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RESEARCH ARTICLE

Shelf life enhancement of low calorie and fiber-enriched *Sandesh* by modified atmosphere packaging

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Abstract: *Sandesh* is the most popular *chhana*-based sweet delicacy of the eastern part of India, especially West Bengal, India. *Sandesh* is a heat-acid coagulated product that is rich in high quality animal protein, fat, minerals, and vitamins. The present research was conducted to study the effect of three different combinations of gases i.e. 98% CO_2, 98% N_2 and 50% N_2: 50% CO_2 on the shelf life of low calorie and fiber-enriched *sandesh* samples. The samples packed under air were kept as control. The samples were stored in a BOD incubator at 25 and 37°C and analysed for microbial, textural and sensorial changes at an interval of 7 days up to 28 days. The samples packed with air showed significantly higher textural and sensorial changes and microbial spoilage as compared to the other three combinations. The results showed that samples packed with 50% N_2: 50% CO_2 combination had better shelf stability as compared to the samples packed under air, 98% N_2 and 98% CO_2.

Keywords: *Sandesh,* Sensory attributes, Shelf life, Textural properties

Introduction

Milk and milk-based products have been an important source of nourishment in our daily life (Kumar and Singh, 2017).India is the largest producer of milk in the world with an annual production of around 155.5 million tonnes (NDDB, 2017). About 50-55% of the product is converted to traditional Indian dairy products and forms an important part of the cultural heritage of India (Bandopadhyay and Khamrui, 2007). Advancement of technology and incorporation of novel ingredients to restructure traditional dairy products has been the current trend in the market which is majorly leaning towards the development of low calorie and more shelf-stable products (Gawande et al. 2012). *Sandesh* is a popular traditional dairy product prepared by acid or heat coagulation of milk and mainly admired in the eastern part of India, especially in West Bengal (Saha et al. 2018). It is famous for its palatability, aroma and nutritional value attributed by the presence of good quality proteins, fat, vitamins, minerals etc. It is prepared by the constant mixing of *channa* with sugar over medium heat (Bandyopadhyay et al. 2008). Cow milk is preferably used for the preparation of *channa* as it gives smooth texture with uniform grains which are mainly desired for preparation of *sandesh* (Husain and David, 2018). Limited shelf-life of these products due to their susceptibility to undergo deterioration during storage makes them unfit for consumption (Londhe et al. 2012). Innovations in packaging systems such as vacuum packaging, modified atmosphere packaging have provided an excellent solution by retaining the freshness of perishable as well as non-perishable foods for a comparatively longer time (Chowdhury et al. 2017).

Modified atmosphere packaging (MAP) has come up as an efficient approach to enhance the shelf-life of perishable products without the addition of any chemical additive (Floros and Matsos, 2005). It involves altering the composition of the product surroundings within the food package to protect the product from various microbial and oxidative changes during storage that is triggered by the presence of oxygen in the product surrounding (Jha et al. 2015). Therefore, the presence of a low concentration of residual oxygen in the product surrounding within the packaging system is the key approach utilized in the modified atmosphere packaging of foods for shelf life extension (Sandhya, 2010). Several types of research have been conducted to study the effect of modified atmosphere packaging on the preservation of *lal peda* (Londe et al. 2012), *paneer* (Thippeswamy et al. 2011) and *brown peda* (Jha et al. 2015) which demonstrated modified atmosphere packaging as a promising technique to extend the

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shelf-life of traditional dairy products. In view of above-mentioned prospect, the present work was undertaken to study the effect of modified atmosphere packaging on the shelf life of low calorie and fiber-enriched *sandesh* based on sensorial, microbial and textural parameters.

Materials and Methods

The present work was carried out in the laboratory of the Department of Dairy Science and Food Technology, Banaras Hindu University, Varanasi, India. Low calorie and fiber-enriched *sandesh* was manufactured using milk standardized to 3% fat and 8.5% SNF. The milk was procured from the Dairy Farm, Banaras Hindu University, Varanasi, India. Stevia and sorbitol used for the preparation of low calorie and fiber-enriched *sandesh* were procured from the local market of Varanasi, India and online sources. The level of sorbitol, oat flour, and stevia optimized using response surface methodology based on sensory scores were 4%, 15% and 0.25% respectively. The detailed manufacturing process of low calorie and fiber-enriched *sandesh* was represented with the help of a flow diagram (Figure 1).

Packaging and storage of low calorie and fiber-enriched *sandesh*

Three different combinations of gases i.e. 98% CO_2, 98% N_2 and 50% N_2:50% CO_2 were used to pack the *sandesh* samples. The samples packed under air were kept as control. The samples were stored in a BOD incubator at 25 and 37°C at 60% relative humidity and analyzed for microbial and textural changes at an interval of 7 days up to 28 days. Tray of dimension 18 x 12.5 cm^2 (Containing 6 pieces of low calorie and fiber enriched *sandesh*) manufactured by Elixir Technologies was used for packaging.

Microbial analysis

All the samples were subjected to total plate count (TPC), yeast and mold count (YMC) and coliform count. One gram of sample was properly mixed with distilled water. 1ml of resultant homogenate was added to 9ml of sterile saline water in a test tube and diluted serially to obtain a series of dilutions up to 10{ w . 1ml or 0.5ml of the appropriate dilutions from each tube was aseptically pipette out and plated on to different selective and differential media using pour plate technique. The TPC was determined on plate count agar (PCA) and incubated at 37°C for 24–48 hours. For mold and yeast detection, sample was spread on potato dextrose agar (PDA) and incubation was done at 25°C for 24–48 hours. Coliforms in the samples were estimated by plating on violet red bile agar (VRBA) before being incubated at 37°C for 24–48 hours (Kumbhar et al. 2009). The number of microbial counts was calculated using the following formula:

$$\text{Colony-forming units (CFU)/ml} = \frac{\text{No. of colonies x dilution factor}}{\text{Weight of aliquot taken (ml)}}$$

Texture profile analysis (TPA)

TPA on samples was performed by using the Texture Analyser (TA.XT plus texture profile analyzer, Stable Micro Systems, UK) to characterize the hardness, adhesiveness, springiness, cohesiveness and gumminess of the optimized *sandesh*. During the textural analysis, samples of optimized *sandesh* were cut into 1.5 cm^3 size pieces and their temperature was maintained at 25°C.

Sensory analysis

The sensory quality of low calorie and fiber-enriched '*sandesh*' samples were judged by a panel of 10 semi-trained judges from the Department of Dairy Science and Food Technology. The samples were evaluated for sensory attributes viz., color and appearance, flavor, sweetness, body and texture and overall acceptability based on a 9-point hedonic scale (Amerine et al. 1965).

Statistical Analysis

All experiments were performed in triplicate. Data is expressed as mean value. The means were compared using Duncan's multiple range test (DMRT) at $P < 0.05$. One-way analysis of variance (ANOVA) was performed as described by Snedecor and Cochran (1989), to test the significance of data in each trial and parameter.

Results and Discussion

Microbial changes of low calorie and fiber-enriched *sandesh* samples were analyzed at an interval of 7 days of storage. Total plate count and yeast and mold count on day zero was 4.87 and 2.85 $\log_{10}$ CFU/g, respectively. Coliforms were not detected in the samples during the entire study period. Microbial loads in different gas combinations are shown in Table 1. In the samples stored under air at 25 and 37°C, microbial activity reached the critical limits after 14 days of storage. Hence, the samples were discontinued after 14 days of storage. In other samples stored with 98% N_2, 98% CO_2 and 50% N_2:50% CO_2 at 25 and 37°C, there was an increase in the TPC and YMC, within 28 days and no coliforms were detected. Critical limits were reached at 28 days of storage. All the samples stored under MAP displayed a continuous increase in the total plate count and yeast and mold populations during 28 days of storage period. However, if compared with the samples containing 98% N_2 and 98% CO_2, the growth of the microbial populations was lower in the case of 50% N_2: 50% CO_2 atmosphere package during the 28 day storage period. The samples containing 98% nitrogen displayed delayed microbial growth as nitrogen is an inert gas that does not support microbial growth. However, as observed, samples with 98% CO_2 displayed increased inhibition of microbial growth when compared to samples containing 98% N_2, probably due to the bacteriostatic effect of CO_2, as mentioned in several earlier reports (Daniels et al. 1985; Banks and Annis, 1990; Davis, 1998; Devlieghere and Debevere, 2000). Smith et al. (1986) reported

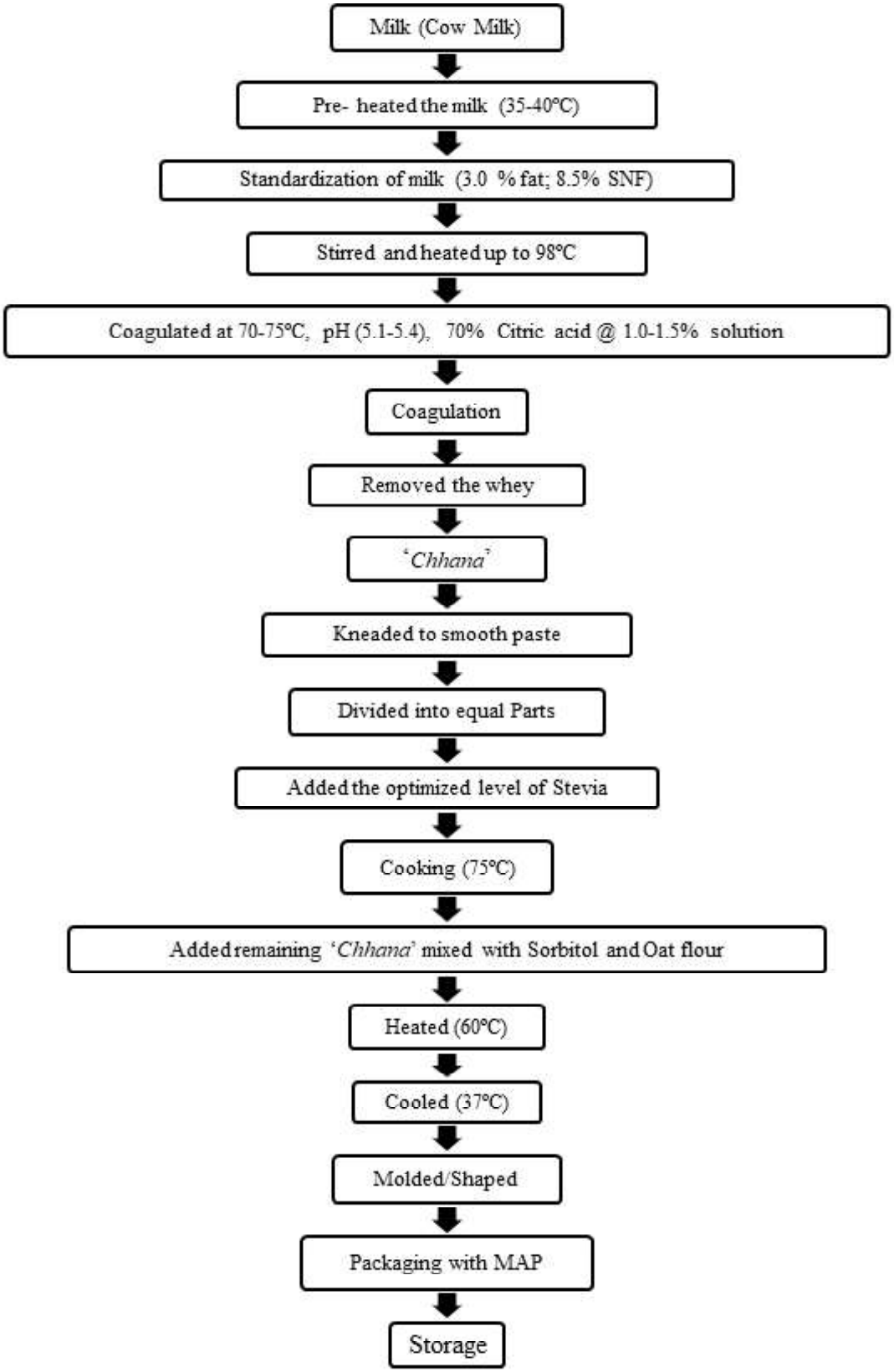

Fig. 1 Flow diagram of low calorie and fiber enriched *sandesh* preparation

that the gas packaged (40% N_2:60%CO_2) crusty rolls with the headspace O_2 concentration never increased beyond 0.05% and the rolls remained mold-free even after 60 days.

Changes in Textural properties

The textural properties of any product are important criteria to determine the acceptability of the product. Table 2 depicts the textural changes in *sandesh* during storage. There was a continuous increase in the hardness of the *sandesh* samples with an increase in the storage period for the control samples and the MAP samples. The hardness varied significantly with variation in the gas composition and the storage temperature. Table 2 shows that the hardness of the *sandesh* samples increased significantly ($P<0.05$) with an increase in the temperature, the hardness of the samples packed under air increased to a greater extent than those packed under the MAP conditions. The hardness of any product is directly related to its moisture content. It can be observed from Table 2, that the samples packed under 50% N_2: 50% CO_2 showed the minimum changes in hardness, which could be attributed to its better moisture retention under the MAP conditions.

The cohesiveness of a product is the ratio of the area under the second bite curve before reversal compression to under the first bite curve. It is the measure of the extent to which the structure of the product was disrupted during the first compression. The average cohesiveness of the samples remained constant throughout the storage period with no significant variation. Also, change in temperature did not show any significant effect on the cohesiveness during 14 days of storage but varied significantly after 14 days with temperature variation. The cohesiveness increased initially during the storage period, but later it decreased marginally. These observations are similar to those reported by Londhe et al. (2012) in brown *peda* and Jha et al. (2015) in lal *peda*. Loss in moisture content could be the reason for the loss of cohesiveness with the progression of the storage period. Gupta et al. (1990) also reported similar findings in *khoa* with an increase in total solids.

The springiness of a food refers to its ability to return to its original form after compression. It is the height that the product recovers between the first and the second compression. The springiness for *sandesh* samples did not vary significantly ($P>0.05$) for up to 07 days of storage at all the temperatures in the control and the MAP samples. However, the springiness increased with further increase in storage period and varied significantly ($P<0.05$) with variation in the storage temperature and gas composition. Jha et al. (2015) reported similar observations in lal *peda* samples stored under MAP conditions.

The adhesiveness of a product is related to its sensory stickiness. Table 2 shows that the average adhesiveness of the *sandesh* samples decreased gradually, with increasing the storage period. The average adhesiveness of the samples had a significant change with an increase in temperature from 25 to 37°C. This decline in the adhesiveness could be due to the decrease in free moisture during the storage. A similar trend in adhesiveness was observed in the lal *peda* samples by Jha et al. (2015).

Gumminess is the product of hardness and cohesiveness. It can be seen from Table 2, that the average gumminess of *sandesh* was significantly ($P<0.05$) affected by variation in the temperature.

Table 1 Microbial changes in low calorie and fiber enriched *sandesh* during storage packaged under air and under MAP

Days	Atmosphere	Total plate count (log_{10} cfu/g)		Yeast and mold count(log_{10} cfu/g)	
		25 ^{0}C	37 ^{0}C	25 ^{0}C	37^{0}C
0		4.87±0.004	4.87 ±0.04	2.85 ±0.02	2.85 ±0.02
07	Control	5.43 ±0.04^{aA}	5.58 ±0.03^{Aa}	2.94 ±0.03^{aA}	3.12±0.02^{aA}
	98 % CO_2	4.94 ±0.02^{aA}	4.99 ±0.02^{Ab}	2.87 ±0.01^{aA}	3.03±0.02^{aA}
	98 % N_2	4.97±0.03^{aA}	5.08 ±0.04^{Ab}	2.88±0.03^{aA}	3.08 ±0.03^{aA}
	50:50::CO_2:N_2	4.90. ±0.01^{aA}	4.95 ±0.05^{Ab}	2.86±0.02^{aA}	2.93±0.01^{aA}
14	Control	6.69 ±0.02^{aA}	6.82±0.01^{Aa}	3.42±0.02^{aA}	3.55 ±0.03^{aA}
	98 % CO_2	5.01± 0.03^{bA}	5.13 ±0.04^{Ab}	2.95 ±0.02^{bA}	3.19 ±0.02^{bA}
	98 % N_2	5.13 ±0.01^{bA}	5.48 ± 0.03^{Ab}	3.01 ±0.02^{bA}	3.26 ±0.04^{bA}
	50:50::CO_2:N_2	4.96 ±0.02^{bA}	5.16 ±0.03^{Ab}	2.89 ±0.01^{bA}	3.01±0.02^{bA}
21	98 % CO_2	5.38± 0.01^{aA}	5.68 ±0.03^{Ba}	3.09 ±0.03^{aA}	3.19 ±0.02^{aA}
	98 % N_2	5.43 ± 0.03^{aA}	5.81±0.03^{Ba}	3.15±0.01^{aA}	3.26 ±0.04^{aA}
	50:50::CO_2:N_2	5.10 ±0.03^{aA}	5.39 ±0.02^{Bb}	2.94 ±0.03^{aA}	3.01 ±0.02^{aA}
28	98 % CO_2	5.89 ±0.03^{aA}	6.19±0.02^{Aa}	3.18 ±0.03^{aA}	3.28±0.03^{aA}
	98 % N_2	6.01 ±0.04^{aA}	6.21±0.03^{Aa}	3.32 ±0.02^{aA}	3.45 ±0.02^{bA}
	50:50::CO_2:N_2	5.28 ±0.02^{bA}	5.78±0.02^{Ba}	3.12 ±0.03^{aA}	3.19 ±0.02^{aA}

Values are mean ± standard deviation, n=3

* Values with different small superscripts in columns are significantly different ($p<0.05$) within each interval

* Values with different capital superscripts in rows are significantly different ($p<0.05$) within each interval

Table 2 Textural changes in low calorie and fiber enriched *sandesh* during storage packaged under air and under MAP

Days	Atmosphere	Hardness		Cohesiveness		Springiness		Adhesiveness		Gumminess	
		25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C
0		3408±0.56	3408±0.56	0.052±0.05	0.052±0.05	0.25±0.02	0.25±0.02	15.60±0.03	15.60±0.03	177.21± 0.84	177.21± 0.84
7	Control	6220±0.36^{aA}	6570±0.43^{aB}	0.059±0.03^{aA}	0.063±0.03^{aA}	0.32±0.03^{aA}	0.35±0.01^{aA}	13.10±0.02^{aA}	12.50±0.04^{aA}	366.60± 0.55^{aA}	410.86±0.61^{aB}
	98% CO_2	4210±0.24^{bA}	4780±0.63^{bB}	0.056±0.03^{aA}	0.059±0.02^{aA}	0.27±0.03^{aA}	0.29±0.03^{aA}	13.70±0.01^{aA}	12.90±0.03^{aA}	235.76±0.46^{bA}	257.39±0.43^{bB}
	98% N_2	4420±0.44^{cA}	5101±0.24^{cB}	0.058±0.01^{aA}	0.061±0.01^{aA}	0.30±0.02^{aA}	0.32±0.05^{aA}	13.60±0.03^{aA}	12.78±0.01^{aA}	256.36±0.84^{cA}	280.62±0.37^{bB}
	50:50::CO_2:N_2	4050±0.65^{dA}	4308±0.58^{dB}	0.053±0.02^{aA}	0.055±0.03^{aA}	0.26±0.01^{aA}	0.28±0.06^{aA}	13.90±0.02^{aA}	13.10±0.02^{aA}	14.65±0.63^{bA}	232.75±0.91^{cB}
14	Control	9500±0.83^{aA}	9814±0.78^{aB}	0.066±0.04^{aA}	0.071±0.03^{bA}	0.38±0.05^{aA}	0.40±0.02^{aA}	12.60±0.03^{aA}	12.30±0.02^{aA}	527.11±0.23^{aA}	582.21±0.47^{aB}
	98% CO_2	5510±0.83^{bA}	5901±0.56^{bB}	0.059±0.02^{aA}	0.061±0.02^{cA}	0.33±0.06^{aA}	0.36±0.03^{aA}	13.60±0.04^{aA}	12.19±0.02^{aB}	336.17±0.47^{bA}	396.01±0.34^{bB}
	98% N_2	5620±0.45^{bA}	6080±0.14^{bB}	0.064±0.03^{aA}	0.065±0.03^{cA}	0.35±0.04^{aA}	0.38±0.02^{aA}	13.50±0.01^{aA}	12.08±0.03^{aB}	377.25±0.34^{cA}	430.31±0.63^{cB}
	50:50::CO_2:N_2	5380±0.64^{cA}	5840±0.86^{cB}	0.054±0.02^{aA}	0.059±0.04^{cA}	0.31±0.02^{aA}	0.32±0.04^{aA}	13.75±0.04^{aA}	12.25±0.04^{aB}	295.03±0.96^{bA}	09.29±0.24^{dA}
21	Control	12100±0.58^{aA}	13200±0.34^{aB}	0.061±0.01^{aA}	0.064±0.05^{aA}	0.54±0.03^{aA}	0.57±0.03^{aA}	9.60±0.04^{aA}	8.90±0.03^{aA}	670.01±0.83^{aA}	702.07±0.64^{aB}
	98% CO_2	6820±0.63^{bA}	7408±0.43^{bB}	0.058±0.05^{aA}	0.060±0.02^{aA}	0.38±0.05^{bA}	0.41±0.02^{bA}	13.20±0.03^{bA}	12.09±0.05^{bB}	415.11±0.39^{bA}	447.22±0.85^{bB}
	98% N_2	6970±0.22^{bA}	7620±0.23^{cB}	0.062±0.06^{aA}	0.063±0.04^{aA}	0.40±0.03^{bA}	0.43±0.02^{bA}	12.70±0.03^{bA}	11.60±0.06^{bB}	435.15±0.46^{bA}	491.09±0.48^{cB}
	50:50::CO_2:N_2	6602±0.36^{cA}	7301±0.42^{dB}	0.053±0.04^{aA}	0.058±0.03^{aA}	0.37±0.02^{bA}	0.40±0.01^{bA}	13.45±0.04^{bA}	12.80±0.04^{bA}	355.02±0.57^{cA}	381.05±0.73^{dB}
28	98% CO_2	9508±0.58^{aA}	9807±0.37^{aB}	0.057±0.02^{aA}	0.059±0.03^{aA}	0.49±0.03^{aA}	0.51±0.04^{aA}	12.80±0.02^{aA}	11.69±0.03^{aA}	580.11±0.64^{aA}	610.13±0.62^{aB}
	98% N_2	10008±0.82^{aA}	12118±0.29^{bB}	0.060±0.03^{aA}	0.062±0.01^{aA}	0.51±0.03^{aA}	0.53±0.02^{aA}	12.05±0.03^{aA}	11.09±0.03^{aB}	597.09±0.53^{aA}	641.11±0.34^{aB}
	50:50::CO_2:N_2	8108±0.57^{bA}	8438±0.61^{cB}	0.052±0.02^{aA}	0.057±0.01^{aA}	0.45±0.02^{aA}	0.48±0.02^{aA}	12.98±0.02^{aA}	12.10±0.05^{aA}	522.21±0.48^{bA}	545.21±0.24^{bB}

Values are mean ± standard deviation, n=3

* Values with different small superscripts in columns are significantly different ($p<0.05$) within each interval

* Values with different capital superscripts in rows are significantly different ($p<0.05$) within each interval

Table 3 Sensory changes in low calorie and fiber enriched *sandesh* during storage packaged under air and under MAP

Days	Atmosphere	Body and	texture	Flavour		Colour and	appearance	Sweetness		Overall acceptability	
		25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C	25 ^{0}C	37 ^{0}C
0		8.40±0.04	8.40±0.04	8.30±0.04	8.30±0.04	8.50±0.04	8.50±0.04	8.40±0.04	8.40±0.04	8.50±0.04	8.50±0.04
7	Control	6.50±0.03^{aA}	4.95±0.03^{aB}	6.00±0.03^{aA}	5.80±0.03^{aA}	6.70±0.03^{aA}	6.50±0.03^{aA}	7.00±0.03^{aA}	4.91±0.04^{aB}	6.70±0.03^{aA}	5.10±0.04^{aB}
	98% CO_2	7.90±0.02^{bA}	7.65±0.02^{bA}	7.60±0.02^{bA}	7.35±0.02^{bA}	8.10±0.02^{bA}	7.90±0.02^{bA}	8.05±0.02^{bA}	7.93±0.02^{bA}	7.86±0.02^{bA}	7.60±0.02^{bB}
	98% N_2	7.80±0.02^{bA}	7.60±0.02^{bA}	7.45±0.02^{bA}	7.20±0.02^{bA}	7.93±0.02^{bA}	7.68±0.02^{bB}	7.96±0.02^{bA}	7.80±0.03^{bA}	7.70±0.02^{bA}	.50±0.03^{bA}
	50:50::CO_2:N_2	8.00±0.03^{bA}	7.80±0.03^{cA}	7.70±0.03^{bA}	7.45±0.03^{bA}	8.21±0.03^{bA}	8.01±0.03^{bA}	8.30±0.03^{cA}	8.20±0.02^{cA}	7.95±0.03^{bA}	.75±0.02^{bA}
14	Control	5.30±0.04^{aA}	5.10±0.04^{aA}	5.93±0.04^{aA}	5.73±0.04^{aA}	6.03±0.04^{aA}	5.83±0.04^{aA}	6.23±0.04^{aA}	5.90±0.03^{aB}	5.90±0.04^{aA}	.85±0.03^{aA}
	98% CO_2	7.50±0.02^{bA}	7.30±0.02^{bA}	7.60±0.02^{bA}	7.24±0.02^{bA}	7.90±0.02^{bA}	7.70±0.02^{bA}	8.04±0.02^{bA}	7.45±0.02^{bB}	7.60±0.02^{bA}	.40±0.02^{bA}
	98% N_2	7.30±0.03^{bA}	7.10±0.03^{bA}	7.20±0.03^{cA}	7.00±0.03^{bA}	7.71±0.03^{bA}	7.56±0.03^{bA}	7.40±0.03^{cA}	7.30±0.04^{bA}	7.40±0.03^{bA}	.20±0.04^{bA}
	50:50::CO_2:N_2	7.70±0.01^{bA}	7.50±0.01^{cA}	7.80±0.01^{bA}	7.65±0.01^{cA}	8.00±0.01^{bA}	7.95±0.01^{bA}	7.60±0.01^{cA}	7.95±0.02^{cB}	7.90±0.01^{bA}	.75±0.02^{cA}
21	98% CO_2	7.21±0.03^{aA}	6.95±0.03^{aB}	7.21±0.03^{aA}	6.91±0.03^{aB}	7.41±0.03^{aA}	7.11±0.03^{aB}	7.40±0.03^{aA}	7.20±0.02^{aA}	7.40±0.03^{aA}	7.00±0.02^{aB}
	98% N_2	7.01±0.01^{bA}	6.80±0.01^{aA}	6.81±0.01^{bA}	6.70±0.01^{bA}	7.21±0.01^{aA}	6.95±0.01^{aB}	7.11±0.01^{aA}	6.90±0.02^{aA}	7.21±0.01^{aA}	6.72±0.02^{aB}
	50:50::CO_2:N_2	7.41±0.02^{cA}	7.17±0.02^{aA}	7.50±0.02^{cA}	7.20±0.02^{aA}	7.60±0.02^{aA}	7.36±0.02^{bB}	4.96±0.02^{bA}	4.81±0.03^{bA}	7.65±0.02^{bA}	7.20±0.03^{aB}
28	98% CO_2	6.80±0.01^{aA}	6.68±0.01^{aA}	6.80±0.01^{aA}	6.70±0.01^{aA}	6.90±0.01^{aA}	6.80±0.01^{aA}	6.50±0.01^{aA}	6.22±0.04^{aB}	6.38±0.01^{aA}	.20±0.04^{aA}
	98% N_2	6.53±0.03^{bA}	6.43±0.03^{bA}	6.63±0.03^{aA}	6.43±0.03^{bA}	6.73±0.03^{aA}	6.53±0.03^{bA}	5.33±0.03^{bA}	5.00±0.03^{bB}	6.23±0.03^{aA}	5.95±0.03^{bB}
	50:50::CO_2:N_2	7.10±0.03^{cA}	6.90±0.03^{cA}	7.00±0.03^{bA}	6.90±0.03^{aA}	7.20±0.03^{aA}	7.00±0.03^{aA}	6.80±0.03^{aA}	6.60±0.03^{aA}	6.70±0.03^{bA}	6.40±0.03^{aB}

Values are mean ± standard deviation, n=10

* Values with different small superscripts in columns are significantly different ($p<0.05$) within each interval

* Values with different capital superscripts in rows are significantly different ($p<0.05$) within each interval

It was lower in samples stored at 25°C, which gradually increased with an increase in the storage temperature to 37°C. The variation in gas composition had a significant (P<0.05) effect on the gumminess of *sandesh* sample during the storage period.

Changes in sensory attributes

The average score for all sensory attributes decreased significantly (P<0.05) with the storage period. The control samples were found to be unacceptable after 14 days, hence discarded from the further sensory evaluation. The samples packed under 50% N_2:50% CO_2, scored the maximum among all the samples for all the sensory properties at their respective storage temperatures and storage periods. The sensory scores for body and texture, flavor, color and appearance, sweetness and overall acceptability varied significantly (P<0.05) among MAP samples during storage at every temperature (Table 3). An increase in the storage temperature had a negative effect on the sensory score of the product and this can be deduced from the fact that the samples stored at 37°C showed lower sensory score as compared to samples stored at 25°C. The samples stored at 25°C packed under 50% N_2:50% CO_2 showed the highest sensory characteristics of the samples.

Conclusions

An attempt was made to evaluate the shelf life of *sandesh* stored under air and MAP with variation in gas composition viz. 98% N_2, 98% CO_2 and 50% N_2:50% CO_2 during two different storage temperatures (25 and 37°C). The samples stored under air had a short shelf life as compared to samples stored under MAP. Therefore, the MAP could be considered as a better option for storage of *sandesh*. The samples packed under 50% N_2:50% CO_2 was optimally effective in preserving the microbial and textural properties of *sandesh*. During the storage period, the textural property of optimized products also varies significantly. The hardness of the product increases significantly as the storage time increases and was more prominent at 37°C due to greater loss of moisture as compared to the storage temperature of 25°C. Gumminess and springiness also increase over the storage period and the adhesiveness of the experimental product decreases during the storage at both storage temperature. This study could prove to be helpful in the preservation of other traditional dairy products using MAP.

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