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REVIEW

Emulsifiers in bread making

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The literature on the application of emulsifiers for baking as dough conditioners and anti-staling agents, is reviewed. The first part of the paper is devoted to reviewing the various studies on dough handling and bread quality improvement due to emulsifiers. In the second part, emphasis is given to the presentation of the phenomenon of staling in bread. Considerable work has dealt with the application of emulsifiers in bread and bread models to understand the staling mechanism. Nevertheless, staling cannot be explained by one theory alone; it is more likely that staling is the result of numerous reactions between the different flour fractions.

INTRODUCTION

Breadmaking is a handicraft which has a long tradition. Bread is also a basic food. But today the mechanization, large scale production and the increased consumer demand for high quality, convenience and longer shelf-life have created the need for functional food additives such as emulsifiers to achieve those desired aims.

For the baking industry, the optimization of dough properties and the quality improvement of the finished product are first of all of interest. For the consumer, the sensorial appeal of the finished product is the most important. After baking, the freshness of bread deteriorates very fast (staling) and therefore 'old bread' cannot be sold. The losses for the baking industry due to bread staling, are economically of great significance. Best (1991) refers to 8–10% of bread production which is unsalable because of staling.

Therefore, it is a challenge for cereal science to improve dough properties and to understand and retard staling to keep bread quality high as long as possible.

EMULSIFIERS

Emulsifiers belong in the general class of compounds called surface-active agents or surfactants. Emulsifiers are fatty substances possessing both lipophilic and hydrophilic properties. The surface tension between two normally immiscible phases is reduced by emulsifiers; therefore the two liquids are able to form an emulsion (Dziezak, 1988; Flack, 1987; Krog, 1981).

For the baking industry the characteristics which are expected of emulsifiers are mentioned by Marnett (1977), Knightly (1981), Potgieter (1992), Kamel and Ponte (1993):

- improved dough handling including greater dough strength;
- improved rate of hydration and water absorption;
- greater tolerance to resting time, shock and fermentation;
- improved crumb structure: finer and closer grain, brighter crumb, increased uniformity in cell size;
- improved slicing characteristics of bread;
- crust thickness;
- emulsification of fats and reduction of shortening;
- improved symmetry;
- improved gas retention resulting in lower yeast requirements, better ovenspring, faster rate of proof and increased loaf volume;
- longer shelf-life of bread.

Any one emulsifier does not possess all of these characteristics. The efficiencies of the different emulsifiers are closely related to their chemical structure (Krog, 1990). Lecithin, being a natural emulsifier, is becoming more and more popular; therefore authors like Schaefer (1988), Schmitt (1992), Ziegelitz (1992) and Silva (1993) all report the special properties of this emulsifier.

Food emulsifiers can be classified on the basis of several characteristics (Artz, 1990; Kamel & Ponte, 1993):

- origin: either synthetic or natural;
- solubility properties;
- the presence of functional groups;
- hydrophilic/lipophilic balance (HLB);
- potential for ionization (nonionic versus ionic).

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In practice, the most widely used methods are the HLB index and the potential for ionization. The HLB index is based on the relative percentage of hydrophilic to lipophilic groups within the emulsifier molecule (Artz, 1990). The potential for ionization is based on the electrochemical charge of the emulsifiers in aqueous systems. Emulsifiers are therefore classified either as ionic or nonionic. Nonionic emulsifiers do not dissociate in water due to their covalent bonds. Ionic emulsifiers may be anionic or cationic, but cationic emulsifiers are not used in foods. Amphoteric emulsifiers contain both anionic and cationic groups and their surface-active properties are pH-dependent (Dziezak, 1988). Table 1 shows the most used emulsifiers and their abbreviations in this paper.

According to the required properties in bread making, the emulsifiers are normally divided into dough strengtheners and crumb softeners, although some emulsifiers (i.e. SSL) show properties for both dough strengthening and crumb softening. The ability of emulsifiers to improve bread volume and to produce longer crumb freshness is comparable to the effects usually reached by adding shortening. Shortening is a term used in the baking industry to describe fats, oils, their derivatives or a blend of them, which improve bread quality. Since all lipids are quite expensive and consumers demand low-fat products, the reduction of shortening in bread is of great interest. A lot of work has been done to compare the effects and the mechanisms of these two different ingredients to see if shortening can be replaced by emulsifiers.

DOUGH STRENGTHENER

In the industrial production of bread, the rheological properties of the dough are important. The dough is expected not to stick to metal surfaces and to show a good resistance to vibration and mechanical shock. Therefore emulsifiers are used as dough conditioners to obtain a good machine tolerance (Krog, 1984). Krog (1984) reported that bread made of shock-treated doughs without dough conditioners shows a loss of volume of 45% in comparison with bread of doughs containing DATEM. Barry and Tenny (1983) demonstrated that with SSL the volume of bread made with an abusive dough procedure was better than bread made without dough conditioner. Aust and Doerry (1992) demonstrated that the specific volume of previously shocked bread was higher than the control bread, when a monoglyceride–lecithin blend was used.

DATEM, SSL, CSL and Polysorbate are the most commonly used dough strengtheners. They exert their effects during fermentation, mechanical handling, shaping and transport, as well as during the proofing and the first part of the baking period. The final results are higher volume and improved crumb structure of the finished goods (Tamstorf, 1983).

The mechanism of dough strengthening due to emulsifiers, is not fully understood. Several theories exist and are reviewed by Krog (1981) and Tamstorf (1983). One explanation says that all good dough strengtheners are able to form liquid films of lamellar structure in the interphase between the gluten strands and the starch. They improve the ability of gluten to form a film which retains the gas produced by the yeast (Krog, 1981). The ability of emulsifiers to form different phases in water is extensively explained by Krog (1990).

In spite of the consequences of bad dough properties on the final product, relatively little has been reported about the effect of emulsifiers on dough mixing characteristics. Different methods for determining the rheological properties of dough (Brabender farinograph, mixograph, research water absorption meter, extensigraph, structural relaxation method, Chopin alveograph, Hageberg falling number, Brabender visco-amylograph, expansograph, Brabender maturograph and Brabender oven-rise recorder) are reviewed by Venkateswara and Haridas (1993).

The effect of emulsifiers on farinograph properties was studied by Knightly (1968) who reported that glycerol monoesters of high iodine value decreased the water absorption and that pure glycerol monostearate and monopalmitate had no effect on water absorption. Tsen and Weber (1981) found no differences in water absorption using SSL, CSL, DATEM, EMG, Poly-60,

Table 1. Classification and abbreviation of emulsifiers

Classification	Emulsifier	Abbreviation	EEC No	Softening[a]	Strengthening[a]
Amphoteric					
	Lecithin	None	E322	Good	None
Ionic					
§ catonic	Not used in foods				
§ anionic	Diacetyl tartaric acid esters of monodiglycerides	DATEM	E 472e	Fair	Excellent
	Sodium stearoyl-2-lactylate	SSL	E 481	Very good	Excellent
	Calciumstearoyl-2-lactylate	CSL	E 482	Good+	Excellent
Nonionic					
	Monodiglycerides	MDG	E 471		
	Distilled monodiglycerides	DMG		Excellent	None
	Ethoxylated monoglycerides	EMG		Poor	Very good
	Sucrose esters of fatty acids	SE	E 473	Good	Excellent
	Polysorbate-60	Poly-60	E 435	Fair	Very good

[a]From Kulp and Ponte (1981, 1993).

monoglycerides and sucrose monopalmitate, but they reported an increased stability for SSL, CSL and DATEM and an increased development time for SSL, CSL and EMG. In contrast, Tamstorf (1975) found no effect of DATEM, CSL and DMG on farinogram characteristics. The results of Watson and Walker (1986) showed no difference in water absorption, but the stability decreased with SSL and increased with SE. Lang *et al.* (1992) studied the effect of different additives (i.e. SSL and SE) on flour water dough mixograms. They found that an increasing concentration of SSL had no influence on peak heights, but the mixing time increased. SE showed no major changes in mixing characteristics. The effect of emulsifiers on extensigraph properties was studied by Knightly (1968) for glycerol monooleate, which reduced resistance to extension and produced greater extensibility.

Addo and Pomeranz (1992) studied the effect of lipids and emulsifiers (lecithin, EMG, pure fatty acids) on alveograph characteristics of defatted flour. They found that none of the emulsifiers alone could restore alveograph characteristics when adding them to defatted flour but, in combination with shortening, the rheological properties of the dough were more similar to the original flour than when adding shortening alone.

Tsen and Weber (1981) found that some emulsifiers (Poly-60, EMG) prolonged proof times and inhibited gassing power, others (DATEM, SSL, CSL) shortened proof times and promoted gassing power. Moore and Hoseney (1986) showed that DMG has similar and SSL improved CO_2 retention properties compared with shortening, resulting in similar or higher bread volume. The differences in the volume of bread made with emulsifiers instead of shortening have been investigated by many authors. The results showed that the loaf volume of bread made with DATEM, SSL, CSL, EMG, SE, monoglycerides, ascorbyl palmitate and sucrose monopalmitate was similar or higher, than bread baked with shortening (Chung *et al.*, 1976; Junge & Hoseney, 1981; Tsen & Weber, 1981; Rogers & Hoseney, 1983; Lorenz, 1983; Breyer & Walker, 1983; Bruinsma & Finney, 1984; Koch *et al.*, 1987; Kamel & Hoover, 1992; Xu *et al.*, 1992*a*; Mettler *et al.*, 1992*c*).

Jodlbauer *et al.* (1992) showed that, with fractions of lecithin, the bread volume was as high as bread made with DATEM. Shogren *et al.* (1981) reported that, with emulsifiers (DATEM, EMG, sucrose monopalmitate, SSL and lecithin), the deleterious effects of added fibre on bread volume could be minimized. Nierle *et al.* (1991) tested fatty acids, monoglycerides and monoglycerol ethers for their suitability as emulsifiers in bread making and found an increase in bread volume and an improved bread quality. Junge *et al.* (1981) examined emulsifiers (SSL, EMG, POLY-60, DATEM, DMG and propylene glycol monoesters) for their air incorporation in dough and the resulting crumb grain of the bread by using mixograph and scanning electron microscopy (SEM). The SEM results showed that emulsifiers which form more and smaller air cells produced a fine grain in the finished product. Koch *et al.* (1987) mentioned improved crumb grain by using higher fatty acid esters of ascorbyl palmitates, whereas the shorter fatty acid esters tended to give open grain.

Mettler *et al.* (1991*a–d*, 1992*a–c*) and Mettler and Seibel (1993) conducted a detailed study on the effects of emulsifiers (MDG, DATEM and lecithin) and hydrocolloids during the whole breadmaking process. They measured dough properties by final proof time, fermentation stability, dough elasticity, followed the oven rise during the baking process, and determined the bread quality by specific volume, crumb grain, crumb elasticity and increase in crumb firmness during storage. DATEM showed a positive influence on the fermentation of the dough measured by maturograph and oven rise recorder. With increasing dosage, the fermentation time and the stability of fermentation increased and the dough standing was improved. The effect of MDG and lecithin were only small and occurred only by application of high dosages. All emulsifiers increased the oven rise during baking. DATEM showed a strong CO_2 retention coefficient. The influence of emulsifiers on defatted flour was measured by thin-layer chromatography, which demonstrated that MDG increased the extractability of lipids. Already Chung *et al.* (1981) reported that EMG, DMG and SSL lowered extractability of certain bread lipid components by complexing with them.

CRUMB SOFTENER

Crumb softeners create a longer lasting softness in the crumb of bread by interacting with the flour components and retarding the staling. The changes in crumb softness are generally called staling and they are normally related to changes in the starch fraction. Typical crumb softeners are the monoglycerides.

The generally accepted theory about the mechanism by which crumb softeners retard the firming process is based on the ability of monoglycerides to form complexes with amylose. Tamstorf (1983) reported that this amylose monoglyceride inclusion complex is insoluble in water. Therefore, the part of the amylose which is complexed by the monoglycerides does not participate in the gel formation which normally occurs with the starch in the dough during baking. Therefore, upon cooling, the complexed amylose will not recrystallize and will not contribute to staling of the bread crumb. The ability of different emulsifiers to form inclusion complexes with amylose varies (Osman *et al.*. 1961; De Stefanis *et al.*, 1977; Morad & D'Appolonia, 1980; Tamstorf, 1983; Mettler *et al.*, 1991*e*; Inagaki & Seib, 1992) and therefore their contributions to a reduction of the staling rate are different (Lehmann & Plocher, 1978; Conde-Petit & Escher, 1991).

STALING

Staling is a phenomenon which describes the deterioration of bread quality during storage. Consumers associate staling with some typical sensorial changes in the bread such as loss of flavour, loss of crispness in the crust, increased crumbliness and crumb firmness.

Scientific attempts to prevent staling require appropriate emulsifiers for practical use and an understanding of the mechanism of staling. After a century of research, there are several theories such as starch recrystallization, moisture migration and interaction between starch and gluten, which are discussed in many reviews: Herz (1965), Elton (1969), Zobel (1973), Maga (1975), Knightly (1977), D'Appolonia and Morad (1981), Kulp and Ponte (1981), Schuster (1985), and Kamel and Ponte (1993). Kamel and Ponte (1993) exposed, in their detailed review, the different chemical characteristics of the different emulsifiers, their classification, their application and the different staling theories.

However, the phenomenon of staling is still not completely understood. The application of emulsifiers to wheat white bread to study their effect on the staling mechanism has been reported by numerous authors (Toeroek & Moor, 1982; LaBell, 1983). The approaches of the different studies, to prevent and to understand staling, are various. Crumb firming over storage time is one of the most important attributes of bread staling. It is also the simplest to define objectively (Persaud *et al.*, 1990*a*) and shows a good correlation with sensorial evaluations (Bashford & Hartung, 1976); therefore it is one of the most used measurements in staling studies. To follow the changes in the flour components during staling, many investigators monitor starch retrogradation by differential scanning calorimetry (DSC).

ROLE OF WATER

The changes in bread during storage are not only due to water loss since, with an appropriate packaging, the crumb moisture during storage can be maintained, but the firming of the crumb cannot be prevented (He & Hoseney, 1990). Nevertheless, the moisture content of the bread plays an important role in crumb firming. Rogers *et al.* (1988) and Xu *et al.* (1992*a*) found that the moisture content was inversely proportional to the rate of firming. He and Hoseney (1990) supported this, reporting that the higher the moisture content, the slower the firming rate and the lower the final firmness. Longton and LeGrys (1981) showed, by DSC studies, that the moisture content of wheat starch gels determines the extent of their ageing. Zeleznak and Hoseney (1986) confirmed these results. Bechtel and Meisner (1954) showed that during the storage of the intact loaves, a continuous migration of moisture from crumb to crust occurred. Larsen and Greenwood (1991) demonstrated that there is a moisture gradient between the centre and edges of loaves and that this fact has consequences for studies on water migration in loaves, physical properties of bread crumb and staling mechanism.

Pisesookbunterng and D'Appolonia (1983) investigated the effect of emulsifiers (SSL, MDG and a blend of 40% Poly – 60 + 60 % MDG) on moisture migration from the crumb to the crust in bread. After storage for 1 and 4 days, bread with emulsifiers had greater moisture migration from the crumb to the crust than the control bread. They suggested that, in bread containing emulsifiers, the adsorption of emulsifiers onto the starch surface might not allow the starch granules to take up water released by gluten to the same extent as the control bread. Therefore, this water would be available for migration from the crumb to the crust. These results were confirmed by the investigations of Xu *et al.* (1992*a*).

Kim-Shin *et al.* (1991) studied the changes in water mobility during bread staling by nuclear magnetic resonance (NMR). They compared the behaviour of surfactants-treated bread (SSL, MDG, SE) with that of control samples. The water mobility decreased during ageing, but the sample containing surfactants did not differ significantly from the control. The authors found no correlation between the amylopectin crystallization (measured with DSC) and the decrease in water mobility. As the addition of antistaling surfactants inhibits amylopectin crystallization, but not the water mobility, they concluded that the observed effects were not caused by amylopectin crystallization, but were more likely due to changes taking place within the amorphous region.

ROLE OF THE STARCH FRACTION

The starch fraction plays an important role in the staling mechanism. By reheating bread up to 50°C, bread can be refreshed and the staling phenomenon reversed. Under these conditions retrograded amylose is not reversed, but retrograded amylopectin reverts to its amorphous state. Schoch and French (1947) suggested that during baking, starch granules swelled, amylose was partially leached out of the granules, and amylopectin was dilated. While amylose associates rapidly in bread after baking and therefore affects only the initial firmness, amylopectin associates gradually during storage, causing bread staling. The amylopectin recrystallization theory was improved by Prentice *et al.* (1954), Axford and Colwell (1967) and Colwell *et al.* (1969) by using either bread models with a high amylopectin content or by using differential thermal analysis. Kim and D'Appolonia (1977) found that the composition of the soluble starch extracted from bread crumb was predominantly amylopectin but that small amounts of amylose were also extracted. Although the amylose content in the extract was small, it progressively decreased during bread staling. Therefore, they suggested that also amylose takes part in the staling during the first 24 h. Ghiasi *et al.* (1984) supported this using a high amylopectin bread model. Morad and D'Appolonia (1980) confirmed the decreasing amylose content in the soluble starch during storage.

The reactions between the emulsifiers and the starch fraction have been studied by many authors (Carlson *et al.*, 1979; Bulpin *et al.*, 1982; Ruohoniemi, 1990). Eliasson

(1985) showed that the amount of amylose leached from the granules decreased in the presence of emulsifiers. Krog *et al.* (1989) found that the addition of DMG or DATEM reduced the rate of firming in proportion to their concentration in wheat flour. DATEM effects on DSC measurement were less than those of DMG. It was concluded that the crystallinity of amylopectin in bread plays an important role in the development of firmness. The measurements of crumb firmness and DSC showed that DMG interacts primarily with the free, soluble amylose in the dough, increasing the natural content of the amylose–lipid complex. When more than 1% DMG was added, all free amylose was bound and an increased interaction with the amylopectin fraction took place, reducing the degree of retrogradation. DATEM was less effective with regard to forming amylose lipid complexes and also gave less reduction in amylopectin retrogradation than DMG. Inagaki and Seib (1992) showed, in a model system, that bread containing added waxy barley starch with a high amylopectin content, firmed faster than bread made without addition. They concluded that amylose may play a passive role in the firming of bread crumb, but the main factor of crumb firming was associated with the recrystallization of amylopectin.

The fact that emulsifiers reduce the crumb firming rate is well documented (Pisesookbunterng & D'Appolonia, 1983; Joensson & Toernaes, 1987; Joensson, 1989; Krog *et al.*, 1989; Hartunian-Sowa *et al.*, 1990; Conde-Petit & Escher, 1991; Mettler *et al.*, 1992*b*; Xu *et al.*, 1992*a*).

The efficiencies of the emulsifiers in retarding crumb firmness depends on their ability to form complexes with amylose. De Stefanis *et al.* (1977) found that SSL not only complexed with amylose but also with amylopectin. Lehmann and Plocher (1978) examined the reduction in iodine affinity of monoglycerides and lecithin on retrograded starch after different storage times. Lecithin did not form a complex with the starch and bread made with lecithin firmed faster than bread with monoglycerides. Conde-Petit and Escher (1991) demonstrated, with DSC and crumb firming measurements and using a 40% starch gel as a model for bread crumb, that complex-forming emulsifiers (glycerol monostearate, CSL) have a greater efficiency to retard crumb firmness than non-complex forming emulsifiers (lecithin). Further, they pointed out that the emulsifiers have to be added in the correct physical state, so that they can interact with the starch fraction. The importance of the physical state in which different lecithins are added to improve the baking performance, was already emphasized by Eliasson and Tjerneld (1990).

Yasunaga *et al.* (1968) suggested the possibility of using an amylograph to measure the extent of staling. Osman and Dix (1960) and Morad and D'Appolonia (1980) found that surfactants increased pasting temperature and viscosity. Mettler *et al.* (1992*b*) found that the gelatinization viscosity decreased with increasing complexing ability of the emulsifiers.

Xu *et al.* (1992*a,b*) conducted bread crumb amylograph studies with flour lipids, shortening and various surfactants. Amylograph readings of bread made with different additives (SSL, DMG, DATEM, sucrose monopalmitate), were significantly correlated to crumb firmness. An inverse relationship between crumb compressibility and crumb amylograph viscosities was found. They suggested that, in the amylograph, starch in the bread crumb, which had been swollen and pasted to different degrees due to its interaction with different fatty additives, underwent further swelling and dispersion in the presence of the same additives. Therefore those additives that have more starch-complexing power, giving softer bread crumb, would yield higher amylograph crumb pasting temperatures and viscosities. This would explain the negative correlations of crumb firmness with the viscosity parameters. They found no significant effect of the storage time of bread on the amyloram readings of bread crumb.

ROLE OF THE PROTEIN AND OTHER FRACTIONS

Although the starch recrystallization theories are not rejected today, many investigators (Dragsdorf & Varriano-Marston, 1980; Rogers *et al.*, 1988) report that factors other than starch retrogradation are involved in the firming process.

Cornford *et al.* (1964), Axford *et al.* (1968), LaBell (1983), Pomeranz *et al.* (1984) and Xu *et al.* (1992*a*) reported that an increased bread loaf volume was accompanied by a reduction in crumb firmness. Studies by Maleki *et al.* (1980) showed that different flours staled at different rates and the quality of protein appeared to be responsible for the differences in rate. Moisture content and loaf size of bread affected the absolute softness but not the staling rate. Pomeranz *et al.* (1991) demonstrated the effect of lipids, shortening and emulsifiers on volume, softness and overall score, when added to defatted flour. Defatting significantly reduced volume and softness, indicating that wheat flour lipids are important functional components in baking bread. The overall quality of the defatted flour could be reconstituted, albeit incompletely, by adding the extracted lipid. Sucrose fatty acid esters, DATEM and SSL had no improving effects at low levels. DMG increased bread volume, but did not improve the softness of the freshly baked bread. Lecithin and EMG were added to regular and defatted flour. They showed no significant effect on bread volume or softness on the control flour. In defatted flour, however, they increased volume and made the crumb softer and were superior to shortening. The combination of different emulsifiers was deleterious for the quality.

Pisesookbunterng *et al.* (1983) conducted refreshening studies with and without emulsifiers. They found that emulsifiers (MDG, SSL) were helpful in restoring original freshness. Using higher storage temperature, they concluded that factors other than starch retrogradation occurred. Protein changes and moisture redistribution, both of which are not heat-reversible, were suggested to be partly responsible for the staling.

Persaud *et al.* (1990*b*) examined the dynamic rheological properties of bread crumb refreshed by microwaves versus conventional oven and with and without emulsifiers. The water loss because of microwave heating was greater, although the baking time was essentially shorter. The firming rate was also faster than with conventional heating. Emulsifiers (hydrated monoglycerides, SSL) reduced the firmness of the bread crumb compared to bread containing shortening. They concluded that the mechanisms by which shortening and emulsifiers affect firming are different.

Kou and Chinachoti (1991) stated that little is known about the quantitative changes in cellular structure of bread during staling in terms of cell wall rigidity, elasticity and susceptibility to fracture upon compression. Textural properties, such as crumbliness (a loss in bread resilience) usually decrease during staling, but crumbliness and resilience have seldom been investigated to describe the cellular elasticity and susceptibility to fracture. Therefore they studied the recoverable work and stress–strain relationship of bread crumb during storage. The percent recoverable work decreased significantly with an increased degree of deformation and storage time. The recoverable work increased curvilinearly with moisture content and relative humidity, depending on the degree of deformation. Nussinovitch *et al.* (1992) determined the recoverable work of bread crumb at various storage periods and found that most of the changes occurred within the first 24 h after baking. Rao *et al.* (1992) found that different types (DMG, SSL, SE), levels and HLB values of emulsifiers had a varying effect on amylopectin recrystallization, loaf volume, cellular structure and recoverability of bread. Their results showed that amylopectin crystallization did not contribute to the ease of collapse and the fracturability of the cells. The loss in recoverability of the bread during aging was thus contributed to by changes in the amorphous components.

Martin *et al.* (1991) suggested a model in which interactions (crosslinks) occur between gluten and starch. They suggested that during staling, as the crumb loses kinetic energy, interactions increase in number and strength. Gluten is the continuous phase, and remnants of starch granules are the discontinuous phase. During baking, monoglycerides and shortening interact with starch molecules and decrease starch swelling. Because starch granules are less swollen, less solubilization of starch molecules occurs. With less surface area exposed to gluten, fewer and/or weaker cross-links occur with protein, and the firming rate is reduced. According to their theory, monoglyceride, shortening, and water can plasticize gluten and decrease bread firmness. Inagaki and Seib (1992) confirmed that the degree of starch swelling during baking correlated with the firming of bread crumb. The more highly swollen the starch granules were in the bread crumb, the higher the rate of crumb firming.

CONCLUSION

In spite of all the work performed up to now the phenomenon of staling still remains unsolved. It seems that staling is not due only to one reaction, but it is the consequence of different reactions which take place within the different flour components. The positive effect of emulsifiers can help to improve dough properties and bread quality. Therefore emulsifiers will remain important additives in breadmaking, despite increases of other additives such as enzymes. Himmelstein (1989) emphasizes that emulsifiers and enzymes are synergistic and that enzymes do not replace emulsifiers, because they act in different ways and have other functions to accomplish.

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