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Importance of WPC 70 and Calcium Caseinate on Sensory and Textural Properties of Milk Fermented with *L. rhamnosus*

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ABSTRACT

Product was prepared using optimized 1.5% WPC 70 or 2.0% Ca-caseinate for *L. rhamnosus* MTCC 5945 (NS4) culture. These products were evaluated for its storage stability at refrigeration temperature (7±2°C). Sensory attributes of 1.5% WPC, 2.0% Ca-caseinate and control *dahi* were analyzed up to 15 days at intervals of 5 days at refrigeration temperature. *Dahi* supplemented with WPC 70 had improved scores for flavour, body & texture, acidity, colour & appearance and overall acceptability as compared to control and Ca-caseinate supplemented *dahi*. All of these products were analyzed for textural profiles during refrigerated storage (7±2°C) for 15 days. Textural profiles showed that 1.5% WPC or 2.0% Ca-caseinate supplemented in *dahi* samples which prepared using NS4 culture had better texture properties as compared to control during storage at refrigerated temperature.

Introduction

Since time immemorial, human beings have made use of lactic acid bacteria (LAB), which are distributed widely in nature. LAB has traditionally been employed to produce fermented milk products, including yoghurt, leiben, *dahi*, lassi, shrikhand, kefir and koumiss (Miyazaki and Matsuzaki, 2008). Milk, although a rich growth medium, contains low concentration of free amino acids and peptides to efficiently support growth of LAB (Vasiljevic *et al*., 2005). LAB are the most common microorganisms found in dairy products and therefore are one of the most extensively studied groups of microorganisms, of which *Lactobacillus*, *Lactococcus*, *Streptococcus* and *Bifidobacterium* genera are most common (Christensen *et al*., 1999). Fermented milk products are significantly more digestible than the processed milk (Tamime and Robinson, 1999).

Fermentation is a method that has been used for thousands of years to provide longer shelf life for perishable foods and to increase the flavor and odour of final food products. Fermentation is carried out by yeast, molds or bacteria. During the growth of these microorganisms, fermented foods are produced incidentally (Gahruie *et al*., 2015). *Dahi* (Sanskrit: Dadhi) is considered as the oldest Indian fermented milk product, which is similar to Western Yoghurt in most aspects except a few parameters such as type of culture, incubation temperature, principle flavor compounds, type of milks and its total solids. Similar products are known by different names throughout the world, *viz*. Laben in Egypt, Matzoon in Armenia, Gioddu in Italy, Naga in Bulgaria, etc. Some of the fermented milks and different types of *dahi* consumed throughout India have been categorized as follows:

North Zone: *Dahi*, Lassi
South Zone: *Dahi*, Buttermilk (Mattha)
East Zone: Payodhi or Lal*dahi* or Mishtidoi
West Zone: Shrikhand, Chakka, Chhash, *Dahi*

Dahi contains various strains of LAB. For *dahi* fermentation, a small portion of product containing microbes of a previous fermentation (back slopping) is generally added to milk. However, production of *dahi* with an individual culture of *Lactococcus lactis* (Yadav *et al*., 2006) or a combination of cultures containing *Lactobacilli* and *Lactococci* (Yadav *et al*., 2007) was reported. Currently, India is the largest milk producer in the world with an annual milk production of about 140 million tones (NDDB, 2014). About 7 % of the total annual milk produced in India is utilized for *dahi* preparation for direct consumption and this sector is showing an annual growth rate of more than 20% per annum (Singh, 2007). *Dahi* accounts for around 90 % of the total cultured milk products produced in India (Behare and Prajapati, 2007).

WPC also provide nutrition to the LAB during fermentation as well as give compact body and texture with low wheying off in fermented milk products like *dahi*, yoghurt. Akalin *et al*., (2007) used WPC (1.5%, w/v) in reduced-fat probiotic yoghurt. They observed that addition of WPC to yoghurt increased the buffering capacity around pH 4 which controlled the progress of acidification during storage. They reported that this effect of WPC on slow acidification in probiotic yoghurt contributed to the enhanced shelf life of the product. Whey protein concentrate supplemented yoghurt exhibited improved viability and survival rate of *S. thermophilus* and *B. animalis* until the 21st day of storage. They attributed the growth promoting activity obtained by WPC to its whey protein content.Fortification of the milk base is one of the most important steps that enhances functional and nutritional properties and prevents textural defects such as poor gel firmness and syneresis as assessed by sensory evaluations and instrumental measurements (Marafon *et al*., 2011). Pal *et al*., (2010) found that supplementation of whey protein in over weight/obese individuals for 12 weeks decreased total cholesterol and LDL cholesterol levels compared with casein and control (glucose). These results indicated that whey protein supplementation can significantly improve metabolic risk factors associated with chronic diseases in overweight and obese individuals.

Damin *et al*., (2009) studied supplementation of milk with SMP, WPC and Na-Cn at different levels caused a number of changes in the acidification kinetics and rheological properties of nonfat stirred yoghurt. Calcium caseinate is a protein derived from the casein in milk. The dairy industry commonly used calcium caseinate in powder form. During fermentation process, bacteria release the peptides using calcium caseinate also. Calcium is added to milk products not only for nutritional but also for functional purposes. Moreover, the calcium fortification in milk improved solubility, dialysis, transport and uptake rate of calcium, thus increasing its bioavailability, as well as enhancing heat stability of milk (Singh *et al*., 2007). Caseinate and WPC have been preferred in order to improve both the texture and the functional properties of yoghurt. Addition WPC and calcium caseinate in yoghurt causes an increase in density of the protein matrix in the gel microstructure, and reduction of syneresis in yoghurt (Amatayakul *et al*., 2006).

Materials and Methods

To optimize the process for production of *dahi*, the study involved several phases; one of them is effect of selected rate of WPC and Ca-caseinate on shelf-life study and textural profiles of *dahi* was prepared using *L. rhamnosus*.

Materials used

The double toned milk (DTM) was purchased from Amul Parlour, Anand, Gujarat for making *dahi*. Culture was obtained from the Culture Collection of Dairy Microbiology Department, SMC College of Dairy Science, Anand. WPC 70 and Ca-caseinate were procured from Charotar Casein Company, Nadiad, Gujarat.

Process for manufacturing of *dahi* with supplementing WPC 70 and Ca-caseinate

Double toned milk (Fat 1.5% and SNF 9.0%) was received from Amul Parlour, Anand. At warm temperature, WPC 70 @1.5% or Ca-caseinate @2.0% was added to milk. The supplemented milk was heat treated at 90°C/ 10 min and mixed homogenously. The temperature of supplemented milk was lowered to 37°C. At this stage, culture *L. rhamnosus* MTCC 5945 (NS4) was inoculated @2.0% and filled the cups and covered with aluminum foil, then, incubated at 37°C for 12 h. The final product was transferred to refrigerator (7±2°C) for overnight storage. The final products obtained as above were evaluated on the basis of sensory (i.e. flavour, body and texture, acidity, colour and appearance, and overall acceptability score) and textural profiles (i.e. hardness, fracturability, cohesiveness, springiness, gumminess, resilience, adhesiveness and chewiness).

Analysis

Sensory evaluation

The product was subjected to the sensory evaluation by an expert trained panel of seven judges using nine point hedonic scale (Appendix-III). The score for colour and appearance, flavour, body and texture and overall acceptability were recorded. Fresh product at 0 day and the stored products (5, 10, 15 days at 7±2°C) were brought to 10°C before giving for judging (Stone and Sidel, 2004).

Texture Profile Analysis (TPA)

Texture analyser model TAHD plus made by Stable Microsystems was used for determining the textural properties of fermented milk samples. The instrument is having inbuilt software (macro) for calculations and presentation of measurements. During Texture profile analysis force is measured in compression, trigger force was 5 gm. The cylindrical probe of P36R (36 mm in diameter) was used for TPA. Pre-test, test speed and post-test speed was kept1.0 mm/sec, 1.0 mm/sec and 2.0 mm/sec respectively. Measurement depth was 25 mm.

The experiments were conducted by compression test that generated plot of force (gm) vs. Time (sec), from which texture values were obtained using different formula that was programmed in TAHD plus software. The parameters were quantified and defined by Bourne (1982) which includes hardness, fracturability, cohesiveness, gumminess, springiness, adhesiveness and chewiness. These parameters were measured during entire period of study at previously mentioned intervals. The properties analysed are shown in Fig. 1.0. Hardness value was the peak force that occurs during the first compression. The force at the first peak was measured as fracturability. Adhesion was measured as the negative work between the two cycles. Other properties were calculated as follows.

Cohesiveness = Area 2/Area 1.
Springiness = Distance 2 / Distance 1.
Gumminess = Hardness × Cohesiveness.
Resilience = Area 4/Area 3.
Chewiness= Gumminess × Springiness.

Statistical analysis

The mean values generated from the analysis of *dahi* samples were subjected to statistical analysis using factorial completely randomized design (FCRD) as per Steel and Torrie (1980).

Results and Discussion

Effect of WPC and Ca-caseinate on sensory characteristics of *dahi* during storage at refrigerated temperature (7±2°C)

The *dahi* samples were studied for the estimation of shelf life at refrigerated temperature up to 15 days. Different sensory properties viz. flavour, body and texture, acidity, colour and appearance and overall acceptability were evaluated using effective testing method based on 9-point hedonic scale by seven distinguish experts panel members (Stone and Sidel, 2004).

Effect on flavour

The average flavour scores of the *dahi* samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 1. All parameters viz., sample, storage period and their interaction had a significant (*P<0.05*) effect on flavour score of *dahi* samples. A significant *(P<0.05)* decrease in the flavour score with increased length of storage period was observed throughout the storage study. The initial flavour score of samples decreased from 6.98 to 3.95 up to 15 days of storage at refrigerated temperature.1.5 % WPC 70 added *dahi* and control *dahi* showed acceptable flavour score (6.23 and 6.50 respectively) up to 10 days of storage as compared to 2.0% Ca-caseinate. Defects such as bitterness and off flavour were perceived in case of *dahi* sample prepared using 2.0% Ca-caseinate during the storage (Table 1). Zhao *et al*., (2006) reported sensory evaluation scores on the flavor, the body and texture, and the color and appearance of the yogurts fortified with casein hydrolysates decreased by storage time (upto 28 days). This report supported our study whenever we prepared *dahi* by supplementing 2.0% Ca-caseinate, the flavour score decreased throughout the storage periods.

Effect on body and texture

The average body and texture scores of *dahi* samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 1. All parameters *viz*., sample, storage period and their interaction had a significant (*P< 0.05*) effect on body and texture score of *dahi* samples. A significant *(P<0.05)* decrease in the body and texture score with increased length of storage period was observed throughout the storage study. The initial body and texture score of samples decreased from 7.49 to 5.43 up to 15 days of storage at refrigerated temperature. Sample prepared using 1.5 % WPC exhibited good firmness with no whey separation up to 15 days whereas sample prepared with 2.0% Ca-caseinate showed whey separation after 5 days of storage (Table 1). In a study, Marafon *et al*., (2011) reported that the supplementation of the milk base with milk proteins increased the consistency of the probiotic yogurt in terms of sensory attributes. This report supported our data whenever prepared *dahi* by supplementing 1.5% WPC upto 10 days of storage.

Effect on acidity

The average acidity scores of *dahi* samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 1. All parameters *viz*., sample, storage period and their interaction had a significant ($P< 0.05$) effect on acidity score of *dahi* samples. A significant *(P<0.05)* decrease in the acidity score with increased length of storage period was observed throughout the storage study. The initial acidity score of samples decreased from 6.74 to 3.84 up to 15 days of storage at refrigerated temperature. 1.5 %WPC added *dahi* and control *dahi* showed acceptable acidity score (6.43 and 6.40 respectively) up to 5 days of storage as compared to 2.0% Ca-caseinate added *dahi* (Table 1). In a study, Chick *et al*., (2001) studied the control sample had higher lactic acid content than the 1.0% WPC yoghurt sample on the first day of storage (P<0.05). This report supported our data whenever we prepared *dahi* by supplementing 1.5% WPC.

Effect on colour and appearance

The average colour and appearance scores of *dahi* samples prepared using NS4 culture during storage at refrigerated temperature (7±2°C) were presented in Table 1. All parameters viz., sample, storage period and their interaction had a significant ($P< 0.05$) effect on colour and appearance score of *dahi* samples. The initial colour and appearance score of samples decreased from 7.69 to 5.17 up to 15 days of storage at refrigerated temperature. A significant *(P<0.05)* decrease in the colour and appearance score with increased length of storage period was observed throughout the storage study. 1.5%WPC added *dahi* showed acceptable colour and appearance score 6.10 upto 15 days and control *dahi* showed 7.05 upto 10 days of storage compared to 2.0% Ca-caseinate added *dahi* (Table 1). In a study, Zhao *et al*., (2006) reported sensory evaluation scores on the flavor, the body and texture, and the color and appearance of the yogurts fortified with casein hydrolysates decreased by storage time (up to 28 days). This report supported our data whenever prepared *dahi* by supplementing 2.0% Ca-caseinate.

Effect on overall acceptability

The average overall acceptability scores of *dahi* samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 1. All parameters *viz*., sample, storage period and their interaction had a significant ($P< 0.05$) effect on overall acceptability score of *dahi* samples. A significant *(P<0.05)* decrease in the overall acceptability score with increased length of storage period was observed throughout the storage study. The initial overall acceptability score of samples decreased from 7.12 to 4.44 up to 15 days of storage at refrigerated temperature. The lower average score of sample prepared using 2.0% Ca-caseinate might be because of little bit whey separation, loose body & texture and unacceptable flavour during the storage (Table 1).

In a study, Martín-Diana *et al*., (2003) studied cow's fermented milk had a low grading for appearance due to wheying-off on the fermented milk surface. The fermented goat's milk supplemented with 3.0% WPC was scored the highest, showing a high overall acceptability, similar to that for cow's fermented milk. This report supported our data whenever prepared *dahi* by supplementing 1.5% WPC.

Effect of WPC and Ca-caseinate on textural analysis of *dahi* during storage at refrigerated temperature (7±2°C)

The *dahi* samples prepared with 1.5% WPC 70 and 2.0% Ca-caseinate were inoculated with 2.0% NS4 culture and incubated at 37°C for 12 h. The samples were stored at refrigerated temperature. Determination of texture properties (i.e. hardness, fracturability, cohesiveness, springiness, gumminess, resilience, adhesiveness and chewiness) of samples at the interval of 0 day, 5 days, 10 days and 15 days.

Changes in hardness (g)

The effect of WPC 70 and Ca-caseinate on hardness of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were exhibited in Table 2. Storage period, sample and their interaction had a significant effect on hardness of samples. The average hardness of all samples increased significantly (*P<0.05*) was observed throughout the storage period. The initial average hardness of samples had been increased from 146.12g to 169.76g up to 15 days of storage at refrigerated temperature. In a study, Akalın *et al*., (2012) reported fortification with SCaCN (sodium calcium caseinate) has been found to increase the firmness more than WPC in probiotic yogurts during storage (P < 0.05). These results are in agreement with the results of Guzmán-González *et al*., (1999) who reported that casein-based products tended to produce firmer gels with less syneresis than yogurts fortified with whey protein. This report supported our data whenever we prepared *dahi* by supplementing 2.0% Ca-caseinate.

Changes in fracturability (g)

The effect of WPC 70 and Ca-caseinate on fracturability (g) of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were shown in Table 2.Storage period, sample and their interaction had a significant (*P<0.05*) effect on fracturability of samples. The average fracturability of all samples increased significantly (*P<0.05*) was found throughout the storage period. The initial average fracturability of samples had been increased from 130.75g to 157.23g up to 15 days of storage at refrigerated temperature. In a study, Sodini *et al*., (2004) reported that when the milk base was supplemented with proteins obtained from ultrafiltration, WPC, or caseinate, the firmness of the yogurts increased compared with a product fortified with SMP. This was due to the increase of the protein content in relation to the TS level. This report supported our data whenever *dahi* was prepared by supplementing 1.5% WPC and 2.0% Ca-caseinate.

Changes in cohesiveness

The effect of WPC 70 and Ca-caseinate on cohesiveness of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were shown in Table 2. Both storage period and sample had a significant (*P<0.05*) effect but their interaction had a non-significant effect on cohesiveness of samples. The average cohesiveness of all samples increased significantly (*P<0.05*) was observed throughout the storage period.

The initial average cohesiveness of samples had been increased from 0.47 to 0.53 up to 15 days of storage at refrigerated temperature. In a study, Landge (2009) reported the yogurt texture parameters i.e. adhesiveness, cohesiveness, firmness and syneresis were not influenced by the storage time. The above reports are contradictory to our study whenever *dahi* was prepared by supplementing 1.5% WPC and 2.0% Ca-caseinate.

Changes in springiness

The effect of WPC 70 and Ca-caseinate on springiness of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were shown in Table 2. Both storage period and sample had a significant (*P<0.05*) effect but their interaction had a non-significant effect on springiness of samples. The average springiness of all samples increased significantly (*P<0.05*) was found throughout the storage period. The initial average springiness of samples had been increased from 1.00 to 1.04 after 15 days of storage at refrigerated temperature. In a study, Akalın *et al*., (2012) reported milk fortification had an effect on the WHC (water holding capacity) of yogurts, which varied from 68.78 to 43.22%. The higher WHC was obtained for yogurts made using milks fortified with WPC and then with blends of WPC and SCaCN, representing the values of 68.78 and 59.38%, respectively, for the first day. The separate use of caseinate to fortify milk gave yogurts with lower WHC similar to the control samples.

Changes in gumminess (g)

The effect of WPC 70 and Ca-caseinate on gumminess (g) of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 2. Storage period, sample and their interaction had a significant effect on gumminess of samples. The average gumminess of all samples increased significantly (*P<0.05*) was observed throughout the storage period. The initial average gumminess of samples had been increased from 62.95g to 85.03g up to 15 days of storage at refrigerated temperature. In a study, Sady *et al*., (2009) reported the type of kefir did not have significant influence on the texture parameter obtained from TPA analysis. Hardness and gumminess of kefir had changed significantly after 21st day of storage. During storage these both parameters systematically grew and got the maximum value at the end of storage period. Supplementation of milk solid for kefir caused increase of the adhesiveness of products. The highest value of this parameter got product with SMP. Although, there were no statistically significant differences during the storage, after 7 days kefir had a maximal value of adhesiveness. This report supported our study whenever *dahi* was prepared by supplementing 1.5%WPC and 2.0% Ca-caseinate.

Changes in resilience

The effect of WPC 70 and Ca-caseinate on resilience of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were shown in Table 2. Storage period and sample had a significant (*P<0.05*) effect but their interaction had a non-significant effect on resilience of samples. The initial average resilience of samples had been increased from 0.08 to 0.13 up to 15 days of storage at refrigerated temperature. In a study, Stijepic *et al*., (2012) reported significantly higher WHC, with about 30% higher value of WHC, had the yoghurt samples with WPC and combination of WPC and WPC and honey whose WHC slightly decreased during the storage time. WPC had significantly increased water-holding capacity even at 0.3 or 0.5% addition and it was about 75% (Milanovic *et al*., 2009). Stable values of WHC of yoghurt samples enriched with WPC during the storage time could be explained by the fact that WHC can be increased by adding stabilizers that interact with the casein network, which in this case is WPC, but also honey.

Changes in adhesiveness (g)

The effect of WPC 70 and Ca-caseinate on adhesiveness (g) of samples prepared using

NS4 during storage at refrigerated temperature (7±2°C) were shown in Table 2. Storage period, sample and their interaction had a significant (*P<0.05*) effect on adhesiveness of samples. The average adhesiveness of all samples increased significantly (*P<0.05*) throughout the storage period. The initial average adhesiveness of samples had been increased from 177.46g to 313.83g up to 15 days of storage at refrigerated temperature. In a study, Akalın *et al*., (2012) studied the influence of milk protein-based ingredients on the textural characteristics, sensory properties, and microstructure of probiotic yogurt during a refrigerated storage period of 28 d was studied. Milk was fortified with 2.0% (wt/vol) skim milk powder as control, 2.0% (wt/vol) sodium calcium caseinate (SCaCN), 2.0% (wt/vol) whey protein concentrate (WPC) or a blend of 1.0% (wt/vol) SCaCN and 1.0% (wt/vol) WPC. A commercial yogurt starter culture and *Bifidobacterium lactis* Bb12 as probiotic bacteria were used for the production. The fortification with SCaCN improved the firmness and adhesiveness. This report supported our study whenever *dahi* was prepared by supplementing 2.0% Ca-caseinate.

Table.1 Changes in the sensory attributes* of dahi prepared using NS4 during storage at refrigerated temperature (7±2°C)

Attribute*	Sample	Storage period (days)				$CD_{0.05}$ A	$CD_{0.05}$ B	$CD_{0.05}$A*B	F-value
		0	5	10	15				
Flavour	Control	7.25±0.05	6.70±0.10	6.23±0.06	4.00±0.10	0.06	0.07	0.12	1.30
	1.5% WPC	7.63±0.06	7.15±0.05	6.50±0.11	5.40±0.10				
	2% Ca-caseinate	6.05±0.05	3.45±0.07	3.15±0.05	2.45±0.05				
	Mean	**6.98**	**5.77**	**5.29**	**3.95**				
Body and texture	Control	7.63±0.15	7.30±0.10	6.87±0.15	6.30±0.30	0.14	0.17	0.29	2.61
	1.5% WPC	7.85±0.05	8.15±0.05	7.65±0.05	6.77±0.25				
	2% Ca-caseinate	7.00±0.10	6.00±0.20	4.27±0.15	3.23±0.25				
	Mean	**7.49**	**7.15**	**6.26**	**5.43**				
Acidity	Control	6.75±0.15	6.40±0.10	5.83±0.15	4.23±0.25	0.14	0.16	0.27	3.03
	1.5% WPC	6.85±0.15	6.43±0.21	5.90±0.10	4.60±0.12				
	2% Ca-caseinate	6.63±0.15	4.13±0.15	3.73±0.17	2.70±0.20				
	Mean	**6.74**	**5.66**	**5.16**	**3.84**				
Colour and appearance	Control	7.90±0.10	7.70±0.10	7.05±0.17	5.30±0.10	0.12	0.14	0.25	2.24
	1.5% WPC	8.05±0.15	7.70±0.10	7.20±0.10	6.10±0.26				
	2% Ca-caseinate	7.13±0.15	6.03±0.16	4.70±0.20	4.10±0.10				
	Mean	**7.69**	**7.14**	**6.32**	**5.17**				
Overall acceptability	Control	7.25±0.05	7.07±0.15	6.70±0.20	5.10±0.20	0.13	0.15	0.27	2.62
	1.5% WPC	7.90±0.10	7.60±0.10	6.87±0.15	5.30±0.20				
	2% Ca-caseinate	6.20±0.10	4.97±0.15	3.90±0.22	2.93±0.25				
	Mean	**7.12**	**6.54**	**5.82**	**4.44**				

*mean values; n=3; A- sample; B- storage period; CD- critical difference

Table.2 Changes in textural profilesof dahi prepared using NS4 during storage at refrigerated temperature (7±2°C)

Textural profiles	Sample	Storage period (days)			$CD_{0.05}A$	$CD_{0.05}B$	$CD_{0.05}A*B$		F-value
		0	5	10	15				
Hardness	Control	92.98±2.01	96.33±2.12	102.64±2.37	102.68±2.37				
	1.5% WPC	94.92±1.01	120.96±2.00	122.30±3.84	122.60±5.77	2.82	3.25	5.63	2.07
	2% Ca-caseinate	250.45±2.71	267.40±3.15	284.30±4.00	284.00±5.29				
	Mean	**146.12**	**161.57**	**169.75**	**169.76**				
Fracturability	Control	93.66±3.06	100.38±5.83	104.17±5.30	105.82±7.99				
	1.5% WPC	97.59±3.87	111.62±6.39	113.97±2.05	119.33±4.04	4.52	5.22	9.05	3.62
	2% Ca-caseinate	201.02±3.63	241.36±6.64	241.60±3.01	246.55±8.23				
	Mean	**130.75**	**151.12**	**153.24**	**157.23**				
Cohesiveness	Control	0.50±0.02	0.52±0.02	0.53±0.01	0.55±0.04				
	1.5% WPC	0.55±0.02	0.56±0.03	0.56±0.02	0.57±0.02	0.02	0.03	NS	5.24
	2% Ca-caseinate	0.36±0.01	0.42±0.01	0.44±0.04	0.47±0.05				
	Mean	**0.47**	**0.50**	**0.51**	**0.53**				
Springiness	Control	1.00±0.00	1.00±0.00	1.01±0.01	1.02±0.02				
	1.5% WPC	1.00±0.00	1.00±0.00	1.03±0.03	1.05±0.02	0.01	0.01	NS	1.49
	2% Ca-caseinate	1.00±0.00	1.01±0.01	1.03±0.02	1.05±0.03				
	Mean	**1.00**	**1.00**	**1.02**	**1.04**				
Gumminess	Control	46.45±1.71	50.07±1.90	54.43±1.31	56.47±2.34				
	1.5% WPC	52.23±1.01	67.73±2.08	68.50±2.55	67.43±2.38	1.69	1.96	3.39	2.62
	2% Ca-caseinate	90.17±1.91	112.33±1.73	125.07±2.59	131.20±1.97				
	Mean	**62.95**	**76.71**	**82.67**	**85.03**				
Resilience	Control	0.10±0.01	0.11±0.02	0.14±0.03	0.17±0.02				
	1.5% WPC	0.14±0.02	0.16±0.03	0.16±0.02	0.18±0.03	0.02	0.02	NS	17.61
	2% Ca-caseinate	0.02±0.01	0.04±0.01	0.04±0.02	0.05±0.01				
	Mean	**0.08**	**0.10**	**0.11**	**0.13**				
Adhesiveness	Control	94.95±5.32	94.37±4.77	110.67±4.04	195.84±4.53				
	1.5% WPC	102.67±4.73	141.83±4.54	177.67±5.13	226.00±5.57	4.87	5.62	9.73	2.51
	2% Ca-caseinate	334.76±6.37	358.45±6.81	400.76±5.26	519.67±9.87				
	Mean	**177.46**	**198.22**	**229.70**	**313.83**				
Chewiness	Control	46.45±1.71	50.06±1.79	54.93±1.90	57.60±2.16				
	1.5% WPC	52.22±0.83	67.80±2.31	70.50±1.80	70.83±2.84	1.74	2.01	3.49	2.64
	2% Ca-caseinate	90.20±1.39	113.47±2.34	128.83±2.84	137.77±2.04				
	Mean	**62.96**	**77.11**	**84.76**	**88.73**				

*mean values; n=3; A- sample; B- storage period; CD- critical difference; NS- non significant

Fig.1 Two cyclic graph for texture profile analysis

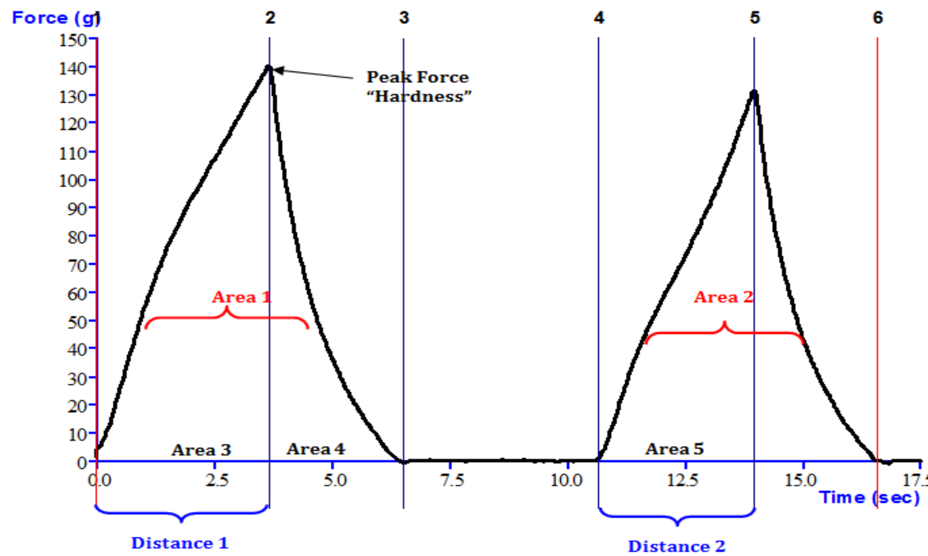
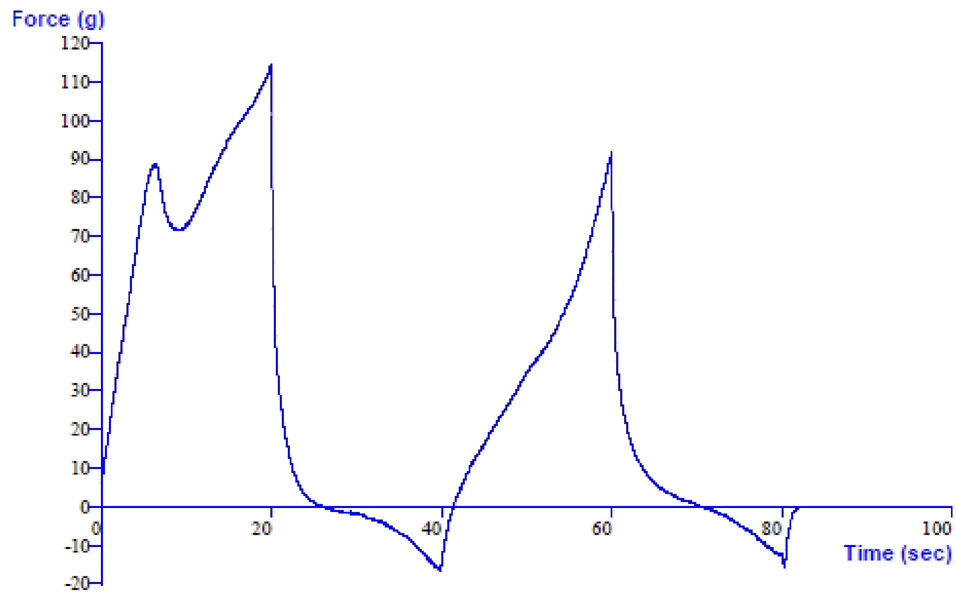


Fig.2 Textural profiles of dahi prepared with 2.0% Ca-caseinate using NS4 after 15 days of storage



Changes in chewiness (g)

The effect of WPC 70 and Ca-caseinate on chewiness (g) of samples prepared using NS4 during storage at refrigerated temperature (7±2°C) were presented in Table 2. Storage period, sample and their interaction had a significant (*P<0.05*) effect on chewiness of samples. The average chewiness of all samples increased significantly (*P<0.05*) was observed throughout the storage period. The initial average chewiness of samples had been increased from 62.96g to 88.73g up to 15 days of storage at refrigerated temperature. In a study, Marafon *et al*., (2011) reported that the rheological properties of probiotic yogurts were greatly enhanced when SMP was partially replaced with WPC and SC. This report supported our study whenever *dahi* was prepared by supplementing 1.5%WPC.

In conclusion, it was observed that the1.5% WPC 70 was more convenient for manufacture of *dahi* and this level was selected for product. All the parameters of sensory profile showed that 1.5% WPC 70 supplemented in *dahi* samples were more acceptable as compared to control and 2.0% Ca-caseinate supplemented *dahi*. All the parameters of textural profile showed that 1.5% WPC 70 supplemented in *dahi* samples showed better texture properties as compared to control and 2.0% Ca-caseinate during storage at refrigerated temperature (7±2°C).

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