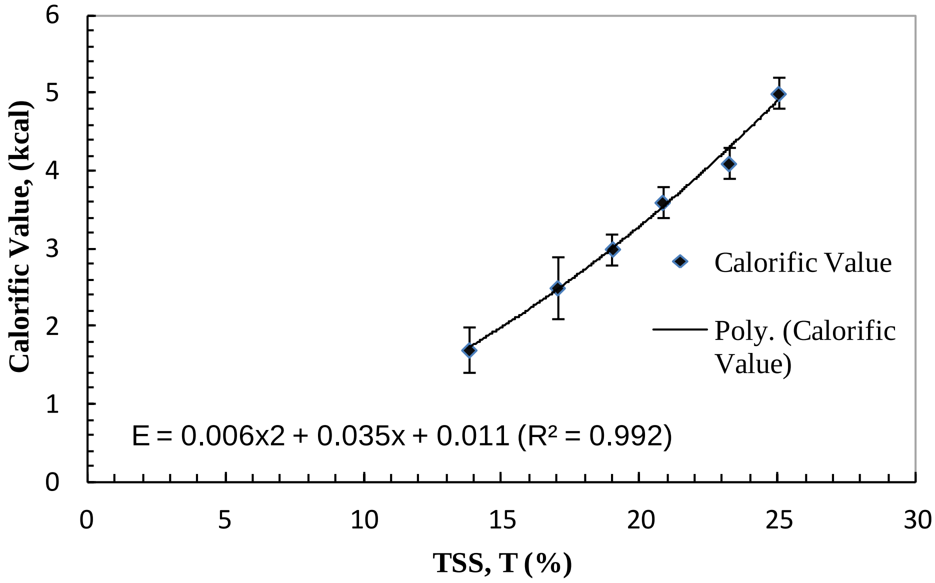

Fig. 8Variation of calorific value of yoghurt powder for different sample

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Lactic acid bacterial load

Results of the lactic acid bacteria plate count in terms of colony forming units of different yoghurt samples at different concentrations (13.8%, 17%, 19%, 20.8%, 23.2% and 25%) were found to be 1×10^6, 1.33×10^6, 1.66×10^6, 1.66×10^6, 2×10^6 and 2.3310^6 cfu/g, respectively. Lactic acid bacterial load of yoghurt powder samples prepared at different concentrations is shown in **Fig. 9**.

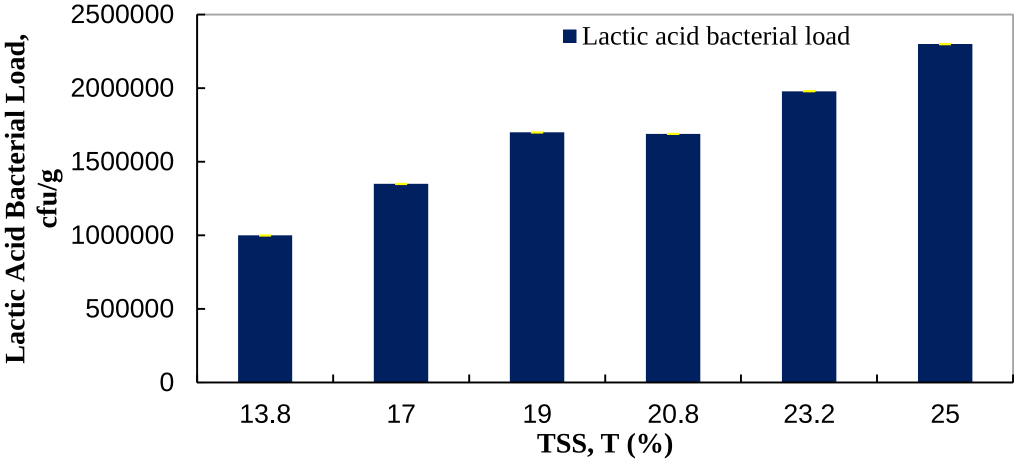

Fig. 9 Variation of lactic acid baterial load of yoghurt powder for different sample

Sensory Evaluation

So prepared yoghurt powder was mixed with water in the ratio of 1:1 (yoghurt powder:water) for yoghurt making and these products are served to different panelists for sensory evaluation of the final products on the basis of 9-point Hedonic scale. The higher degree acceptance levels were recorded for final product prepared at total soluble solid concentration 23.2%. The highest scores recorded against color, taste, appearance and texture are 8.142, 7.582, 8.285 and 7.857, respectively **(Fig. 10).**

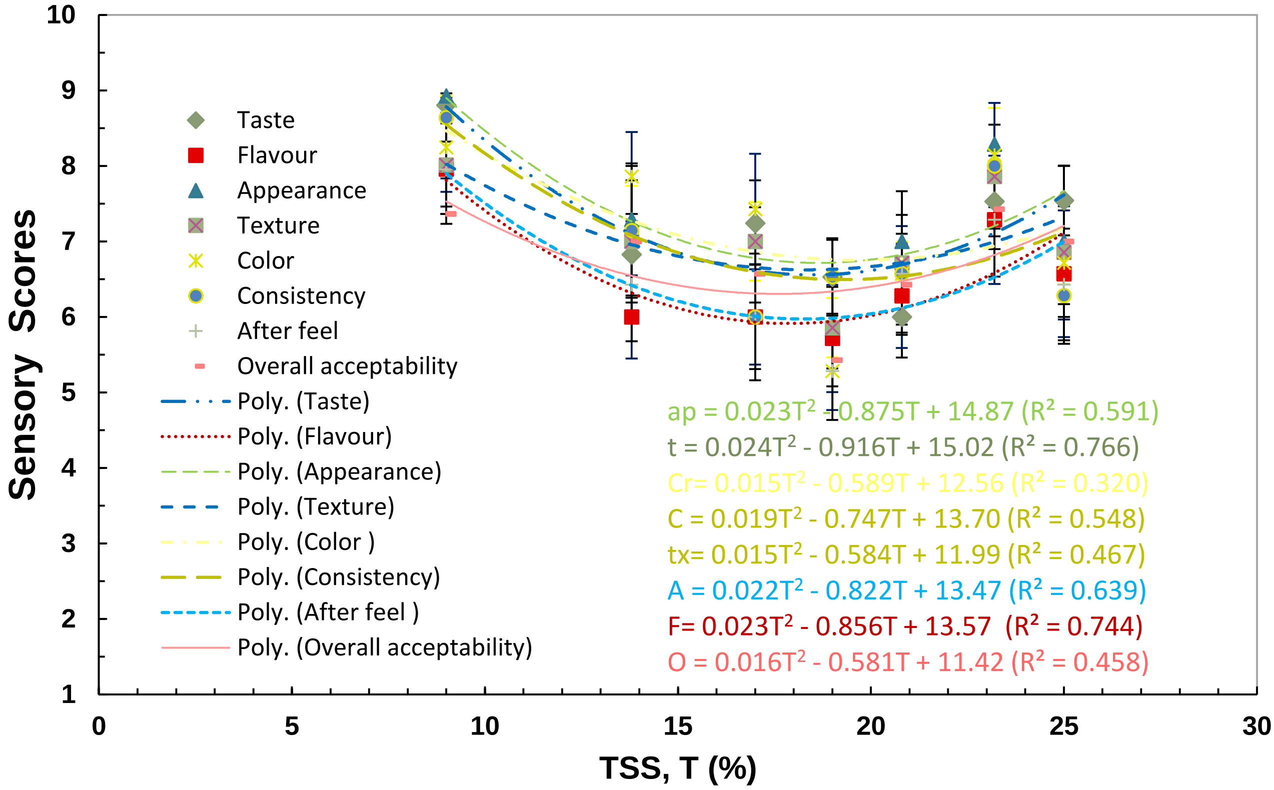

Fig. 10 Average sensory scores of yoghurt powder for different samples

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CONCLUSIONS

Yoghurt is the most popular indigenous fermented dairy product. yoghurt contains more protein, calcium and other nutrients but yoghurt has a short shelf life, i.e., about one or two days under ambient conditions. Drying is best method for increasing the shelf life of the yoghurt and makes it available for long time.

Yoghurt was produced using *Lactobacillus delbrueckii subsp. Bulgaricus* and *Streptococcus thermophilus.* Yoghurt samples with varied skim milk powder were taken which exhibit TSS Concentrate 13.8%, 17%, 19%, 20.8%, 23.2% and 25%. Yoghurt powder was prepared by spray drying yoghurt. Powder was produced with a pilot plant spray-dryerspeed of blower was set at 2400 rpm and inlet/outlet temperature of 170 ºC and 65-70 ºC. The prepared powder was analyzed for determining the moisture content, particle size distribution, tapped bulk denisty, loose filled bulk denisty, wettability, titratable acidity, energy value, lactic acid bacterial load count and sensory evaluation of yoghurt powder.

Within the experimental range of the independent and dependent variables studied the following conclusions were drawn:

1. With the increase in TSS concentrate in yoghurt samples, yoghurt powder produced also increases.
2. Highest overall acceptability scores were observed for yoghurt powder of TSS concentrate 23.2%.
3. The mix ratio of 1:1 is recommended as best combination for making reconstituted yoghurt.
4. Yoghurt powder prepared from yoghurt at 23.2% concentrate showed significantly high acceptable.

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