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Impact on Rheological Properties of Fermented Milk Products Due to Lactic Acid Bacteria

Kele VD.
College of Dairy Technology, Udgir, District Latur, Maharashtra, India
Behare PV.
College of Dairy Technology, Udgir, District Latur, Maharashtra, India
Bajad DN.
College of Dairy Technology, Udgir, District Latur, Maharashtra, India

Abstract:
EPS producing lactic cultures have tremendous potential as functional starters, which can be better substituted to many commercial additives in use. They have significant effect on rheological and organo-leptic properties of a food. Incorporation of these cultures in to food products not only satisfy consumer demands of natural, healthy and low calorie food product but also provide food with as few food additives as possible. Use of EPS producing cultures reduce the amount of total solids required to manufacture dahi, lassi and yoghurt and thus making the process cost effective. Fermented milks, especially made by traditional method in rural areas, are the potential reservoir for isolation of EPS producing cultures for Consumers' demand for natural, healthy and low-calorie food has increased interest in the dairy industries for development and manufacture of low-fat/fat-free fermented milk products.

Keywords*: EPS, commercial additives, dairy, fermented milk product, consumer*

1. Introduction

Consumers' demand for natural, healthy and low-calorie food has increased interest in the dairy industries for development and manufacture of low-fat/fat-free fermented milk products. But fat removal has several undesirable effects on physical properties of fermented milks such as inferior flavour, texture and rheo-logical properties that consequently hamper their acceptability. Several attempts were made including increase in milk solids and addition of stabilizers to tackle such problems (Rohm and Schimid 1993). However, these approaches did not address an increasing consumer demand for products with natural, low-cost and with as few food additives as possible. Furthermore, additives particularly, stabilizers are strictly prohibited in some fermented milk products like *dahi*(similar to yoghurt) in India and yoghurt in Norway by the stringent regulations. In this con- text, there is no alternative to use EPS producing lactic cultures, which offer a natural and usually acceptable way for making low-fat/fat-free fermented milks Lactic acid bacteria (LAB) are widely used in the dairy and food industry since time immemorial. Apart from production of lactic acid, flavouring compounds and bacteriocin like substances, several strains of LAB secrete extracellular polysaccharide in favourable environment such as milk (Cerning and Marshall 1999). The term exopolysaccharide (EPS) is used to describe extracellular polysaccharide either attached as capsule with bacterial cell wall or liberated into the medium as ropy polysaccharide (Sutherland 1972). The EPS play an important role in the improvement of physical properties of fermented milks, which act like a food stabilizer, viscosifier, emulsifier or gelling agent providing a product with natural thickness (Ruas-Madiedo and Reyes-Gavilan 2005). Some of the examples of LAB EPS are dextran, mutan and fructanproduced by *Leuconostocmesenteroides*, *Streptococcus mutans*and *Strep. salivarius*subsp. *thermophilus*, respectively (Montiville et al 1978, Cerning 1990). The Gram negative bacteria, *Xanthomonascampestris*, *Acetobacterxylinum*and *Sphingomonaspaucimovilis*also produce EPS xanthan, acetan and gellan, respec- tively that are commercially available asfood additives (Harvey and McNeil 1998). However, EPS extracted from Gram negative bacteria, although produced in larger quantities than EPS produced by food grade LAB, may not be preferred, as former is derived from non-food grade non-GRAS (Generally Recognized As Safe) status organism and had high cost involved in their recovery. Moreover, addition of purified EPS into the food product may not have similar effects as EPS produced *in situ* by LAB during milk fermentation (Doleyreset al 2005). The properties of EPS in purified form differ considerably from the properties of EPS produced *in situ* (Dubocand Mollet 2001), latter being a more desirable approach. The *in situ* EPS production may play useful role in the manu- facture of a variety of cultured dairy products such as yoghurt, drinking yoghurt, cheese, cultured cream and milk-based dessert (Crescenzi 1995, Bouzar et al 1997,).

A large variety of LAB, with some strains of Bifidobacteriaare reported to produce EPS (Zotta et al 2008). Most of them belong to the genera of *Lactococcus*, *Streptococcus*, *Lactobacillus*, *Leuconos-toc* and *Pediococcus*. The use of polysaccharide producing lactic culture strains in the fermented milk manufacture is not new. The EPS producing LAB have been traditionally used in the Scandinavian fermented milk products to impart desirable texture and rheological properties (Macura and Townsley 1984). The products made with ropy strains have smooth body, high viscosity and less syneresis than the products made with non-ropy strains (Wacher-Rodarte et al 1993).The EPS producing lactic bacteria are isolated from dairy and non-dairy environment using different media supplemented with one or more type of sugars. The media used for isolation of EPS producing cultures are: liquid EPS selection medium (ESM) containing (g/l) 90 skim milk, 3.5 yeast extract, 3.5 peptone and 10 glucose (Van den Berg et al 1993), milk indicator agar and M17 lactose agar (Terzaghi and Sandine 1975), MRS with high concentration of sugars (100/g) (Van Geel-Schutten et al 1998) and milk agar (Mozzi et al 2001).

Milk fat contributes to the body, texture and flavour development of dairy products. Fat reduction to satisfy consumers demand leads to textural and functional defects in low-fat yoghurt, cheeses, *dahi*, and kefir (Mistry 2001, Guven et al 2005). In low-fat yoghurt and *dahi*, lack of flavour, weak body and poor texture are the major problems. Mechanical breaking particularly in stirred yoghurt, strongly affects the rheology of the coagulum and favour syneresis since the network formed by the gel is broken(Duboc and Mollet 2001). Low-fat cheeses have poor moisture retention ability, which otherwise moisture present in the cheese partially overcomes the problem of firm, rubbery body and texture created by high casein content (Mistry2001). Generally for cheese manufacture, the casein to fat ratio is 0.68-0.70, which gives desirable textural attributes. Due to fat reduction, the casein to fat ratio is disturbed and casein content is more in the resultant cheese consequently generating some textural defects. Low-fat Mozzarella cheeses have less tendency to melt and inferior baking characteristics (Fife et al 1996). These defects can be reduced by the use of additives to some extent but may not find wide acceptance to produce wholesome product. The consistent manufacture of good quality products that have good texture, mouthfeel and stability is important to the dairy industry. The manufacturers have used texture promoting or ropy cultures for many years particularly where addition of stabilizer is prohibited (Marshall and Rawson 1999). These cultures may impart higher intensity to flavour to the yoghurt due to the carbohydrate masking the flavour, mouth feel and other attributes (Tamimeand Robinson 1999). To reduce the amount of added milk solids, improve yoghurt viscosity, to enhance texture and mouthfeel and to avoid syneresis during fermentation or upon storage of the fermented milk products, EPS producingfunctional starters are interesting (De Vuyst et al 2003).

The apparent viscosity of skim milk gel made by both ropy cultures increased as compared to that made by non-ropy cultures (Tamime and Robinson 1999). However, combining two ropy cultures for yoghurt manufacture may not have always, additive effect (Faber et al 1998). Marshall and Rawson (1999) found that mixing a non-ropy strain of *Strep. thermophilus*with a ropy strain of *Lact. delbrueckii*subsp. *bulgaricus*had a greater effect on viscosity of stirred yoghurt than combining 2 ropy strains. The authors suggested the interaction and cooperative growth that occur in mixed cultures, which also appear to influence EPS production in yoghurt. The presence of EPS in stirred yoghurt makes the product less susceptible to mechanical damage from pumping, blending and filling machines (Robinson 1981). Although, mechanical processing steps do increase the syneresis of the final product, use of EPS cultures can control this defect (Duboc and Mollet2001). Hassan et al (1996a, b) examined the rheological and textural properties of yoghurt made with strains differentiated as encapsulated non-ropy (in which an EPS capsule is formed), encapsulated ropy (secretes extracellular slime) and non-encapsulated non-ropy. Yoghurt made with ropy cultures exhibited increased viscosity and shear stress values; however, differences attributed to the type of polysac-charide secretion (capsule or slime) were apparent. The presence of bacterial capsule may enhance some rheological properties such as viscosity, but may weaken the gel structure. This has caused lower shear stress value compared to slime producers, which produce a more stretchable gel structure (Hassan et al 1996a). The types of EPS produced by the yoghurt bacteria have effects on the texture and syneresis. Yoghurt made with encapsulated non-ropy cultures had the lowest firmness and curd tension, but exhibited less syneresis than unencapsulated cultures. The lower firmness in the yoghurt made by slime producing cultures might have been due to the polysaccharide interfering with the casein structure (Hassan et al 1996b). Several microstructural studies have indicated that it is not the amount of EPS, which is important to the rheo-logical properties of fermented milk but the type of EPS and therefore the interaction of the polymer with the bacterial cell and the milk protein is important during the fermentation (Marshall and Rawson 1999). Folkenberg et al (2005) observed 2 types of microstructure in yoghurt made with different EPS producing cultures, one in which EPS is associated with the protein network and another where EPS appeared to be incompatible with the protein. Yoghurt in which the EPS were associated with protein had ropiness, low serum separation and appeared more resistant to stirring than EPS appeared incompatible with protein.

Incorporation of EPS strains in the starter culture retains significant amount of moisture in a variety of low-fat cheeses that positively influence their functionality (Awad et al 2005, Zisu and Shah 2005). Perry et al (1997) investigated the influence of an EPS-producing starter pair *Strep. thermophilus*MR-1C and *Lact. delbrueckii*subsp. *bulgaricus*MR-1R on the moisture and melt properties of low-fat Mozzarella cheese. Cheese manufactured with MR-1C and MR-1R contained significantly ($p<0.05$) more moisture and had better melting properties than cheese made with an EPS negative commercial starter pair (*Strep. thermophilus*TA061 and *Lact. helveticus*LH 100). The water binding properties of *Strep.thermophilus*MR-1C was ascribed to its large capsule. Cheddar cheese made with EPS-producing *Lact. lactis*retained more moisture (45.8-47.2%) than control made with no EPS producing strains (44.9-45.8%). The texture profile analysis revealed that cohesiveness, chewiness and tortion shear strain values of the *Lact. lactis*cheeses were lower than those of control and the meltability and springiness values were higher because EPS contained cheese had a more open structure, which is more conductive to mastication and melting (Tunick et al2003). EPS producing cultures improved textural, melting and sensory characteristics of reduced fat cheddar cheese (Awadet al 2005). A ropy *L. lactis*subsp. *cremoris*strain produced reduced-fat cheddar cheese with a moisture in the non-fat substances level and textural and melting properties similar to those of the full-fat type due to the ability of EPS to bind significant amounts of free water. Nauthand Hayashi (2004) patented the process of manufacture of fat-free cream cheese, added with ropy culture. The fat-free cream cheese has comparable firmness, consistency and flavour of a conventional higher fat cream cheese.

Besides yoghurt and cheese, the other fermented milk products in which EPS cultures have been shown to affect physical properties are sour cream, kefir and European cultured dairy products. Use of slime producing *Strep.thermophilus*strains greatly improved rheological properties of cream turo and number of other Hungarian cultured milk and cultured cream products (Obert 1984). Kefir is traditional self-carbonated slightly alcoholic fermented milk from Eastern Europe (Roginski 1999, Tamime and Robinson 1999). Kefir is prepared by inoculating kefir grains, which consists of homofermentative, heterofermentativeLAB, yeasts and acetic acid bacteria. The cells are embedded in kefiran, a slimy polysaccharide, which also found to affect texture of kefir (Micheli et al 1999).

2. Conclusion

Food and Dairy industry is looking for the multifunctional strains of LAB that contribute to the organoleptical, technological, nutritional and health properties of fermented milk products. EPS producing lactic cultures have tremendous potential as functional starters, which can be better substituted to many commercial additives in use. They have significant effect on rheological and organo-leptic properties of a food. Incorporation of these cultures in to food products not only satisfy consumer demands of natural, healthy and low calorie food product but also provide food with as few food additives as possible. Use of EPS producing cultures reduce the amount of total solids required to manufacture dahi, lassi and yoghurt and thus making the process cost effective. Fermented milks, especially made by traditional method in rural areas, are the potential reservoir for isolation of EPS producing cultures.

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