

Effect of cheddar cheese whey incorporation on composition, characteristics and shelf life of cake

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Abstract

Whey generated as a by-product of cheese, paneer, chhana production in dairy industry is a cause of concern and is a financial burden on account of its disposal treatments. Further, if it is drained in effluent treatment plants, vital constituents of whey go in vain. The nutritional benefits of whey constituents can be availed if the whey is incorporated into various dairy or food products. Bakery products are suitable medium for incorporating whey either fully or partially. In this work, Cheddar cheese whey and water were admixed in different proportions and used for batter preparation of the cake. Admixing of cheese whey in equal proportion with water for batter preparation of cake produced the resultant cake with improved crust colour and surface characteristics than control cake (without whey). The per cent mean values of moisture, fat, total protein, ash and total carbohydrate of cake without Cheddar cheese whey were 10.46, 22.25, 6.68, 0.87 and 59.74, respectively, while, these values for cake prepared by 50 per cent incorporation of cheese whey were 10.62, 22.93, 7.34, 0.91 and 58.20, respectively. Microbiological quality of cake did not get affected by whey addition. During storage, sensory attributes like volume, crust colour & surface characteristics and crumb colour of the cake with Cheddar cheese whey remained unaffected. Peroxide value of both the types of cakes during storage was non-significant. The addition of cheese whey during preparation of cake resulted improvement in compositional parameters and physicochemical characteristics of cake.

Keywords: Cake, Cheddar cheese whey, Physicochemical properties, Sensory characteristics

Highlights

- Addition of cheese whey in cake produced better sensory characteristics.
- It increased the protein, major minerals and total carbohydrates content of cake.
- Cheese whey addition improved characteristics & texture of cake.
- Incorporation of cheese whey did not affect the microbial quality and shelf life of cake.

INTRODUCTION

Whey is a liquid by-product generated from dairy plants manufacturing dairy products like cheese, paneer, chhana and casein. High cost is incurred for treatment of whey through effluent treatment plant. Incorporation of whey in recipe of different bakery products sounds easy and effective way of whey disposal. Several workers have incorporated the whey directly or by concentrating it in bakery products and studied its effect on physico-chemical parameters of products. Attempts were made to utilize whey either as such or after concentration in various products like soups, beverages (Joshi et al., 2020), soups sticks and rusks (Mallik & Kulkarni, 2009 and 2010), bread (Divya & Rao, 2010; Paul et al., 2016) and bun (Reddy et al., 2016). The above studies involved processing of whey in one or other way before its final

use. Paneer whey and Cheddar cheese whey were directly incorporated in dough preparation of biscuit and bun and evaluated for their effect on various physicochemical parameters of the products (Parmar et al., 2017; Parmar et al., 2018). Whey constituents improve functional properties and nutritional value of bakery products. Therefore, use of whole whey in preparation of batter of cake in place of water seems appropriate and economical way of its utilization.

MATERIALS AND METHODS

Cheddar cheese whey was procured from commercial dairy Plant, Anand, Gujarat. Ingredients required for cake preparation such as *Maida* (Uttam brand), sugar, salt, shortening/vegetable fat, yeast and other related ingredients were procured from local market of Anand city, Gujarat.

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Method for cake preparation

The purpose of the study was to incorporate whey in cake preparation. The batter for cake was prepared by creaming method using water/whey for dispersion of ingredients. The cake was prepared using the formulation (Table 1) mentioned by Kamaliya and Kamaliya (2001) and baked at 170°C (350°F) temperature for 15 to 20 min. in an electrically heated baking oven.

Table 1. Formulation for preparation of cake

Ingredients per 100 g flour/maida (%)	Formulation
Maida	100 g
Vanaspati/shortening	60 g
Sugar	100 g
Milk powder	30 g
Essence (orange)	1 mL
Baking powder	2.5 g
Salt	0.25 g
Water/whey	90 mL
Baking soda	0.25 g
Vanilla powder	1 g

Sensory evaluation of cake

Sensory evaluation of the cake for colour & appearance, volume, crust colour, crumb colour, body and texture, flavour and aroma, taste and overall acceptability was done by semi-trained panel of 8 judges using a numerical a 9-point hedonic scale, where 1-disliked extremely to 9-liked extremely.

Analysis of cake

Gross composition: Gross composition (moisture, protein, fat and ash) of cake samples was determined according to Association of Official Analytical Chemists [AOAC] (2010) standard methods. Total carbohydrates were determined by difference.

Rheological analysis of cake: Four samples of cake were subjected to uniaxial compression to 70 per cent of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England.

Mineral analysis -sample preparation: One gram of ground cake was transferred into a 150 mL conical flask and 10 mL of Nitric acid (conc.) was added. It was covered with a watch glass and kept for overnight. The contents were heated on a hot plate until solid particles have nearly disappeared. Cooled and added 10 mL of Diacid mixture (Perchloric acid and HNO₃

1:3). Then heated gently at first and then more vigorously until a clear, colourless solution obtained. Discontinued heating when the volume was reduced to approximately 2 mL. Cooled and transferred quantitatively to a 50 mL volumetric flask. Volume was made up with glass distilled water and mixed. Kept it overnight and then filtered through a dry paper to remove silica without washing (Jackson, 1973). This solution was use for analysis of Ca, Mg, P and K and trace elements like Fe, Mn, Zn and Cu. Calcium, magnesium and potassium were analysed using methods of Richards (1954). The calcium was determined by titrating it with Versenate reagent and Mg was determined through difference. Available potassium in samples was determined by using neutral normal ammonium acetate extraction method. For P, the analysis of the samples was carried out by diacid mixture as per the procedure outlined by Jackson (1973) and acid extracts were prepared. This acid extract of samples was used to analyze for total phosphorous content.

Trace elements like Fe, Mn, Zn and Cu were determined by Atomic Absorption Spectrophotometer (Perkin Elmer, Model: 3110; Plate 3.3.).

Microbial analysis of cake: The cake samples were analysed for microbial parameters like yeast and mold, coliform and SPC. The counts were taken after 3–5 days of incubation at 30°C.

Peroxide value of cake during storage: The peroxide value of cake was determined by the method (iodometric method) as described by AOAC (2010).

Statistical analysis

Descriptive statistical tools were employed as and when required in data analysis. Differences between treatments was analysed at 5% level of significance using Analysis of Variance (James et al., 2013).

RESULTS

Initial trials were conducted to establish suitability of whey obtained from Cheddar cheese and paneer for cake preparation. Both the whey was used for batter preparation and the cake was evaluated for sensory characteristics. Cake prepared by addition of Cheddar cheese whey produced higher sensory scores over the cake prepared with paneer whey. Therefore, Cheddar cheese whey was selected for cake preparation. To optimize the rate of cheese whey addition in cake, water required for batter preparation of cake was replaced by 25, 50, 75 and 100 per cent with Cheddar cheese whey.

Cake without whey served as control sample. As the addition rate of cheese whey increased, concurrent improvement in various sensory characteristics of cake was evident. Score for all sensory characteristics were at its highest when equal admixing of water and cheese whey for cake was done (Fig. 1). The scores for colour & appearance, volume, crust colour, crumb colour, body and texture, flavour and aroma, taste and overall acceptability were 9.00, 9.00, 9.00, 8.77, 9.00, 8.53, 9.00 and 8.99, respectively when cheese whey was incorporated at equal amount to water for batter making. Hence, in latter part of the study, batter of the cake was prepared using Cheddar cheese whey and water in equal (50:50) proportion.

Analysis of cake

Analysis of cake for sensory characteristics, proximate composition, rheological parameters, minerals content, microbial quality, physicochemical characteristics and storage related changes were carried out to establish the effect of addition of whey in cake.

Sensory characteristics of cake prepared using cheese whey: The scores of colour & appearance, volume, crust colour, crumb colour, body & texture, flavour & aroma, taste and overall acceptability of the cake with Cheddar cheese whey were 8.10, 8.55, 8.54, 8.55, 8.89, 8.83, 8.90 and 8.88, whereas, that of control cake were 8.08, 7.53, 7.89, 7.94, 8.29, 7.55, 8.49 and 8.52 respectively (Fig 2).

Proximate composition: The mean (%) values of moisture, fat, total protein, ash and total carbohydrate

of control cake (i.e. no cheese whey incorporation) were 10.46, 22.25, 6.68, 0.87 and 59.74, respectively. On the contrary, the mean values (%) of moisture, fat, total protein, ash and total carbohydrates content in cake prepared by equal admixing of whey and water were 10.62, 22.93, 7.34, 0.91 and 58.20, respectively indicating an increase in moisture, fat, total protein and ash in cake (Table 2).

Rheological parameters: The mean values of hardness (N), springiness (mm), cohesiveness, gumminess (N), adhesiveness (Nmm) and chewiness of cake with cheese whey were 33.66, 4.74, 0.23, 7.41, 12.93 and 35.06, whereas, that of control cake were 17.56, 6.90, 0.22, 3.87, 0.89 and 26.63, respectively (Table 3).

Minerals content: The average calcium, magnesium, potassium and phosphorus content in control cake were 56.35, 135.33, 149.71 and 199.54 mg/100 g cake. The values for the same after addition of cheese whey were 62.50, 136.93, 205.04 and 225.61 mg/100 g cake, respectively. The average values of trace elements like iron, manganese, zinc and copper in control cake were 25.20, 1.19, 8.08 and 0.48 ppm. The same after incorporation of Cheddar cheese whey were 25.35, 1.64, 8.2 and 0.47 ppm respectively (Table 4).

Microbial quality: The yeast & mold counts and coliforms (cfu/g) were absent at first dilution in cake with or without addition of cheese whey. The standard plate count (cfu/g) in control samples of cake was 28, whereas, that of added with cheese whey was 26 at first dilution.

Table 2. Proximate composition of cake samples

Parameters	Cake with water and cheese whey (50:50)		Cake prepared using water (control)	
	Range	Mean±SD *	Range	Mean±SD *
Moisture (%)	10.53 – 10.71	10.62±0.09	10.19 – 10.93	10.46±0.41
Fat (%)	22.7 – 23.19	22.93±0.25	22.05 – 22.55	22.25±0.26
Total protein (%)	7.25 – 7.42	7.34±0.09	6.57 – 6.74	6.68±0.10
Ash (%)	0.87 – 0.94	0.91±0.04	0.84 – 0.89	0.87±0.03
Total carbohydrate (%)	57.81 – 58.41	58.20±0.34	59.29 – 60.31	59.74±0.52

*mean of 3 analysis

Table 3. Minerals content of cake

Cake	Major minerals (mg/100g)*				Trace elements (ppm)*			
	Ca	Mg	K	P	Fe	Mn	Zn	Cu
Control cake	56.35	135.33	149.71	199.54	25.20	1.19	8.08	0.48
Cake with cheese whey	62.50	136.93	205.04	225.61	25.35	1.64	8.2	0.47

*Average of three analysis

Table 4. Effect of cheese whey incorporation on rheological parameters of cake

Rheological parameters	Cake prepared using water and cheese whey (50:50)		Cake with water (control)	
	Range	Mean±SD	Range	Mean±SD
Hardness (N)	33.32 – 34.0	33.66±0.34	16.19 – 18.28	17.56±1.19
Springiness (mm)	4.46 – 4.92	4.74±0.24	6.68 – 7.21	6.90±0.28
Cohesiveness	0.22 – 0.24	0.23±0.01	0.22 – 0.23	0.22±0.01
Gumminess (N)	7.26 – 7.55	7.41±0.14	3.54 – 4.25	3.87±0.36
Adhesiveness (Nmm)	11.54 – 13.78	12.93±1.21	0.79 – 0.98	0.89±0.10
Chewiness (Nmm)	32.42 – 37.12	35.06±2.42	25.50 – 28.36	26.63±1.52

Table 5. Physicochemical characteristics of cake incorporated with cheese whey

Cake	Physico-chemical characteristics of cake			
	Loaf weight (g)	Rise in loaf volume (%)	Crumb colour	Crust colour
Control cake	431.33±4.04	57.14	Light yellow	Dark brown
Cake with cheese whey	442.0±3.0	59.09	Light yellow	Dark brown

Physicochemical characteristics: The cake with selected formulation was prepared using 110 g quantity of wheat flour. The cakes were analysed for physical characteristics. The mean loaf weight of control cake was 431.33 g, while, that with Cheddar cheese whey was 442 g. The crust colour and crumb colour of the cake after addition of whey were improved over control cake (Table 5). The rise in loaf volume in cake with cheese whey was 59.09 per cent as compared to 57.14 per cent rise in control cake sample.

low-density polyethylene (LDPE) packaging, stored at room temperature in an oven and periodically evaluated for changes in sensory characteristics and peroxide value at the interval of two days.

The overall acceptability scores of control cake were 8.52, 8.10, 7.52, 7.10, 6.40 and 4.85 for fresh cake followed by cake samples evaluated at 2, 4, 6, 8 and 10th day, respectively. Similarly, the overall acceptability scores of cakes with cheese whey were 8.82, 8.61, 7.73, 7.21, 6.58 and 5.08 for fresh cake followed by cake samples evaluated at 2, 4, 6, 8 and 10th day, respectively (Table 6).

Storage (shelf life) study: Cakes were packed in a

Table 6. Sensory characteristics of cake incorporated with cheese whey during storage

Treatments	Storage period (Days)					
	0	2	4	6	8	10
Colour & Appearance						
Control	7.80	7.80	7.80	7.68	7.61	7.56
Sample	8.68	8.60	8.60	8.59	8.49	8.47
CD (P-0.05): T=0.10, P=NS, TxP=NS						
Volume						
Control	7.64	7.15	6.58	6.06	5.53	5.00
Sample	8.84	8.53	7.73	7.24 ^{bd}	6.68	6.11
CD (P-0.05): T=0.10, P=0.17, TxP=NS						
Crust colour						
Control	7.54	7.53	7.47	7.40	7.32	7.25
Sample	8.63	8.63	8.59	8.51	8.50	8.45
CD (P-0.05): T=0.10, P=NS, TxP=NS						
Crumb colour						
Control	7.54	7.53	7.50	7.40	7.31	7.23
Sample	8.63	8.62	8.57	8.43	8.40	8.36
CD (P-0.05): T=0.13, P=NS, TxP=NS						

Cont. Table 6.

Table 6., Cont. ...

Treatments	Storage period (Days)					
	0	2	4	6	8	10
Body and texture						
Control	8.30	8.00	7.50	7.10	6.40	5.50
Sample	8.90	8.62	7.69	7.19	6.40	5.39
CD (P-0.05): T=0.06, P=0.10, TxP=0.14						
Flavour and aroma						
Control	7.58	7.24	6.89	6.54	6.07	5.26
Sample	8.83	8.49	8.08	7.23	6.51	5.44
CD (P-0.05): T=0.08, P=0.14, TxP=0.20						
Taste						
Control	8.28	8.00	7.46	7.10	6.40	5.27
Sample	8.91	8.57	7.73	7.19	6.40	5.39
CD (P-0.05): T= 0.06, P=0.10, TxP=0.14						
Overall acceptability						
Control	8.52	8.10	7.52	7.10	6.40	4.85
Sample	8.82	8.61	7.73	7.21	6.58	5.08
CD (P-0.05): T= 0.09, P= 0.15, TxP=0.22						

Data are presented as means (n=3).

The peroxide values of the control cake for 0, 2nd, 4th, 6th, 8th, and 10th days was found to be 0.13, 0.22, 0.37, 0.62, 0.77 and 0.90 milliequivalents of peroxide/ kg of sample, whereas that of cake with Cheddar cheese whey during same storage period were 0.14, 0.21, 0.37, 0.61, 0.81 and 0.92 milliequivalents of peroxide/kg of sample respectively (Fig. 3).

DISCUSSION

As the addition rate of Cheddar cheese whey amount increased, concurrent improvement in different sensory characteristics of cake was observed. The scores for all sensory characteristics of cake were highest when equal proportion of cheese whey and water were admixed in batter preparation (i.e. 50:50 of cheese whey and water) of cake (Fig. 1). Henceforth, cheese whey and water were used in equal ratio for the batter preparation of the cake during the study.

Proximate composition: Incorporation of cheese whey led to increase in moisture, fat, total protein and ash content in cake. This increase could be correlated to the total solids of cheese whey. Binding of water by whey proteins might have led to retention of moisture in cake.

Sensory characteristics of cake prepared by incorporation of whey: Addition of cheese whey in cake improved the scores of various sensory attributes. However, colour and appearance of cake with and

without the cheese whey did not differ significantly. Other sensory characteristics of cake were significantly enhanced upon addition of whey. Peripheral appearance of cake (i.e. crust colour) was unaffected on addition of cheese whey but a spongy and more open core crumb structure in cake was developed by whey incorporation than the control cake (Fig. 2). Cheese whey contains milk proteins and can demonstrate similar effects if used in cake preparation. Mallik and Kulkarni (2010) prepared rusks by incorporating concentrated cheese and paneer whey and opined no significant difference between control and experimental samples in all the sensory characteristics of rusks.

Divya and Rao (2010) used concentrated paneer whey (CPW) in preparation of bread and observed a significant difference ($P<0.05$) between the scores of the control and those of the experimental samples. However, incorporation of CPW (15% TS) did not affect the sensory quality scores of bread samples, but the use of CPW (26% TS) adversely affected the quality of bread.

Rheological parameters and Physicochemical characteristics: In context to rheological parameters of cake, the hardness in the cake with cheese whey can be attributed to water binding capacity of proteins of whey. The springiness of cake incorporated with whey has been less to that of control cake. Cheese whey did not affect the cohesiveness of cake. The gumminess, adhesiveness and chewiness of cake prepared with

Cheese whey utilization in cake

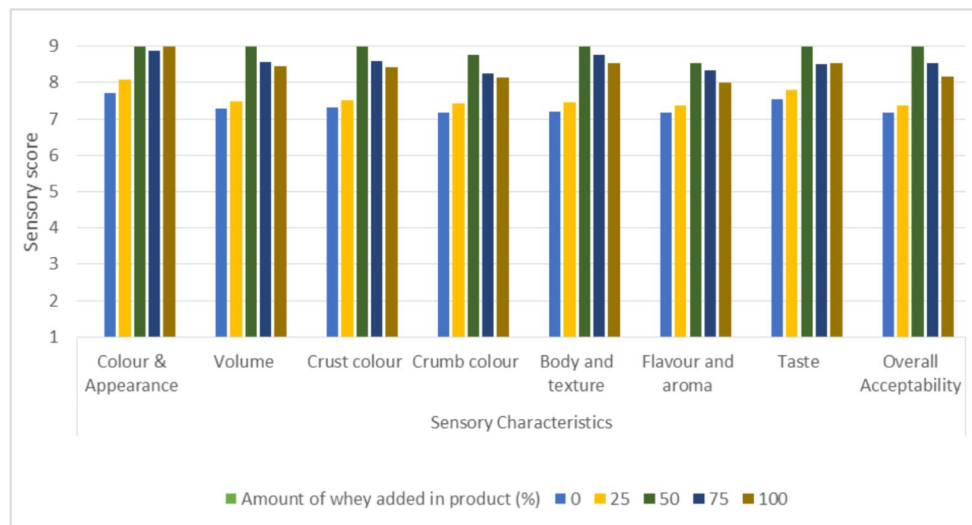


Fig. 1. Effect of rate of cheese whey addition on sensory characteristics of cake

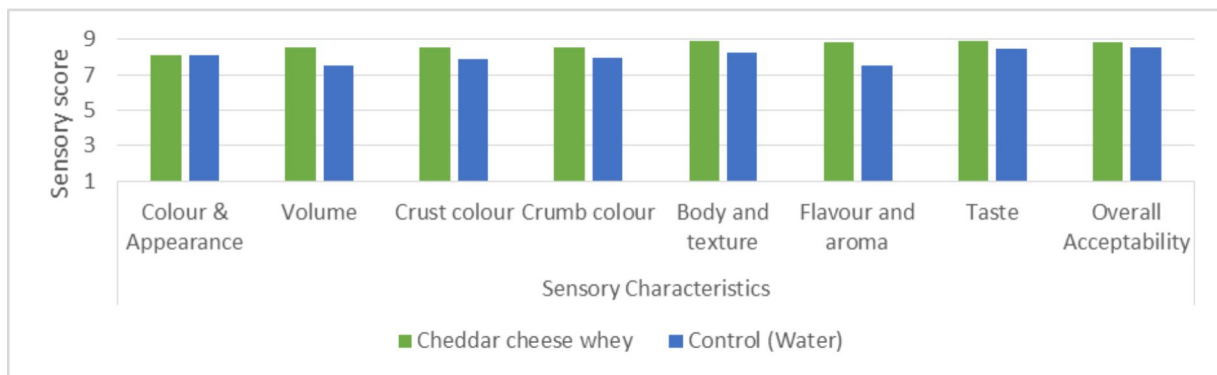


Fig. 2. Effect of Cheddar cheese whey on sensory characteristics of cake

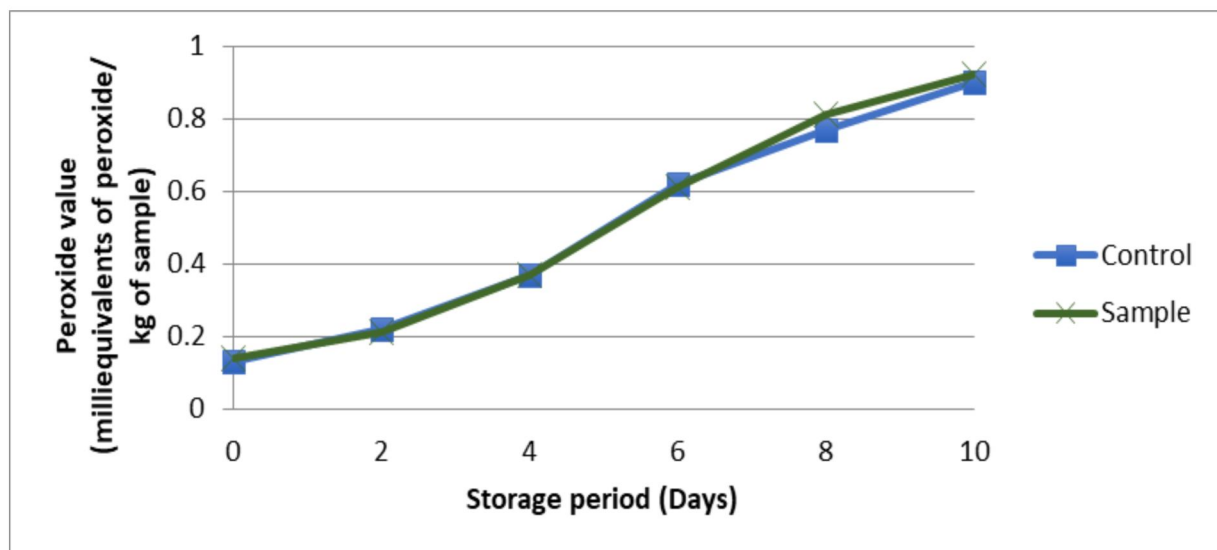


Fig. 3. Changes in peroxide value of cake during storage

cheese whey were higher as compared to control cake (Table 3).

Jyotsna et al. (2007) used WPC in preparation of egg less cake and found that cake with 20 per cent WPC was better in quality characteristics.

Abdul Hussain and Al-Oulabi (2009) observed increase in cake volume by increasing the level of whey proteins. Tan et al. (2015) observed increase in volume of cake after addition of ultra sound treated WPC suspension. This was attributed to higher number of smaller gas cells in the aerated baked cakes structure. Divya and Rao (2010) used concentrated paneer whey (CPW) in preparation of bread and observed an increase in firmness of bread at 26% level of TS in CPW than control bread sample.

Minerals content: Incorporation of Cheese whey in cake has increased the level of calcium, potassium and phosphorous while, trace elements like Fe, Mn, Zn and Cu differed marginally. Bilgin et al. (2006) investigated the effect of pasteurised whey and/or butter milk on functionality of bread and observed that replacement of water with whey and buttermilk in the bread recipe significantly ($P < 0.05$) increased macro (Na, K, Ca, Mg and P) and micro mineral (Zn, Mn, Cu and Fe) contents. Hassan et al. (2013) studied effect of fermented skim milk (FSM), acid cheese whey (ACW) and buttermilk (BM) on dough properties and baking quality of pan bread and observed that replacement of water with FSM, ACW and BM increased macro-minerals concentration ($P < 0.05$), particularly calcium and potassium levels in bread samples compared to the control bread samples.

Microbial quality: Microbiological spoilage is the major factor limiting the shelf life of bakery products. The cakes with or without addition of whey were evaluated for their microbiological quality. The microbiological quality of the cakes remained unaffected by addition of cheese whey.

Storage (shelf life) study: The scores of different sensory characteristics of the products changed during

storage. However, volume, body & texture, flavour & aroma, taste and overall acceptability of the control cake and cake prepared after whey incorporation were significantly decreased as storage period advanced. Volume shrinkage in cake is a major problem during storage. The crumb of cake became harder as storage period advanced (Table 6). It may be due to loss of moisture from the cake.

As the storage period advanced, a significant increase in peroxide values in the cake samples was observed.

Conclusion

Nutritious milk solids of cheese whey go in vain if dumped in effluent treatment plant incurring additional cost to the dairy industry. It can be incorporated in cake manufacture as a replacement of water (fully or partly) in batter preparation. Cheese whey incorporation in cake improved the sensory characteristics apart from increasing the protein and mineral content of the cake. The cheese whey addition in cake improved its physico-chemical attributes and did not affect the keeping quality.

Conflict of interest: Authors have no conflict of interest in this research study.

Author's contributions: SCP: Involved in investigation, data generation, preparing original manuscript; KDA: Conceptualization and supervision of the investigation; AKJ, AIS: Engaged in data curation and final editing of the manuscript.

Data availability statement: Data will be provided on the request to corresponding author.

Use of artificial intelligence tools: No use of artificial intelligence.

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