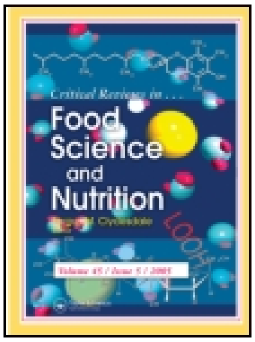

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Asif Ahmad , Nazish Arshad , Zaheer Ahmed , Muhammad Shahbaz Bhatti , Tahir Zahoor , Nomana Anjum , Hajra Ahmad & Asma Afreen

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Perspective of Surface Active Agents in Baking Industry: An Overview

ASIF AHMAD,[1] NAZISH ARSHAD,[1] ZAHEER AHMED,[2] MUHAMMAD SHAHBAZ BHATTI,[1] TAHIR ZAHOOR,[3] NOMANA ANJUM,[2] HAJRA AHMAD,[2] and ASMA AFREEN[2]

[1]Department of Food Technology, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Rawalpindi, Pakistan
[2]Department of Home & Health Sciences, Allama Iqbal Open University, Islamabad, Pakistan
[3]National Institute of Food Science & Technology, University of Agriculture Faisalabad, Faisalabad, Pakistan

Different researchers have previously used surfactants for improving bread qualities and revealed that these compounds result in improving the quality of dough and bread by influencing dough strength, tolerance, uniform crumb cell size, and improve slicing characteristics and gas retention. The objective of this review is to highlight the areas where surfactants are most widely used particularly in the bread industries, their role and mechanism of interaction and their contribution to the quality characteristics of the dough and bread. This review reveals some aspects of surface-active agents regarding its role physiochemical properties of dough that in turn affect the bread characteristics by improving its sensory quality and storage stability.

Keywords Dough, rheological, characteristics, bread

INTRODUCTION

Bread is one of the most widely consumed food products in the world (Selomulyo and Zhou, 2007) and bread-making technology is possibly one of the oldest technologies known (Sawa et al., 2009). New materials, ingredients, and equipments are added in this technology continuously over the years for the production of improved bread quality (Scanlon and Zghal, 2001). However the research has generated impressive and steady progress in bread making (Haros et al., 2001; Leon et al., 2002).

The major ingredients for bread making are flour, water, salt, fat, and sugar. Many additives are extensively used for improving the dough and bread quality (Dobraszczyk et al., 2001; Caballero et al., 2007) among which the most commonly used ones are enzymes, oxidants, surface active agents, emulsifiers, soy flour, reductants, stabilizers, emulsifiers, supplementary enzymes (e.g., α-amylases, lipases, exogenous proteases, lipoxygenases, hydrolases for noncellulosic polysaccharides), and gums (Ravi et al., 2000; Orthoefer, 2008). The intensifying addition of surface active agents in the bakery industry has increased to a great extent because of the advantage of more improved bread volume, improved texture, crumb, shelf-life and slicing properties of bread (Crowley et al., 2000; Azizi and Rao, 2005; Grigoriev et al., 2006; Ahrne et al., 2007).

Different researchers have previously used various types of surfactants including SSL, CSL, GMS, and polysorbates in bread (Collar, 2003; Matuda et al., 2005; Asghar et al., 2006) that exert a positive affect during fermentation, proofing, first part of the baking period, mechanical handling (Haros et al., 2001; Dobraszczyk and Morgenstern, 2003), shaping, and transportation (Ravi et al., 2000; Curic et al., 2008). These substances have a role in bakeries as dough strengtheners, dough conditioners, anti hardening agents, and antistaling agents in bread. These are also supposed to improve the technological characteristics in bread by altering the multiphase food systems (Aken et al., 2003).

Previously, a lot of work has been reported on various aspects of surface-active agents on bread quality including its physical, chemical, rheological, and sensory qualities. This review reveals some aspects of surface-active agents regarding its role in physiochemical properties of dough that in turn affects the bread characteristics by improving its sensory quality and storage stability.

Address correspondence to Zaheer Ahmed, Department of Home & Health Sciences, Allama Iqbal Open University, Islamabad, Pakistan. E-mail: zaheer_863@yahoo.com; zaheer.ahmed@Aiou.edu.pk

SURFACE ACTIVE AGENTS

The "surface active agents" are collectively known as surfactants that are used in the bakery industry in the form of monoglycerides and diglycerides since 1920s (Krog, 1981) mainly as dough conditioners (Grigoriev et al., 2006), crumb softeners, dough strengtheners (Azizi and Rao, 2005; Decock and Cappelle, 2005), and as agents that form complex structures with the amylose fractions (Phatthalung et al., 2008). Surfactants are amphiphilic compounds surrounded by both water loving and non-water loving parts that give them ability to accumulate between fluid phases such as oil/water or air/water resulting in decreasing the surface and interfacial tensions and emulsions formation occur (Nunes et al., 2009).

These compounds are responsible for the adjustment of surface properties and surface tension of the liquid or solid to which they are applied or these are the compounds that lower the surface tension of a liquid allowing easier spreading by lowering the interfacial tension between two substances (Knightly, 1996; Deffenbaugh, 1997). The surfactant has a hydrophilic head that is water loving and a hydrophobic tail that repels water (Krog, 1981; Kruglyakov and Nushtayeva, 2004). Surfactants consist of hydrophobic fatty acid chains esterified to the hydrophilic polar group that can originate from different type of polyvalent alcohols. The polar group can be modifying by esterifying with organic acids (Stefanis et al., 1977).

Surfactants include the detergents, emulsifiers, and lipids. When surfactants are added to an oil or water phase, they absorb in one or more layers at the interphase between the oil and water (Kurakake et al., 2004). In terms of energy, this adsorption at the interphase is a more favorable situation than a complete solution of surfactants in either oil or the water phase. Surfactants reduce the interfacial tension and promote the emulsification of the two liquids result in increased emulsion stability (Krog, 1981). Surfactants stabilize foams and emulsions most effectively if they form a fluid adsorbed layer (Roach and Hoseney, 1995; Quoc et al., 2002), which permits them to move around to regions with a reduced surfactant concentration, due to perturbation during formation, combination, or transport processes (Raphaelides, 1992).

CLASSIFICATION OF SURFACTANTS

The surfactants are classified into following main categories according to the nature of the hydrophilic group:

- Anionic surfactants
- Cationic surfactants
- Amphoteric surfactants
- Nonionic surfactants

Among them most commonly used ones are anionic and nonionic in bread industries (Imberty et al., 1991; Stampfli and Nersten, 1995).

Anionic Surfactants

In these types of surfactants, the hydrophilic head has negative charge on it. DATEM, CSL, and SSL are the examples of anionic surfactants that are used in food industry (Lucassen, 1981; Stampfli and Nersten, 1995; Dobraszczyk et al., 2001); other applications include their use in washing of clothes and dishes because they have very good cleaning properties; and also as alkyl sulfates, alkyl ethoxylate sulfates, and soaps. The Stearoyl lactylates that are anionic surfactants are the esters of lactic acid and fatty acid, which are incompletely neutralized to form SSL and CSL (Krog, 1981) and exert excellent strengthening effect and act as good softening agent (Kulp and Ponte, 1981; Mezger, 2006).

Many researchers (Chung and Tsen, 1975; Stauffer, 2000) have described the mode of action of anionic surfactants. These compounds react with the gluten protein due to their positively charged nature (Greene, 1975) during dough mixing and form strong hydrophobic bonds with the glutens (Chung et al., 1981). This will result in lower net charge of gluten protein, which will aid in the aggregation of the gluten proteins (Shibanuma et al., 1994), thus enhancing the gluten strength and improving mixing tolerance and the gassing power of the dough. A different theory suggests that surfactants and proteins form direct interactions with each others, which are of ionic nature, resulting in the aggregation of gluten by hydrophobic side of the alkyl chains of the surfactants (Mezger, 2006).

During baking, the temperature of the dough starts to rise (Russell, 1983; Moayedallaie et al., 2009), which will in turn decrease the interactions of surfactants and the glutens (Tsen and Weber, 1981). When the temperature reached where the starch starts to gelatinize (Yasunaga et al., 1968), which is increased in the presence of surfactants (Eliasson, 1983) resulting in prolonged gas retention period (Veraverbeke and Delcour, 2002). Throughout the gelatinization process, the starch ties high amounts of water (Tester et al., 2004; Srichuwong and Jane, 2007) and results in redistribution of water in the dough (Yasunaga et al., 1968). The continuous decrease of water results into coagulation of the gluten proteins (Tang and Copeland, 2007) as the gas holding power is reduced and the polar lipids that were bounded begins to release (Silverio et al., 1996). The surfactants are able to block the openings that are created by the coagulated gluten proteins (Venkateswara and Haridas, 1993) and then progressively take over the complete interface resulting in further prolonged oven spring (Fainerman and Reynders, 2002).

Nonionic Surfactants

In these surfactants, the hydrophilic head is polar but not fully charged. These surfactants have no net charge on them that makes them protective to water hardness deactivation (Chung and Tsen, 1975). Nonionic surfactants used in food industries are monoglyceriods, polysorbate 60, sucrose esters of fatty acids, ethoxylated monoglyceriods, and distilled monoglyceriods (Addo et al., 1995; Stampfli and Nersten, 1995). Other industrial applications include grease removers in laundry products, household cleaners, and dish washing liquids. The most common used nonionic surfactants are ethers of fatty alcohols.

Many researchers (Azizi et al., 2003; Azizi and Rao, 2005) concluded that the combination of anionic and nonionic surfactants give strength to dough due to the formation of strong bonds with the gluten proteins (Bushuk, 1985) and have positive effect on the fresh bread characteristics (Azizi et al., 2003), volume (Azizi and Rao, 2005), and crumb texture (Barcenas et al., 2003a) can be ensured with long proofing times (Nuessli et al., 2003) so their addition is only suitable for long proofing times (Gomez et al., 2004). The surfactants having Krafft point beneath room temperature are categorized as water insoluble. There solubility in water is very less so the deviating actions is based on differences in their self-association in water (Watanabe et al., 2005). Ethoxylated monoglyceriods are nonionic highly hydrophilic surfactant (Krog, 1981).

ROLE OF SURFACTANTS IN BREAD

The role of surfactants in bread making has been reported by many researchers as crumb softeners (Gray and Bemiller, 2003; Bollain and Collar, 2004; Mondal and Datta, 2008), dough conditioners (Scanlon et al., 2000; Srichuwong and Jane, 2007), dough strengtheners (Azizi et al., 2003; Resurreccion, 2008), antistaling agents (Rosell et al., 2001), and to improve shelf life (Azizi and Rao, 2005), the bread volume (Xiujin et al., 2007), specific volume (Gunning et al., 2003), texture, and overall quality characteristics (Azizi and Rao, 2005). Some of the important functionalities of surfactants are illustrated in Table 1. These functionalities are attributed to formation of complexes either with starch or proteins (Richardson et al., 2004b) thus increasing the strength of the gluten to hold up tightly the expanded dough structure (Richardson et al., 2003) and reduce the rate of starch crystallization (Rasmussen and Hansen, 2001; Ahlborn et al., 2005).

Surfactant as Dough Strengtheners

The effect of surfactants as dough strengtheners are reviewed by many scientists (Shogren et al., 1981; Stampfli and Nersten, 1995; Azizi et al., 2003). These compounds work by forming complexes with the gluten during dough mixing and results in increased bread volume (Azizi et al., 2003), increased dough absorption (Ahrne et al., 2007), improved mixing tolerance of dough (Addo and Pomeranz, 1992), reduction in frequency of dough collapse during handling (Junge et al., 1981), minimized use of shortening (Resurreccion, 2008), improved gas retention (Tsen and Weber, 1981), and better air incorporation (Ribotta et al., 2004).

The mode of actions of different surfactants that act as good dough strengtheners is still not completely understood. One group of authors (Stampfli et al., 1996; Gomez et al., 2004) states that the dough strengthener like mono and diglycerides exerts their strengthening effect by affecting the dough fermentation while other group (Mettler and Seibel, 1993) believes that these compounds bring about changes through modification in gluten interactions with other compounds (Miyazaki and

Table 1 Surfactants used in bread making

Surfactants	Results	References
DATEM	Improve dough stability, dough consistency, dough and gluten rheology, dough strengthening, tearing quality of pita bread, volume and texture of frozen bread dough and bread resulting in increase shelf-life, more air trapping during mixing	Mettler and Seibel, 1993; Farvili et al., 1995; Kokelaar et al., 1995; Stampfli et al., 1996; Kohler and Grosch, 1999; Azizi et al., 2003; Bollain and Collar, 2004; Gomez et al., 2004; Ribotta et al., 2004; Azizi and Rao, 2005
SSL	Improve loaf volume, specific volume, overall baking characteristics, improve color and bread texture	Junge et al., 1981; Farvili et al., 1995; Kokelaar et al., 1995; Farvili et al., 1997; Azizi and Rao, 2005; Kralova and Sjoblom, 2009
MG	Improve dough rheological characteristics, act as anti hardening agents and antistaling in bread	Azizi et al., 2003; Gomez et al., 2004
SE	Exert softening effect in bread	Gomez et al., 2004; Kralova and Sjoblom, 2009
POLY-60	Increase bread volume and improve crumb texture	Stampfli and Nersten, 1995; Stampfli et al., 1996; Gomez et al., 2004
LECITHIN	Improve dough rheological characteristics, loaf volume, antistaling and anti hardening agents in bread	Stampfli et al., 1996; Azizi et al., 2003; Gomez et al., 2004; Kurakake et al., 2004
DMG	Improve dough characteristics	Stampfli et al., 1996
EMG	Improve loaf volume, open crumb grain	Junge et al., 1981
MDG	High volume, good crumb grain, increased shelf life	Mettler and Seibel, 1993; Kralova and Sjoblom, 2009
GMS	Increase volume, specific volume, crumb value, uniform color of crumb and texture	Bajwa, 1990; Farvili et al., 1997; Azizi and Rao, 2005
DGMS	Increase bread volume, good crumb grain, improve overall bread quality	Azizi and Rao, 2005

Morita, 2005). This may result in resilient texture and enhance bread volume through formation of strong proteins networks (Ahrne et al., 2007). Other scientists state that stretchiness in the wheat dough is due to the glaidins that are present naturally in the dough; it permits the gas cell to increase more efficiently (Krog and Jensen, 2007) and the consequence is in the form of improved volume of bread (Ribotta et al., 2004).

During baking, due to high temperature, the dough temperature begins to increase (Kamel and Hoover, 1992; Lodi et al., 2007a, 2007b), which loosens the bond between gluten proteins and polar lipids (Ribotta and Bail, 2007). Dough strengtheners like Diacetyl tartaric acid esters of monodiglycerides (DATEM) help in the formation of liquid films between the strands of glutens and starch fractions that result in enhancing the glutens capability to entrap the gases (Krog, 1990) and the temperature at which the starch gelatinized is enhanced (Eliasson, 1985), which results in improved gas retention and promotes the oven spring (Russell, 1983). These practices occur in an atmosphere where there is low availability of water (Tsen and Weber, 1981; Joensson and Toernaes, 1987) and in case of the surfactants having single carboxyl group are more readily active as compared to those having two carboxyl groups on them (Watson and Walker, 1986) and result in high bread volume (Azizi et al., 2003). The surfactants having two carboxyl group on them are very important during the entrapment of gases (Lorenz, 1983; Bruinsma and Finney, 1984) but if the bread is baked in the unlimited supply of water then the fractions having single carboxyl group are effective (Lang et al., 1992) that at higher temperatures results in the high loaf volumes (Moorthy, 1985).

The addition of anionic surfactants—i.e., DATEM, SSL, and CSL—improve the elasticity tenacity, extensibility (Grigoriev et al., 2006), texture (Collar, 2003), and bread volume (Xiujin et al., 2007) because these substances form complexes with both amylose as well as amylopectin (Stefanis et al., 1977). Addition of SSL at three levels (Grant et al., 2001) increased rates of mass transfer of carbon dioxide in bubbles proofing (Matuda et al., 2005). The surfactants, if added in the form of gels with different combination of shortenings, will result into better extensographic and farinographic properties (Stampfli et al., 1996; Azizi and Rao, 2005) and also will increase the gelatinization temperature of wheat starch (Azizi et al., 2003). The addition of GMS reduces the rate of firmness more effectively in forming amylose-surfactant complexes that result in decrease amylopectin retrogradation (Junge et al., 1981).

The adding up of CSL, SSL, GMS and PS-60 (Breyer and Walker, 1983; Lorenz, 1983; Krog et al., 1989; Venkateswara and Haridas, 1993; Azizi et al., 2003; Azizi and Rao, 2005) also improve physical and rheological properties of bread (Kamel and Hoover, 1992; Barcenas et al., 2003a) because they exert their positive affect on entire bread making process resulting in superior volume and better crumb structure of the bread (Kiskini et al., 2007). These surfactants also affect the water absorption from the environment (Watson and Walker, 1986). DATEM components are most effective in the dough (Rogers and Hoseney, 1983) due to their two anionic residues, which helps to neutralize the positive charge that are present on the gluten proteins fractions (Xu et al., 1992) and exerts dough strengthening effect (Moorthy, 1985; Amero and Collar, 1996).

Surfactants as Crumb Softeners

Use of surfactants as crumb softener was reviewed by many researchers (Langhans and Thalheimer, 1971; Krog et al., 1989; Roach and Hoseney, 1995) and it was concluded that the crumb softening effect is due to the development of strong linkages between surfactants and starch fractions (Mondal and Datta, 2008), especially the amylose that are having straight chains (Rogers and Hoseney, 1983). These compounds, besides softening the bread, also stop the rate at which the bread mostly stales (Petit and Escher, 1992) by slowing down the starch crystallization process (Appelqvist and Debet, 1997; Azizi and Rao, 2005) during storage (Gray and Bemiller, 2003).

Staling process is due to a series of complex reactions; the most dominating factor is the starch retrogradation (Eliasson, 1994) after the bread is baked (Barry and Tenny, 1983; Arendt and Moore, 2006). The mode of action of the process of bread firming by the surfactants that act as crumb softeners (Patel et al., 2005) stands on the capability of these compounds to form strong linkages with the starch principally linear amylose fractions (Krog and Jensen, 2007) to retard bread staling (Azizi and Rao, 2005). This complex is insoluble in water (Xu et al., 2001; Srichuwong and Jane, 2007) so do not contribute in the gel development process, which is naturally due to the starch fractions (Blazek and Copeland, 2008) in the dough during baking (Leon et al., 2002). On cooling this complex, amylose will not recrystallize (Pisesookbunterng et al., 1983) and will not result in the staling process (Morad and Appolonia, 1980). The process of bread firming can be reduced by the formation of strong linkages with the amylopectin fraction that are present in the starch granules (Kamel and Hoover, 1992).

Different surfactants form different linkages with the amylose fractions (Osman and Dix, 1960; Bulpin et al., 1982; Inagaki and Seib, 1992; Mira et al., 2005) so the end result in the reduction of the bread staling process is also different (Petit and Escher, 1992; Barcenas et al., 2003b). The most commonly used crumb softeners Monoglycerides (MG) or diglycerides (Watanabe et al., 2005) delay staling by the formation of compound with the amylose present in the bread and starch (Carlson et al., 1979) thus results into soft breadcrumb but their method of interaction in the bread to increase the shelf life is controversial (He and Hoseney, 1990). Another point of view is that surfactants during the early bread staling or firming process have very small effect but they work efficiently during the storage of bread (Knightly, 1988; Mondal and Datta, 2008). Lecithin and lecithin enriched with the oats have proved a noteworthy affect over the reduction of bread staling process during the 2 hours of proofing time but monoglyecides showed the superlative effect on the bread softness (Gomez et al., 2008). The direct interactions of bread firmness and organoleptic properties have been elucidated previously by many scientists (Hartunian et al., 1990; Xu et al., 1992; Mettler and Seibel, 1993). Other scientists believed that crumb softning process by addition of surfactants is due to control of moisture in such products (Bollain and Collar, 2004).

Surfactants as Dough Conditioners

The dough conditioners contain both crumb softeners and dough strengtheners (Potgieter, 1992) that are the most important ingredients in the bread formulation (Rao et al., 1992) to improve product quality (Barry and Tenny, 1983). The bakery products are classified on the basis of prevailing function of the surfactants, which normally act as dough strengthener or the crumb softener (Bulpin et al., 1982) or both functions (Wood, 1985; Barcenas et al., 2003b; Barcenas and Rosell, 2006a). These compounds contain the functional component that works during the whole processing of the bread (Srichuwong and Jane, 2007) and enhances the product quality (Scanlon et al., 2000).

Dough conditioners strengthen the dough (Grigoriev et al., 2006) and improve finished product volume (Jovanovich and Anon, 1999; Sahin and Sumnu, 2006) by formation of complexes with the gluten strands. Several dough conditioners function to soften the crumb (Bollain et al., 2005) and enhance the shelf life by forming strong bonds with the amylose and the starch fractions (Krog and Jensen, 2007) to decrease the staling. Surfactants can be added in the bread alone or different blends of the surfactants can be used for the desired strengthening and softening effects (Moayedallaie et al., 2009). The lecithins that are naturally present also come under the category of surfactants due to the presence of both hydrophilic and hydrophobic groups (Addo et al., 1995) and these compounds easily dissolve at low concentrations in oils and water jointly. The lecithins that are naturally present also come under the category of surfactants due to the presence of both hydrophilic and hydrophobic groups (Addo et al., 1995) and also show strengthening and softening affect (Richardson et al., 2004b).

Various scientists revealed that nonionic surfactants—e.g., Monodiglycerides (MDG), Ethoxylated monoglycerides (EMG), Distilled monodiglycerides (DMG), PS-60, Sucrose esters of fatty acids (SE), and anionic surfactants, e.g., DATEM, SSL, and CSL—have proved to be good dough conditioners (Kamel and Hoover, 1992; Barcenas et al., 2003a; Collar et al., 2007) and function in the dough by interacting with gluten proteins (Mira et al., 2005) and resulting in reinforcement of gluten network (Lindeboom et al., 2004) by development of prearranged structures with water that is present in the dough (Baik and Chinachoti, 2000) resulting in the foam stability (Schuster and Adams, 1984). GMS behaves in another way to achieve these properties by reducing the amylopectin retrogradation when it forms a complex with amylose (Azizi et al., 2003) to introduce desirable physical and rheological properties in bread. DATEM, CSL, SSL, and PS-60 increase volume of finished bread (Miles et al., 1985) and bring about wanted properties through either of the described mechanisms.

Crumbs softeners such as monoglycerides or diglycerides have the ability to delay staling process (Hartunian et al., 1990) but how this process is delayed is a controversial issue (Labell, 1983). Some researchers believe that monoglycerides form strong bonds with the amylose to bring about crumb softness but this will rarely retard bread staling (Nuessli et al., 2003). Other researchers thought that the role of surfactants as bread softeners could be achieved only if these are added in the bread during the early phases of mixing and these effects are time dependent during storage (Knightly, 1988).

Surfactants as Antistaling Agent

Staling involves a combination of related mechanisms (Emmanuel and Salvadori, 2007) that may be due to the changes in starch fractions, changes in the gluten functionality (Maga, 1975; Kulp and Ponte, 1981), migration/ redistribution of moisture (Shimiya and Nakamura, 1997), the glassy/rubbery state of bread polymers (Slade and Levine, 1987), and decreased water mobility, which is discharged from the gluten due to the stabilized starch that gradually increases in size during staling (Kim-Shin et al., 1991).

The process of bread staling is characterized by crumb firming (Goesaert et al., 2009a), flavor loss, loss of crispness, increased leathering (Goesaert et al., 2005), and changes in water content (Cauvain, 1998). An indirect relationship exists between the staling process and the water content in the bread (Longton and Legrys, 1981; Rosell et al., 2001; Demirkesen et al., 2010). These changes during storage (Copeland et al., 2009) can be explained on the basis of changes on molecular level in the side chains of amylopectin (He and Hoseney, 1990; Xu et al., 1992; Zobel and Kulp, 1996; Gray and Bemiller, 2003; Grenier et al., 2003), while the amylose is responsible for staling in freshly prepared bread at and at initial day storage (Ghiasi et al., 1982; Hug-Iten et al., 2003).

During the whole bread baking process, a small part of amylose is insolubilized (Nuessli et al., 2003). The rest portion produces an amorphous halo affect, which is created by the gelatinized starch (Barcenas et al., 2003a). When the bread is stored, this starch that is amorphous in nature crystallizes the starch fractions into the crystals of B type, while the amylose-surfactant complexes, which produce the V type complexes, remain unchanged. During the whole bread making process, SSL stops starch molecules' migration from granules (Dragsdorf and Marston, 1980), thus slows down the crumb firming process (Rosell et al., 2001; Gelders et al., 2006; Rosell et al., 2006) or reduces the rearrangement of water from gluten to starch (Zobel, 1973), this will help in preventing the tightening and firming of the gluten phase (Buleon et al., 1998; Tang and Copeland, 2007) and exerting positive effect during entire bread making process (Atwell et al., 1988; Baik and Chinachoti, 2002; Caballero et al., 2007; Ribotta and Bail, 2007). Such complex starches have a tendency to resist recrystallization and thus contribute antistaling properties to breadcrumb (Bollain et al., 2005).

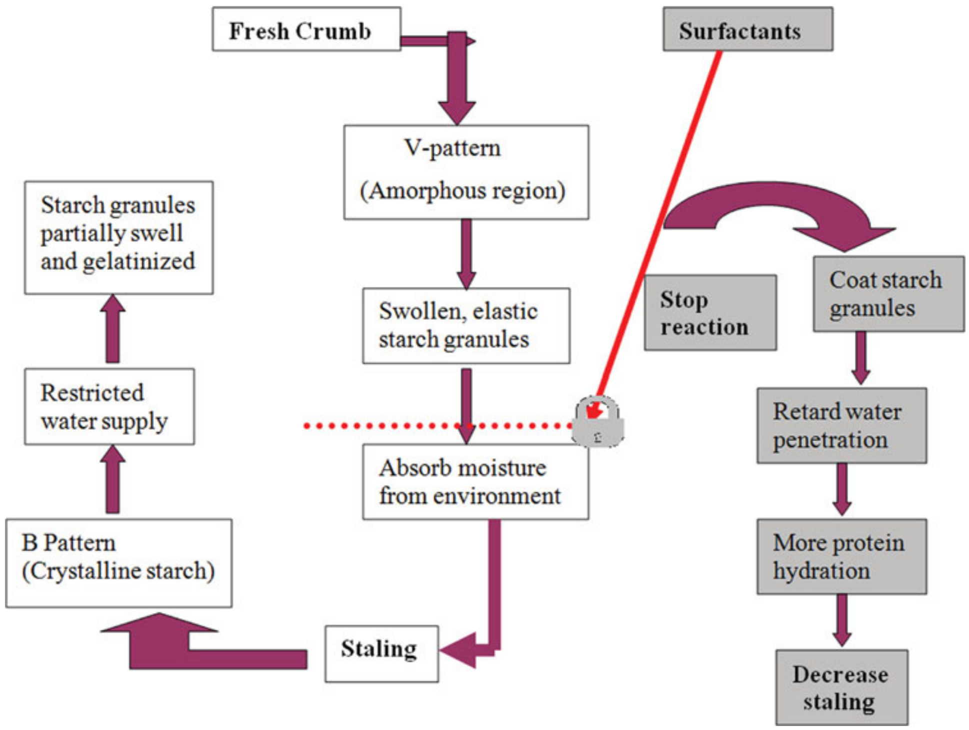

Figure 1 Mechanism of reduction in staling by addition of surfactants. (Color figure available online.)

A brief description of the process by which the surfactants are helpful for the reduction of staling is depicted in Figure 1. The antistaling process is based on their capability of holding up the amylose fractions (Ribotta et al., 2003; Tester et al., 2004), which varies from one surfactant to another (Petit and Escher, 1992). The surfactants like DATEM having strong ability of formation of complexes with the amylose fraction reduce the crumb firmness more effectively as compared to others (Rosell and Gomez, 2007). It also works by preventing dissolution and oozing of amylose fractions (Zeleznak and Hoseney, 1986; Richardson et al., 2004a), which are the main cause for the reduction in swelling of granules (Barcenas and Rosell, 2007); as the surfactants also form linkages with the amylopectin granules (Russell, 1983), the process by which there is decline in the process of staling is correlated with the decline in the granule swelling (Thompson, 2000), which is also responsible for the decrease in the movement of the starch polymer due to strong complexes that further decrease crystallization (Gray and Bemiller, 2003).

Besides, water binding surfactant also reduces the staling process (Bushuk, 1985; Schiraldi et al., 1996) by inhibiting the amylopectin crystallization during storage (Rao et al., 1992). Some surfactants such as Lecithin (Gomez et al., 2004) DATEM, SSL, CSL, and MGs exert antistaling effect by acting on the swelling starch (Rouille et al., 2000; Sanchez, 2000), which increases the pasting temperature and viscosity (Osman and Dix, 1960; Morad and Appolonia, 1980; Zuniga and Bail, 2009) and decreases gelatinization viscosity (Mettler and Seibel, 1993). Owing to higher starch complexing affinity of SSL, DMG, DATEM, and Sucrose monopalmitate (Xiujin et al., 2007), softer breadcrumb can be produced (Xu et al., 1992; Mandala et al., 2009).

Emulsifiers

Emulsifiers, fat-based ingredients, are the substances that possess both hydrophobic (lipophilic) and hydrophilic characteristics like the surfactant molecule and belong to general class of compounds called surfactants (Stampfli and Nersten, 1995; Knightly, 1996; Gray and Bemiller, 2003), but their mode of action is different. The addition of emulsifiers in the bread production is now a regular practice either in the form of dough strengtheners or crumb softeners (Kulp and Ponte, 1981; Stampfli and Nersten, 1995) that results in the crumb softness and hindering the bread staling rate (Pisesookbunterng et al., 1983; Roach and Hoseney, 1995; Knightly, 1996).

The adding up of the emulsifiers in the bread lessens the swelling of starch (Eliasson and Gudmundsson, 1996) that further results in the movement of the starch polymer and prevents the oozing of the amylose thus ensuing less crystallization (Gray and Bemiller, 2003). DATEM and EMG are best strengtheners, while monoacylglycerols are good softening agents in bread (Stampfli and Nersten, 1995). Many researchers studied that by the addition of emulsifier in the bread, it will result in the formation of complexes with the amylopectin but their complexing power is low as in contrast to the amylose (Lagendijk and Pennings, 1970; Stefanis et al., 1977).

The antistaling properties are the result of interactions between the emulsifiers and amylase (Goesaert et al., 2005), amylopectin (Gomez et al., 2004), and/or protein (Collar et al., 2007) that relate to their capacity to form insoluble linkages with the amylose fractions. The amylose that forms complexions with the emulsifiers is not responsible for the formation of gel and does not contribute to the starch recrystallization. As a result, the addition of emulsifiers also influences the network of the amylose after the baking process (Goesaert et al., 2009b). Different emulsifiers form variable complexes with the bread components (Knightly, 1996; Cauvain, 1998) so their effectiveness for the reduction in the staling process is also different (Osman and Dix, 1960).

APPLICATION OF SELECTED SURFACTANTS IN BREAD

Monoglycerides

About one third of the emulsifiers in the baking industry contain monoglycerides (Stauffer, 2000; Nuessli et al., 2003), which are responsible for improving dough machining properties (Greene, 1975), enhancing slicing characteristics (Gomez et al., 2004), and making bread characteristics better (Genc et al., 2000). The monoglcerides decrease the firmness of bread by interacting with the starch fractions, amylose, and amylopectin (Chin et al., 2004). Researchers have concluded that monoglycerides decrease the crumb-firming rate but do not interact with the initial crumb firmness (Sawa et al., 2009).

Monoglycerides are derived from vegetables or animals by treating it with glycerin in the existence of a catalyst (Dziezak, 1988; Inoue et al., 1995). The process of development will influence the effectiveness of a monoglyceride (Carlson et al., 1979). Monoglycerides generally act as crumb softeners (Elton, 1969; Dubois and Ash, 1971) and have little of the dough strengthening effect (Gray and Bemiller, 2003). Hard monoglycerides are used in the low fat breads while soft monoglycerides exert excellent effect in the high fat products and are available in the form of soft hydrates to fine powder (Finney and Shogren, 1971).

Several scientists (Aust and Doerry, 1992; Inoue et al., 1995; Cauvain, 2000) have shown that the saturated triglyceriods that have long chains have higher antistaling properties as compared to unsaturated fatty acids as they have more starch binding ability (Azizi et al., 2003). The monoglycerides function by forming complexes with amylose (Gudmundsson and Eliasson, 1990) resulting in the formation of monoglycerol inclusion complex that is insoluble in water (Gunning et al., 2003). The monoglycerides do not favor gel formation (Grant et al., 2001; Gelders et al., 2006). This monoglyceride-amylose network does not recrystallize upon cooling (Gelders et al., 2004) and results in decreased staling (Chinachoti and Vodovotz, 2001).

Distilled Monoglyceriods (DMG)

Distilled monoglycerides have similar effect as SSL in improving bread volume (Azizi et al., 2003), with reduction in firming (Krog et al., 1989). The researchers concluded that the crystallinity of amylopectin plays a significant role in the bread firmness (Hizukuri, 1985; Hizukuri, 1986; Collar and Bollayn, 2005) by improving the amylose-lipid complex (Xu et al., 1992). The addition of DMG at the level of more than 1% will decrease the starch retrogradation (Kaur and Singh, 2000; Campbell et al., 2001). DATEM forms strong complexes with the amylose fractions (Carson and Sun, 2000) and results in small decrease in retrogradation of amylopectin as compared to DMG (Rao et al., 1992).

The amylograph readings of bread show that the addition of DMG significantly correlated to crumb firmness (Junge et al., 1981). Many researchers suggested that the swollen starch intermingles with different surfactants (Kamel and Ponte, 1993), undergoes further swelling (Kou and Chinachoti, 1991), forms dispersions (Karkalas and Raphaelides, 1986), and results in higher crumb pasting temperatures (Lindeboom et al., 2004). The scientists show that DMG has no noteworthy effect on the storage time of bread (Kralova and Sjoblom, 2009).

Ethoxylated Monoglycerides (EMG)

EMG is a viscous liquid formed by the interaction of mono or diglycerides with ethylene oxide and results in an increase in the bread volume (Jovanovich and Anon, 1999; Kralova and Sjoblom, 2009), decreases the lethal effects of the extra fiber on bread volume (Shogren et al., 1981), improves bread quality (Carson and Sun, 2000), makes air incorporation better (Junge et al., 1981), improves crumb grain texture (Knightly, 1988), and improves dough strengthening effect but very low crumb softening effect (Stampfli and Nersten, 1995). Excessive dosage of this compound will result in fall down of the bread in the oven (Aust and Doerry, 1992) and form gel with the water (Lorenz, 1983).

Succinylated Monoglycerides (SMG)

SMG is formed by the interaction of distilled monoglycerides and succinic anhydride, having waxy nature and showing improved dough strengthening effect (Stampfli and Nersten, 1995) with a little crumb softening effect (Kulp and Ponte, 1981). These have benefit of enhancing oven spring (Stampfli et al., 1996) but it is difficult to handle due to its waxy nature. SMG can also be added in the bread where melted fats are used as these are melted with the fat (Kralova and Sjoblom, 2009).

Monodiglycerides (MDG)

Many researchers (Krog, 1990; Mettler and Seibel, 1993; Mira et al., 2005) study the effects of monodiglycerides during the whole bread making process and conclude that these are responsible for specific volume (Lagendijk and Pennings, 1970), crumb grain (Azizi et al., 2003), decrease the staling during storage by complexing with them. The nuclear magnetic resonance

(NMR) study proved that bread treated with MDG decreases the water mobility during ageing (Kim-Shin et al., 1991). These substances also have antistaling properties by inhibiting amylopectin crystallization (Ravi et al., 2000) and are helpful in restoring original freshness (Pisesookbunterng et al., 1983).

Diacetyl Tartaric Acid Esters of Monodiglycerides (DATEM)

DATEM is an anionic emulsifier that is formed by the esterification of Mono and diacylglycerols with the mono and diacetyltartaric acid, which serves as dough strengthener (Selomulyo and Zhou, 2007) to improve bread quality (Xiujin et al., 2007) by improved crumb softening (Stampfli and Nersten, 1995), increased mixing tolerance, gas retention (Mettler and Seibel, 1993), and dough resistance to collapse (Moayedallaie et al., 2009). It also results in improving loaf volume (Ribotta et al., 2004) and gives resilient texture to crumb, fine crumb grain, and also improves slicing characteristics (Inoue et al., 1995) by forming strong hydrogen bonds by interacting with glutamine and starch fractions (Kralova and Sjoblom, 2009). DATEM can also form blends with the monoglycerides and also with the other dough conditioners and is available as fine and dry powder (Lorenz, 1983).

DATEM can form tight linkages with the protein surfaces that are non-water loving, which are responsible for the production of strong protein networks. This process can further aid in giving better texture to the crumb (Azizi and Rao, 2005) and also enhance the volume (Azizi et al., 2003; Campbell, 2003). The emulsifiers, which are of hydrophilic nature, form tight linkages with the glaidins in the form of lamellar liquid-crystalline phases (Ribotta et al., 2004). The production of these structures aids in the extension of gas cells which further on contributes to the dough elasticity and increased bread volume as well (Turabi et al., 2007). DATEM are added in the bread and other fermented products at the concentration of 0.3% on the flour weight basis (Cauvain, 1998). The addition of these compounds in the dough phase helps to improve the mixing tolerance, make gas retention better, increase dough resistance (Ribotta et al., 2004), improve loaf volume, make crumb texture good (Ribotta et al., 2003), fine the crumb grain, and also make slicing properties of bread good (Selomulyo and Zhou, 2007).

DATEM forms strong hydrogen linkages with the starch fractions (Slade and Levine, 1987), with the glutamine, and is also capable of forming complexions with the gluten proteins present in the dough and also has the capability of forming lamellar liquid crystalline phases in water that links with the gliadins (Ribotta et al., 2004). These processes will result into tough protein networks, which are further on responsible for production of better textured bread (Stear, 1990) with improved volume as well (Stauffer, 2000). Such processes also allow the expansion of gas cells that aid in the dough elasticity (Selomulyo and Zhou, 2007) with improved bread volume (Primo-Martin et al., 2006). In the case of wheat flours that are weak in nature, the addition of DATEM have proved in giving excellent expansion in the bread volume (Ravi et al., 2000) and when these compounds are added in the frozen dough's then they also result in increased bread volume, give slightly lower crumb firmness (Ribotta and Bail, 2007), and are also responsible for the reduction in the bread staling process (Ribotta et al., 2004).

Sucrose Esters of Fatty Acids (SE)

Sucrose esters have advantage of superior crumb, increased volume (Aust and Doerry, 1992; Wijnans et al., 1993), extensive shelf life, and increased mixing tolerance (Bushuk, 1985; Barrett et al., 2002). In starch, SE form inclusion complexes with the amylose molecules during gelatinization (Bulpin et al., 1982), inhibiting starch retrogradation (Chung and Tsen, 1975), and leads to the bread with decreased staling rates (Chung et al., 1976).

Sucrose esters act as dough conditioners in bread making; however, are costly as compared to other dough conditioners (Barrett et al., 2002). The crumb softening effect in bread is exerted by an interaction with protein part, which aids in modifying the structure of gluten as a result of complexion with the amylose fraction (Krog, 1981). These not only improve bread making qualities but also, to a great extent, the Sensory characteristics of the bread, including the firmness, cohesiveness, and chewiness. The usefulness of sucrose ester is proportional to their monoester content (Chung et al., 1976). The adding up of SE not only improves the wheat dough stability (Watson and Walker, 1986) but also of frozen dough (Lang et al., 1992). SE increase bread compressibility after 5 days storage (Xu et al., 1992) due to the retardation of the amylopectin recrystallization which occurs within the initial 2 weeks of storage (Rao et al., 1992), and results into an increased bread volume (Chung et al., 1976; Barcenas et al., 2003a).

Throughout the process of gelatinization, the sucrose fatty acid esters usually form linkages with the amylose that results into the helical inclusion complexes (Chung et al., 1981). These linkages result in increasing the shelf life and storage stability of the bread by hindering the starch retrogradation (Pomeranz, 1994; Selomulyo and Zhou, 2007). The researchers concluded that the presence of SE will slow down the yeast cell damage in very low temperatures as in case of frozen breads. The mechanism of action is that the SE enhances the total quantity of water that is nonfrozen in the wheat starch; so in this way, they operate as a cryoprotectant for yeast cells (Watson and Walker, 1986) and also the denaturation of the wheat protein during freezing process. In this way, the frozen bread quality is improved by minimizing the damage to their baking properties (Selomulyo and Zhou, 2007).

Lecithin

Lecithin, natural anionic surfactant, is a phospholipid compound (Cauvian, 1998) found in all plant and animal organisms, but the primary commercial source is the byproducts from the

Table 2 Application of surfactants

Surfactants	Applications	Reference
Nonionic surfactants	Dough conditioner, dough softener, dough strengtheners, detergents, wetting agents, emulsifiers, foam stabilizers, pharmaceuticals and cosmetics industries, Solubilizers, Starch complex, protein modifier	Kulp and Ponte, 1981; Stampfli and Nersten, 1995; Lim et al., 2000; Sun and Liu, 2008
Cationic surfactants	Softening action for fabric and hair rinsing, mineral floatation collectors, hydrophobing agents, corrosion inhibitors, coating in inks, magnetic slurry, sterilize containers in dairy and beverage industries, antiseptic agents, disinfectants and sterilizing agents. Not used in food industries	Stampfli and Nersten, 1995; Lim et al., 2000; Sun and Liu, 2008
Amphoteric surfactants	Pharmaceuticals and cosmetics industry, antistatic agent, lubricants for hair and fabrics, wetting agent and bactericide, textile softeners, soaps, corrosion inhibition, additives, starch complex, protein modifier	Stampfli and Nersten, 1995; Soontravanich et al., 2008
Anionic surfactants	Dough conditioners, dough softeners, soaps, foaming agent, wetting agents, detergents, emulsion polymerization, paints, sanitization, petrol industry, hair washing agents, hand washing materials, liquid crystal modifier, solubilizers, starch complex, protein modifier	Stampfli and Nersten, 1995; Hosseini et al., 2007; Soontravanich et al., 2008

soybean degumming process (Silva, 1993). The details of anionic and cationic surfactants are illustrated in Table 2. These are widely used in many food applications as emulsifiers and work synergistically with other surfactants. Lecithin is a major contributor of natural surfactants (Watanabe et al., 2005), which strengthens the dough (Azizi et al., 2003) but this compound does not interact with the starch, resulting in staling at faster rate as compared to the bread having surfactants (Orthoefer, 2008); however, improves baking performance (Eliasson, 1994).

Lecithin, a valuable emulsifying agent is used in breads to increase the gassing power of the dough and improve the crust development (Cauvain, 1999). This compound is extracted by soybean (Dobraszczyk and Morgenstern, 2003) as it is tightly bound with the starch fractions, amylose, and so results in decreased crystallization rate (Watanabe et al., 2005). This compound also decreases the amylopectin crystallization as it is enriched with the lysophospholipids (Gomez et al., 2004). The studies shows that the lecithin extracted from the oats reduces the staling at faster rate as compared to the lecithin extracted from the soybean (Gray and Bemiller, 2003). The structure of lecithin is represented in Figure 2.

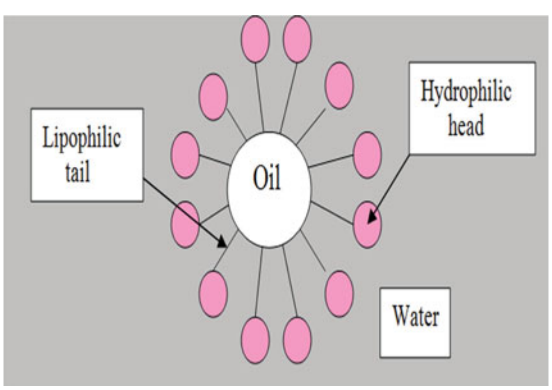

Figure 2 Structure of lecithin. (Color figure available online.)

Sodium Stearoyl-2-Lactylate (SSL) and Calcium Stearoyl-2-Lactylate (CSL)

Addition of CSL and SSL for manufacturing of bread not only improves the crumb softness (Stampfli and Nersten, 1995; Flores et al., 2007) but also increases the mixing tolerance (Kamel and Hoover, 1992), improves gas retention (Kokelaar et al., 1995; Whitworth, 2002; Ribotta et al., 2004), improves bread volume, finer crumb grain, improves slicing characteristics (Eliasson, 1994; Cauvian, 1998; Azizi and Rao, 2005) and extended shelf life (Barrett et al., 2002; Grigoriev et al., 2006). During the whole bread making process SSL works in the gas and dough interface that aids in the gas bubble stability in the dough (Tenny and Schmidt, 1968) and continues this activity by holding gases throughout the bread baking process (Gudmundsson and Eliasson, 1990; Stampfli et al., 1996; Kohler and Grosch, 1999; Gelders et al., 2004; Orthoefer, 2008).

It also exerts positive effect on the pasting properties of the bread, which later on can lead to the delay in the bread firming process (Collar and Bollayn, 2005). These compounds are not useful for the reduction of proofing time of the dough but give significant improvement in the rheological properties of the frozen dough during frozen storage (Matuda et al., 2005). The gas and dough interface has to meet certain surface rheological properties for the retardation of instability of foam (Kokelaar et al., 1995), so the addition of SSL in the bread and other bakery products is steady in their x-crystal (Schuster and Adams, 1984).

SSL and DATEM are equally beneficial in decreasing the surface tension in dough that will aid in the better air incorporation (Tsen and Weber, 1981) and also helpful in trapping smaller bubbles throughout the mixing stage (Tenny and Schmidt, 1968). Both of these affects are collectively helpful in the retardation of disproportionation, which also enhances the bread improving abilities and cause the raise in bread volume and also gives fine crumb texture (Kokelaar et al., 1995; Barcena and Rosell, 2006b).

Polysorbates

Polysorbate-60 is produced by the interaction of ethylene oxide and sorbitan monostearate (Langhans and Thalheimer, 1971). These compounds act as gentle dough strengtheners and crumb softeners (Stampfli and Nersten, 1995) but their affect can be increased if used in combination with mono or diglycerides (Lagendijk and Pennings, 1970). Most commercial form of PS-60 is in combination with monoglycerides. In synergism with flour components these compounds increase the dough stability (Xie et al., 2004; Azizi and Rao, 2005), aid in more migration of starch molecule and preventing excessive up take of water as compared to the bread having no surfactants. The incorporation of this surfactant in the frozen dough does not affect the unfrozen water content (Matuda et al., 2005).

The mixture of PS-60 and MDG along with SSL and MDG has a significant effect on moisture migration (Pisesookbunterng et al., 1983) that is higher for first 4 days attributed to association of surfactant with starch molecule (Xu et al., 1992). The effect of polysorbate 80 (PS-80) on frozen dough showed that the water contents that are not frozen are not affected by the presence of the surfactants as the texture is changed in freezing period. Resistance to extension was also partial by CSL and PS-80 (Matuda et al., 2005).

Glycerol Monostearate (GMS)

GMS is the most commonly used surfactants in the bread industry but the mode of action of this improving agent is not fully elucidated (Bajwa, 1990; Lonkhuysen and Blankestijn, 2006). This compound shows superior results when mixed with water but can be added in dough in form of powder (Aust and Doerry, 1992). GMS functions in bread by decreasing the rate of staling; however, it does not improve dough gassing power, bread volume, and bread softening (Azizi et al., 2003). The addition of this compound does not modify the capability of dough to absorb water extensively but slightly increases the dough stability (Ravi et al., 2000).

INTERACTIONS OF SURFACTANTS

Many researchers (Robins et al., 2003; Lindeboom et al., 2004; Caballero et al., 2007) concluded that starch retrogradation is caused by additives and some of the natural compounds present in flour and results in bread firming process, which includes moisture redistribution (Ozmutlu et al., 2001; Leon et al., 2002; Osorio et al., 2003), protein content of flour (Maleki et al., 1980), starch (Ribotta et al., 2003), which results in bread staling process (Ribotta and Bail, 2007). Reducing can be done by bread staling process by the use of surfactants (Azizi and Rao, 2005) as these compounds interact with amylose, amylopectin, starches, and proteins.

Interaction with Starch

The bread firming rate is greatly influenced by the starch portion (Copeland et al., 2009). The starch fractions enlarge in the oven and the amylose ooze out from these fractions (Miyazaki and Morita, 2005; Sandhu et al., 2008) and amylopectin is dilated (Gray and Bemiller, 2003; Gelders et al., 2004; Collar et al., 2007). The preliminary softening of the bread is linked to the amylose portion while amylopectin plays its role at the time of storage (Xie et al., 2004). Starch complexes with surfactants have been studied extensively by DSC, XRD, viscometers, and image analysis (Gasic et al., 2002; Debet and Gidley, 2006; Turabi et al., 2007) and it is concluded that starch surfactant complexes stop the crystallization due to amylose and amylopectin fractions (Crowley et al., 2000; Goetz et al., 2003; Chin et al., 2004; Azizi and Rao, 2005; Mousia et al., 2007; Srichuwong and Jane, 2007; Tian et al., 2009).

The addition of MDG, EMG, SE, DMG, and PS-60 (Kaur and Singh, 2000) results in increasing the pasting temperature of corn starch (Osman and Dix, 1960; Krog et al., 1989). The monoglycerides, SSL, CSL at 0.5% concentrations resulted in slight reduction in the peak viscosity of cassava (Krog, 1990). The viscosity during the holding period was stabilized by GMS while it was destabilized by DATEM (Inagaki and Seib, 1992). The pasting temperature increased by the addition of GMS and SSL while CSL and DATEM had no effect. MG can reduce the swelling and solubility of starch (Gandikota and MacRitchie, 2005) and decrease the level of firmness and firming rate of breadcrumb (Krog and Jensen, 2007).

Role of Amylose

Amylose form helical inclusion complexes (Hizukuri, 1985; Shibanuma et al., 1994; Buleon et al., 1998; Hoover, 2001; Tester et al., 2004; Jane, 2006; Collar et al., 2007; Copeland et al., 2009) with a number of substances resulting in V type X-ray diffraction pattern (Eliasson and Gudmundsson, 1996). The amylose and amylopectin structure in the bread have been studied extensively by many scientists (Blanshard, 1987; Zobel, 1988; Srichuwong and Jane, 2007).

Many studies (Ghiasi et al., 1982; Eliasson, 1986; Becker et al., 2001; Patel et al., 2005; Barcenas and Rosell, 2007) have shown the amylose surfactant complexes by the use of x-ray diffraction and electron microscopy (Morad and Appolonia, 1980). These studies revealed that addition of 0.5% surfactant in bread will form strong bonds with the amylose portion (Buleon et al., 1998; Becker et al., 2001) and decrease leaching from the granule (Eliasson, 1985; Bollain and Collar, 2004) and also result in either an increase (Raphaelides, 1992; Nuessli et al., 2003) or a decrease in viscosity of starch (Karkalas and Raphaelides, 1986). The amylose more readily forms complexes with surfactants (Figure 3) as compared to the amylopectin (Lagendijk and Pennings, 1970; Pisesookbunterng et al., 1983).

DATEM and DMG affect on DSC measurement prove (Xu et al., 1992) that DMG forms strong bonds with the amylose

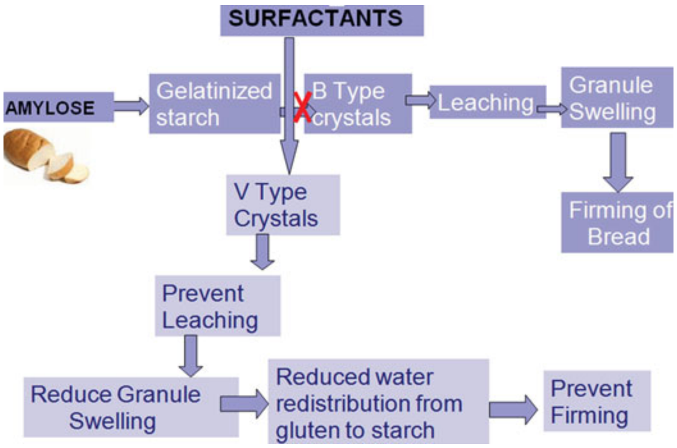

Figure 3 Mode of action of surfactants on amylose in decreasing staling. (Color figure available online.)

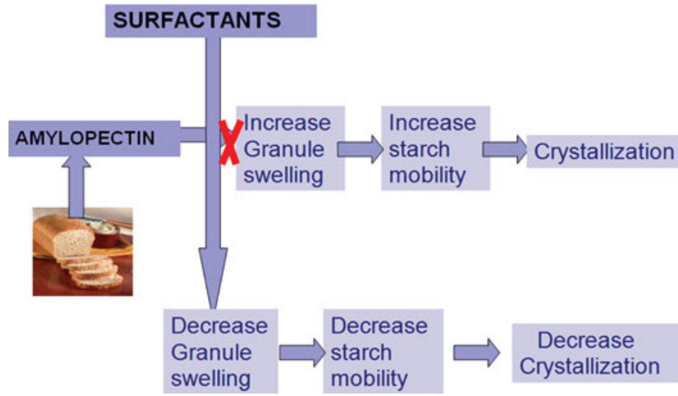

Figure 4 Mode of action of surfactants on amylopectin in decreasing staling. (Color figure available online.)

present in the dough, which further increases normal content of the amylose-surfactant complex (Richardson et al., 2003), while DATEM results in little decrease in amylopectin retrogradation (Krog et al., 1989). MG has best amylose complexing ability among nonionic surfactants and SSL, and CSL have best among ionic ones. EMG and PS-60 form a water soluble complex with amylose fraction of wheat (Kim-Shin et al., 1991).

Role of Amylopectin

The theory of amylopectin recrystallization was investigated by many researchers (Bonny et al., 2004; Debet and Gidley, 2006) by studying the breads having more amylopectin or by using thermal investigations (Axford and Colwell, 1967). These studies show that soluble starch composition removed from bread principally contains amylopectin, while little quantity of amylose was also extracted, which progressively decreased during bread staling (Knightly, 1988). The amylose is accountable for staling during first day of storage (Morad and Appolonia, 1980).

Amylopectin crystallization is main factor in bread staling. Many researchers (Zobel, 1973; Eliasson and Gudmundsson, 1996; Knightly, 1996; Klucinec and Thompson, 1999) concluded that the surfactant interacts with amylopectin forming amylopectin surfactant complexes (Figure 4), which results in decreased rate of staling. It is generally accepted that it is the amylopectin that determines the gelatinization properties of starch (Yasunaga et al., 1968). There are several reports in the literature that some lipids and surfactants can interact with amylopectin, thereby affecting starch properties (Hizukuri, 1985; Evans, 1986; Gudmundsson and Eliasson, 1990).

The firming phenomenon of bread has been attributed to the retrogradation of amylopectin fraction in the starch (Evans, 1986; Slade and Levine, 1987; Eliasson, 1994; Hoover, 2001) rather than the amylose fraction (Zobel, 1988). Studies with bread made from defatted bread show that MG reduces crumb firmness as compared to shortenings (Roach and Hoseney, 1995). SSL, SMG, and GMS complex evenly with both amylose and amylopectin (Stefanis et al., 1977), which are confirmed by using electron spin resonance (Becker et al., 2001), supported by using x-ray diffraction techniques and DSC (Gudmundsson and Eliasson, 1990). The inherited fats and the starch molecules interact with the MG resulting in decrease retrogradation (Azizi et al., 2003).

Interaction with Protein

Wheat proteins are divided into two main groups; the gluten and the non-gluten proteins (Veraverbeke and Delcour, 2002; Pena et al., 2006). The major storage protein of wheat is gluten proteins (Bushuk, 1985; Singh and MacRitchie, 2001; Singh, 2005), which plays a crucial role in bread making with its viscoelastic and gas holding properties (Ornebro et al., 2000; Li et al., 2003; Fessas and Schiraldi, 2005; Goesaert et al., 2005). The gliadin comes under the category of gluten protein (Shewry et al., 1986; Pena et al., 2005; Pilli et al., 2007) and also the glutenin that improves the dough properties (Delcour and Hoseney, 2009).

Many researchers (Dragsdorf and Marston, 1980; Labell, 1983; Pomeranz, 1994; Xu et al., 1992; Xu et al., 2001; Don et al., 2003; Kovacs et al., 2004) studied that wheat flours show great differences in their staling behaviors, which is mainly due to functionality of protein fractions (Maleki et al., 1980; Pomeranz, 1994; Primo-Martin et al., 2006) and these protein changes are heat-irreversible resulting in bread staling (Singh and MacRitchie, 2001). During staling process gluten and starch interact with one another (Martin et al., 1991; Fessas and Schiraldi, 2000) resulting in loss of crumbs kinetic energy. Surfactants interact with starch molecules (Stefanis et al., 1977; Lucas et al., 2007) resulting in decreased starch swelling during the baking process (Shibanuma et al., 1994; Lodi et al., 2007a), which results in less solubilization of starch molecules (Petit and Escher, 1992; Whitworth, 2002). As little exterior surface is exposed to the gluten, weaker bonds are formed with proteins that result in the decreased staling rate (Inagaki and Seib, 1992; Li et al., 2003; Fessas and Schiraldi, 2005; Flander et al., 2007; Wiggins and Cauvain, 2007). If the starch fractions are extra enlarged in the bread then it will result in increased crumb softening (Rao et al., 1992).

The mechanisms by which surfactants decrease the firmness of the bread are different (Kou and Chinachoti, 1991). Mono and diglycerides and SSL reduce the crumb softness more as compare to butter added breads (Azizi et al., 2003) and are helpful in restoring original freshness (Pisesookbunterng et al., 1983). At low levels, SSL do not affect the bread quality characteristics (Rao et al., 1992); however, at moderate levels result in increased bread volume (Azizi and Rao, 2005). DMG increased bread volume (Barcenas et al., 2003a) without improving the smoothness of fresh bread, while others like Lecithin and EMG result in increased volume if added to the ordinary flour or the flour that does not contain any fat (Azizi et al., 2003; Chiotellis and Icheme, 2003).

CONCLUSION

Surfactants have been extensively used not only in food industries but also in other industries due to their surface tension properties. In bread making, it is now considered as a key factor for improving the physiochemical characteristics of the bread as no bread will yield its high quality characteristics and will not fetch high price without the addition of these compounds. But the selection of proper surfactants is very important to obtain good quality bread.

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