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Derleme Makalesi / Review Article

Exopolysaccharides in Milk And Dairy Products as a Functional Component

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Abstract: Polysaccharides produced out of cell wall by some lactic acid bacteria strains are called exopolysaccharides. The synthesized exopolysaccharide amount and the characters are influenced by environmental conditions such as incubation time, pH and temperature. Exopolysaccharides may be used primarily in many areas of food industry due to functional properties. Exopolisaccharides improves appearance, flavor, viscosity and the organoleptic properties of fermented milk products such as cheese and yoghurt. It was also reported that exopolysaccharides can be used as functional starter cultures in yoghurt. Structural defects occurred in reduced-fat dairy products may be reduced by using exopolysaccharide. Moreover, prebiotics activity has been reported with some exopolysaccharides. At the same time, it is also reported that EPS show antitumor, antiulcer, anti-viral and cholesterol-lowering activity contributing positively to human health. Besides all these features, the lack of any restrictions on exopolysaccharide consumption and absence of any allergic reactions increase the possibilities of feeding sensitive individuals. In this study, usage possibilities of exopolysaccharides as a functional component in milk and dairy products will be discussed in the light of current studies.
Keywords: Exopolisaccharides, milk products.

Süt ve Ürünlerinde Fonksiyonel Bileşen Olarak Ekzopolisakkaritler

Özet: Bazı laktik asit bakteri (LAB) suşlarının hücre duvarı dışında ürettikleri polisakkaritler ekzopolisakkarit (EPS) olarak isimlendirilmektedir. Sentezlenen EPS miktarı ve özellikleri pH, sıcaklık ve inkübasyon süresi gibi ortam koşullarından etkilenmektedir. EPS'ler çeşitli fonksiyonel özelliklerinden dolayı başta gıda sektörü olmak üzere pek çok alanda farklı amaçlarla kullanılabilmektedir. EPS'ler peynir ve yoğurt gibi fermente süt ürünlerinin görünüş, tat, viskozite ve duyusal özelliklerini iyileştirmektedir. EPS üreten laktik asit bakterilerinin yoğurtlarda fonksiyonel starter kültür olarak kullanıldığı da bilinmektedir. Süt ürünlerinde yağ oranının azaltılmasıyla meydana gelen yapısal kusurların EPS'lerle giderilebildiği ifade edilmektedir. Ayrıca bazı EPS'lerin prebiyotikler gibi özellikler gösterdiği bildirilmiştir. Aynı zamanda EPS'lerin antitümör, antiülser, anti-viral ve kolestrol düşürücü aktivite göstererek insan sağlığına olumlu katkıda bulunduğu söylenmektedir. Bütün bu özelliklerinin yanı sıra, EPS'lerin tüketilmesiyle ilgili herhangi bir sınırlama bulunmaması ve tüketilmeleri durumunda herhangi bir alerjik reaksiyon rapor edilmemesi, bu maddelerin özellikle hassas bireylerin beslenmesinde kullanılma imkanlarını arttırmaktadır. Bu çalışmada EPS'lerin süt ve ürünlerinde fonksiyonel bileşen olarak kullanım olanakları yapılan çalışmalar ışığında tartışılacaktır.
Anahtar Kelimeler: Ekzopolisakkaritler, Süt Ürünleri

Introduction

Some lactic acid bacteria (LAB) strains produce polysaccharides outside of the cell wall. These polysaccharides are called as EPS (Hassan et al. 1996; Bouzar et al. 1997; Hassan et al. 2001). EPS produced by LAB are divided into two main groups as homopolysaccharide and heteropolysaccharide (Şimşek ve Çon. 2003). While homopolysaccharides are formed with a combination of a monosaccharide with a single carbohydrates character or a disaccharide, heteropolysaccharides consist of different monomer structures (Kılıç, 2001). Synthesized EPS amount and character is affected from pH, temperature and incubation time and may show variation according to the amount of substrate and its composition (Garti ve Reicmen 1993; Fajardo et al. 1997; Ruas-Madiedo et al. 2002; Mozzi

et al.1985). In the composition of EPS, there are mostly galactose and glucose Rhamnose also often take place in this embodiment (Cerning, 1990). EPS' usually differ depending on the monosaccharide composition, electric charge, bonding units (as a result of this molecule stiffness) and to the presence of repeated side chains. Also, since the frequency of chain branching and chain length affect the compact structure of EPS, it strongly affects the rheological properties (Perry et al.1997; Perry et al.1998; Broadbent et al. 2001; Duboc and Mollet. 2001).

Also place of the EPS' in the gel is an important factor that affects the viscosity (Sodini et al. 2004). Conclude that keeping protein colloidal particles and casein micelles in the serum together is also effective on the viscosity (Tuinier et al. 1999). As it is known, the rheological characters is very important for formation of a consistency in the fermented dairy products so that its has an attractive appearance for the consumer and felt good in the mouth (Sebastiani and Zelger. 1998; Skriver et al. 1993).

Even if the recognition of fermented milk products goes back to the antiquity, the knowledge of the bacteria that causes its formation is new (Kılıç, 2001). A large part of the LAB is used as starter cultures in the dairy industry. Some of these bacterial form milk acid by decomposing milk sugar and the others form various ingredients by breaking milk fat and the protein. Doing this, they help the formation of particular taste, aroma, appearance and structure of the product (Yaygın and Kılıç. 1993).

By the way entering interaction with the protein matrix, the exopolysaccharides increase their water binding capacities (Hansen et al.1994; Hess et al. 1997; Amatayakul et al. 2005). Having new functions and many interesting physical, chemical and rheological properties, EPS' acts like the newly implemented many other biomaterials and they offers a wide usage potential in such applications as textiles, detergents, adhesives, oil and waste water improvements, river bed cleaning, fermentation, stream processing process, cosmetic, pharmaceutical and food additive (Becker et al. 1998).

The İmportance of exopolysaccharides in terms milk products

Today, it is known that lactic acid bacteria used in the production of fermented milk products synthesizes EPS (Kılıç, 2001). EPS' plays a major role in the production of cheese, yoghurt, butter, and various dairy desserts. Because of its properties such as viscosity enhancement, structure regulation structure, binding water, stabilizing and emulsifying, EPS' have a positive effect on the structural features of dairy products. EPS' are especially effective on the texture and stability of the final product (Duboc and Mollet. 2001; Frengoven et al. 2002).

Functions of exopolysaccharides in cheese production

Having perfect water-holding capacity EPS have in a wide usage area in cheese technology especially to develop functional properties low-fat cheeses (Broadbent et al. 2001). Low-fat cheese became a rubbery and stiff structure and more heat is needed for its melting (Low et al. 1998). It is a major disadvantage for Mozerella and such kind of cheeses. Mozerella cheese, widely used in the construction of pizza, is required to have a good dissolution characteristic. Therefore, about the low-fat cheeses that are hard to melt, many studies were carried out to eliminate this

deficiency (Broadbent et al. 2001). In one study, it was reported that EPS-producing *L. helveticus* increases water holding property in the production of Mozerella cheese. According to the results obtained in other studies, it was reported that *Str. Salivarius* ssp. *thermophilus MR-IC* significantly enhances the amount of water of cheese and this effect is related to the capsular EPS produced by the same bacteria (Duboc and Mollet. 2001; Low et al. 1998).

EPS starters are effective in moisture retention in low-fat cheese. When EPS is used in the production of Mozerella cheese functional properties are greatly improving and efficiency is increasing in the cheese. However, since some of EPS switch to the whey and increase the viscosity during the output stage, usage of starter cultures which produce EPS is restricted. As a result of the other studies, it was found that starters which produce EPS in mucosal structure cause such problems not the capsular EPS producing bacteria. Therefore, in terms of cheese-making technology, capsular EPS-producing strains were reported to be more suitable than the others (Broadbent et al. 2001; Petersen et al. 2000).

Functions of exopolysaccharide in the production of yoghurt

Features that are very important in yoghurts are textural properties, hardness and water binding ability. These properties are resulting from gel structure or used cultivars (Duboc and Mollet. 2001). During the production of yoghurt, the most common seen physical problems, such as loose structure and serum separation are undesirable by both producers and consumers and this can be usually avoided by the use of appropriate additives (Kılıç et al. 2000). Most consumers choose pure food or foods defects of which are naturally remedied (Duboc and Mollet. 2001).

EPS have two major functions on texturing of dairy products like yoghurt and similar products. The first is to absorb the water thanks to its hydrophilic character and the second one is to prevent movement of the free water in the protein matrix. Moreover, EPS, by entering interaction with the protein matrix increases their water binding capacities (Hansen et al.1994; Hess et al. 1997; Amatayakul et al. 2005). Also EPS producing *Str.salivarius* ssp. *thermophilus* and *Lb. delbrueckii* ssp. *Bulgaricus* strains are widely used in the production of yoghurt to fix the structure, to reduce the viscosity and to increase serum separation. One factor influencing the viscosity is the hardness of the chain of EPS. Although having almost the same molecular weight with the xanthan gum of EPS that is formed by *Lactobacillus sake* 0-1 strain, its viscosity is higher (Ruas-Madiedo et al. 2002).

With a study, it is determined that yoghurt manufactured with strains of mucous structure EPS has a higher viscosity compared to the yoghurt produced from cultures without EPS synthesis and it is appropriate to use EPS producing cultures in the production of fruit yoghurt to secure the clot (Hassan et al. 2001). It is very important for the consumer that yoghurt and fermented milk products should have an attractive appearance and a consistency perceptible in the mouth in terms of rheological properties (Skriver et al. 1993). It was found that an improvement happens in the rheological character of yoghurt made with EPS. It is reported that the type of EPS is also effective due to the amount of polysaccharide produced on rheological behavior and different interactions with milk protein and cells and the polymer (Hess et al. 1997;

Rawson and Marshall.1997). With the use of EPS positive strains in yogurt making, sinerezis can be prevented (Laws and Marshall. 2001). In another study, it was found that sensory and textural defects formed by reducing the fat content are less in the yoghurt samples which EPS producing cultures are used. It is reported that especially the sensory properties of yoghurt fatty ratio of which is adjusted to % 1.5 and produced with EPS cultures have similarities with full fat yoghurt (%3) and it is preferred more by the panelists (Korkmaz, 2005).

Functions of exopolysaccharides in the production of ice cream

In a study, the fact that two different kind of exopolysaccharide obtained from whey (EPS1-EPS2) and combination of some stabilizers (Xs-CMC) have effect on some properties of ice cream were investigated. According to this study, it is determined that in general dissolution time of ice cream produced by using EPS1 is longer than the other examples and the values of volume increase in these examples were lower than other samples. Except in the case EPS1, serum separation has not been established in other instances and ıt was reported that structure stiffness values of ice cream produced by using only EPS2 and the combination EPS2-Xs was significantly lower than of other ice-creams. As a result, to use appropriate EPS alone or in combination with commercially stabilizers in the production of 'ice-cream is possible but the specificity or but physicochemical properties of thes elected EPS should be deeply investigated (Altun, 2012).

Functions of exopolysaccharides in the production of kefir

Kefir, with nearly 1 % alcohol found in, is a fermented milk product manufactured by using kefir grains or special starter cultures. Kefir grains are mainly formed by polysaccharides which are consisted of by yeast and bacterial cells (Frengova et al. 2002). Kefir grains form kefir polymer which constitutes matrix of kefir grains that include a large amount of the *Lactobacillus kefir anofaciens* (Schillinger, 1999). In a study, it was determined that some strains of *Lactobacillus hilgardii* that are used in producing kefir produce polysaccharide at a significant point (Kılıç, 2001).

It was reported that among the Lactic acid bacteria that are isolated from kefir, *Lb.delbrueckii* ssp. *Bulgaricus* strains are the most capable bacteria producing EPS . Other bacteria and yeasts contained in kefir were found to increase these bacteria's ability of producing EPS (Frengova et al. 2002).

Functions of exopolysaccharides on other fermented milk products

Lactococcus lactis ssp. *cremoris* strains that are capable of producing EPS are being used mostly in the production of fermented dairy products like Vila and Longfil that are consumed in the Nordic countries. It was found that this bacteria isolated from Villi produces EPS that comprise rhamnose, galactose and glucose (De Vusy and Degeest. 1999; Duboc and Mollet. 2001). By using EPS producing strains in the production of Vila, tackiness of these products increases, sineresiz reduced and the structure consists by holding of bacterial cells to the protein matrix (Schillinger, 1999).

Effects of exopolysaccharides on health

It is at least 40 years in Japan and longer than 20 years in Germany that the human origin lactic acid bacteria (LAB) are used in the manufacture of fermented

dairy products. Recently, according to scientific studies, due to its positive effects on human health, some strains of LAB producing EPS are reported to be used as functional starter cultures in fermented dairy products such as yoghurt (Schillinger, 1999; De Vuyst et al. 2003; Welman and Maddox. 2003).

Lately, many developed food products and dairy products containing probiotic bacteria have taken place in market. It is known that dairy products containing probiotic bacteria are the second most consumed products in European countries. At the same time, some EPS' acting like prebiotics contribute to human health by correcting micro flora of digestive system (Ruas-Madiedo et al. 2002; Stanton et al. 2001; Mattila-sandholm et al. 2002; Menrad, 2003; Helland et al. 2004). In addition, acting as the prebiotic immune system regulators and cholesterol-lowering against to the some of the offending diseases to human health, EPS' have a positive effect on human health (Ruas-Madiedo et al. 2002; Sullivan and Nord 2002; Kumar et al. 2004; Bayram and Heperkan 2006). Having no restriction of consuming and no nutrition problems insensitive individuals if consumed make consumption facilities of these products to spread (Altun, 2012).

Other functional features of exopolysaccharide

Besides its beneficial effects on textural and rheological properties of milk and milk products and health of the consumers, EPS protect against natural environment dangers like water activity whose producer strain is decreasing, phage hazards, protozoa plunder, toxic compounds, antibiotics and the osmotic pressure, etc. also, it helps cell to adhere surface environment and to colonize (Schillinger, 1999). Due to their new functionality and many interesting physical, chemical and rheological properties, EPS act like many other newly implemented biomaterials and offer a wide usage potential in such applications as textiles, detergents, adhesives, oil and waste water improvements, cleaning the river bed, fermentation, stream processing, cosmetics, pharmaceutical and food additive (Becker et al. 1998).

Result

Having such properties as viscosity enhancer, regulatory structure, water-binding, stabilizing and emulsifying, EPS have a positive effect on the structural features of dairy products. EPS' are especially effective on the texture and stability of the final product. Due to these characteristics, usage of EPS-producing strains has a great importance in the production of dairy products. But having a lack of synthesis and not being stable genetically limits usage advantages of EPS. However, this disadvantage can be eliminated by the creation of optimum fermentation conditions and new starter can be gained the dairy industry. Acting like prebiotics, EPS because will maintained people. Also due to their different functions, EPS can be utilized in other industrial sectors.

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