Rheology and Sensory Characteristics of Low Fat Dairy Spread

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Abstract:

This research was conducted to assess the rheological and sensory characteristics of low fat dairy spread (LFDS) both under room and refrigerated storage condition. Standardized recipe were followed for the preparation of LFDS by utilizing co-precipitate alone, considered as control and co-precipitate blended with cream or oil at 10 percent, 20 percent level (treatments) respectively. During the preliminary trails, Physicochemical and Sensory quality studies revealed that spread prepared using 80:20 co-precipitate/cream blends was preferred when compared to spreads prepared by other combinations. Rheological studies indicated that the addition of cream and oil blend at 10 percent, and 20percent levels had a significant ($p<0.01$) influence on penetration value and cone stress index (firmness) values both at room and refrigerated temperatures. Addition of Tri-sodium citrate at 1 percent level to improved the emulsifying properties of the spread.

Key words: *Physicochemical properties, Sensory, Rheological, Low fat dairy spread*

Introduction

According to (Economy survey, 2012), India has emerged as the largest milk producer in the world with its annual milk production of approximately 127.9 million tonnes. The country accounts for 17 per cent of world's total dairy production. India exported about 87.82 thousand MT of dairy products worth 1,412.1 crore during 2012-13 (APEDA,2013). Low fat spread is a dairy product contains approximately 40% fat against the reduced spreads and spreads which contains 60% and not less than 80% fat respectively. This could be possible to achieve either by using less fat containing food substances or by removing fat from raw materials. Even for a dairy processor is a big challenge, because such products require number of new processing technologies. Moreover, the ratio of fat to protein will affect firmness, mouth feel, texture and the flavour qualities of dairy products (Guinee and McSweeney, 2006) and are thus sensitive to fat reduction. Such effect can be nullify by addition of many functional ingredients both dairy and non-dairy origin without adversely affecting the nutritional, rheological and sensory properties of product. Spreadability is a rheological property and is dependent on the composition and solid fat content of the product, together with the morphology of the fat crystal network and the different forms this might adopt as well as the type and strength of interactions that might occur between the phases of the emulsion at a given temperature (Campos et al. 2002). The main advantages of the spread include good spreadability at refrigeration temperature and contain low fat, low

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calorie and more protein content compared to butter meanwhile it readily blends with various flavor enhancers/ ingredients like spices (pepper and garlic), common salt, and other optional ingredients, limited equipment needed for its manufacture (Arun kumar et al. 2010). Keeping in view the demand for low fat dairy spreads and availability of surplus cow's milk, trials were conducted to standardize the process of spreads with different functional ingredients having desirable sensory attributes along with flavoring compounds, besides rheological too both at room as well as refrigerated temperature and of high nutritional quality.

Materials and Methods

Milk samples: Hygienically procured cow's milk from livestock research station, kattupakkam farm, skimmed by centrifuging (2500 rpm for 30 min at 5˚ C) and thus obtained skim milk was used for the preparation of dairy spread.

Preparation of cream

Fresh cream harvested by centrifugation process were standardized to meet the desirable fat percent (40%) and further subjected to pasteurization at 71˚ C for 20 minutes.

Preparation of oil blend

Oil blend was prepared by mixing sunflower oil and hydrogenated vegetable fat [Dalda/Vanaspathi] in the proportion of 50:50 (as per method of Prajapathi et. al., 1992). For this, both the fat source were pre-heated at 50-60˚ C and then subjected to clarification process to remove extraneous material. Later pasteurized at 75˚ C for 30 minutes and then cooled rapidly at 30˚ C within 3-5minutes, further cooling was achieved by overnight chilling at 5˚ C. Both the fat sources were tempered at 30±2˚ C for 6hours before blending.

Preparation of Co-precipitate Spread

High calcium co-precipitate curd/spread was prepared from standardized cow milk as per method of Muller et al (1967). Milk protein co-precipitate was obtained by precipitation of casein and whey protein from skim milk using a combination of heat treatment (90˚ C for 1-2 minutes) and addition of calcium salts viz., CaCl2 at the rate of 0.2 percent. The protein concentrate filtered through muslin cloth to drain excessive whey and the curd obtained was broken down into small pieces and blended with water at 20 ml/100g of curd and salt (1.5-2.0%) to prepare co-precipitate spread. Packed in polystyrene cups and stored at refrigerated storage condition.

Preparation of Dairy Spread by blending co-precipitate and cream

The co-precipitate curd obtained was ground in a domestic mixer; 20ml of water was added for every 100 g of the curd so that the final moisture content was maintained at 68 percent. Spreads were prepared by using co-precipitate and cream at 90:10 and 80:20 proportions. A weighed quantity of co-precipitate curd was taken and to that cream was added in incremental quantities and then mixture was blended in the domestic mixer with addition of salt at the rate of 1.5-2.0 percent. Blending of the two products continued till a homogenous mass was obtained. Packed in polystyrene cups and

stored at refrigerated storage condition. Preparation of dairy spread by mixing co-precipitate and oil blend: As similar to that of cream blended dairy spread, high calcium co-precipitate was taken in a domestic mixer. To this, 20ml of water added for every 100g of co-precipitate curd to maintain 68% moisture in it. The oil blend was added at the level of 10% and 20% respectively along with 1.5-2.0% salt. All these ingredients were blended till the homogenous paste was obtained. Packed in polystyrene cups and stored at refrigerated storage condition.

Packaging and storage of the product

The low fat dairy spreads were packaged separately in polystyrene cups with proper labeling and stored at both room and refrigerated (4±1ºC) temperature for a period of about 14 days.

Analytical procedure for physico-chemical, rheological and sensory characteristics of low fat dairy spread

Physico-chemical analysis

pH

The pH of the sample was determined by using a portable pH meter (Hanna, Italy), as per the procedure described by AOAC (2002).

Proximate analysis: (Fat, Total protein, Moisture, Ash and Calcium)

The fat, total protein, moisture, ash and calcium content in all the samples were determined as per the procedure described by AOAC (2002).

Rheological characteristics viz., penetration value and cone stress index of the low fat dairy spread with added preservatives Penetration value

The hardness of the spread was measured in terms of penetration value with the help of cone penetrometer as described by Dixon and Parekh (1979).

Cone stress index

The firmness was determined using a cone penetrometer as described by Patel and Gupta (1989). The mean penetrometer value (p) obtained by this method was used to express firmness as cone stress index (Cv) as follows

$$C_v = \frac{C \times A^{-1.65}}{P^2} \times 106$$

Where

C = Mass of the dropping assembly in 'g'

A = Angle of cone

P = Corrected penetrometer reading

$$P = p + \frac{\text{Diameter of truncated tip of the cone}}{2\tan(A/2)}$$

P = Penetration value of the spread

Effect of emulsifying salts on the rheological qualities of the spread

The effect of various emulsifying salts viz., tri-sodium citrate, di-sodium hydrogen phosphate; tri-sodium phosphate added to the spread at rate of 1 percent was studied. Penetration value and firmness were determined using cone penetrometer for the samples containing with and without emulsifying salts both at room temperature and refrigerated temperature.

Sensory analysis

The spreads were evaluated for their sensory quality viz., flavor (garlic & pepper), body and texture, colour and appearance, and spreadability (both at room and refrigerator temperature) and acceptability at regular intervals during

storage period by a panel of judges using 9-point Hedonic scale (Prajapathi et al., 1992).

Statistical analysis

The data generated from this study were subjected to statistical analysis with analysis of variance (ANOVA) using SPSS software 17 as per standard procedure (Snedecor and Cochran, 1995) and significance of difference was expressed at 1% level.

Results and Discussion

The data on physico-chemical properties of low fat dairy spread prepared by blending co-precipitate with different proportions of cream and oil are shown in Table 1.

Table-1 Physico-chemical characteristics of the low fat dairy spread

Spreads	pH	Fat (%)	Total protein (%)	Moisture (%)	Ash (%)	Calcium (%)
Co-precipitate (C)	6.4±0.026	0.32±0.02 ^{a}	28.67±0.48^{d}	68.0±0.30^{a}	2.56±0.03^{c}	1.01±0.02^{c}
Co-precipitate: Cream 90:10 (T1)	6.38±0.014	4.29±.0.04^{b}	25.90±0.18^{c}	66.64±0.17^{d}	2.25±0.07^{b}	0.93±0.02^{b}
Co-precipitate; Cream 80:20 (T2)	6.35±0.018	8.28±0.05^{c}	23.27±0.015^{b}	65.33±0.29^{a}	2.10±0.03^{a}	0.83±0.0^{a}
Co-precipitate: Oil blend 90:10 (T3)	6.42±0.031	10.27±0.04^{d}	25.90±0.21^{c}	61.17±0.18^{b}	2.30±0.04^{b}	0.92±0.02^{b}
Co-precipitate: Oil blend 80:20 (T4)	6.44±0.020	20.23±0.13^{e}	22.90±0.23^{a}	54.30±0.21^{a}	2.03±0.03^{a}	0.83±0.01^{a}
F	2.4096^{NS}	12637.618**	71.061**	567.384**	24.351**	22.034**

NS – Not Significant, ** -- Significant at (P≤0.01)

All the formulations of dairy spreads had recorded uniform pH value and no significant differences were noticed between control and treated samples. Although, oil blend incorporated spreads had recorded slightly higher pH value than control and cream blend added dairy spread. That indicated, the addition of cream or oil blend into the dairy spreads had no detrimental effect on the physical characteristics of low fat dairy spread. Moisture and protein percentage decreased significantly ($p<0.01$) with addition of cream or oil blend into the different formulation of dairy spreads compared to control. High protein percentage in control could be due to high protein content of co-precipitate. Addition of cream or oil blend

into the samples increased fat percentage significantly ($p<0.01$) when compared to control. This might be due to presence of more amount of fat in the cream as well as oil blend. Similarly, ash and calcium percentage had recorded significantly higher value in control than other formulations. These findings are in agreement with Chappalwar et al (2010) who reported that addition of cream into channa spread upto 7.5% resulted in decrease of moisture, protein and ash contents and increase in fat content in the product.

The penetration value and cone stress index of dairy spreads at room temperature (Table 2).

Table-2 Penetration Value and Cone Stress Index of the dairy spread at room temperature

Spreads	**Without emulsifiers**		**Trisodium citrate**		**Disodium hydrogen phosphate**		**Trisodium phosphate**	
	PV	Cv	PV	Cv	PV	Cv	PV	Cv
Co-precipitate	225.67± 1.41	3.483±0 .041	235.67± 0.88	3.191±0 .024	233.00± 2.85	3.281±0 .079	231.0±0 .86	3.329±0 .023
Co-precipitate: Cream 90:10	233.00± 2.85	3.281±0 .079	241.33± 1.48	3.062±0 .036	238.33± 0.56	3.135±0 .014	236.67± 0.56	3.182±0 .012
Co-precipitate; Cream 80:20	241.33± 1.48	3.062±0 .036	248.00± 2.63	2.908±0 .060	245.67± 1.73	2.960±0 .041	242.00± 1.00	3.045±0 .024
Co-precipitate: Oil blend 90:10	230.00± 0.61	3.347±0 .017	242.33± 0.92	3.036±0 .022	235.67± 0.88	3.191±0 .025	233.00± 2.85	3.281±0 .079
Co-precipitate: Oil blend 80:20	242.33± 1.05	3.037±0 .025	253.00± 2.03	2.797±0 .044	248.00± 2.63	3.075±0 .168	243.00± 0.97	3.020±0 .023

Average of 6 Replications

Anova for Penetration Value and Cone Stress Index of Dairy Spreads at Room Temperature

Source of variation	d.f.	sum of squares	mean sum of squares	'F'	SE	CD
penetration value between treatments within replications	19 100	5485.958 1764.833	288.735 17.648	16.360**	1.7150	4.7531
cone stress index treatments within replictions	19 100	3.164 1.897	0.167 0.019	8.780**	0.0563	0.1560

NS – Not Significant, ** -- Significant at (P≤0.01)

It was found that spreads prepared by co-precipitate, cream at 10%, 20% levels showed a higher penetration. This is in accordance with Fisker and Jansen (1973) observation that incorporation of cream resulted in spread with optimum consistency and water absorption character. The penetration value and cone stress index of spread prepared with oil blend at 10%, 20% level show equally competent values with spread made with cream. which are in accordance with observations of Prajapathi et al. (1991) that a oil blend of 50:50 vegetable oil and hydrogenated fat incorporation resulted higher penetration value. It also shows the effect of various emulsifying salt on rheological characteristics of the spread. Addition of Tri-sodium citrate at 1% level possesses better emulsification capacity which is similar to observations of Patel and Gupta (1989). Statistical analysis of data reveals that there was high significant ($p<0.01$) difference of penetration value in the spreads with different emulsifiers.

Table-3 shows the penetration value and cone stress index of the spread at refrigerated temperature, it can be seen that the spread prepared by using co-precipitate and oil blend at 80:20 proportion increased penetration value. It also shows the penetration value and cone stress index of the spread stored at refrigerated (4±1˚C) temperature. It was observed that the spread prepared by using co-precipitate and oil blend at 80:20 proportion increased penetration value; this finding was accordance with the observation of Prajapathi et. al., (1991) who indicated that the reduced firmness in low fat butter flavored spread at refrigerated temperature. The added emulsifying salts to the spread, tri-sodium citrate at 1% level had showed increased penetration value and reduced the firmness of the spread which is in accordance with Patel and Gupta(1989) observed that tri-sodium citrate had greater emulsifying ability and reduced firmness of spread at refrigerated temperature.

Table-3 Penetration Value and Cone Stress Index of the dairy spread at refrigerated temperature

Spreads	Without emulsifiers		Trisodium citrate		Disodium hydrogen phosphate		Trisodium phosphate	
	PV	Cv	PV	Cv	PV	Cv	PV	Cv
Co-precipitate	187.00± 2.24	4.994±0 .116	210.00± 0.73	3.997± 0.026	206.67± 0.56	4.120± 0.021	200.67± 4.02	4.382± 0.164
Co-precipitate: Cream 90:10	207.00± 1.83	4.113±0 .069	218.33± 1.87	3.712± 0.06	211.33± 1.20	3.951± 0.043	210.00± 0.73	3.997± 0.026
Co-precipitate; Cream 80:20	215.00± 0.77	3.820±0 .027	225.17± 0.87	3.497± 0.026	221.00± 3.48	3.636± 0.111	218.33± 1.87	3.712± 0.060
Co-precipitate: Oil blend 90:10	207.17± 0.48	3.992±0 .093	219.17± 1.94	3.686± 0.063	212.00± 1.00	3.927± 0.036	209.67± 0.61	4.009± 0.022
Co-precipitate: Oil blend 80:20	219.67± 2.43	3.672±0 .077	231.00± 0.86	3.329± 0.024	225.33± 1.52	3.493± 0.045	223.33± 0.42	3.551± 0.013

Average of 6 replications

Anova for Penetration Value and Cone Stress Index of Dairy Spreads at Refrigerated temperature

source of variation	d.f.	sum of squares	mean sum of squares	'F'	SE	CD
penetration value between treatments within replications	19 100	11361.092 1870.500	597.952 18.705	31.968**	1.7656	4.8934
cone stress index treatments within replictions	19 100	15.471 2.810	0.814 0.028	28.973**	0.0683	0.1893

NS – Not Significant, ** -- Significant at (P≤0.01)

TABLE-4 Changes in Sensory quality of dairy spread during storage

Spreads	Flavour		Body and Texture	Colour and Appearance	Spreadability		Acceptability
	Garlic	Pepper			Room	Refrigerated	
Co-precipitate (C)	7±0.29	5.8±0.25	6.5±0.34	6.8±0.25	6.8±0.25	6.5±0.17	7.0±0.37
Co-precipitate: Cream 90:10 (T1)	7.5±0.17	6.0±0.21	7.5±0.17	7.0±0.21	7.2±0.13	6.6±0.22	7.7±0.42
Co-precipitate; Cream 80:20 (T2)	8.0±0.00	6.3±0.21	7.8±0.13	7.8±0.013	7.8±0.13	7.3±0.21	8.5±0.42
Co-precipitate: Oil blend 90:10 (T3)	6.5±0.27	5.3±0.30	6.2±0.20	6.8±0.25	7.0±0.26	6.8±0.13	6.8±0.48
Co-precipitate: Oil blend 80:20 (T4)	6.7±0.21	5.4±0.27	6.3±0.15	6.7±0.26	8.0±0.00	7.5±0.17	7.3±0.33
'F'	76.486**		12.037**	3.969**	9.898**	4.320**	9.1404**

**Significant at (P<0.01)

Table – 4 reveals that the sensory evaluation scores of dairy spreads prepared using co-precipitate, co-precipitate with cream or oil blends for flavour (Garlic and Pepper), body and texture, colour and appearance. Spreadability at room and refrigerated temperature, acceptability based on a 9 point Hedonic scale. Spread prepared by using co-precipitate with cream at 80: 20 proportions (T3) had scored higher value for flavour, body & texture, colour & appearance and acceptability; along with spreadability both the storage condition and significantly (P<0.01) differed. Whereas, the spread containing co-precipitate and oil at 80: 20 proportion (T2) had scored lower value for the sensory attributes but higher spreadability value noticed both in room and refrigerated storage condition. This finding was similar agreement with observation made by Patel and Gupta (1989) in protein enriched low fat spread. Moreover, use of flavoring components (garlic) in low fat dairy spreads increased its acceptability and significantly (P<0.01) differed. The garlic flavour preference was maintained till the 14 day of storage. The average Body and texture scores indicated superiority of T3 over all other preparation due to improved smoothness and better body. As the level of oil addition increases subsequently gumminess also increased. Regarding colour of the dairy spread, marked difference were observed in T3. Even for the spreadability also T3 has scored high in both room as well as refrigerated storage temperature and had showed better acceptability by the panelist up to the last date of storage. Similar to the

findings in the present study, decline in organoleptic scores of low fat dairy spread was reported by Chappalwar et al (2010) in Channa spread blended with cream.

Conclusion

From the present study, it was concluded that good quality low fat dairy spread can be prepared by replacing 20% of co-precipitate with cream. Incorporation of cream at 20% level in low fat dairy spread was found to be optimum and comparable to the control with respect to physico-chemical, rheological and sensory characteristics of the product. Such products could be safely stored for 14 days at refrigerated temperature (4±1˚C) without any undesirable changes in quality. This novel product development approach not only raises the protein but also reduces fat and production cost of the finished product. This investigation could help food industries to produce a novel low fat dairy spread with improved rheological properties.

The rheological properties of the spread prepared by addition of cream and oil blend at 10%, and 20% level showed higher the penetration value and lower cone stress index (firmness value).

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