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Effect of storage of surfactant gels on the bread making quality of wheat flour

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Abstract

Sodium stearoyl-2-lactylate (SSL), diacetyl tartaric acid esters of monoglyceride (DATEM), glycerol monostearate (GMS) and distilled glycerol monostearate (DGMS) surfactant gels were made with water and varying shortening contents. The SSL, DGMS, GMS and DATEM gels, with and without shortening in them, were stored for 3, 6, 9 and 15 days and their effects on bread-making quality were studied. All the gels improved the bread-making quality, to varying extents depending on the surfactant. On storage of gels, the improving effect was gradually reduced with increasing time, for all the gels made, with or without shortening. The adverse effect of storage on gels with shortening on bread-making quality was greater than that on gels without shortening and it varied from surfactant to surfactant. The results brought to light the adverse effect of storage of gels in improving the quality of bread.

Keywords: Surfactant; Bread quality; Staling; Gel

1. Introduction

Labell (1983) has reported the effect of addition of surfactants to dough on bread staling. The mechanism by which the surfactants retard the firming process of crumb is based on their ability to form complexes with amylose. The abilities of various surfactants to form inclusion complexes with amylose vary (Destefanis, Ponte, Chung, & Ruzza, 1977; Morad & D'Appolonia, 1980; Osman, Leith, & Fles, 1961; Tamstorf, 1983) and consequently, their contributions to a reduction in the staling rate are different (Conde-petit & Escher, 1991). Rao, Nussinovitch, and Chinachoti (1992) found that different types, levels and HLB values of surfactants had varying effects on amylopectin recrystallisation and loaf volume of bread. The reduction in crumb firming rate with surfactants has been reported by a few workers (Joensson & Toernase, 1987; Krog, Olesen, Toernaes, & Joensson, 1989). Destefanis et al. (1977) found that Sodium stearoyl-2-lactylate (SSL) not only complexed with amylose but also with amylopectin. Conde-petit and Escher (1991) demonstrated (with DSC) that complex forming surfactants had a strong efficiency to retard crumb firmness. The staling process involves three factors, namely, firming of the crumb, loss of flavour, and loss of crispness in the crust, with resultant leathering (Knightly, 1977). Surfactants, do not soften bread, they inhibit the firming of the crumb, associated with staling, by retarding the rate at which starch crystallizes (Knightly & Lynch, 1966). Crumb firming has been attributed, primarily, to changes in the starch fraction. It is theorized that the complex is formed by the surfactants and the amylose fraction during baking, and the complex retards the firming or retrogradation of the branched amylopectin fraction after the product is baked (Krog, 1979). The function of surfactants, as crumb softening agents, is closely related to their interaction or complex formation with starch, particularly the linear amylose fraction, to retard bread staling. Surfactants may also slow the rate of bread firming by

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forming a complex with the amylopectin fraction within the starch granule (Kamel & Ponte, 1993). Improvement in the bread crumb softness with surfactants has been reported by many workers (Joensson & Toernase, 1987; Krog et al., 1989; Langhans & Thalheimer, 1971; Lorenz, 1983; Roach & Hoseney, 1995; Rogers & Hoseney, 1983). Changes in characteristics of surfactant gels during storage and their interrelationship with quality of bread were investigated in this study.

2. Materials and methods

2.1. Materials

Glycerol monostearate (GMS) was obtained from M/s Fine Organic Industries, 15/2, Neelkanth Market, M. G. Road, Ghatkopar (East), Mumbai-400 077, India. Distilled GMS, sodium stearoyl-2-alactylate and diacetyl tartaric acid esters of monoglycerides (DATEMs) were obtained from M/s Enzyme India Pvt. Ltd., No. 7, Briethpet Road, Vepery, Chennai-600 007, India. A commercial aestivum wheat flour, procured from the local market, was used for the studies. Shortening (Hindustan lever limited, 165/166, Backbay reclamation, Mumbi 400 020) was procured from the local market. All other chemicals, reagents and solvents used in the present study were of analytical grade and these were obtained from reputed companies. Distilled water (twice distilled) was used in all the experiments throughout the study.

2.2. Methods

2.2.1. Chemical characteristics

Moisture, total ash, wet and dry gluten, Hagberg falling number, Zeleny sedimentation test, damaged starch and Kent Jones colour grade value were determined according to the standard procedures of AACC (1990). Nitrogen content was determined by the micro-Kjeldahl procedure. A conversion factor of 5.7 was used for calculating the protein content.

2.2.2. Preparation of surfactant gels

Gels were prepared using surfactant and water in the ratio of 0.5:2 and surfactant, water and shortening in the ratio of 0.5:2:1 and 0.5:2:2 using the surfactants SSL, distilled glycerol monostearate (DGMS), GMS and

Table 1
Influence of storage of gels[a] from ssl[b] on bread-making quality[c] of wheat flour

Parameters	Shortening[d] (%)	Storage of gel (days)					SEM (±)[e]
		0	3	6	9	15	
Volume (ml)	0	555a	555a	545b	540b	530c	2.87
	1	565a	560b	550c	545c	535d	3.41
	2	585a	575b	570b	560c	550d	3.23
Specific volume (ml/g)	0	4.11a	4.07b	4.04b	3.97c	3.96c	0.02
	1	4.17a	4.09b	4.06b	3.98c	3.97c	0.04
	2	4.33a	4.23b	4.15c	4.05d	4.04d	0.07
Texture (g. force)	0	309a	339b	347c	362d	370e	2.73
	1	295a	308b	329c	356d	358d	3.13
	2	271a	281b	302c	343d	351e	3.88
Crumb value score	0	39.5a	39.5a	29.0b	29.0b	13.0c	0.82
	1	39.5a	39.5a	29.0b	29.0b	13.0c	0.74
	2	45.0a	39.5b	39.5b	39.5b	29.0c	0.96
Baking quality score	0	168.6a	168.6a	155.3b	153.0b	140.3c	3.53
	1	173.4a	171.0a	157.5b	155.3b	142.4c	2.75
	2	192.5a	178.0b	175.5b	171.0c	157.5d	3.71
Overall quality score	0	208.0a	208.0a	184.3b	182.0b	153.3c	3.31
	1	212.9a	210.5a	186.5b	184.3b	155.4c	2.64
	2	237.5a	217.5b	215.3b	210.5c	186.5d	3.28
Crumb colour (ΔE)	0	29.9a	31.1b	32.1c	32.9d	33.1d	0.22
	1	29.7a	31.0b	31.6c	32.5d	32.7d	0.19
	2	29.6a	29.8a	31.5b	32.3c	32.5d	0.27

[a] Prepared with surfactant, water and with or without shortening.
[b] Surfactant added at 0.5%, on flour basis.
[c] Values in the same row followed by different letter differ significantly.
[d] Added on flour basis.
[e] Standard error of mean at 17° of freedom.

DATEM. First, dispersions were made, and then the dispersions, under continuous agitation, were heated to a temperature of 65 °C for GMS, 60 °C for DGMS, 45 °C for SSL and 48 °C for DATEM. On cooling, gels were obtained. Three types of gels, one without and another two with, varying shortening contents were obtained for each surfactant.

2.2.3. Bread making and evaluation of breads

Breads were prepared with wheat flour according to the remix procedure of Irvine and Mcmullan (1960). With the modification of 2% compressed yeast and reduced fermentation time of 90 min. Breads were cooled, packed in polypropylene bags and evaluated, after 24 h, by a panel of six experienced judges, following the procedure described in Standard methoden fuer Getreide et al. (1987). The volume of bread was measured by a rapeseed displacement method (Malloch & Cook, 1930).

2.2.4. Measurement of crumb firmness (Texture)

The crumb firmness, in terms of force (g) required for 25% compression of a 25 mm thick bread slice, was measured using an Instron, model-1140 (Instron Ltd., UK). An aluminium plunger, of 36 mm diameter, was used and the cross-head and chart speed were adjusted to 100 and 200 mm, respectively (AACC 1990).

2.2.5. Measurement of crumb colour

The crumb colour of bread in terms of ΔE was measured using a UV–Vis recording spectrophotometer, model UV-2100 (Shimadzu Corporation, Japan). A standard white board made from barium sulphate (100% whiteness) was used as a perfectly white object for setting the instrument with illuminant G. A bread slice of 12 mm thickness was placed in the sample holder and the reflectance was auto-recorded for the wavelengths ranging from 360 to 800 nm. The colour difference value (ΔE) for the bread slice in comparison to the standard barium sulphate board was recorded (Anon Spectrophotometer).

2.2.6. Effect of stored surfactant gels on the quality of bread

Influences of surfactant gels of SSL, DGMS, GMS, and DATEM, at the level of 0.5% surfactant, and 0%, 1% and 2% shortening, on flour basis, and storage for 0, 3, 6, 9 and 15 days, on bread-making quality of wheat flour were studied.

Table 2
Influence of storage of gels[a] from dgms[b] on bread-making quality [c] of wheat flour

Parameters	Shortening[d] (%)	Storage of gel (days)					SEM (±)[e]
		0	3	6	9	15	
Volume (ml)	0	545a	540b	535c	525d	515e	3.17
	1	560a	550b	545c	535d	525e	4.25
	2	570a	565b	555c	545d	530e	3.26
Specific volume (ml/g)	0	3.97a	3.92b	3.89b	3.82c	3.80c	0.09
	1	4.05a	4.01a	3.91b	3.84c	3.82c	0.04
	2	4.19a	4.08b	4.00c	3.96d	3.93d	0.06
Texture (g. force)	0	322a	348b	355c	369d	379e	3.35
	1	302a	342b	350c	362d	373e	3.61
	2	278a	321b	334c	351d	368e	2.75
Crumb value score	0	29.0a	29.0a	13.0b	13.0b	13.0b	0.83
	1	39.5a	29.0b	29.0b	13.0c	13.0c	0.76
	2	39.5a	39.5a	39.5a	29.0b	13.0c	0.74
Baking Quality Score	0	155.3a	153.0a	142.4b	138.0c	133.9d	3.74
	1	171.0a	157.5b	155.3b	142.4c	138.0d	3.56
	2	175.8a	173.4a	168.6b	155.3c	140.3d	2.86
Overall quality score	0	184.3a	182.0a	155.4b	151.0b	146.9c	2.95
	1	210.5a	186.5b	184.3b	155.4c	151.0d	3.41
	2	215.3a	212.9a	208.0b	184.3c	153.3d	2.84
Crumb colour (ΔE)	0	32.4a	32.8b	33.3c	33.5c	33.7c	0.18
	1	32.3a	32.6b	33.1c	33.3d	33.4d	0.31
	2	31.6a	32.4b	33.0c	33.2d	33.1d	0.26

[a] Prepared with surfactant, water and with or without shortening.
[b] Surfactant added at 0.5%, on flour basis.
[c] Values in the same row followed by different letter differ significantly.
[d] Added on flour basis.
[e] Standard error of mean at 17° of freedom.

2.2.7. Statistical analysis of data

All the values reported are average of quadruplicates. The statistical analysis of data was carried out according to a completely randomized design, using Duncan's multiple range test to separate the means (Steel & Torrie, 1980).

3. Results and discussion

3.1. Chemical quality characteristics of wheat flour

The quality characteristics of wheat flour indicated that the flour was of medium strong quality. The flour had 0.55% ash, K.J. colour grade value of 3.2, wet gluten 35.3%, dry gluten 12.3% and protein 11.1. The sedimentation value, which indicates quantity and quality of protein, was 23.1. The falling number, which is related to α-amylase activity was 434 and indicated the requirement of an α-amylase supplement for bread-making. The damaged starch content was 11.3%. The flour characteristics were within the specifications laid down for bread flour by the Bureau of Indian Standards (IS 7464, 1988) except for the ash content standard of 0.5% on a dry basis.

3.2. Effect of storage of surfactant gels on bread making quality

The gels, prepared using SSL, DGMS, GMS and DATEM, at the level of 0.5% surfactant, and 0%, 1% and 2% shortening, on flour basis, were stored for 0, 3, 6, 9 and 15 days. The influence of stored gels on bread-making quality of wheat flour was studied. Data on the effects of stored SSL, DGMS, GMS and DATEM gels on bread-making quality of wheat flour are presented in Tables 1–4, respectively. There was significant improvement in the quality of bread with the addition of gels from surfactants. Addition of 1% or 2% shortening, through gels, further improved the quality of breads, significantly. The influence of surfactant gels from SSL, DGMS, GMS and DATEM, with increasing shortening content, on bread making quality showed increase in volume, specific volume, crumb value, baking quality, overall quality and improvement in colour and texture. In general, the results showed that maximum improvement in quality of bread was obtained with SSL gels,

Table 3
Influence of storage of gels[a] from gms[b] on bread-making quality [c] of wheat flour

Parameters	Shortening[d] (%)	Gel storage days					SEM (±)[e]
		0	3	6	9	15	
Volume (ml)	0	530a	525a	515b	505c	490d	2.94
	1	540a	535a	525b	515c	495d	4.47
	2	555a	545b	535c	520d	505e	3.18
Specific volume (ml/g)	0	3.93a	3.90a	3.87b	3.85b	3.79c	0.05
	1	4.01a	3.94b	3.91b	3.90b	3.85c	0.03
	2	4.12a	4.07b	3.97c	3.96c	3.93d	0.08
Texture (g. force)	0	349a	379b	390c	414d	419e	3.16
	1	339a	357b	375c	401d	413e	3.54
	2	313a	336b	359c	393d	401e	3.23
Crumb value score	0	13.0a	13.0a	13.0a	7.5b	7.5b	0.71
	1	29.0a	13.0b	13.0b	13.0b	7.5c	0.69
	2	39.5a	29.0b	13.0c	13.0c	7.5d	0.83
Baking quality score	0	140.3a	138.0b	133.9b	114.4c	108.8d	3.23
	1	153.0a	142.4b	138.0c	133.9c	110.6d	2.42
	2	168.6a	155.3b	142.4c	136.0d	114.4e	2.93
Overall quality score	0	153.3a	151.0a	146.9b	121.9c	116.3d	3.42
	1	182.0a	155.4b	151.0b	146.9c	118.1d	3.78
	2	208.0a	184.3b	155.4c	149.0c	121.9d	3.17
Crumb colour (ΔE)	0	32.5a	32.9b	33.1b	33.4c	33.7d	0.24
	1	32.4a	32.6a	32.9b	33.2c	33.5d	0.28
	2	32.2a	32.5b	32.7c	33.0d	33.3e	0.19

[a] Prepared with surfactant, water and with or without shortening.
[b] Surfactant added at 0.5%, on flour basis.
[c] Values in the same row followed by different letter differ significantly.
[d] Added on flour basis.
[e] Standard error of mean at 17° of freedom.

Table 4
Influence of storage of gels[a] from datem[b] on bread-making quality [c] of wheat flour

Parameters	Shortening[d] (%)	Gel storage days					SEM (±)[e]
		0	3	6	9	15	
Volume (ml)	0	540a	535a	525b	520b	505c	2.78
	1	555a	545b	540b	530c	515d	3.21
	2	565a	560a	550b	540c	525d	2.66
Specific volume (ml/g)	0	3.94a	3.90b	3.87c	3.83d	3.80d	0.06
	1	4.05a	3.97b	3.91c	3.88d	3.85e	0.04
	2	4.19a	4.04b	3.97c	3.92d	3.90d	0.05
Texture (g. force)	0	338a	352b	361c	375d	386e	3.12
	1	326a	347b	356c	367d	380e	2.81
	2	301a	325b	347c	360d	374e	2.93
Crumb value score	0	29.0a	13.0b	13.0b	13.0b	7.5c	0.95
	1	29.0a	29.0a	29.0a	13.0b	13.0b	0.87
	2	39.5a	39.5a	29.0b	29.0b	13.0c	0.68
Baking quality score	0	153.0a	142.4b	138.0c	136.0c	114.4d	2.65
	1	168.6a	155.3b	153.0b	140.3c	133.9d	3.61
	2	173.4a	171.0a	157.5b	153.0c	138.0d	2.27
Overall quality score	0	182.0a	155.4b	151.0b	149.0c	121.9d	2.46
	1	208.0a	184.3b	182.0b	153.3c	146.9d	3.81
	2	212.9a	210.5a	186.5b	182.0c	151.0d	3.23
Crumb colour (ΔE)	0	32.5a	32.7a	33.2b	33.5c	33.6c	0.31
	1	32.3a	32.5b	33.0c	33.3d	33.4d	0.27
	2	31.6a	32.3b	32.9c	33.1d	33.2d	0.21

[a] Prepared with surfactant, water and with or without shortening.
[b] Surfactant added at 0.5%, on flour basis.
[c] Values in the same row followed by different letter differ significantly.
[d] Added on flour basis.
[e] Standard error of mean at 17° of freedom.

followed by DGMS, DATEM and GMS. As the storage period of gel increased, the improvement of bread quality gradually decreased. The volume of bread was decreased by 25–40 ml without shortening, 30–45 ml with 1% shortening and 35–50 ml with 2% shortening in gels of different surfactants after storage of gels for 15 days. After storage, The gels containing shortening caused more reduced volume of bread more than those without shortening. Specific volume of bread also showed a similar trend. The texture of breads significantly changed with addition of stored gels made with or without shortening. The softness of breads decreased, as shown by the increasing force required to compress the breads made with gels of increasing storage period. In general, the improvement in crumb value baking quality, overall quality and colour, of breads with gels, decreased gradually when breads made with gels stored for increasing periods of time. This was the case for all the surfactants, However, the degree of influence varied from surfactant to surfactant. The results clearly indicated that surfactant gels were better performers in quality improvement of bread, alone, than in the presence of shortening. The adverse influence of storage of gels on volume of bread was maximum with GMS, followed by DATEM, DGMS and SSL. The texture of breads was also influenced, with reduction in softness due to storage of gels of surfactants in the order: GMS > DATEM > DGMS > SSL. The gels from GMS were more reduced in softness with increasing storage period, than those of DATEM, DGMS and SSL gels, in that order. The control breads, made with 0%, 1% and 2% shortening, and without any surfactant, had 440, 485 and 505 ml volumes, 3.22, 3.60 and 3.81 ml/g specific volumes, 461, 421 and 411 g forces for texture and 2.5, 2.5 and 7.5 for crumb value, 84.0, 106.0 and 114.4 for baking quality, 86.5, 108.5 and 121.9 for overall quality, and 34.6, 34.1 and 33.4 for colour value, respectively. These results and the data in Tables 1–4 clearly showed that, even after 15 days of storage, the gels had played a role in improving the quality of bread. However, the improvement in quality of bread due to surfactants was reduced on increasing the storage period of gels made with or without shortening.

The results of the present studies demonstrate some improvement effects in bread-making quality, depending on the role played by different surfactant gels. On storage of gels, the improving effect was gradually reduced with increasing the time of storage. The improving effect

on quality of bread, with increasing amount of shortening in the gels, also showed reduction in quality with stored gels. The adverse effect of storage of gels on bread making quality using gels with shortening was greater than with gels without shortening and it varied from surfactant to surfactant. Hence, it can be concluded that storage of gels would reduce the improving effect on bread-making quality, with or without shortening in the gels.

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