ROLE OF STARTER CULTURE IN ENHANCING GHEE FLAVOUR: A REVIEW

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The pleasing flavour of ghee is different from that of milk, cream, dahi and butter from which it is made. The flavour of ghee is highly variable and depends on many factors, one of them is the method of preparation. More pleasant flavour of desi ghee (which involves souring by microorganisms) as compared with creamery butter ghee and direct cream ghee has attracted the attention of scientists and technologists towards the use of microorganisms in imparting flavour to ghee. In the last two decades, a few workers have investigated the effect of using starter cultures on the flavour of ghee in terms of change in flavour compounds and/or sensory score. In the following pages, a summary of the attempts made by different workers in this direction, is presented.

Malhan (1973) reported that there was an increase in the carbonyl compounds in goat ghee when the cream used was ripened with a starter culture. The extent of increase in the carbonyl compounds varied with the period of ripening. The cream samples ripened for 0, 12, 24 and 36 hours and having titratable acidities 0.10, 0.50, 0.59 and 0.61% lactic acid, yielded ghee with carbonyl content (μM/g fat) of 4.8, 5.4, 5.4 and 5.5, respectively. Ramamurthy and Jain (1973), however, reported that ripening of cream/butter method of preparation of ghee and temperature of clarification of cream/butter showed no effect on total carbonyl content of ghee. Abdel-Salam et al (1973) compared the monocarboxyls of Samna (an Egyptian product similar to ghee) prepared from fresh butter, fresh cream, ripened butter and washed cream and butter fat (prepared by heating butter at 40°C and filtration) and found the highest content of total monocarboxyls in Samna prepared from ripened cream and the lowest in butter fat. However the differences between fresh and ripened butter or cream were small indicating that ripening had a little effect on the monocarboxyl content. Similar results were found in the four classes of monocarboxyls viz. methylketones, saturated aldehydes, 2-enals and 2,4-dienals. Qualitative as well as quantitative differences were also observed in the distribution of different monocarboxyls in Samna prepared by different methods.

In an elaborate study on carbonyls in ghee Gaba (1974) showed that total carbonyl content of cow ghee prepared from ripened butter (9.66 μM/g fat) was significantly higher than that prepared from fresh butter (7.26 μM/g fat). However no significant differences were observed in the total carbonyl content of buffalo ghee prepared from fresh and ripened (8.6 μM/g fat in each case) butter. He also found that the volatile carbonyl contents of fresh ghee (cow's and buffalo's) prepared from ripened butter (0.42 μM/g fat and 0.28 μM/g fat, respectively for cow and buffalo ghee) was significantly higher than that prepared from fresh butter (0.33 μM/g fat and 0.26 μM/g fat respectively for cow and buffalo ghee). However, the differences were more marked in case of cow ghee. The ripening of butter did not cause
any significant changes in the relative proportions of volatile and total monocarbonyl classes of fresh ghee (cow and buffalo). Anon (1974) reported that creamery butter-ghee with desirable flavour characteristics can be prepared by replacing fresh cream with cream which is "aged" to an acidity level of about 1% lactic acid or ripened with Streptococcus lactis subsp. diacetilactis DRC-I culture to an acidity level of 0.5—1.0% lactic acid. There was however, no marked difference between the flavours of cow ghee and buffalo ghee so prepared. This report also revealed that use of DRC-I culture at a level more than 1% at the "dahi" making stage of desi ghee was unnecessary as far as the flavour of the resulting ghee was concerned. Also the use of ripened cream butter in the preparation of ghee led to an increase in desirable flavour score irrespective of the method of preparation of ghee. Furthermore, the impact of using ripened cream/butter on the quantity and quality of volatile carbonylic flavour compounds was less marked and less consistent. Later Gaba and Jain (1975) reported that volatile as well as total carbonyls in ghee prepared from ripened butter were significantly higher than those in ghee prepared from fresh butter.

A report by Singh et al (1979) indicated that ghee made from ripened cow cream showed significantly higher carbonyl content than the corresponding sample made from unripened cream. However, the flavour characteristics of these two types of ghee were almost similar. This latter view is supported by the earlier findings of Kulkarni and Vyas (1976) and Singh and Ram (1978) who observed that there was no influence of ripening of cream (upto titratable acidity of 0.25 and 0.30% lactic acid, respectively) on the initial flavour quality of ghee. They further pointed out that during storage the flavour deterioration was faster in the ripened cream ghee. This was, however, in contrast with the findings of Abraham and Srinivasan (1980) and Srinivasan et al (1982). However, recently, Ramamurthy (1980) reported that the composition of carbonyls of ghee is not altered by the method of manufacture and ripening of cream or butter. On the other hand, they have a significant effect on the flavour development. He claimed that ripening of cream or butter gives intense ghee flavour provided the temperature reaches around 120°C. In an earlier study, Munro and Jepsen (1974) ripened the cream with Streptococcus lactis subsp. diacetilactis using 1% level of inoculum, at 18°C till the acidity reached 0.3% (lactic acid). The ripened cream was then churned into butter and the latter was clarified into ghee at 130°C followed by bubbling of N₂ gas through the finished product and cooling to ambient temperatures before filling. The process had been claimed to produce satisfactory ghee.

Like carbonyl compounds, other flavour components in ghee viz, free fatty acids, lactones, alcohols etc. have also been reported to change due to ripening of cream or butter. Singh et al (1979) have indicated that free fatty acid (FFA) content of fresh ghee made from ripened cream/cow cream-butter was considerably higher than that of unripened cream/butter ghee (0.23 to 0.28%). Whereas the FFA content of fresh ghee made by desi method as well as from ripened cream/butter was approximately of the same order ranging from 0.34% to 0.40%. Similar observations on increase in FFA of ghee due to ripening of cream with different starter cultures has been reported by Abraham and Srinivasan (1980) and Srinivasan et al, (1982). However, Rajput and Narayanan (1968) reported that acidity of ghee obtained from ripened cream did not differ appreciably from that of ghee obtained from fresh cream. The values (% oleic acid) ranged from 0.25 to 0.30.

More elaborate studies on the effect of using starter cultures on flavour components and flavour score of ghee have been reported after 1980's. In laboratory experiments by Rajorhia (1982), manufacture of ghee from ripened cream
Role of starter culture in ghee flavour

resulted in the significant increase of total carbonyl content, free fatty acids and flavour scores. Desi ghee prepared from curd had the highest total carbonyl and FFA contents followed by direct-cream ghee and creamery-butter ghee. Singh (1982) also reported an increased total carbonyl content in fresh ripened-cream ghee (6.6 μM/g fat) as compared to fresh unripened-cream ghee (3.9 μM/g fat). He also pointed out that unripened-cream ghee, ripened-cream ghee and desi ghee respectively, contained 0.23, 0.40 and 0.37 FFA levels (% oleic acid) and 0.23, 0.13 and 0.09 total reducing substances levels (mg-cyst-HCl/g). This showed that there was increased production of FFA and decreased production of reducing substances in ghee on ripening of cream. However, the flavour scores of ripened and unripened-cream ghee were 7.0 and 6.5, respectively. Recently, Rao and Ramamurthy (1984) have reported a higher amount of polar carbonyls in ghee made from 'aged' cream (naturally soured cream) as compared to ghee made from fresh cream.

In most of the foregoing studies on ripening of cream for ghee-making, only one culture had been used. Recently a work from this laboratory has been reported (Abraham and Srinivasan, 1980) on the comparison of four starter cultures namely Streptococcus lactis C-10, S. lactis subsp. diacetylactis DRC-1, S. thermophilus and Lactobacillus bulgaricus. It was observed that ripening of cream with DRC-1 and C-10 cultures enhanced the flavour score of ghee while ripening with the rest two cultures had no effect. Subsequently, on the basis of this screening, the DRC-1 culture was selected for a further detailed study on the role of starter culture in the enhancement of flavour in ghee (Yadav, 1982). It was observed that ripening of cream led to the enhancement of flavour score of ghee. The amounts of total and individual carbonyls and free fatty acids in ripened cream ghee were more than those in unripened cream ghee and were comparable to those of desi ghee. The flavour score (out of 10) of ripened cream ghee (8.83) was much higher than that of unripened cream ghee (5.4) and was comparable to that of desi ghee (8.7). However, no qualitative differences were observed in the flavour components; the FFA profile and carbonyl make-up of unripened-and ripened-cream ghee were identical (Yadav and Srinivasan, 1984). The mechanism of enhancement of flavour on using starter culture has also been elucidated on the basis of radiotracer studies with 14C-labelled compounds. It has been conclusively proved that action of starter culture on cream constituents like lactose, glucose and citrate, generates various flavour compounds (FFA and carbonyls) which get incorporated in ghee on moisture removal during the heat clarification step of ghee making (Yadav and Srinivasan, 1985a). The various biotechnological parameters for the preparation of creamery-ghee with improved flavour using DRC-1 culture have also been optimized. Cream (40% fat), steamed and cooled, when ripened with DRC-1 culture at 3% level of inoculum at 30°C for 18 hrs and clarified at 115°C for 5 min, resulted in a product with most pleasing flavour almost comparable to that of desi ghee. This standardised process has also been extended to pilot-plant scale manufacture of ripened-cream ghee (Yadav and Srinivasan, 1985b, c). In a further modification, the ripening period of cream could be reduced by 6 hours on using a starter concentrate (viable count: 68 x 10⁶ cells/ml) at 1% level (Yadav and Srinivasan, 1986).

Flavour compounds of ghee flavour: The flavour of fresh ghee has been believed to be due to the presence of various flavour components namely carbonyls, free fatty acids, lactones, reducing substances etc. Among these groups of compounds, carbonyls and lactones play a major role in imparting typical ghee flavour. Based on different studies, it could be conclusively stated that it is not the absolute
quantity but a definite blend of carbonyls in qualitative and quantitative terms which appears to be critical as far as the characteristic ghee flavour is concerned, the same holds true for the product obtained from ripened material (Yadav and Srinivasan, 1984). Like carbonyls, a definite proportion of lactones and a balanced ratio is responsible for the normal pleasing flavour in ghee. The increase in these flavour compounds to unbalanced proportions as obtained during storage, leads to off-flavours in ghee.

Mechanism of flavour enhancement in ghee: by starter culture: The flavour enhancement in ghee obtained from ripened materials is ascribed to the metabolic activity of the starter bacteria on various cream/butter constituents like lactose, citrate, glucose and not to the cell debris. Various flavour compounds (carbonyls and free fatty acids) produced during ripening process by starter activity get incorporated in the final product on moisture removal during clarification process. The incorporation is facilitated by the acidity in the ripened cream/butter. In addition, it is likely that the lower pH produced by the starter activity also helps in increasing the intensity of chemical reactions like caramelization, during the heat clarification. These reactions are reported to contribute to the flavour components in ghee.

Simulation of ghee flavour: The possibility of increase in flavour components (carbonyls FFA, etc.) of ghee on ripening its raw material like milk, cream or butter, as reported by a few workers, and the pleasing flavour of desi ghee have stimulated the interest in utilizing various forms of starter cultures for simulating ghee flavours.

Munro and Jebson (1974) reported the continuous manufacture of ghee from anhydrous milk fat (AMF). A skim milk concentrate containing 15% SNF was inoculated with 1% Streptococcus cremoris culture and held at 30°C up to a pH of 4.5. The culture so obtained was spray dried and added at 2% (w/w) level to AMF and then the mixture of AMF and spray dried culture was heated to 140°C for 5 min. The resulting ghee had clean and pleasant caramel flavour and texture. Bhatia (1978) made a comparative study on the simulation of ghee flavour in butter oil by remixing and heating it with different quantities (10%, 20%, 30%, and 50% w/w levels) of sweet and sour butter milk. He concluded that the product obtained by heating a mixture of butter oil and cultured sour buttermilk (acidity: 0.8-1.0% lactic acid; level: 20-30% w/w) possessed the best simulated flavour along with all good characteristics of ghee.

Flavour almost similar to that of desi ghee was induced in butter oil by Wadhwa et al (1977) when they treated it under good stirring with skim milk dahi (5% w/w) at 120°C for 3 minutes. It was observed that a mixed culture of Streptococcus thermophilus and Lactobacillus bulgaricus and a pure culture of Streptococcus diacetilactis (DRC-1) were comparable in inducing ghee flavour in butter oil. Spray dried skim milk powder could also induce ghee flavour in butter oil but it was inferior to spray dried skim milk dahi in this respect.

In an attempt to utilise curdled milk, Kumar et al (1980) studied the preparation of ghee from such naturally curdled milk. It was observed that ghee obtained in this way was more acceptable than control dairy ghee made from fresh milk, in sensory quality. A similar observation on good sensory quality ghee, made from curdled milk was also made earlier by Srivastava and Singh (1979). Later Wadhwa and Jain (1982) were able to simulate ghee flavour in butter oil on semi-commercial scale. Recently, Rajorhia (1982) has also suggested a few approaches to simulate desired quality attributes in ghee by using starter cultures in various forms.

From the foregoing account it appears that the common dairy cultures especially Streptococcus diacetilactis produce various ghee...
flavour compounds and therefore the use of these cultures in the process of ghee manufacture can lead to enhancement of pleasing flavour in ghee. Since, standardisation of this process under industrial conditions has been attained only to a limited extent, there is a need to study it under more diverse cultural and technological parameters by using different forms (single or mixed or concentrated) of starter cultures, different types of raw materials (cream or butter obtained from different sources) and different routes of ghee manufacture (direct-cream method, creamery-butter method, prestratification method, etc.) Also, the technical and economic feasibilities of ghee manufacture by the microbial process under Indian conditions need to be worked out.

REFERENCES


