Storage related changes in ghee-based low-fat spread

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Revised: 4 March 2011 / Accepted: 7 March 2011 / Published online: 13 April 2011

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Abstract In order to assess the shelf life of a low fat spread (LFS) based on ghee, the product with (PS) and without (CS) added 0.05 % (w/w) preservative potassium sorbate and packaged in 200 g polystyrene tubs was stored at 5 °C and evaluated for changes in sensory, physico-chemical and microbiological properties. On the basis of flavour score, the PS spread could be stored for 10 weeks without appreciable loss in quality as against the CS spread which could be stored only for 5 weeks. From the point of view of spreadability, body and texture and colour, the CS product was acceptable even after 11 weeks of storage. Use of preservative had an inhibitory effect on the development of free fatty acids (FFA) and thiobarbituric acid (TBA) reactive substances. While both the products showed an increasing tendency to whey off during storage, CS wheyed off more than PS. The two spreads showed similar oiling off, which increased slightly during the storage. Microbiologically, the ghee-based low fat spreads with and without preservative was stable for 9 and 3 weeks, respectively, from the view point of yeast and mould growth; but the preservative had little effect on the total viable count. Coliforms were absent in all the samples in fresh and during storage.

Keywords Storage · Low-fat spread · Ghee · Physico-chemical properties · Sensory properties · Microbial qualities

Introduction

Butter is one of the most palatable dietary items. However, its very high fat content makes it not only expensive but also very rich in calorie content. The increasing calorie consciousness among consumers renders butter less acceptable. Further, the conventional butter suffers from a serious functional problem viz., that of spreadability. Butter, when stored under refrigeration, becomes hard and brittle, and loses its spreadability, whereas at ambient temperature, it becomes sloppy. It is therefore necessary to provide a product that is acceptable in all respects including spreadability at refrigeration temperature. This opens up a new avenue for dairy manufacturers to introduce low-energy and low-cost fat products with improved functional properties. Low-fat spreads comprise one such category of dairy products that have thus emerged.

Table spreads are the products harmonizing with the idea of healthy nutrition. At the same time, they have good flavour and very good spreadability at refrigeration temperature and are able to retain their stand-up property even at ambient temperatures. Spreads have lower caloric content than butter and blend easily with other foods for convenience in cookery and serving. Dairy spreads are obtained from cream, butter or butter oil. Ghee could also serve as a source of fat for spread-making. It would be particularly relevant in situations where surplus fat converted into ghee in the flush season needs to be properly disposed off so that seasonal gluts of ghee could be effectively handled. Both the dietary and convenience requirements of the consumer

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have been sought to be met by table spreads. This trend is reflected in the increase in the market of table spreads particularly in USA and EU (Mann 2002; Dostalova 2003). Anon (2003) reported that the annual per capita consumption of spreads in France was 1.85 kg while in the UK it was 4.39 kg. Spanish dairy industry also experienced increase in the functional spread market. In the year 2002, the share of dairy spreads in the international yellow-fat market was 7 % by volume and 6 % by value. Many investigations have been carried out in the past for producing a low-fat dairy spread using a variety of fat sources such as cream (Kulkarni and Rama Murthy 1988; Devdhara et al. 1991; Verma et al. 1998; Balasubramanyam and Kulkarni 1999), paneer and channa (Tiwari and Sachdeva 1991), butter, chakka and chhana (Reddy et al 2001), cheese and chakka (Dholu et al 1994), cheese and buttermilk (Gokhale et al. 1998), UF (ultrafiltration) retentate (Deshpande and Thompkinson 2001) and safflower milk blended with buffalo milk (Deshmukh et al 2003). The exploitation of ghee in the manufacture of products such as low fat spread is the need of today's dairy industry in the Indian subcontinent due to its easy availability and better shelf life at ambient temperatures. This present paper concerns itself with keeping quality of ghee based low-fat dairy spread (LFS) developed at this institute and discusses its quality in terms of certain physico-chemical properties, sensory attributes and microbial counts during storage.

Material and methods

Ghee based LFS was prepared (Bullock and Kenney 1969; Prajapati et al 1991) using ghee, skim milk powder, carrageenan, Tween-80, glycerol, citric acid, butter annatto colour and diacetyl flavour in appropriate concentration. The average gross composition of the LFS was 41.0 % fat, 6.7 % protein, 8.9 % carbohydrate, 2.9 % ash and 40.5 % moisture. The product with and without added preservative (0.05% potassium sorbate) was packed in air tight polystyrene tubs (capacity 200 g), which were pre-sterilized by dipping for a few min in 0.5 % potassium sorbate solution and covered with similar treated polyethylene closures after filling. The product, with (PS) or without (CS) added sorbate, was stored at 5 ± 1 °C and examined at weekly intervals for 11 weeks. The quality of fresh and stored product was evaluated in terms of physico-chemical, sensory and microbiological parameters. The evaluation of LFS without preservatives was discontinued upon the mold growth becoming visible on the surface of the product.

Physico-chemical properties The spread was analyzed for free fatty acids (FFA) content (Deeth et al 1975) and

oxidative deterioration in terms of thiobarbituric acid (TBA) value (King 1962). The pH of the spread was measured by pH meter (Lab India Instruments Pvt. Ltd., Mumbai). To estimate the wheying off and oiling off or free oil in the product, five slices of spread (3 mm thick and 1.5 cm diameter each) were cut and placed on set (5 nos.) of moisture free, tared Whatman no.1 (2) filter-papers. These filter circles together with (5 no.) the sample slices were then weighed, held for 48 h at 20 ± 1 °C and then transferred to refrigerator for 30 min. The slices were then separated from the filter paper and the spread sticking to the paper was scraped off and the filter-paper weighed to get the weight gain from the sample. Thereafter, the filter papers were dried in an oven at 100 ± 2 °C for 3 h, cooled in desiccator and weighed again to determine the weight of the absorbed oil. The amount of oil absorbed after deducting the total soluble solids in the product was taken as oiling off from spread at 20 °C and then the moisture absorbed was taken as wheying off (deMan and Wood 1958).

Sensory evaluation The acceptability of spread was assessed by a panel of 5 judges selected from the faculty of Dairy Technology Division, NDRI, Karnal. The colour and appearance, spreadability, body and texture, flavour and overall acceptability, of the product were assessed by using 9-point rating scale (1-disliked extremely; 9- liked extremely). Spreadability was assessed by the panelists using a piece of bread slice to spread the product at uniform experimental temperature 5 ± 1 °C.

Microbiological quality For microbiological examination, samples were first tempered in a water-bath at 35 ± 1 °C for 5–7 min. Eleven grams of the sample was dispersed in previously autoclaved 99 ml buffer peptone water (BPW) (Himedia, Mumbai). This represented the first dilution (1:10), subsequent dilutions being prepared by transferring 1 ml of a particular dilution to 9 ml of BPW. The diluted sample was examined for yeast and mould counts, total viable count (TVC), and coliform count (CC) (Robert 1992).

Statistical analysis Data ($n=5$) were analysed for variance (anova) using SYSTAT version 10.2.05 (SYSTAT Software Inc., Richman, CA, USA).

Results and discussion

Free fatty acids (FFA) FFA increased in both the spreads during storage (Fig. 1). The rate of increase was higher in the CS wherein free fatty acids increased from initial 24.0 to 32.8 μ equiv/g after 5 weeks of storage. The rate of

Fig. 1 Changes in physico-chemical quality of the low fat spread during storage at 5 °C ($n=5$). CS-control; PS-0.05 % potassium sorbate

increase in FFA was much lower in PS, the value increasing from initial 23.6 to 29.4 μ equiv/g after 11 weeks of storage. Thus there was a significant inhibitory effect of the potassium sorbate on FFA development. Despite the steady and significant ($p<0.05$) increase in FFA in both the CS and PS spreads during storage, none of the samples had rancid flavor indicating that the level of FFA production was not to an extent that would cause the off flavor. An increase in FFA in a 'low-calorie butter' during storage due to the continuous lipolytic breakdown as a result of the growth of yeasts and moulds has been reported in a previous study (Ibrahim et al 1994). Patel and Gupta (1989) also reported increase in the FFA content of a low-fat soya spread with progressive storage. Similar trends of rise in the FFA content of stored spreads were also observed by other workers (Devdharma et al 1991; Deshmukh et al 2003; John and Tyagi 2003).

TBA value The initial TBA numbers of the CS and PS products were 0.160 and 0.164, respectively, which increased to 0.208 and 0.199 at the end of the respective storage periods of 5 and 11 weeks at 5 °C (Fig. 1). Further, the TBA value remained almost unchanged during the first 2 weeks of storage in both the spreads, but tended to increase later. The increase was significant

towards the end of storage ($p<0.05$). The flavor score had a negative correlation with the TBA value, the correlation coefficient being -0.812 . The findings of other workers (Ibrahim et al 1994; Reddy et al 2001) also corroborated the present results.

pH At the end of 5 weeks of storage, the pH (initially 5.3) increased slightly but significantly ($p<0.05$) to 5.6 in the CS product, and to 5.6 after 11 weeks in the PS spread (Fig. 1). These findings are in accordance with Dalaly et al (1968), Spurgeon et al (1970) and Balasubramanyam and Kulkarni (1999) who found an increased pH in stored spread. This may be attributed to protein breakdown owing to microbial growth during storage. Furthermore, it can also be seen from the table that the stored PS spread showed a significantly ($p<0.01$) lower pH value as compared to that of control. Presumably the added preservative checked the microbial growth and proteolysis.

Wheying off A small but statistically significant ($p<0.01$) increase in wheying off was noticed (Fig. 1) in both CS and PS spreads during storage. The increase in wheying off from 7.5 to 8.0 % in CS and from 7.6 to 8.2 % in PS spreads indicated a steadily decreasing ability of the non-fat phase to hold water. The rate of increase in wheying off in

the PS samples was lower than that in that control samples. This finding is in accordance with the findings of Goel et al (1969) and Verma et al (1998).

Oiling off With progress in storage, oiling off of the spread increased gradually in nearly linear manner in both spreads but the increase was non-significant (Fig. 1). This small increase implied that the spread had good emulsion stability during storage. The oiling off recorded at the end of storage period for CS and PS spread were 3.9 and 4.1 %, respectively. Verma et al (1998) also reported a little change in oiling off in LFS during storage.

Colour and appearance As the storage period progressed, the scores for colour and appearance decreased significantly ($p<0.01$) in both the spreads (Fig. 2). While the rate of decline was nearly similar in both the spreads during the first three weeks, it was higher in CS than PS upon further storage. If a score of 7 ('like moderately') is taken as the minimum for an acceptable product, both spreads remained acceptable during storage from colour point of view. Also, there was no significant influence of the preservative. It may,

however, be noted that surface discolouration became evident towards the end of storage. A high negative correlation ($r=-0.70$) was also observed between colour scores and yeast and moulds counts indicating a definite effect of mould growth during storage. On the other hand, Kristensen et al (2000) observed a darker and more yellow colour during storage. No perceivable change was observed in colour of an o/w type spreads during storage by Patel and Gupta (1989) and Verma et al (1998). Although the colour scores for the present table spread showed a decrease from 8.1 to 7.6 after five weeks in CS and 8.0 to 7.4 in PS after 11 weeks, the stored product rating was between "liked moderately" and "liked very much" on a 9-point hedonic scale.

Spreadability Spreadability score of the CS decreased from the initial 8.0 to 7.8 after 5 weeks storage and that of PS from 8.0 to 7.6 after 11 weeks (Fig. 2). The spreadability score of the PS (8.0) remained unchanged for up to 2 weeks. Thereafter, a slight but significant decrease was noticed during the rest of the storage period. Yet the spreadability of the CS and PS remained acceptable (score, more than 7). The changes in spreadability scores of the

Fig. 2 Changes in sensory quality score of the low fat spread during storage at 5 °C ($n=5$ panelist). CS-control; PS-0.05 % potassium sorbate

product during storage may be attributed to the changes in overall consistency of the product presumably due to protein degradation and/or decreased water holding by the non-fat fraction resulting in increased softening of the spread particularly towards the end of storage. In LFS, role of biopolymers such as protein is highly significant to cross-link and form interconnected molecular network in water suitable for spreading (Chronakis and Kasapis 1995). Spreadability assessment can be also made using instrumental methods involving mostly large deformations which break down the products' structure like extrusion, compression etc (Wright et al. 2001) and small deformations (Rohm and Weidinger 1993; Brunello et al. 2003). These data are generally highly correlated with sensory analysis of spreadability (Rousseau and Marangoni 1998; Staniewski et al 2006). The lowest score of 7.7 obtained at the end of the storage period in our samples indicates that the product was "Moderately" to "Highly" liked as perceived by the judges and therefore was acceptable throughout the storage period.

Body and texture Body and texture scores remained more or less unchanged for up to four and eight weeks of storage in CS and PS spreads, respectively (Fig. 2). Thereafter, the scores decreased to 7.6 after five weeks of storage in the CS spread, and to 7.2 after eleven weeks in PS spread. These changes were statistically significant ($p < 0.01$). The decline in body and texture scores during storage may be attributed to the changes occurring in the non-fat portion of the table spread probably due to proteolytic action of microorganisms. The changes in protein are expected to result in reduction of its water holding capacity, thereby increasing the free moisture in the product. The presence of free moisture could contribute to softness of the product affecting the overall consistency. Softening of spreads during storage has been reported by several workers (Dalaly et al. 1968; Spurgeon et al. 1970). A negative correlation ($r = -0.65$, $p < 0.01$) was observed between body and texture scores and total microbial count indicating that the increased microbial count attributable to the growth of psychrotrophic bacteria might have contributed to degradation of protein resulting in softening of the stored product. The present findings are in agreement with those reported by Ibrahim et al (1994). Although the final body and texture scores ranging from 7.2 to 7.6 were lower than the initial score of 7.8, these scores represented an acceptable product (higher than "like moderately").

Flavour Flavour scores of both the CS and PS spreads declined during storage, the decline being rapid and significant for the spread without preservative (Fig. 2). The rate of flavour deterioration was slower during the initial period of storage but it increased appreciably towards the end of storage. The decrease in flavour scores

may be attributed to loss of freshness. Spurgeon et al (1973) reported that decline in the flavour score of a butter-flavoured spread was considered to be due to reduction in diacetyl content of the spread during storage. The findings of the present study are also in accordance with the reports of Devdhar et al (1991), Reddy et al (2001) and Deshmukh et al (2003). A significant ($p < 0.01$) negative correlation ($r = -0.74$) was observed between flavour score and the FFA content. Patel and Gupta (1989) observed development of fruity flavour in stored low calorie soya spread. The flavour score (6.8) of the present product after 11 weeks of storage was considerably lower than initial score of 8.0 in PS; i.e the stored spread was "slightly to moderately desirable" on a 9-point scale. Considering a flavour score of 7.0 as the minimum desirable limit for an "acceptance" product, the keeping quality of the PS spread containing preservative could be taken as 10 weeks.

Overall acceptability The fresh samples were highly acceptable, scores being 7.9 and 8.0, respectively for CS and PS produce (Fig. 2). The scores however decreased significantly during storage. The rate of decrease in samples without preservative was higher as compared to that in the spread with preservative implying a significant ($p < 0.01$) effect of potassium sorbate. However both the products had an acceptability score appreciably higher than the minimum desired (7.0) during the entire storage study. The decreasing score with advancing storage period may be attributed to the decline in flavour of the spread as also to softening of the product. There

Fig. 3 Changes in microbiological quality of the low fat spread during storage at 5 °C. CS-control; PS-0.05 % potassium sorbate

was also a negative correlation ($r=-0.72$) between the TBA number and overall acceptability score ($p<0.01$).

Yeast and mould count (YMC) There was little increase in the yeast and mould count of spread containing preservative during the first three weeks of storage (Fig. 3). After that, the count increased gradually but significantly by the end of 11 weeks of storage in the case of PS spread. After 3 week of storage, the control (CS) spread showed 9/g of YMC which increased to 26/g during the 4th week. Thus the YMC of CS was within the limit (20/g) for the first three weeks prescribed for table butter by the Bureau of Indian Standards (IS: 13690 1992). After 5 weeks of storage the count sharply rose to 71/g. Moreover, after 6 weeks, the control spread showed a visible growth of yeast and moulds and so this spread was not stored further. On the other hand the YMC of PS remained within the limit for 9 weeks (17/g). Hence it could be concluded that the PS spread could be stored for 9 weeks at 5 °C whereas CS spread could remain acceptable for only three weeks of storage. The increase in the count of yeast and mould can be attributed mainly to post-pasteurization contamination. Verma et al (1998) also reported a definitive YMC increase in low fat spread after 30 days and 10 days at 5 and 10 °C, respectively. A highly negative correlation ($r=-0.70$) was observed between colour scores and yeast and mould counts indicating a definite effect of mould growth during storage. A similar negative correlation ($r=-0.70$) was also observed between yeast and mould count and flavour scores as affected by period of storage.

Total viable count (TVC) There was a significant increase in the TVC of control spread (from 2.1 to 3.0 to 4.8 log cfu/g) as well as in the preservative added spread (from 2.1 to 3.2 log/g) between 0 to 5 weeks of storage (Fig. 3). Between 6 and 9 weeks of storage, the increase in TVC continued up to 4.4 log/g in the PS spread.

However, during the last two weeks of storage the count increased only slightly (from 4.6 to 4.7 log cfu/g). It was thus apparent that the preservative had little effect on TVC. The increase in the TVC with progressive storage indicated that the product with a substantial initial bacterial load provided a fairly good medium for the growth of the organisms. Ibrahim et al (1994) and Reddy et al (2001) reported noticeable increases in TVC of LFS. Similarly, Charteris (1996) also reported significant increase in the standard plate count due to wide usage of dairy ingredients such as skim milk, buttermilk and SMP etc. in the formulation of table spread. Bullock and Kenney (1969), Gokhale et al. (1998) and John and Tyagi (2003) reported similar findings on the TVC of stored spread.

Coliform count In the present study coliforms were absent in all the samples in fresh and during storage. This indicates

that proper hygienic precautions had been taken during the production and packaging of spread.

Conclusion

Ghee-based LFS was evaluated for storage life with and without addition of potassium sorbate as preservative. Although there was a progressive increase in pH, FFA and TBA in the preservative-added LFS, none of these rendered the product unacceptable for up to 9 weeks of storage at 5 °C. The main cause of spoilage, especially in the spread without the preservative, was found to be the surface growth of yeasts and moulds. The shelf life of the product was found to be considerably influenced by the presence of the preservative. The product without preservative and packaged simply in pre-sterilized polystyrene tubs with lids was found to keep good only for 3 weeks. With the addition of 0.05 % potassium sorbate, the spread's shelf life could be increased by 6 weeks i.e. up to 9 weeks under the same packaging and storage conditions.

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