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Techno-functional attribute studies of dairy whitener brands available in Bengaluru market

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Abstract
Dairy whitener is one of the most preferred additives to coffee and tea beverages. In the present study, available five different dairy whitener brands (B_1, B_2, B_3, B_4 and B_5) were purchased from local markets in Bengaluru and analysed for their techno-functional properties. The reconstitution behaviour at different temperatures, pH and water quality in terms of hardness used for the reconstitution of powder also investigated. The functional properties of five different dairy whitener brands showed a significant (P=0.05) difference with respect to the reconstitution properties, foaming properties, emulsification properties, oil and water binding capacity. Among the five brands, the B_4 brand had highest wettability (7.10 sec), dispersibility (3.45 sec), solubility (99.5%), foam capacity (86.40%), emulsification capacity (56%), emulsion stability (77%), oil binding capacity (9.20 g /g of protein), water binding capacity (8.70 g/ g of protein) and dissolution behaviour (3 min) as compared to other brands. The reconstitution behaviour of the B_4 brand showed high solubility, wettability and viscosity at different temperatures, pH and water quality used for the reconstitution of powder as compared to other brands, which could be due to low fat content, high carbohydrate content and higher particle size of powder.

Keywords: Dairy whitener, functional properties, reconstitution behaviour, flow properties, emulsification and foaming properties

1. Introduction
Milk converted into milk powder extends its shelf life and allows it to be stored for longer periods of time, even at room temperature. Skim milk powder, whole milk powder, partly skimmed milk powder and dairy whitener are some of the milk powders available in India. Coffee is now one of the most extensively consumed pharmacologically active beverages and it is ingrained in people's daily lives all over the world. The majority of the population prefers coffee with milk because it contains a variety of constituents that contribute rich flavour to the coffee Al-Ghafari *et al*. (2017) [1].
People are currently interested in purchasing instant powders because they offer greater convenience for both manufacturers and consumers in terms of packing, handling, storage, transportation costs and ease of preparation. Coffee creamers, often known as “coffee whitener”, “coffee sweetener” or “Dairy Whitener” are liquid or granular compounds that are used in coffee or other beverages to replace milk or cream because of its intrinsic functional properties, added sugar and ability to withstand higher temperatures (85-90 ºC) and low pH (4.50) Hedayatnia *et al*. (2018) [2]. Some of the popular dairy whitener brands available in India are Nestle, Mother Dairy, AMUL, Britannia and Nandini Dairy.
Specific techno- functional attributes, notably in terms of solubility, viscosity and stability should be present in a desirable coffee creamer. It should also have a nice whitening effect when mixed with hot coffee or other hot liquids. The performance of dairy components as ingredients in finished products or formulated foods can be defined using their functional properties. Functional properties affect the final quality of the dried products, which is influenced by the components present in the food material. The functional properties of dairy whitener are mostly affected by the manufacturing and storage conditions and they alter the state of the components present in powder. To earn consumer trust and maintain our footprint in these countries, we must meet the quality criteria and specifications for milk powder. Existing Indian regulations for dairy whitener are insufficient in some areas and do not cover some parameters such as emulsification capacity, foaming capacity and oil and water binding capacity of the powder. As a result, it was thought that gathering information on the functional quality of dairy whiteners manufactured in various dairy sectors and sold in the Bengaluru

market would be worthwhile. Therefore, the current investigation was intended to study the techno-functional attributes of various dairy whitener brands available in the Bengaluru market.

2. Materials and Methods
2.1 Materials
Five dairy whiteners including both medium and high fat dairy whitener types were purchased from the Bengaluru market. In that three of them such as B_1, B_2 and B_3 come under high fat dairy whiteners and B_4, B_5 come under medium fat dairy whiteners. These five dairy whiteners were purchased from three different outlets at local markets in Bengaluru, Karnataka state. Instant coffee powder and refined palmolein oil were also purchased from local Bengaluru markets.

2.2 Methods
2.2.1 Wettability
Wettability of dairy whitener was measured as per the method mentioned in Fitzpatric *et al*. (2016) [3]. Measure 250 ml of water into 600 ml of beaker and close the beaker with steel plate (no edges). Spread the 10 g of sample on the steel plate and withdraw immediately. Record the time when the sample comes into contact with water.

Calculation

$$\text{Wetting time} = (\text{Time recorded in seconds } - 10)$$

2.2.2 Sinkability
Sinkability of dairy whitener was measured as per the method mentioned in Zainil *et al*. (2019) [4]. The spectrophotometer was calibrated at 760 nm at first. In a spectrophotometer, the cuvette was half filled with distilled water and the transmittance was set to blank. Before inserting the cuvette into the spectrophotometer, 0.1 g of a sample was taken and transferred to a cuvette that already contained 3.5 ml of distilled water. The cuvette was then tapped six times. The transmittance was measured three to four times, with intermittent tapping about six times at intervals of 0, 2 and 4 minutes.

2.3 Dispersibility
Dispersibility of dairy whitener was measured as per the method mentioned in

Kalhoro *et al*. (2014). At 60 ºC, 10 g of milk powder was mixed with 100 ml of distilled water. A stop watch was started at the same moment, and the initial time was recorded. The sample was stirred until all lumps were completely dispersed. Finally, the time difference was taken into consideration, and the results were calculated accordingly.

2.4 Solubility
Solubility of dairy whitener is measured as per the method mentioned in Meena *et al*. (2017) [6]. Total 100 ml, 5% (w/v) solution powders was continuously stirred at 400 rpm at 25 ± 1 ºC for 30 min (bulk solution). 40 ml bulk solution was transferred to two 50 ml falcon tubes and centrifuged at 1000 ×g for 10 min at 20 ºC. The total solid contents of bulk and supernatant solutions were determined and then solubility powders were calculated using the following equation:

$$\text{Solubility percentage} = \frac{\text{Solids in supernatant}}{\text{solids in the bulk solution}} \times 100$$

2.5 Foam capacity and stability
Foam capacity and stability of dairy whitener were measured as per the method mentioned in Shilpashree *et al*. (2015) [7] with a slight modification in the temperature of the sample. Add 3 g protein to 100 ml of 0.05 mol / L phosphate buffer (pH 7). The suspension was mixed using a magnetic stirrer for 45 min and then heated to 60 ºC. After magnetic stirring and heating, the solution was mixed with a hand mixer (INALSA) at its maximum speed for exactly 6 min. The sample was then transferred to a 500 ml graduated cylinder as quickly as possible. Foam capacity is calculated as follows:

$$\text{Foam capacity} = \frac{B-A}{A} \times 100$$

Where,
A = volume of liquid before whipping (mL)
B = Total volume (foam plus liquid) obtained immediately after whipping (mL)

2.6 Foam stability
Foam stability was analyzed by the volume of foam that remained after 30 min at 30 ± 2 ºC expressed as a percentage of the initial foam volume.

2.7 Emulsification capacity and stability
Emulsification capacity and stability of dairy whitener were measured as per the method mentioned in Shilpashree *et al*. (2015) [7]. Prepare 50 ml of sample solution containing 1 g protein in 100 ml of water. Add 25 ml refined palmolein oil to the solution and the emulsion was prepared by using a micronizer at 5 ºC for 20 min. The emulsions were centrifuged at 1100 × g for 5 min. The height of emulsified layer and that of the total contents in the tube were measured.

$$\text{Emulsifying capacity,\%} = \frac{\text{Height of the emulsified layer in the tube}}{\text{Height of the total content in the tube}} \times 100$$

"Emulsion stability" is measured by heating emulsion at 80 ºC for 30 min and then centrifuge at 1100 × g for 5 min.

$$\text{Emulsifying stability,\%} = \frac{\text{Height of the emulsified layer after heating}}{\text{Height of the emulsified layer before heating}} \times 100$$

2.8 Water binding capacity
Water binding capacity of dairy whitener was measured as per the method mentioned in Shilpashree *et al*. (2015) [7]. Add 3 g of protein to a previously weighed empty centrifuge tube. Hold the centrifuge tubes for 30 min after the addition of 10 ml of deionized water. Centrifuge the tubes for 10 min at 3000 ×g, discard supernatant and weigh the tube. Results are expressed in g of water per g of protein.

2.9 Oil binding capacity
Oil binding capacity and stability of dairy whitener is measured by as per method mentioned in Shilpashree *et al*. (2015) [7]. Add 3 g of protein to previously weighed empty centrifuge tube. Hold the centrifuge tubes for 30 min after addition 10 ml of oil. Centrifuge the tubes for 10 min at 3000 ×g or 3700 rpm and discard supernatant and weigh the tube. Results are expressed in g of water per g of protein.

2.10 Coffee stability
Coffee stability of dairy whitener was measured as per method mentioned in Zbikowska *et al*. (2006) [8]. 4 g of dairy whitener was added to 200 ml of coffee infusion (3.0 g of

coffee powder/ 200 ml). The solution was stirred for 6 sec by 6 times in a clockwise and 6 times anti clock wise direction and set aside for 10 min. 50 ml of solution is transferred to calibrated centrifuge tube and set aside for another 5 min. Then the tubes are centrifuged for 5 min at 164 ×g centrifugal force and results are directly read from the scale.

2.11 Bulk density
Bulk density of dairy whitener was measured as per the method mentioned in Banjrae *et al*. (2019) [9]. Fill the powder up to the rim of the previously weighed empty cylinder. Weigh the cylinder with powder and then tap the cylinder 100 times to determine the tapped bulk density. Finally take the weight of the cylinder after tapping.

$$\text{Bulk density} = \frac{M_2 - M_1}{V_C}$$

$$\text{Tapped bulk density} = \frac{M_2 - M_1}{V}$$

Where,
M_1 = Mass of the graduated cylinder
M_2 = Mass of the cylinder containg sample
V_C = Volume of the cylinder (100 ml)
V = Volume after tapping

2.12 Carr index and Haunsner ratio
Carr index and Haunsner ratio of dairy whitener was measured as per the method mentioned in Banjare *et al*. (2019) [9].

$$\text{Carr index} = \frac{\text{Tapped bulk density} - \text{Loose bulk density}}{\text{Tapped bulk density}} \times 100$$

$$\text{Haunsner ratio} = \frac{\text{Tapped bulk density}}{\text{Loose bulk density}} \times 100$$

2.13 Powder dissolution behavior
Powder dissolution behavior of dairy whitener was measured as per the method mentioned in Banjare *et al*. (2019) [9], 30 mg of powder layered on top of water containg 3 ml of water in a cuvette. Measure the absorbance at 620 nm per every minute until full dispersion**.**

2.14 Viscosity
Viscosity of dairy whitener samples were measured by using Ostwald viscometer as per standard procedures IS:SP:18:(Part XI) 1981 [10].

2.15 Statistical analysis
Significant difference between the values was verified by one way analysis of variance (ANOVA) and comparison between means was made by critical difference value by using R software [R. version 4.1.2 (2021-11-01), copyright © 2021, R foundation].

3. Results and Discussion
3.1 Wettability
Table 1 revealed that the wettability of the B_5 sample at 60 ºC had taken a longer time (8.80 Sec) to absorb water at its surface to get wet while B_4 had taken fewer time (7.10 Sec) as compared to other brands. Statistically there was a non significant (P=0.05) difference with respect to the wettabilillty for all the brands. Our results were well correlated with the results of Khatkar *et al*. (2014) [11] who reported that the wettability of UF dairy whitener took a longer time to wet about 19.50 Sec and two different market dairy whiteners took 8.20 Sec and 5.35 Sec, respectively. Observed similar values in instant coffee whitener "Cremilka," at 20 ºC took 47 Sec to get wet on the surface of powder Żbikowska *et al*. (2006) [8]. Kim *et al*. (2002) [12] reported that the wettability of milk powder was mainly affected by the particle size, density, porosity, surface charge and surface area. Therefore, it could be concluded that the presence of lower fat content (15.20%) which forms a low free fat layer on the surface of the powder particle and also higher carbohydrate content (57.50 per cent) and high particle size (112.5 µm) improved the wettability of B_4 Khatkar *et al*. (2014) [11].

3.2 Sinkability
The sinkability of B_4 dairy whitener was superior (0.36 transmittance at 760 nm wavelength) as compared to other brands but statistically there was a non significant (P=0.05) difference with respect to the sinkability among five dairy whitener brands. Similar values were observed in goat milk powder produced at 140 ºC had high sinkability (0.46 transmittance at 760 nm wavelength) compared to milk powder produced at 180 ºC (0.20 transmittance at 760 nm wavelength) and at 200 ºC (0.22 transmittance at 760 nm wavelength) Zainil *et al*. (2019) [4]. As a result, it could be inferred that presence of lower fat content and higher particle size in B_4 might have increased the sinkability compared to other brands.

3.3 Dispersibility
The dispersibility of the B_4 sample took less time (3.45 Sec) to disperse in water, while B_2 sample took more time (4.99 Sec) as compared to other brands (Table 1) but statistically there was a non significant (P=0.05) difference existed with respect to the dispersibility among all five dairy whitener brands. Similar values were reported by Kalhoro *et al*. (2014) [5]. They reported the dispersibility of full cream milk powder at 60 ºC and 40 ºC was 9.7 sec and 8.10 sec while half cream milk powder was 7.90 sec and 9.10 sec, respectively. Instant coffee whitener "Cremilka" has the highest degree of dispersibility (95.6%), followed by skim agglomerated milk powder (94.5%) and instant whole milk powder (92.3%) Żbikowska *et al*. (2006) [8]. Dispersibility of B_4 sample required less time to disperse uniformly in water and this could be due to its high particle size, higher air content, high carbohydrate content which forms hydrophilic characteristics on the surface of the particle and lower fat content.

3.4 Solubility
The B_4 sample had improved solubility (99.5%) as compared to other brands (Table 1) but statistically analysis there was a non significant (P=0.05) difference with respect to the solubility of all dairy whitener samples. Khatkar *et al*. (2014) [11] also reported that the solubility index of UF dairy whitener was high about 0.20 ml as compared to two different market dairy whiteners, which were 0.30 ml and 0.20 ml, respectively. Solubility index of instant whole milk powder, coffee whitener and skim agglomerated milk powders was recorded below 0.05 ml Żbikowska *et al*. (2006) [8]. The presence of granulated sucrose also contributed towards the solubility in milk powders Zainil *et al*. (2019) [4]. Therefore, it could be inferred that the presence of higher dextrin in B_4 and also the lower fat content and higher particle size simultaneously increased the solubility

Table 1: Reconstitution, Foaming and Emulsification properties of selected market dairy whiteners

Brands	Wettability (Sec)	Sinkability (A_{760} nm)			Dispersibility (Sec)	Solubility	Foam capacity	Foam stability	Emulsion capacity	Emulsion stability
		0 min	2 min	4 min		Percent				
B_1	8.30	0.06	0.11	0.26	4.95	99.30	76.00	100.00	53.00	74.00
B_2	8.60	0.08	0.14	0.22	4.99	99.00	78.80	100.00	53.00	73.00
B_3	8.12	0.10	0.15	0.30	4.44	99.30	74.00	100.00	56.00	72.00
B_4	7.10	0.20	0.29	0.36	3.45	99.50	86.40	100.00	56.00	77.00
B_5	8.80	0.09	0.13	0.23	4.75	99.00	68.70	100.00	55.00	74.00
SEm±	0.35	0.02	0.03	0.03	0.22	0.10	1.60	0.32	0.67	0.83
CD (P=0.05)	1.55	0.11	0.17	0.22	1.19	0.68	2.74*	2.62	0.17*	0.78*

B_1, B_2, B_3, B_4 and B_5 – Five different dairy whitener samples, *Significant at P=0.05, All the values are average of three trails

3.5 Foam capacity and stability

The B_4 sample had a superior foaming capacity (86.40%) than other remaining dairy whitener samples (Table 1). Statistical analysis revealed that there was a significant (P=0.05) difference with respect to foam capacity among different brands of dairy whitener. Similar values were observed in skim milk foam (25%) and foam enriched with higher amounts of whey protein concentrate (15%) had the best overall foaming qualities (459 and 534% foaming capacity). Although foams fortified with a higher concentration of sodium-caseinate (5%) had the best foaming capacity (1422%) but their stability was inferior Martínez-Padilla *et al*. (2014). Zouari *et al*. (2021) [14] reported that reconstituted camel milk powder showed the highest foaming properties with 78.33% and 48 sec for foam capacity (FC) and stability (FS), respectively as compared to reconstituted bovine milk (FC and FS were 72.33 and 330 sec, respectively) and skimmed bovine milk (57.0% and 210 sec for FC and FS, respectively) powder. Superior foaming properties in B_4 sample could be due to the lower fat content and higher carbohydrate content. The foaming capacity and stability of five dairy whitener brands were low compared to skim milk powder because of the high fat content in powder, which creates hydrophobicity on the particle surface of powder.

3.6 Emulsion capacity and stability

The B_4 sample had higher emulsion capacity (56.00%) and stability (77.00%) as compared to other brands (Table 1). Statistically there was significant (P=0.05) difference with respect to the emulsion capacity and stability. Our results are corroborating well with the results of Shilpashree *et al*. (2015) [7]. They reported that succinylation of NaCas (96% succinylation) led to a significant increase in emulsion activity and stability of about 100% and 98.2% as compared to NaCas reported values of 99.8% and 99.2% because of increased solubility and structural flexibility of the modified protein and these changes facilitate the diffusion of protein at the oil – water interface. As result, it could be concluded that the higher emulsion properties in B_4 could be due to the higher particle size and large protein aggregates that provide depletion flocculation.

3.7 Water binding capacity

As compared to other dairy whitener brands, the B_4 sample had a excessive water binding capacity about 9.20 g of water/ g of protein(Table 2) but statistically there was a non significant (P=0.05) difference with respect to the water binding capacity among five dairy whitener brands. The reported values in this study were observed to be higher as compared to Meena *et al*. (2017) [6] who reported that the water binding capacity of cow milk protein concentrate 60 powder was 5.22 g/g of protein and Patil *et al*. (2018) [15] who reported that the water binding capacity of buffalo milk protein concentrate 60 powder was 5.49 g/g of protein. The water binding capacity of all brands of dairy whitener was higher as compared to MPC 60 powders, which could be due to the low bulk density, high particle size and presence of sucrose (sucrose had a high hydrophilic – lipophilic characteristics), dextrose and maltodextrin (excellent oil and water binding capacity) and less denaturation of protein during drying.

3.8 Oil binding capacity

The B_4 had a higher oil binding capacity (8.70 g of oil/ per g of protein) as compared to other remaining dairy whitener samples (Table 2). Statistically there was a non significant (P=0.05) difference with respect to the oil binding capacity of all other brand samples. Oil binding capacity of cow milk protein concentrate 60 powder was 3.38 g/ g of protein Meena *et al*. (2017) [6]. Patil *et al*. (2018) [15] reported that the oil binding capacity of buffalo milk protein concentrate 60 powder was 5.18 g/ g of protein. The oil binding capacity of all brands of dairy whitener was superior as compared to MPC 60 powders could be due to the low bulk density and presence of sucrose (sucrose had a high hydrophilic - lipophilic), dextrose and maltodextrin (excellent oil and water binding capacity) and less denaturation of protein during drying.

3.9 Coffee stability

The observed coffee stability of B_3 and B_1 samples had lower coffee stability (0.60 ml) as compared to other brands but statistically non significant (P=0.05) than other brands (Table 2). The values obtained in this study were similar to the Oldfield *et al*. (2000) [16], who found that the coffee stability of instant whole milk powder decreased with increasing temperature from 75 to 120 ºC had a minimum effect on coffee sediment ranging from 0.33 to 0.43 ml. Żbikowska *et al*. (2006) [8] reported that exposing whole milk powder at extreme conditions regarding both temperature 90 ºC and coffee infusion (5 g/ 100 ml) strength resulted in a significant increase in the amount of residues from 0.15–0.40 ml. Therefore, it could be concluded that the coffee stability of five different dairy whitener brands showed improved coffee stability at higher temperature (90 ºC) and coffee infusion (3 g of coffee powder/ 200 ml water).

Table 2: Water binding, oil binding capacity, coffee stability, Bulk density and flow properties of selected dairy whiteners

Brands	Water binding capacity (g of water/g of protein)	Oil binding capacity (g of oil/g of protein)	Coffee stability (ml)	Bulk density (g/ml)		Flow properties	
				Loose bulk density	Tapped bulk density (100 times)	Carr index (%)	Hausnen ratio
B_1	8.90	8.20	0.60	0.50	0.60	24.00	1.32
B_2	8.60	7.70	0.50	0.40	0.60	26.00	1.35
B_3	9.00	8.40	0.60	0.50	0.60	24.00	1.31
B_4	9.20	8.70	0.50	0.50	0.70	24.00	1.32
B_5	8.90	7.80	0.50	0.40	0.60	26.00	1.35
SEm±CD	0.16	0.13	0.03	0.02	0.02	0.30	0.04
(P=0.05)	1.17	0.69	0.18	0.12	0.12	0.82*	0.28

B1, B2, B3, B4 and B5 – Five different dairy whitener samples, *Significant at P=0.05, All the values are average of three trails

3.10 Bulk density
The observed bulk density of the B_4 sample was excessive but the statistically there was a non significant (P=0.05) difference with respect to the bulk density among five dairy whitener samples (Table 2). Khatkar *et al.* (2014) [11] also reported that the loose and tapped bulk density of UF dairy whitener were 0.27 g/ml, 0.37 g/cc as compared to market dairy whitener samples of 0.40 g/ml, 0.61 g/cc and 0.48 g/ml, 0.68 g/cc, respectively. Loose bulk density of the skim and whole milk powders ranged between 407 and 666 kg/m^3 Pugliese *et al*. (2017) [17]. Bulk density of five different types of dairy whitener brands was lower and this could be contributed by their higher particle size and higher amount of occluded air produced during the agglomeration of dairy whitener powder.

3.11 Flow properties
Flow properties or flowability was estimated in terms of Carr index and Hausner ratio. The estimated carr index of B_1, B_2, B_3, B_4 and B_5 dairy whiteners was 24.00%, 26.00%, 24.00%, 24.00% and 26.00%, respectively. The Hausner ratio of B_1, B_2, B_3, B_4 and B_5 dairy whiteners were 1.32, 1.35, 1.31, 1.32 and 1.35, respectively (Table 2). The statistical analysis revealed that there was a significant (P=0.05) difference with respect to the carr index and non significant with respect to the hausner ration among five brands of samples. The results are corroborating well with the results of Pugliese *et al.* (2017) [17] who reported that the Hausner ratio and Carr index of skim milk powder and whole milk powder were 1.37, 1.39 and 26.71%, 28.13%, respectively. Tastemirova *et al*. (2020) [18] reported that camel milk powder produced by spray drying had a low Hausner ratio of about 1.21-1.37 compared to freeze dried milk powder ranging from 1.15-1.31. Dried powders with a greater than 1.34 Hausner ratio and Carr index of more than 25% are considered cohesive and consequently less free to flow Banjrae *et al.* (2019) [9]. Therefore, the results concluded that the flow properties of five dairy whitener brands were cohesive and consequently less free to flow which could be due to the high surface fat composition.

3.12 Dissolution Behaviour
The dissolution behaviour of B_1, B_2, B_3, B_4 and B_5 was 5 min, 4 min, 7 min, 3 min and 6 min, respectively (Table 3). B_4 sample had taken less time to dissolve fully in water at 30 ºC as compared to other samples. Statistically there was a significant (P=0.05) difference with respect to the dissolution behaviour among all other brands. The values obtained in this study were lower as compared to Banjare *et al*. (2019) [9] who reported that WPC dissolved fully in less than 15 min as compared to the WPC–Fe complex took 25 min, which could be due to the spray drying methods / conditions used in their manufacturing

4. Factors affecting the reconstitution behaviour of Dairy Whiteners
Reconstitution properties were mainly affected by the temperature**,** pH and water quality. Wettability, solubility and viscosity considered as the major functional properties during applications of dairy whiteners. Therefore, the properties such as wettability, solubility and viscosity were evaluated were evaluated at different temperatures, pH and water quality used for reconstitution of powder.

Temperature: Wettability of B_4 dairy whitener had taken less time to wet its surface at different temperatures such as 5 ºC, 37 ºC, 50 ºC and 90 ºC as compared to other brands and the reported values were 161.00 min, 0.50 min. 0.20 min and 0.07 min, respectively. The B_5 sample was less soluble at 5 ºC (98.20 per cent) while the B_4 sample had superior solubility (100.00 per cent) at 90 ºC. The B_1 and B_4 samples were showed higher viscosity about1.60 cP at 5 ºC and lower at 90 ºC about 1.40 cP.

pH: Wettability, solubility and viscosity were evaluated at different pH such as pH 4.5, pH 6.5 and pH 8.4. The B_4 sample had better solubility (99.90%, 99.80% and 99.90%), wettability (0.40 min, 0.40 min, 0.20 min, respectively) and viscosity (1.50 cP, 1.30 cP, 1.60 cP) at diffirent pH of water used for reconstitution of powder as compared to other brands.

Water quality; Both RO and tap water were used to evaluate the wettability, solubility and viscosity of dairy whitener. The B_1 sample showed better solubility (99.00%), wettability (0.60 min) and viscosity (1.40 cP) with tap water while B_4 showed superior solubility (99.90%), wettability (0.40 min) and viscosity (1.40 cP) with RO water but Statistically there was a non significant (P=0.05) difference with respect to water quality.

The values obtained in the present study were similar to the Kalhoro *et al*. (2014) [5] who reported that RO water used for reconstitute dried powder produced satisfactory results, with optimum solubility indexes of 0.75 ml, 0.75 ml, and 1.3 ml for full cream, half cream and skimmed milk powders. Reconstitution of whole milk powder was better at water temperature 60 ºC compared to 40 ºC and 24 ºC. Fitzpatrick *et al*. (2017) [19] reported that wettability of skim milk powder at 20 ºC, 50 ºC and 70 ºC were 51 Sec, 16 Sec and 10 Sec, respectively. Wettability of skim milk powder improved with increasing temperature. wettability of high fat powders at 20 ºC, 50 ºC and 70 ºC are > 1 h, 3 min and 1 min, respectively. Temperature was not affected the wettability of caseinate and MPI powders taken more than 1 hr at all temperatures.

Therefore, it could be inferred that the wettability of five different dairy whitener brands was highly affected by different temperatures used for reconstitution while pH and water hardness could not affect the same. This could be due to the melting characteristics of surface fat present on the powder particles at higher temperature. Overall, the reconstitution property of dairy whitener was better at high temperature (90 ºC) with RO water.

Table 4: Effect of temperature on the reconstitution behaviour of dairy whiteners

Parameters	Temperature (ºC)	B_1	B_2	B_3	B_4	B_5	SEm±	CD(P=0.05)
Wettability (min)	5 ºC	194.00	159.00	233.00	161.00	208.00	5.67	2.98*
	37 ºC	4.30	1.40	1.70	0.50	2.20	0.31	0.37*
	50 ºC	0.20	0.10	0.20	0.20	0.20	0.2	0.18
	90 ºC	0.08	0.07	0.08	0.07	0.07	0.12	0.06
Solubility (%)	5 ºC	98.60	98.50	98.90	99.00	98.20	4.45	0.35
	37 ºC	99.70	99.60	99.50	99.60	99.70	4.46	0.13*
	50 ºC	99.90	99.90	99.60	99.80	99.90	4.47	0.17
	90 ºC	99.90	99.90	99.80	100.00	99.90	4.47	0.23
Viscosity (cP)	5 ºC	1.60	1.50	1.50	1.60	1.40	0.56	0.17
	37 ºC	1.40	1.40	1.30	1.30	1.30	0.55	0.35
	50 ºC	1.40	1.40	1.40	1.50	1.40	0.53	0.38
	90 ºC	1.40	1.30	1.30	1.40	1.40	0.53	0.21

B_1, B_2, B_3, B_4 and B_5 – Five different dairy whitener samples, *Significant at P=0.05
All the values are average of three trails

Table 5: Effect of pH on the reconstitution behaviour of dairy whiteners

Parameters	pH	B_1	B_2	B_3	B_4	B_5	SEm±	CD(P=0.05)
Wettability (min)	pH 4.5	0.60	0.50	0.40	0.40	0.40	0.04	0.17
	pH 6.5	0.40	0.30	0.40	0.40	0.40	0	0.26
	pH 8.4	0.50	0.30	0.70	0.20	0.50	0.09	0.35
Solubility (%)	pH 4.5	99.80	99.80	99.50	99.90	99.90	0.07	0.17*
	pH 6.5	99.00	99.60	99.20	99.80	99.90	0.17	0.21*
	pH 8.4	99.80	99.70	99.30	99.90	99.80	0.10	0.35
Viscosity (cP)	pH 4.5	1.40	1.40	1.40	1.50	1.50	0.02	0.26
	pH 6.5	1.20	1.20	1.40	1.30	1.40	0.04	0.10
	pH 8.4	1.80	1.60	1.60	1.60	1.60	0.04	0.21

B_1, B_2, B_3, B_4 and B_5 – Five different dairy whitener samples, *Significant at P=0.05
All the values are average of three trails

Table 6: Effect of water quality on the reconstitution behaviour of dairy whiteners

Parameters	Water quality	B_1	B_2	B_3	B_4	B_5	SEm±	CD (P=0.05)
Wettability (min)	Tap water	0.60	0.40	0.40	0.50	0.50	0.03	0.27
	RO water	0.40	0.30	0.40	0.40	0.40	0.02	0.17
Solubility (%)	Tap water	99.00	99.00	98.10	98.90	98.70	0.17	0.24*
	RO water	99.80	99.70	99.30	99.90	99.90	0.11	0.17*
Viscosity (cP)	Tap water	1.40	1.40	1.40	1.40	1.40	0	0.35
	RO water	1.40	1.40	1.30	1.40	1.30	0.02	0.21

B_1, B_2, B_3, B_4 and B_5 – Five different dairy whitener samples, *Significant at P=0.05
All the values are average of three trails

5. Conclusion

Dairy whiteners are commonly used as a substitute for fresh milk, cream, or evaporated milk in tea, coffee, cocoa, or drinking chocolate. It is also ideal for adding to foods such as soups, sauces, puddings and cereal dishes. Dairy whiteners have a longer shelf life and better functional characteristics; although these properties are not as good after half of their shelf life and also the different dairy whiteners available in the market are not the same. The B_4 brand showed high solubility, wettability and viscosity at different temperatures, pH, and water quality used for reconstitution of powder. Wettability of five different dairy whitener brands was highly affected by different temperatures used for reconstitution while pH and water quality were not affected the wettability could be due to the melting characteristics of surface fat present on the powder particles. The reconstitution property of dairy whitener was better at high temperature (90 ºC) using RO water for reconstitution. The B_4 brand had higher functional properties such as reconstitution properties, emulsification properties, flow properties, oil and water binding capacity as compared to other brands. High functional properties in dairy whitener could be due to the lower content of fat, higher carbohydrate content and maltodextrin added to the powder act as fat filler and improve particle size, bulk density, hygroscopicity, solubility and caking properties.

6. References

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