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Stabilizers: Indispensable Substances in Dairy Products of High Rheology

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Stabilizers: Indispensable Substances in Dairy Products of High Rheology**MADIHA TASNEEM, FARZANA SIDDIQUE, ASIF AHMAD, UMAR FAROOQ*****ABSTRACT***

The functionality of stabilizers is apparent in many food applications including dairy products. The role of stabilizers like gelatin, pectins, alginates, carboxymethylcellulose, gums, ispaghol, sago starch and chitosan in the development of dairy products of high rheology like yoghurt, ice cream and flavored milk is discussed in this review. Attention is also paid to comprehend on interactions among milk proteins, minerals and other milk constituents with the reactive sites of stabilizers to get the desirable properties such as

appearance, body and texture, mouth feel, consistency. The role played by stabilizers in the control of syneresis and overrun problems in the high rheology dairy products is also the topic of discussion.

Keywords stabilizers, dairy products, yoghurt, flavored milk, ice-cream

INTRODUCTION

Stabilizers are indispensable substances in food items and categorized as food additives. They smoothen the texture of the food by making the homogenous dispersion of two or more immiscible materials. Food products acquire a definite framework with well maintained physico-chemical attributes after their addition (Baer et al., 1997). Apart from basic stabilization and improvement in texture, they do behave as nanostructures to control, retain and intensify an existing color and flavor of the food product (Fiszman and Salvador, 1999; El Sayed et al., 2002).

A wide range of stabilizers is being used in food industry and their legitimate use date back for more than half a century (Dickinson, 1988; 1992; 2003) for diversified food products including: bakery, beverages, confectionery, margarine, shortenings and dairy products (Marozziene and de Kruif, 2000). Stabilizers are used customarily to improve thickening, mouth feel, product structure stability (Harris, 1990) water-binding capacity, creamy consistency and viscosity. Their application in food products reduced to rely on egg content and fats thus enabling the development of low calorie products (Keogh and Kennedy, 1998). Water binding phenomenon also ensures a better shelf life of the product (Keogh and Kennedy, 1998). The choice of stabilizer according to nature of food product is important and greatly depends on several variables such as functional properties of the stabilizer, intended use and outcome, interactions with other ingredients, and legal aspects (Harris, 1990; Imeson, 1997; Early, 1998; Phillips and Williams, 2000).

FOOD GRADE STABILIZERS

The stabilizers used to enhance the shelf life of food product by preventing them from the microbial attack are called food grade stabilizers. Alginic acid ($C_6H_8O_6$)_n (Figure 1) is a popular food stabilizer that is derived from brown algae is extensively used in ice-cream and syrups used as toppings on desserts (David et al., 2005). Similarly Carrageenan (Figure 2) is an anionic hydrocolloid and classified as adsorbing polysaccharides used in different dairy products (Hansen, 1993). Agar Agar obtained from red algae and is widely used as thickener in foods

(Livney and Hartel, 1997). Guar gum (Figure 3) is a naturally existing polysaccharide, extracted from the seeds of a leguminous plant *Cyamopsis tetragonoloba* (L.) containing of 1, 4- β -D-mannose backbone and 1, 6- α -D-galactose side chain, with 1:2 ratio of galactose/mannose (Sinha and Kumria, 2001). It is used as thickening and stabilizing agent (Lal et al., 2006) having highly viscous colloidal dispersion property especially in acidic products like yoghurt. Carboxymethylcellulose (CMC) (Figure 4) is a polysaccharide hydrocolloid compound of β -1-4 glucose polymers with extensive application in dairy products (Imeson, 1997). Gelatin ($C_{102}H_{1510}N_{31}$) (Figure 5) is a natural stabilizer derived from collagen (Harris, 1990; Lee et al., 1990; Collins et al., 1991), widely obtained from pigskin, cattle hides, or cattle bones (called ossein). It is best gelling/thickening agent that related to the yoghurt rheology and imparts good resistance to the syneresis (Lal et al., 2006). Aqueous extraction of edible plant material (usually citrus fruits or apples) is used to obtain pectin ($C_6H_{10}O_7$) (Figure 6), a purified water-soluble colloidal carbohydrate product (Tromp et al., 2004). It is applied as stabilizers in dairy products (Maroziene and de Kruif, 2000).

FOOD APPLICATION OF STABILIZERS

The application history of stabilizers in food can be traced well back from traditional to industrial use. Despite conventional food items the stabilizers are now used in number of dairy products due to their functional properties. The objectives of concern are to increase the shelf life and attain the desirable traits in food products with increased kinetic stability of food emulsion that ultimately maintaining the physical attributes of the food (Dickinson, 2009).

Yoghurt

Yoghurt is one of the traditional semi solid fermented milk products, widely consumed all over the world (Farinde et al., 2010). It was originated from Bulgaria, where it is known as “Yourt” and in Turkey it is known as *Yogen*, meaning *thick* (Seckinkomal, 2004; Zehra and Young, 2011). Fermented dairy products are produced on large scale in USA with yoghurt being the second most popular snack among children (Sloan, 2006). Starter culture containing *Streptococcus thermophilus* and *Lactobacillus bulgaricus* is used for milk fermentation to manufacture yoghurt (De Brabandere and De Baerdemaeker, 1999; Tamime and Robinson, 1999; Mehmood et al., 2008; Sahan et al., 2008; Sera et al., 2009). Yogurt culture tends to reduce the harmful effect of pathogenic bacteria in the gut (Vasiljevic and Shah, 2007). The development of a three-dimensional protein network during fermentation is responsible for semi-solid texture of yoghurt. This gel network is often affected by the use of stabilizers through binding of water and other substances. Culture behavior and pH of the yoghurt gel during fermentation process also have a modifying effect on this network (Hassan et al., 1996; Afonso and Joao, 1999). The elastic gel structure having solid-like behavior forms at a pH of around 5.6, causing changes in the micelle structure because of the solubilization of colloidal calcium phosphate, then further reduction in pH makes a more complex and extensive interconnection of casein particles, leading to the formation of a continuous protein network and thus maintaining the structure of yoghurt (Steventon et al., 1990; Shoemaker et al., 1992; Lee and Lucey, 2004; Martin et al., 2005).

Textural properties of yoghurt like viscosity (Marshall and Rawson, 1999), smoothness, thickness (Jaworska et al., 2005) and structural resistance to stress (Skriver et al., 1999) are important attributes based on protein content, heat treatment of the mix (Harwalkar and Kalab, 1986; Lee and Lucey, 2010) and the presence or absence of milk fats, bacterial exopolysaccharides and stabilizers (Modler and Kalab 1983; Schellhaass and Morris, 1985; Teggatz and Morris, 1990). It has been reported that the viscosity of yoghurt appears to be more influential than flavor (van Vliet et al., 1997; Jaworska et al., 2005) and found to be affected by the addition of the stabilizers (Fiszman et al., 1999; Lucey, 2002; Jimoh and Kolapo, 2007).

Natural and modified gums, seaweed extract (carrageenan, alginates) and gelatin are some examples of stabilizers used in yoghurt. These additives have the property to form gel networks and their addition allows the production of yoghurt with firm texture and high resistance for water separation (Augustin, 1999; Maha et al., 2011). Viscosity of yoghurt increased with the addition of up to 2% (w/v) stabilizer, and then decreased until 0.4% (w/v) stabilizer level was reached. Higher quantities of stabilizers cause rapid increase in viscosity. Sedimentation of the milk protein increased with lower levels of stabilizers, but once the level of stabilizer increased beyond the level of minimum viscosity the sedimentation decreased (Towler, 1984).

Stabilizers have the ability to form a network of linkages between themselves and the milk constituents because of the hydrogen or carboxyl radicals present in their structure (Tamine and Robinson, 1999). The negative sides got attached at the interface and water bound in basic

mix due to the presence of stabilizers (Ingenpass, 1980). Level of hydration improved by the attachment of water to milk constituents (proteins), forming a network, that reduces the free movement of water (Ingenpass, 1980). Carrageenan, gelatin, pectin, starch ($C_6H_{10}O_5$)_n, guar gum ($C_{12}H_{24}O_{12}$), locust bean gum (carob bean gum) sodium and propylene glycol alginates ($C_9H_{14}O_7$)_n, xanthan gum ($C_{35}H_{49}O_{29}$)_n and carboxymethylcellulose ($C_8H_{16}O_8$) are applied as stabilizer in yoghurt production (Hagiwara et al., 1996; Rosalina et al., 2004).

The addition of a stabilizer, responsible for gelling or thickening, such as gelatin, describe the rheological and organoleptic properties in yoghurt (Morr, 1985; 1989; Duboc and Mollet, 2001; Kumar and Mishra, 2004; Sodini et al., 2004) since they have the ability to retard the syneresis and offers a good sensation in the mouth (Jawalekar et al., 1993; Fiszman et al., 1999; El-Sayed et al., 2002; Amatayakul et al., 2006; Lal et al., 2006). The use of 0.1-0.3% gelatin improved the appearance, body, texture, and flavor of the yoghurts (Shukla et al., 1988; Shukla and Jain 1991). Animal protein collagen (Harris, 1990; Lee et al., 1990; Collins et al., 1991) obtained from pigskin, cattle hides, or a cattle bone (called ossein) is converted into gelatin through acidic and alkaline hydrolysis process. Gelatin is comprised mostly of amino acids held together with peptide bonds in a left-hand helix with no covalent cross linkage. Though nearly all amino acids are found but proline, hydroxyproline, and glycine are predominant (Fennema, 1994). Gelatin firmer network is attributed to the presence of pyrrolidine (Rolin and Vries, 1990) which is important for forming junction zones. Application of heat in the range of 27°C to 34°C causes the gelatin to melt (Imeson, 1997). Upon cooling, those areas that contain glycine-proline-proline sequences contain a left-hand turn of the helix structure (Phillips

and Williams, 2000). Aggregation of three of these helices creates junction points, similar to those found in collagen and hydrogen bonds stabilize the arrangement (Harris, 1990; Fennema, 1994; Imeson, 1997; Phillips and Williams, 2000) resulting in three-dimensional gel structure. Several factors, including pH, setting time, temperature and interactions with other ingredients affect the strength of the gels. Similarly, these factors may also affect other characteristics of a gelatin gel. For example the melting point may be altered by the setting conditions, concentration and other ingredients as well. Likewise, viscosity may be affected by pH, temperature and concentration. These changes in melting point and viscosity attributes ultimately influence the mouth feel and other sensory characteristics (Harris, 1990; Imeson, 1997; Phillips and Williams, 2000).

Aqueous extraction of edible plant material (usually citrus fruits or apples) is used to obtain pectin ($C_6H_{10}O_7$), a purified water-soluble colloidal carbohydrate product (Tromp et al., 2004) used as stabilizer in yoghurt. It is generally comprised of 1, 4-linked -D-galacturonic acid with degree of esterification up to 80% (Harris, 1990; Imeson, 1997; Phillips and Williams, 2000). Methyl esterified derivatives of pectin often used suitably in food products (Fennema, 1994). Stabilization of multiphase foods is done by the use of pectin, either in the end or in the mid of the process. Although it is typically associated with fruit jellies and preservation but can be utilized for yoghurt production (Harris, 1990; Imeson, 1997) particularly high methoxyl pectin has been reported to improve colloidal stability in fermented milk products (Marozienne and de Kruif, 2000; Tromp et al., 2004). Generally, 0.2-0.3% concentration of the pectin improved the quality attributes of yoghurt like appearance, body, texture, and flavor and reduced whey

separation and extended shelf life (Glahn, 1982; Shukla et al., 1988; Shukla and Jain 1991; Pedersen and Jorgensen, 1991; Kiani et al., 2010). The ability of gelation increases by the gelation of the water phase and reduction in the effective charge on the casein particles, (Rolin and Vries, 1990), casein micelle flocculation is increased through depletion in interactions (Maroziene and de Kruif, 2000) and a gel formation which is low ester pectin occurred (Abbasi and Dickinson, 2002), this phenomenon described the gelling behavior of pectin.

Depending upon the degree of esterification there are two types of pectin ($C_6H_{10}O_7$) including high ester and low ester pectin. By definition, high-methoxy pectin (referred as high-ester pectin), denoted by HMP, is > 50% esterified. Conversely, low-methoxy (low-ester; LMP) pectins have <50% methyl-esterification of the galacturonic subunits (Harris, 1990; Imeson, 1997; Phillips and Williams, 2000). These variations in degree of esterification influence the properties of commercial grade pectin. Addition of high ester and low ester pectin bound the micelle aggregates and increases viscosity, respectively (May, 2000). Large number of methoxy groups associated with HMP mostly inhibits gelling in the presence of calcium. Instead, these highly esterified pectin have gelling ability with sugar and acid, a characteristic not shared with LMP. The acid environment causes the side chains to become protonated while the sugar molecules dehydrate the structure, creating junction zones, which form the gel. Many non-esterified carboxylic acids in LMP prevent the structure from being dehydrated enough for gel formation (Harris, 1990; Imeson, 1997). These two types of pectin also differ in setting. Low methoxy pectin will set almost as soon as appropriate conditions are met. High methoxy pectin, however further categorized as low-set, medium-set, and rapid-set. Generally, higher the degree

of esterification, faster the gel is set (Harris, 1990; Imeson, 1997). In yoghurts HMP is used as a stabilizer to produce the gelling effect in it. This thermally irreversible hydrocolloid can be added to a milk product at higher pH, followed by immediate acidification resulted in a product having gel strength that is maintained to low pH values. HMP is useful for production of yoghurt that exhibits good mouthfeel characteristics and higher viscosity (Phillips and Williams, 2000).

Guar gum, locust bean gum, acacia gum and xanthan gum reduces flocculation at a low concentration of stabilizer, and intent aggregated casein within a gelatinous polysaccharide solution at elevated concentrations. Behaviour is affected by the pre-sharing setting of the stirred yogurt (David et al., 2005). Guar gum is a polysaccharide abundantly found in nature. The commercial source is the seed of a leguminous plant *Cyamopsis tetragonoloba* (L.) consisting of 1, 4- β -D-mannose backbone and 1, 6- α -D-galactose side chain, and the ratio of galactose/mannose is 1:2 (Sinha and Kumria, 2001). It is used as a thickening and stabilizing agent (Goldstein et al., 1973). Guar gum exhibits highly viscous colloidal dispersion in acidic products like yoghurt which increases the viscosity and prevents syneresis (Krishnaiah et al., 2002; Lee et al., 2002; Satyanarayan et al., 2002; Koksoy and Kilic, 2004). High temperature and acidic conditions converts it into monosaccharide and its viscosity decreases upon hydrolysis (Tuinier et al., 2000; Wang et al., 2000) that ultimately increasing its gelling ability. A complex branched heteropolyelectrolyte obtained from the exudates of the acacia tree is known as Gum acacia. It is a fiber source, forms complex and elastic gels due to high molecular weight. It has been shown in studies that flavor intensity in cheese milk improved by emulsification of the fat

with gum acacia (Whitehouse and Hammond, 1995). Use of neutral gums (xanthan and guar gum) as stabilizer enhanced texture and prevented the syneresis defect (Soukoulis et al., 2007).

Another fiber source used as stabilizer is carboxymethylcellulose (CMC), a polysaccharide hydrocolloid composed of β -1-4 glucose polymers that have been derivitized with carboxy methyl groups derived from cellulose. The properties of CMC can vary, depending upon many factors including molecular weight, degree of polymerization and substitution, ingredient interactions and other conditions. Molecular weight and degree of polymerization, for instance, can produce CMC that exhibits range of low to high viscosities at a certain concentration in solution. In addition, the viscosity of CMC solutions is inversely related to temperature, prolonged exposure to high temperatures can irreversibly degrade CMC, which affects the viscosity upon cooling (Imeson, 1997). CMC tends to be used as a gelling agent in dairy products like yoghurt, as this hydrocolloid can react with casein near the isoelectric point, producing a soluble complex (Soukoulis et al., 2010).

CMC/casein complexes are stable under heating, with slight decrease in viscosity. However, this system is affected by shearing and agitating that decreases the viscosity. Consequently, this polymer finds possible use in yoghurt at a recommended usage level of 0.5% at pH 4.3-4.4. These conditions necessitate the stabilizer to be added after fermentation. If added prior to fermentation, protein agglomeration, whey separation and other defects are more likely to occur (Imeson, 1997; Tamime and Robinson, 1999; Phillips and Williams 2000).

Carrageenan classified as adsorbing polysaccharides is an anionic hydrocolloid interacts with the positive charges on the surface of casein micelles to build up the casein network and lessen syneresis (Hansen, 1993). The stabilization mechanism found constant with the model of casein aggregates passing through an area of bridging flocculation, and partial steric stabilization that occur by the increased level of carrageenan (David et al., 2005). Higher strength values in gel can be obtained by increasing amount of carrageenan, which stood responsible for the build-up of a continuous network (Trckova et al., 2004) ultimately reducing the occurrence of syneresis (Therkelsen 1993; Langendorff et al., 1997; Bourriot et al., 1999; Verbekena et al., 2006). Depending upon the type and the concentration used, it helps to develop a product with desired texture (Triaus and Sebranek, 1996; Imeson, 2000; de Vries, 2002).

By using the different thickening and gelling agents, equipment and process conditions a wide range of ready-to-eat milk-based desserts are available to the consumer offering a variety of textures, flavor and appearances. Traditionally, dairy desserts are gelled by combining starch with carrageenan. The hydrocolloid carrageenan, is a sulphated polysaccharide extracted from red seaweeds (De Wijk et al., 2003; Tarrega et al., 2004). Starch affects the structure primarily through omission effects, helping the gelation of the other gelling agents in the aqueous phase (Verbeken et al., 2004). It also enhances mouthfeel by breaking up the consistent carrageenan gel (de Wijk et al., 2003). It has been reported that carrageenan bound electrostatically with the positively charged portion on k-casein (Snoeren et al., 1975) helping in the formation of a coupled network between the k-casein on bound micelles and the charged sulphate groups on k-

($C_{12}H_{17}O_{12}S$)_n and i-carrageenan ($C_{24}H_{34}O_{31}S_4^{-4}$) in the helix state (Arltoft et al., 2007; Langendorff et al., 2000).

Starch imparts body and mouthfeel to the product while carrageenan provides the desired texture by depending on the type and the concentration used (Trius and Sebranek, 1996; Imeson, 2000; De Vries, 2002). A decrease of the starch content and thus of the caloric value of the dessert and lower viscosity during processing are the advantages experienced by the use of starch/ carrageenan blends in comparison to the use of starch alone (Descamps et al., 1986; Rapaille and Vanhemelrijck, 1992). It was also found that shear degradation of starch granules can be protected by carrageenan. Upon heating and subsequent cooling, i- and k carrageenan form thermo reversible gels in the presence of gel-promoting cations (Tye, 1988).

The presence of milk proteins and starch content in the blend form of stabilizer effected the carrageenan gelation in dairy desserts. The influence of interaction between carrageenan and milk proteins on the formation and rheological properties of carrageenan gels have been reported in different studies (Snoeren et al., 1975; Dalgleish and Morris, 1988; Drohan et al., 1997; Tziboula and Horne, 1998; Bourriot et al., 1999; Langendorff et al., 2000; Schorsch et al., 2000; Puvanenthiran et al., 2003; Sedlmeyer et al., 2003). The rate of syneresis increases by decreasing the concentration of carrageen and this increase is more typical at low concentrations (Therkelsen, 1993).

Sago (*Metroxylon sagu*) starch is isolated from sago palm (*Metroxylon spp.*) (Ahmad et al., 1999) having great potential for starch production (Aziz, 2002; Awg-Adeni, et al., 2010) and considered as the highest starch producer (Ishizaki, 1997; Malviya et al., 2010) containing amylose (27%) and amylopectin (73%) (Ito et al., 1979). Sago dana (*Metroxylon sagu*) is the rich source of carbohydrate and it is used as gelling agent. It has self gelling property (Nene et al., 1996). It is more economical and used in different food products such as soups, candies and puddings. Because of its gelling property it has great potential to be used as stabilizer in dairy products of high rheology (Aziz, 2002).

Another stabilizer that can be used in dairy products is ispaghol (*Plantago Ovata*), a psyllium seed husk (portions of the seeds) of the *Plantago Ovata*, extensively cultivated in India and Pakistan (Ruchi and Sashi, 2006) is a very cheap alternative gelling agent (Atici et al., 2008). The seed of *plantago ovata* bears an ash like thing, which is called seed husk. When this husk comes in contact with water it forms a sticky substance (Gupta, 1982) which is actually a mucilaginous polysaccharide swells and expands by water absorption. Ground seeds of ispaghol are added to cereals or yoghurt and the husk mucilage is used as a thickener or stabilizer in certain dairy products. It is also used as hydrocolloidal agent to improve the water retention property (Rubis, 1990) of different food products.

Use of Chitosan ($C_6H_{11}O_4N$)_n (Figure 7) in food industry is well recognized because of its non toxic nature for warm blooded animals (Friedman and Juneja, 2010). Microcrystalline chitin (MCC) shows superior thickening, emulsifying and gelling properties for stabilizing

foods (Dutta et al., 2004). It is a natural, water-soluble, derivative of cellulose with exclusive properties and partially deacetylated polymer of N-acetyl glucosamine. Chitosan is usually prepared from chitin (2 acetamido-2-deoxy b-1, 4-D-glucan) and chitin has been found in a wide range of natural sources (crustaceans, insects, fungi, molluscs, annelids, coelenterata etc.) (Bolat et al., 2010). It is a good emulsifier with the ability to bind water, fat and dye having antimicrobial properties as well (Knorr, 1982; 1983; No et al., 2000; Hafdani and Sadeghinia, 2011; Orgaz et al., 2011). Decrease upon the particle size, increases viscosity and creaming stability, enhance texture and mouth feel property and reduces the phase separation behaviors of dairy products at pH 3 (Speiciene et al., 2007).

FLAVORED MILK

Normal milk is considered as complex food emulsion and colloidal solution as well. The emulsion comprised of fat particles dispersed in protein containing aqueous phase. The protein exist both as colloidal particles in the form of casein micelles and in solution as monomers of whey protein (Jensen and Kroger, 2000).

Flavored milk is a sweetened dairy product manufactured by blending milk with sugar, colorings and artificial or natural flavorings, stabilizers and emulsifiers (Boor, 2001). This type of milk is often treated using ultra-high-temperature (UHT) technique offering it a longer shelf-life than plain milk (Farinde et al., 2010). It has been revealed that its consumption improves the

overall quality of children and adolescents diet by increased nutrient intakes (Frary et al., 2004). It is an excellent nutrient-rich replacement for soft drinks and fruit drinks as children can get the calcium essentially required for growth and development that is absent in conventional soft drinks (Johnson et al., 2002). Lactose intolerant people can easily digested flavored milk (Dehkordi et al., 1995; Lee and Hard, 1989). In chocolate milk the addition of coca enable it to slow down the emptying of stomach, making this beverage better tolerated as compared to unflavored milk. It is the way; individuals could happily drink two cups of milk a day with lactose intolerance condition (Suarez et al., 1997).

For the preparation of flavored milk with desired properties like better mouth feel, body and texture, consistency and viscosity different stabilizers and emulsifiers or their blends are used (Murphy, 2005). These blends are produced by mixing of different ingredients which provide steady fat emulsification process and prevent cream separation during storage and extended shelf life. Other functions of these additives includes the prevention of vegetation juices separation, used in the recipe of the flavored milks by offering certain desired levels of thickeners and, to increase the heat stability of milk protein along with perfect structure of dairy products (Trckova et al., 2004). The most common flavoring agent for milk is chocolate, which is obtained by the addition of cocoa powder. Chocolate milk is complex suspension system, which is composed of milk or dairy fluid as dispersion phase and cocoa particles, sugar, stabilizers, etc. as solid ingredients present as dispersed particles. The rheological properties of chocolate milk are affected by the flow behavior of the dispersion phase and the dispersed solid ingredients interacting with the dispersion phase and with each other (Franck, 2002).

Among these solid ingredients the stabilizers play major role in the stability of rheological properties of flavored milks. Carrageenan and K-carrageenan is the most common stabilizer used in chocolate milk formulations (Langendorff et al., 2000 and Schorsch et al., 2000). Carrageenan provides excellent suspending characteristics to cocoa which imparts homogenous texture and appearance to chocolate milk and provides excellent flavor release. Use of inulin also exhibited a great potential in stabilizing the dispersion of cocoa particles in experimental formulations where it forms a gel network by binding water molecules (Vesa et al., 1996). Addition of inulin in chocolate milk formulations resulted in increased thickness, sweetness, darkness, creaminess and reduced sedimentation of cocoa particles. The best results were obtained when inulin was added at the rate of 3% of the chocolate milk formulation (El-Khair, 2009). As the level of inulin increase, chocolate flavor, sweetness, color intensity and mouthfeel also showed a steady increase in the mean ratings. Higher inulin level resulted in higher ratings of texture, mouth feel and color and more visibly darker and thicker formulations because of a simultaneous increase in a water binding capacity of inulin (Spagnuolo et al., 2005).

A stabilizer has quality to keep the ingredients in suspended form without making the product too thick while adding at low concentrations, (Gohari, 2005). This works in two ways: Firstly, a stabilizer like starch increases viscosity by minimizing the gravitational effects to pull the particles out of the suspension and secondly, a gum, such as carrageenan forms a colloidal network. This network supports particulate matter to remain suspended for longer duration and prevents settling. The stabilizers also prevent air bubbles from collapsing and encourage good

flavor release and hold flavoring compounds well dispersed in solution (Guinard, 1994). Although stabilizers help in the processing of flavored milk but processing parameters, such as pasteurization and homogenization are equally important in combination for successful formulation of flavored milk.

ICE CREAM

Ice cream is a frozen dairy product usually manufactured by freezing a mix stirred slowly to incorporate air, prevent large crystals formation and ensuring a smooth texture (Arbuckle, 1986; Bahramparvar and Mostafa, 2011). It is a complex food colloid that comprises of unfrozen serum phase which consists of fat globules, ice crystals and air bubbles (Caldwell et al., 1992). The fat globules are coated with a protein/emulsifier layer and air bubbles are partially coated with fat globules. The serum phase comprises of high molecular weight polysaccharides and sugars in a freeze-concentrated solution form (Keeney, 1982; Bahramparvar et al., 2010). Processing steps such as pasteurization, homogenization, ageing, freezing, and hardening, can affect the structure, body and texture of this product (Kalab, 1985; Goff and Jordan, 1989; Boode and Walstra, 1993).

The main objectives for using stabilizers in ice cream is to produce smoothness in body and texture, reduction in ice and lactose crystal growth during storage especially during heat shock and to provide consistency to the product and opposition to melting shock (Muhr and Blanshard, 1983). The mechanism of action for stabilizers to improve frozen stability is

primarily related to their effect on unfrozen serum phases and on the ice (Muhr and Blanshard, 1983; Muhr et al., 1986). Mixture/blends of stabilizers are formulated for efficient functioning in full-fat, low-fat or nonfat ice creams (Baer et al., 1999). The presence of stabilizers in a fraction of a percentage can dramatically alter the texture and body in low fat ice cream (Moonen and Bas, 2004). Stabilizers added to ice cream perform numerous important functions, such as reduced whipping time, controlled fat destabilization, improved dryness and increased resistance to melting and shrinkage (Goff, 1997; Goff et al., 1999).

During homogenization of the fat and creation of the mix emulsion, proteins and stabilizers fight for interfacial space (Hartel, 1996). In the course of dynamic freezing process this emulsion undergoes both whipping and ice crystal formation, which contributes to the development of the four most important structural components of the frozen product including a discontinuous foam, a network of partially coalesced fat surrounding the air bubbles, ice crystals, and a continuous, freeze concentrated, unfrozen aqueous solution (Goff, 1997). The modification in rheological properties of ice cream mix is attributed to high water holding capacity of stabilizers (Guinard et al., 1994; Kuntz, 1995; Hagiwara et al., 1996). An increase in stabilizer quantity can increase multifold elevation in viscosity (Igoe and Robert, 1979; Muse and Hartel, 2004; Rosalina et al., 2004). Positive correlation in viscosity and overrun (Tarkashvand and Yadolah, 2005) will allow more incorporation of air with increase in the concentration of stabilizers but excessive increase in viscosity is not desirable that may have negative effect on the product (Kuntz, 1995).

In order to produce a more desirable body and texture in final product polysaccharide stabilizers are often added into ice cream mix which reduce the formation of large ice crystals during storage (McClements, 2005). Ice cream stabilizers are actually blend of ingredients including polysaccharides such as guar, locust bean gum, carboxymethyl cellulose, xanthan, carrageenan and gelatin of animal origin (Naresh et al., 2006). Generally, locust bean gum and carrageenan were most effective to retard ice crystal growth. While gelatin and xanthan gum combined with sucrose or high fructose corn syrup retarded ice recrystallization only at -15°C (Livney and Hartel, 1997). Stabilizers check the growth rate of ice crystals during recrystallization (Donhowe and Hartel, 1996; Hagiwara and Hartel, 1996; Goff et al., 1999) however imparts little (Caldwell et al., 1992) or no (Sutton and Wilcox, 1998) impact on the initial ice crystal size distribution in ice cream at the time of draw from the scraped surface heat exchanger (Flores and Goff, 1999).

Role of stabilizers is evident both before and after storage at fluctuating temperatures and is confirmed by electron microscopy techniques (Caldwell et al., 1992; Goff et al., 1993). Stabilizers act by binding water, rendering it unfreezable and thereby exerting their stabilizing mechanism by reducing the quantity of ice crystals and control the iciness in the final product (Harper and Shoemaker, 1983; Budiaman and Fennema, 1987; Buyong and Fennema, 1988; Levine and Slade, 1988; Sahagian and Goff, 1995). The results also exhibited that stabilizers in ice cream affected fat agglomeration by somewhat modifying the fat structure (Shirai et al., 1985). Other than stabilizers the processing steps involved in the production of ice cream also play significant role in producing high quality ice cream.

CONCLUSION

The stabilizers have confirmed to be effective in formulating functional dairy products. These stabilizers yield gel networks, when incorporated in dairy products leading to firm texture and consequently problem of syneresis in yoghurt is reduced. By addition of relatively minimum amount of stabilizers in ice cream provides desired body and textural characteristics. Stabilizers provide excellent suspending capabilities for cocoa impart homogenous appearance and texture to chocolate milk and provides excellent flavor release. In short by using stabilizers or thickeners high rheology product of excellent texture and body, appearance, consistency, mouth feel, extending shelf life can be formulated. Furthermore, a perspective understanding of the chemical and physical interactions of these stabilizers with the proteins, caseins, fats and water in the milk is important in the development of innovative flavored and functional dairy products.

A single stabilizer or a combination/ blend of stabilizers is used to manufacture the yoghurt and many other products. The objective of using stabilizers blend is to achieve a particular function, or in most of the cases, to overcome one of the limiting properties related with a particular compound. A single stabilizer may be suitable while producing fruit flavored yoghurt but may not be appropriate to manufacture other types of high rheology products. Thus, the selection of a specific type of stabilizer for specific type of product depends upon many factors such as effect or mode of action of the stabilizer and functional properties and optimum concentration of the stabilizers to be used.

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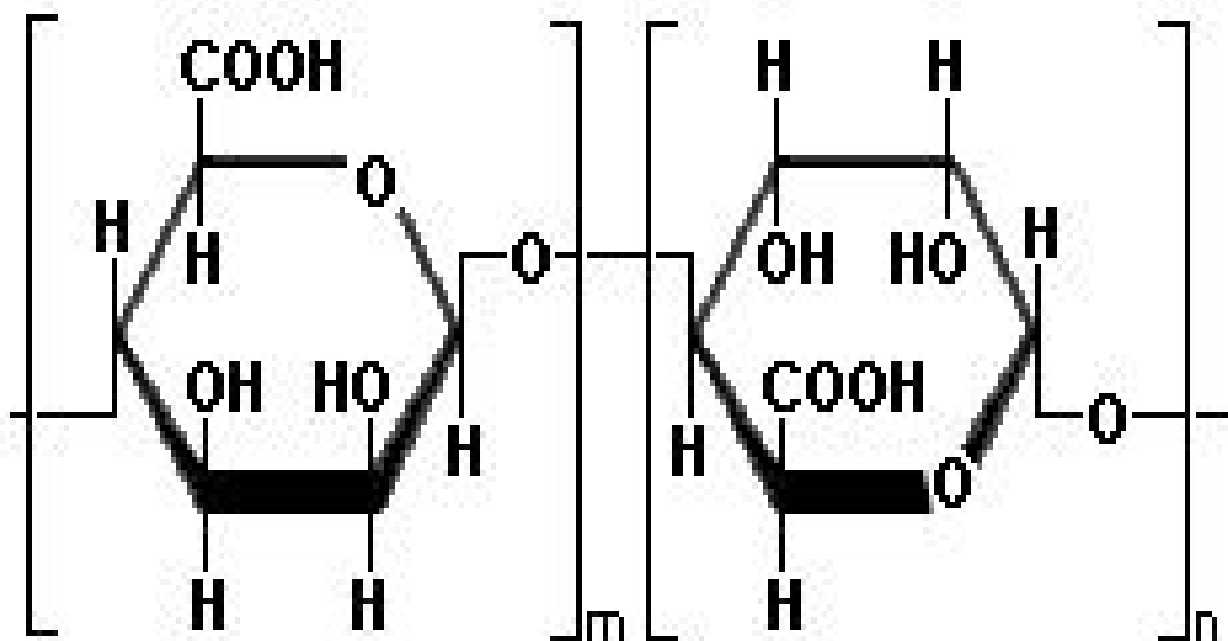


Figure 1 Alginic Acid

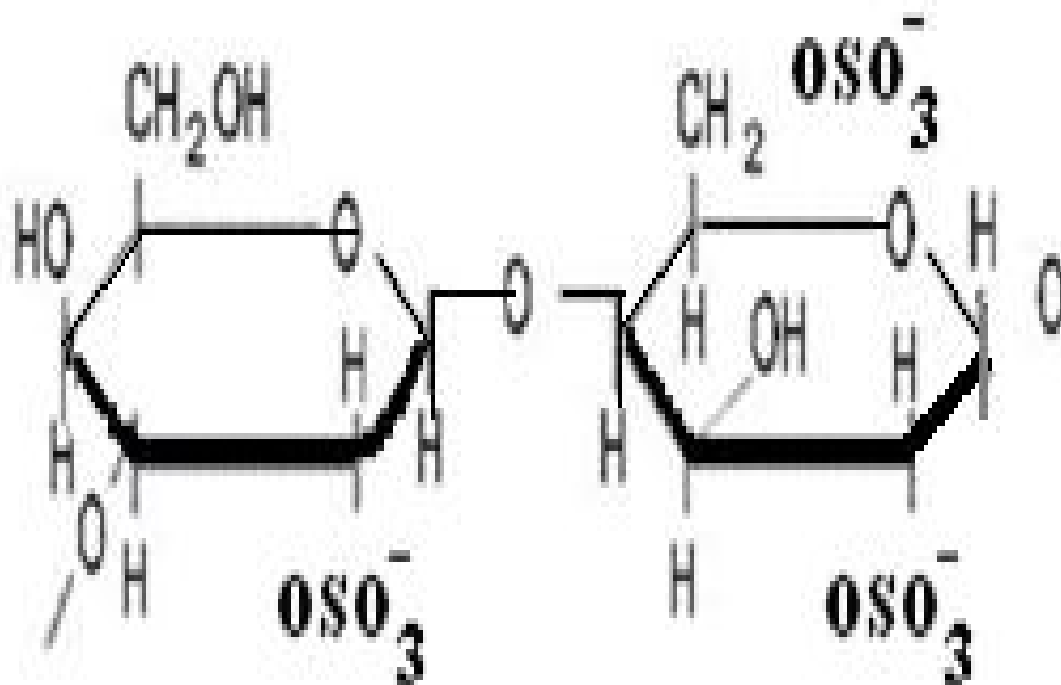


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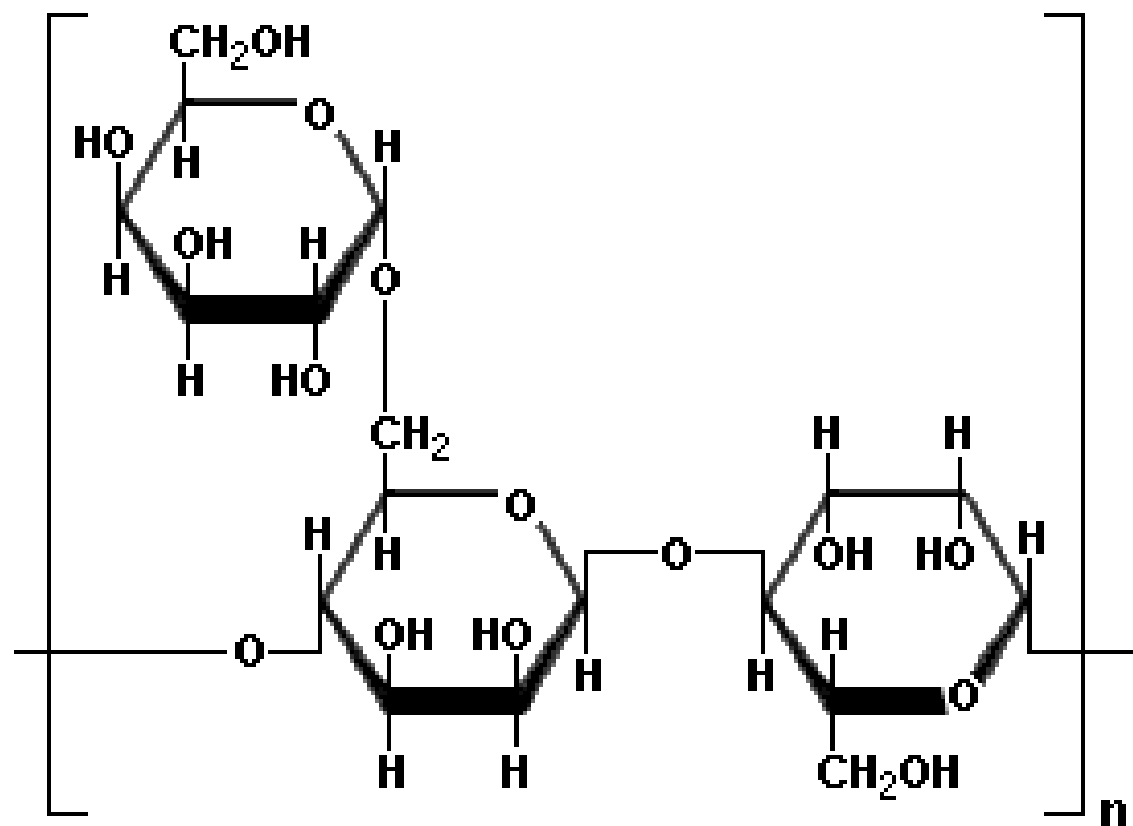


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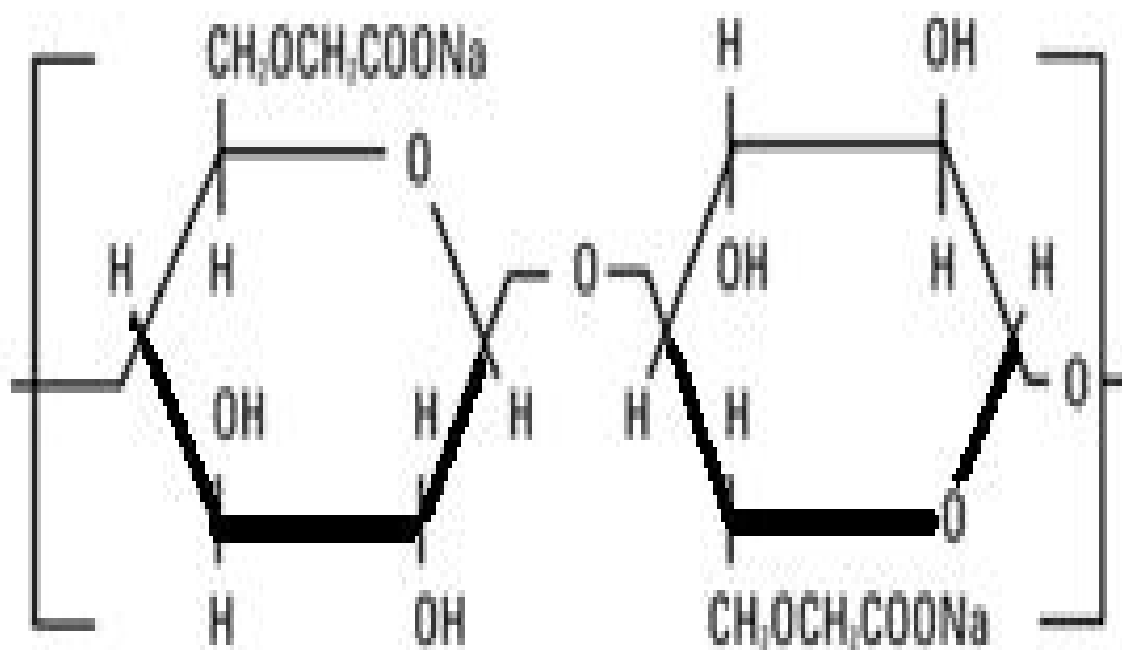


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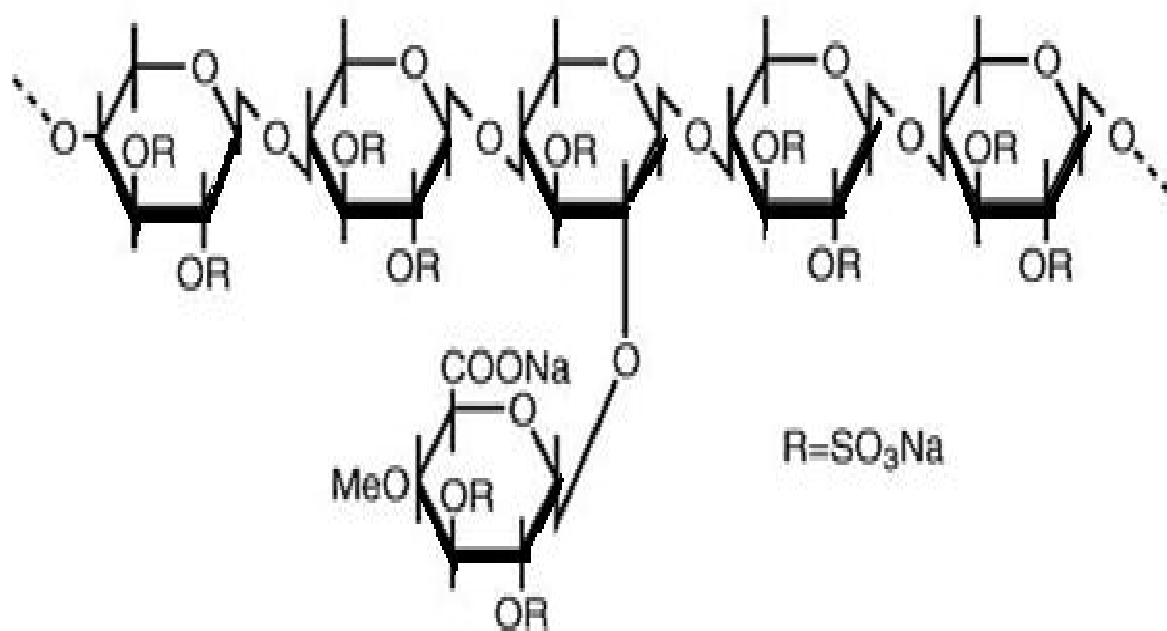


Figure 5 Gelatin

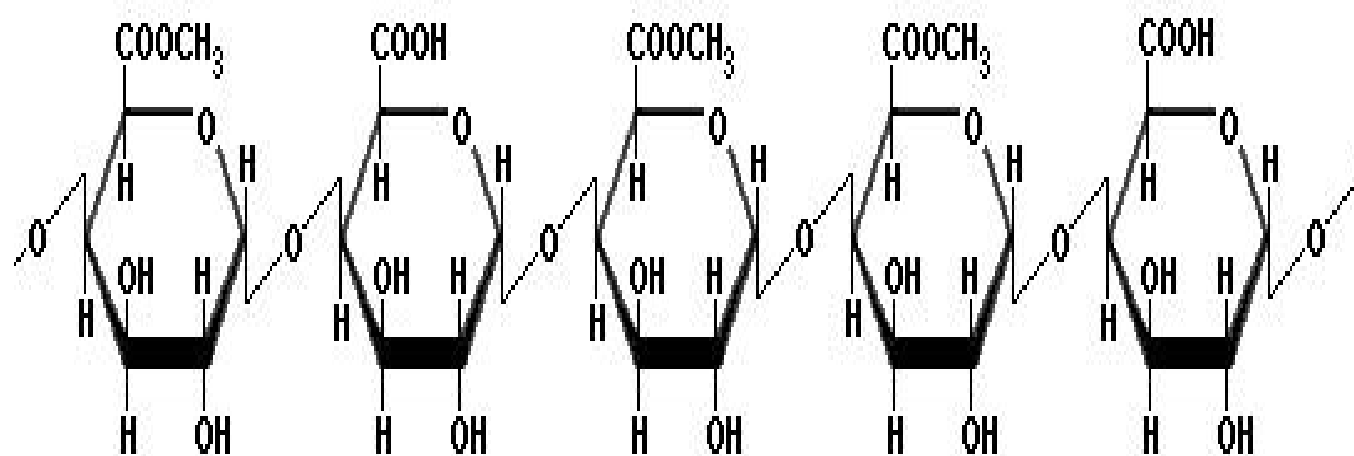


Figure 6 Pectin

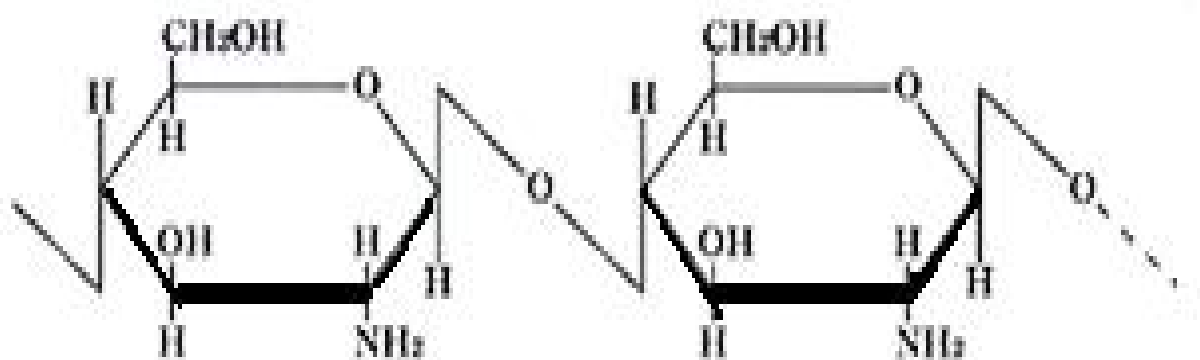


Figure 7 Chitosan

