Transformative Impact of Food Additives in Breads

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Abstract

Bread is a convenient and economical staple worldwide. However, its susceptibility to microbial degradation led to a short shelf life. This perishable nature results in compromised food safety, increases food wastage and results in financial losses. In response to this challenge, bread processing involves the use of food additives. These are indispensable to produce breads with optimum quality. They also offer a feasible and economical solution to these pressing issues by maintaining quality, extend freshness and shelf life of bread. The review looks at a variety of food additives as well as preservatives used in bread and gives a thorough explanation of their distinct functionality and mode of action in order to investigate the possibilities of using conventional along with novel additives for optimized bread formulations and obtain better quality characteristics.

The study explores their vital contributions through a comprehensive assessment of their effects on flavor, texture, colour, shelf life, and the bread baking process, considering different concentrations and pH levels. Additionally, the review addresses food safety aspects and regulations of the additives used in bread preservation. Overall, it emphasizes the indispensable role of food additives and preservatives in meeting consumer preferences along with ensuring product quality within the evolving landscape of the Indian bread industry.

Keywords: Additives, Preservatives, Bread, Baking

1. INTRODUCTION

Bread has long been esteemed as a fundamental staple worldwide, valued for its accessibility and affordability. Its versatility and convenience has made it a favoured choice across diverse cultures. However, despite its widespread popularity, the inherent perishability of bread presents a formidable challenge to its long-term quality and freshness. Among the various types of bread, wheat bread stands out as the most consumed variant due to its high gluten content and desirable texture. The production of bread involves a complex fermentation process, where key ingredients like flour, yeast, salt, oil, and water undergo chemical interactions to produce the final product (Cauvain, 2015a). Interestingly, the bread industry is volatile to significant growth driven by increase in demand and supply dynamics. Despite a moderate growth rate from 122,000 tons in 2007 to 129 tons in 2016, the industry generated approximately $358 billion in global revenue in 2016 (Garcia et al., 2019). In 2024, the bread market recorded a revenue of US $58.36 billion, with an anticipated annual growth rate of 8.13% between 2024 and 2028. Globally, China leads in revenue generation with an estimated US $80 billion in 2024. On a per capita basis, each person contributes approximately US $40.74 to the bread market's revenue in 2024. Also, volume-wise, the bread market is expected to reach 55.91 billion kilograms by 2028, with a projected volume growth of 5.0% in 2025. The average volume per person in the Bread market is expected to be 33.3 kilograms in 2024. These consumption based data highlights the significant of market size and growth prospects within the bread industry, indicating robust demand and consumption patterns globally (Statista, 2024).

In India, bread holds a prominent position as a secondary staple consumable, following chapati, puri, or rice. Its consumption patterns vary across different regions, with Northern States accounting for 27%, Southern States for 32%, Western States for 23%, and Eastern States for 18%. The bread industry is poised for exponential growth, with projected revenue reaching US $58.36 billion in 2024 and Compound Annual Growth Rate (CAGR) of 8.13% between 2024-2028 [All India bread manufacturer association (AIBMA), 2024; Statista, 2024].

Bread is a perishable commodity which presents a key challenge, notably staling. The physical staling, a multifaceted process involving interactions within the bread matrix, leads to organoleptic impairment. Although several theories attempt to elucidate the mechanisms behind physical staling, such as starch retrogradation, gluten structure modification, and moisture migration (Cauvain, 2015b; Fadda et al., 2014). Alongside physical staling, microbiological spoilage poses another significant threat to bread shelf life, with visible mold growth and the production of mycotoxins, particularly in moist environments (Rosell et al., 2015). Additionally, bread may undergo nutritional loss and chemical decay post-baking. In Germany, economic losses stemming from fungal contamination in bread have been approximated to 34.7% of total bread in 2015 (Alpers et al., 2021). Similarly, a report printed by Hindu revealed that in 2022, extreme climate change resulted from serve heat between 2016-2021 has triggered an income loss of $159 bn with 5.4% of its gross domestic product in the service, manufacturing, agriculture, and construction sectors. In response to the imperative need to preserve bread quality, the baking industry has embraced the incorporation of various type of natural and synthetic additives as a transformative solution to the problems encountered in bread. These organic substances play a vital role in enhancing the organoleptic properties of bread, extend shelf life, and preserve its freshness. This review explores the mode of action, functionality, interaction, advantages as well as disadvantages of the conventional and novel food additives used in bread production. It also highlights their role in quality preservation and meeting changing consumer needs in the dynamic baking industry landscape.

2. ADDITIVES

According to Codex Alimentarius, food additive are defined as any substance which is not normally consumed as a food by itself and/or not normally used as a typical ingredient, whether or not it has nutritive value, the intentional addition to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packaging, transportor holding of such food results, or may be reasonably expected to result (directly or indirectly), in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods (Codex Alimentarius Commission, 2014). The term does not include contaminants or substances added to food for maintaining or improve nutritional qualities. Table 1 briefly describes commonly used additives and their limits by FSSAI, India 2010. Food additives and preservatives, either natural, chemical or bio-preservatives are incorporated while making bread to achieve desired improvement, quality, standard and safety.

Table 1: Commonly used additives for bread permitted by FSSAI in India

Name of Additive	Amount (ppm max)
Acidity regulators	
Sodium fumarate	GMP
Potassium Malate	GMP
Sodium hydroxide	GMP
Acetic acid or Lactic acid	2500
Citric Acid	-
Malic Acid	-
Tartaric Acid	-
Emulsifying and stabilizing agents (Singly or incombination)	
Sucroglycerides	-
Hydroxy Propyl methyl cellulose	GMP
Sucrose esters of fatty acids	GMP
Di- Acetyl tartaric acid esters of mono and di-glycerides	GMP
Guar gum	5000
Sorbitol	GMP
Lecithin	GMP
Glycerine	GMP
Glycerol monostearate	GMP
Sodium steroyl 2 lactylate or Calcium steroyl 2 lactylate (Singly or in combination)	5000
Polyglycerol esters of fatty acids and polyglycerol esters of interesterified recinoleic acid	2000
Improver	

Fungal alpha amylase Bacterial amylase Amylases and other enzymes Ammonium persulphate Calcium phosphate Calcium carbonate Potassium bromate and/or Potassium iodate	100 (on flour mass basis) GMP GMP 2500 (on flour mass basis) 2500 (on flour mass basis) 5000 (on flour mass basis) 50ppm max (on flour mass basis)
Flour treatment agent Ammonium chloride L-cystein mono hydrochloride Ammonium phosphate Benzoyl peroxide	 500 (on flour mass basis) 90 (on flour mass basis) 2500 (on flour mass basis) 40
Preservatives/Mould inhibitors singly or in combination Calcium or sodium propionate Sorbic acid or its Sodium, Potassium or Calcium salts (calculated as sorbic acid) Acid calcium phosphate Sodium diacetate Acid sodium pyrophosphate	 5000 1000 10000 4000 5000
Leavening agents Baking powder Ammonium bi-carbonate Ammonium carbonate	 GMP GMP 5000
Yeast	GMP
Artificial sweeteners (Singly) Aspartame Acesulphame K Sucralose	 2200 1000 750

Ref: FSSAI, 2010

2.1 Types of additives used in bread

A. Acidity Regulators

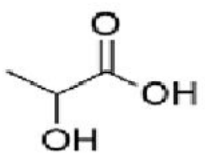
Acidity regulators also known as pH control agents, play a crucial role in food preservation, extends shelf life, enhances taste and ensures food safety. These additives are incorporated to maintain the pH levels of food products (Angioloni & Collar, 2011). FSSAI has established a maximum permissible limit of 2500 ppm for use of lactic and acetic acid in bread. In commercial bread production, various acidulants such as sodium fumarate, potassium malate, sodium hydroxide, acetic acid, or lactic acid are utilized to prolong shelf life. These additives help to regulate acidity levels in bread, contributing to its overall quality and longevity during storage (Eveleva & Cherpalova, 2019) [Table 2].

Table 2: Outlines common acidity regulators used in commercial bread production

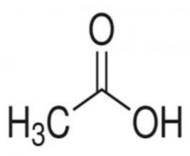
Acidity Regulator	Common Names	Purpose	Maximum Permissible Limit (ppm)	References
Lactic Acid	Lactic Acid	Food preservation, shelf life extension, taste enhancement, food safety	2500	Angioloni & Collar (2011)
Acetic Acid	Acetic Acid	Food preservation, shelf life extension, taste enhancement, food safety	2500	Angioloni & Collar (2011)
Sodium Fumarate	Sodium Fumarate	Shelf life extension	-	Eveleva & Cherpalova (2019)
Potassium Malate	Potassium Malate	Shelf life extension	-	Eveleva & Cherpalova (2019)
Sodium Hydroxide	Sodium Hydroxide	Shelf life extension	-	Eveleva & Cherpalova (2019)

1. Lactic acid and Acetic acid

The effect of lactic acid and acetic acid (Figure 1) in combination with calcium propionate on the sensory characteristics and shelf life was evaluated. Tarar et al (2010) reported that 0.2% and 0.3% lactic acid in combination with 0.2% calcium propionate was most effective combination against microbial spoilage. It was also reported that the increased quantity of acid reduces the bread volume. Therefore, low concentration of lactic acid provides better protection against microbial spoilage without affecting the loaf volume of bread.



a) Lactic Acid



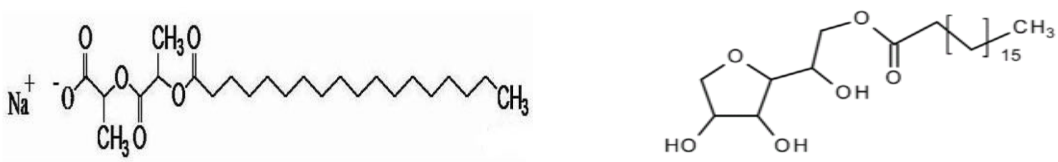
b) Acetic acid

Figure 1: Chemical structures of a) Lactic acid and b) Acetic acid

Acetic acid is used as an alternative to potassium bromate and ascorbic acid in bread processing. A study conducted by Singh et al., 2002 reported the effect of additives such as acetic acid on process variables like dough development and CO_2 release during fermentation and bread making properties. They have observed that acetic acid has shown significant positive effect on raising the height of dough, CO_2 production and pleasing sensory acceptability. Another study by Su et al., 2019 conducted their research on effect of organic acids including acetic acid and studied its effect on bread characteristics. They have reported that acetic acid with 0.1% w/w on flour basis significantly results in higher specific volume, lower moisture content and better texture. Another research conducted to improve gluten free bread quality by enrichment with acidic food additives by Blanco et al., 2011 reported a significant pH change during dough fermentation. It was reported that citric acid added at 0.4% and 1.2% which has significantly reduced dough pH. Interestingly, smaller bread volume was explained considering acetic acids preservative properties. It is known to effective against yeast activity than dough pH.

B. Emulsifying and Stabilising Agents

Emulsifiers are a group of substances used to obtain a stable mixture of liquids which otherwise would not mix. These are surface active agents which consist of hydrophilic and hydrophobic moieties. There are of two kinds- ionic and non-ionic emulsifiers. Ionic emulsifiers are salts of fatty acids [sodium stearoyl-2-lactate (Figure 2)], phospholipids and proteins while non-ionic emulsifiers used are mono- and di-esters of propylene glycol and sorbitan ester (Figure 2) (Garzón et al., 2018). In bread baking industry, emulsifiers are used to enhance the water retention capacity, improve volume and viscoelastic properties of bread (Pourzafar et al., 2013). Some emulsifiers are responsible for improving dough stability while others specifically soften the crumb of bread. Interestingly, emulsifiers like sodium stearoyl lactylate (SSL) enhance both the properties (Stampfli et al., 1995).



a) Sodium stearoyl-2-lactate b) Sorbitan ester

Figure 2: shows emulsifier a) Sodium stearoyl-2-lactate (Ionic) and b) Sorbitan Ester (Non-ionic)

1. **Diacetyl Tartaric Esters of Mono-Glycerides (DATEM)**

DATEM is an ester of diacetyl tartaric acid mono and triglyceride (Figure 3). It is a type of oil- in- water anionic emulsifier that enhance the resistance and decrease the extensibility of dough (Ravi et al., 2000; Stampfli et al., 1995). It diminishes the size of the gas bubble that are formed in dough and thus, results in the formation of micro- structure in bread. In addition, its function as a crumb softener is related to the reaction with starch especially amylose and amylopectin molecules which play a cardinal role in retardation of staling. Pourzafar et al., (2013) investigated the effect of DATEM at four concentrations (0.25, 0.5, 0.75 and 1%) on sensory and staling properties of gluten free barbari bread. The study revealed that DATEM at 1% concentration increases the shelf life and decreases the hardness of bread significantly after 3-days of storage. Samples contained 1% and 0.75% DATEM had better texture, chewiness and porosity (Pourzafar et al., 2013). The effect of Diacetyl Tartaric Esters of Mono-glycerides (DATEM) in different concentrations (10, 30 and 50 ppm) were studied on bugget`s physicochemical characteristics such as volume, crust colour, crumb texture and colour. DATEM and lipases when used together in bread formulation increases the bread volume but phospholipases at 30 and 50 ppm decreases the bread volume. The bread crust is darker by addition of lipases and phospholipases as compared to DATEM. DATEM at 0.5% and 0.75%, 10ppm lipase concentration which significantly reduced the firmness by addition ofsuch surfactants. The staling rate of bread was also delayed when compared to the control. Highest retardation of staling was observed at level of 0.75% DATEM and 10ppm of lipases (Salehifar et al., 2012)

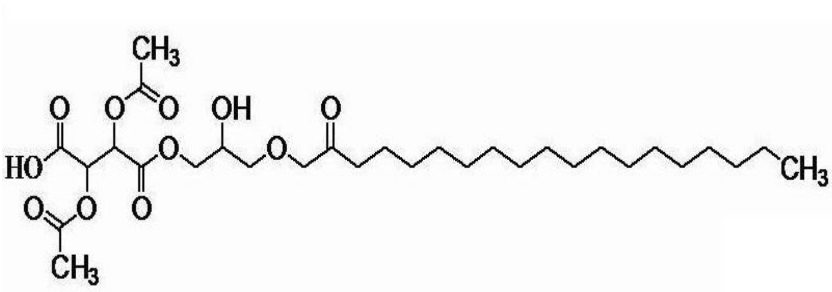


Figure 3: Structure of DATEM

2. **Glycerol Monostearate/Monostearin**

Glyceryl monostearate (GMS), also known as glycerol monostearate or monostearin, is a non-ionic ester of glycerol and stearic acid which is most commonly used as an effective emulsifier, thickening agent and a stabilizer. Food Drug and Administration (21 CFR 184.1324) recognizes it as GRAS. Also, with adequate purity it can be used without any limitation in compliance with GMP. It is mainly used to improve dough quality and stabilize fat/protein emulsion. It aids in improvement of bread texture and retard staling because of starch amylopectin complex formation. Breads baked by addition of monostearin (4.1g/2100g four) improves the dough structure, porosity, elasticity, appearance, bread volume and enhance the taste & odor of bread (Arus et al., 2008). A study by Azizi et al., (2003) reported their findings on the effects of GMS on bread making quality. Significant improvement with addition of GMS was reported. It was seen that with increased addition from 0% to 2% and storage between 3-15days, showed enhanced volume, specific volume, crumb value, baking quality, overall quality and improvement in colour & texture. However, as storage was increased, a decreased effect in these characteristics was observed. Another study by Defloor et al., (1999), extruded starch and glyceryl monostearate were added at concentration of 0-15% and 0-4% respectively. Glyceryl monostearate at 4% concentration increases volume by 30% whereas only 12% increase in volume achieved by addition of extruded starch at concentration of 9-12%.

3. Sodium Stearoyl Lactylate (SSL) And Maltogenic Amylase

Sodium Stearoyl Lactylate (SSL) improves both dough stability and crumb softening (Stampfli et al., 1995). Dough straighteners impart higher volumes and better crumb structure. They also retard the bread staling by interacting with flour components (Pareyt et al., 2011). A surfactant aids in reducing bread staling by mechanism such as formation of complex with amylose (Gomes-Ruffi et al., 2012). This affects SSL which is commonly used in breadmaking industry, particularly in pan loaves. For white breads, the amount of SSL ranges from 0.25-0.5g/100g flour (Sluimer, 2005). Maltogenic amylase provide significant softness to bread and retain high level of crumb elasticity during storage without affecting bread volume or crumb structure. (Rosell et al., 2015). Dudu et al., 2020 reported that cassava flour enriched with SSL complexation through dry heat moisture treatment aided in significant increase in water absorption and dough structural stability. This resulted in increased loaf volume, open cell structure and reduced bread crumb hardness.

C. Polyols

Polyols or sugar alcohols are natural and nutritive group of reduced calorie sweeteners. “These are neither sugars nor alcohols; rather they are group of low digestive carbohydrates which can be used instead of sucrose. They are commonly grouped as monosaccharide (erythritol, mannitol, sorbitol, xylitol), disaccharide (isomaltitol, lactitol, maltitol, trehalose) and polysaccharide (hydrogenated starch hydrolysates). In general, polyols aids in processing, modulation, improve texture, impacts dough rheology, rate of fermentation, specific volume, moisture distribution, starch retrogradation and stating process (Ding & Yang, 2021). Polyols are both considered as Generally Recognized as Safe (GRAS) and approved food additive by FDA. They are documented as sweeteners of food additives in Regulation (EC) No. 1333/2008 of the European Parliament and of the Council and were amended in No. 1129/2011.

A study conducted by Bhise & Kaur, 2014, where polyols i.e. glycerol, sorbitol and mannitol when incorporated at 2%, 4%, and 6% level, has shown that the glycerol at 2 per cent level shows maximum overall acceptability, followed by 4 per cent sorbitol and mannitol respectively. The inclusion of mannitol, sorbitol, and glycerol results in increased bake absorption, loaf height and weight. Elevated polyol levels result in a reduction in both loaf volume and specific volume. Another research by Sahin et al., 2018 reported their observations on the effect of three different polyols i.e. xylitol, mannitol and maltitol on dough characteristics, physiochemical properties, sensory attributes and shelf life of burger buns. The results showed that polyols have significant effect on yeast’s fermentation behavior. An evident decrease in total volume, hardness of bread crumb and lower gas formation were observed. Polyols does not have an aldehyde group, which is a reason behind its non-reducing and non-fermentable action by yeast. Bhise & Kaur, 2017 experimented and reported that the polyols and fibres synergistic effect on bread baking, sensory, textural quality and improved shelf life. They have observed and concluded that polyols along with fibre incorporation resulted in bread acceptance after 10day storage period in polypropylene packaging under ambient conditions. It also aided in developing novel products which can be beneficial for people living with lifestyle disorders such as diabetes, obesity and heart conditions.

D. Hydrocolloids

Hydrocolloids (gums) is the group of homopolymer used in baking industry to improve the texture of the bread and enhances the moisture retention to prevent retrogradation, thus increases the storage quality of bread (Kohajdová et al., 2009). It is comprised of water-soluble polysaccharides having a range of functional properties such as stability, retard staling process, reduced cost and therefore, suitable for bread processing application (Figure 4) (Pahwa et al., 2016). Hydrocolloids holds great importance as it imparts gelling, stabilizing and thickening action in the baked goods. The predominant polymers in the industry included alginates, carrageenans, agar, guar gum, xanthum gums (Table 3) (Gómez-Díaz & Navaza, 2003).

Hydrocolloids also improves the stability and quality characteristics of the baked products. Guar gum is considered to be most preferred additive with respect to its softening properties imparted to bread crumb effect (Rodge et al., 2012; Kohajdová et al., 2009) Hydroxyl propyl methylcellulose (HPMC) at 0.5% flour (wt. basis) addition increases the overall acceptability of bread in terms of lowering the staling process whereas xanthan (0.5% flour wt. basis) addition increases the dough stability (Ghanbari & Farmani, 2013). HPMC is a better hydrocolloid due to its properties such as a bread improver and anti-staling effect on the fresh bread quality (Guarda et al., 2004). HPMC is a cellulosic ether obtained by chemically linked hydroxypropyl and methyl group to the β-1,4-D-glucan cellulosic backbone (Figure 3). This chemical modification leads to a water-soluble polymer with high surface activity and unique properties that enhances hydration characteristics in solution as well as during temperature changes (Sarkar & Walker, 1995). Researchers observed that hydrocolloids like xanthan, k-carrageenan, sodium alginate, and hydroxypropyl methylcellulose (HPMC) affected the fresh bread quality as well as how it affected the bread staling. Significant improvements were seen in the specific volume, loaf volume, reduction in crumb hardness, and overall acceptability of the bread after these additives were added at a 0.1% level (w/w, flour basis). HPMC demonstrated a significant improvement in each of these parameters, among others (Guarda et al., 2004).

Also, during fermentation, dough stability was improved by the addition of hydrocolloids (except xanthan) as it increased the specific volume, moisture retention and water activity of the baked goods. Xanthan and alginates both have pronounced effect on dough properties i.e. strengthening of the dough. Although, HPMC and carrageenan reduces the firmness of bread crumb, it is used as an improver in the bread baking process (Rosell et al., 2001) .

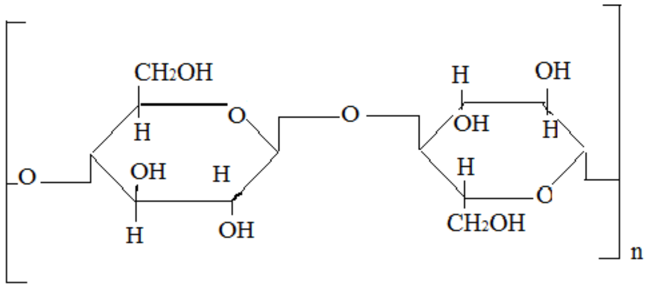


Figure 4: Structure of Hydroxy propyl methyl cellulose (HPMC)

Table 3: Types of Gums And their effects on quality of bread

Hydocolloids	**Concentration (%) on flour wt. basis**	**Water absorption capacity (%)**	**Firmness (g force)**	**Hardness**	**Loaf volume (ml)**	**Dough stability (min)**	**Anti staling**	**Elasticity (BU)**	**Reference**
	Maximum values								
Guar Gum	1.00	64.5	2.86	-	820	5.20	-	74.6	(Rodge et al., 2012)
	1.00	63.3±0.80	Reduced	-	325±4.50	13.5±o.50	Decreased	70±1.50	(Kohajdová & Karovičová, 2008)
Carrageenan	0.1 0.5	65.2 65.6	-	No effect	-	7 4.7	Min. @0.1%	-	(Guarda et al., 2004)
	02 0.5	62.1 62.5	-	-	- -	6.9 6.4	Staling retardation	-	(Ghanbari & Farmani, 2013)
HPMC (hydroxyl propyl methyl cellulose)	0.1 0.5	66.8 68.8	-	Min.@ 0.1%	Increased	7.5 11	Min.@ 0.1%	-	(Guarda et al., 2004)
	0.2 0.5	65.4 67.1	-	No effect	-	7.8 6.9	Delayed staling	-	(Ghanbari & Farmani, 2013)
Alginates	0.1 0.5	66 67.8		Decreased	No effect		No effect	-	(Guarda et al., 2004)
Xanthum	0.1 0.5	65.2 67	-	Increased	Improved		Min. @ 0.1%	-	(Guarda et al., 2004)

					@ 0.5%				
	0.2 0.5	64.8 65.5	-	-	-	7.7 8.9	No effect	-	(Ghanbari & Farmani, 2013)
Arabic gum	1	60.5±0.40	Reduced	-	322±5.50	6.5±0.30	Decreased	60±0.80	(Kohajdová & Karovičová, 2008)
Okra gum	13	62.8	Highest	-	Reduces	Decreases	-	-	

E. Improvers

Flour treating agents also known as bread improvers, dough conditioners or dough improvers) are food additives which are combined with flour to enhance baking functionality. These improvers contribute to improve the dough's rising rate, strength and workability during the bread baking process (State-nigeria & Umelo, 2014). Varieties such as eggs and azodicarbonamide are commonly used to enhance the bread-making qualities of the flour (Dagdelen & Gocmen, 2007). Bread containing egg as improver typically exhibits improved crumb texture, crust texture, flavor and aroma due to its high protein content and maillard reaction, which imparts characteristic flavor. Additionally, ascorbic acid and potassium bromate are an oxidizing agent frequently utilized as dough improvers and conditioners. Chemical oxidizing agents play a vital role in strengthens gluten (protein) through essential oxidation processes, reduced aging time, and aids to achieve the desired properties of the dough (Tebben et al., 2018).

a) Potassium Bromate

Potassium bromate is usually used at 10ppm on a flour basis (Vargas & Simsek, 2021). It became popular in breads because it was a good oxidizing agent as well as cheapest dough improvers. It immediately attacked starch and protein food biomolecule, which in turn were responsible for gelatinization, viscosity, swelling characteristics as well as elasticity. It also has an inhibitory effect on the proteolytic enzymes as it silently improves bread properties by removing the sulfhydryl group by forming disulfide linkages and bromide (Shanmugavel et al., 2020). An active phase is observed during later stages of fermentation as well as baking. This in turn results in rheological enhancement which depends on the flour quantity and quality.

However, due to its toxicological effects in human system such as carcinogenic, mutagenic, cytotoxic prestigious platforms such as European Union has classified it under Group 1.B as cancer causing agent whereas International Agency of Research in Cancer (IARC) has classified potassium bromate under class 2.B (IARC, 1986) and reported that it is a potential human carcinogen. Many countries, including India, has either partially or completely banned it (Shanmugavel et al., 2020; Vargas & Simsek, 2021; Saranjay et al., 2015).

F. Preservatives

The code of Federal Regulation (CFR) defines preservatives "as an antimicrobial agent used to preserve food by preserving growth of microorganism and subsequent spoilage".

1. Calcium Propionate

Propionic acid is an organic acid which is widely used as a preservative in the bakery industry that aid in the inhibition of mold growth. It is an oily liquid with slight pungent, unpleasant rancid odor (Saranjay et al., 2015). Calcium propionate is produced by reaction between propionic acid and calcium hydroxide. It is an antifungal agent that is utilized in bread product to halt the black mold growth by destroying its reproduction and thus, substantially increases the shelf life of the bread. In bakery products, it is used as mold inhibitor typically at 0.1-0.4%. The preservative effect of calcium propionate was examined at various pH 4, 5.6, 7 and concentrations 5 and 10% were used against Rhizopus stolonifer. Maximum inhibition was observed in low pH and at higher concentration (10%). In addition to this, preservative action of calcium propionate decreases with increase in pH. Therefore, it will result in restriction of its use in food materials that have high pH (Prem et al., 2015).
The ability of calcium propionate to prevent bread spoiling was evaluated at different pH and temperature levels and concentrations. Maximum mold growth inhibition (Rhizopus stolonifer, Aspergillus niger, Penicillium chrysogenum, and Mucor spp.) was observed at 0.25% concentration, pH 7.5, and 20°C (Saranjay et al., 2015).

2. Salt (NaCl)

In bread baking, salt is a basic ingredient as well as performing various other functions such as stabilization of yeast fermentation rate, improve flavor, strengthen dough and increase in dough mixing (Miller et al., 2008). Salt is added in bread because of three main reasons, which are processing, sensory and preservation. Furthermore, it also intensifies the color of the crust by controlling the yeast action on sugar due to which small amount of sugar is left for caramelization that improves crust color. In a study, salt solution was incorporated at four different concentration (0, 15, 30 & 50 ml) and gas production was assessed after every 10 min. (0-100 min) of interval. This shows that gas production decreases as we increase the salt concentration because salt has retarding effect on yeast cell which in turn decreases the volume of the bread.

3. Sorbic Acid & Potassium Sorbate

Hussain & Bashari, 2023 documented that sorbic acid and potassium sorbate serve as highly effective preservative for protecting breads because of their antimycotic and antibacterial properties. These chemical preservatives protect variety of food products from spoilage. Their ability to combat microorganism is valuable. Importantly, potassium sorbate metabolizes like food fatty acid, making it harmless for human consumption. The right amount of addition does not alter sensory characteristics of food products. The minimum concentration depends upon the pH and water content of the product. Potassium sorbate acts as a mold inhibitor and is water soluble while sorbic acid dissolves in fats, oils, and a few solvent but is practically insoluble in water.

4. **Essential Oils**

A review conducted by Rahman et al., 2022 has explored the effectiveness of essential oils in prolonging the shelf life of bread. Carvacrol and eugenol is found to be an effective antifungal component in essential oils which exhibit significant antifungal properties. They can extensively damage the inner mitochondrial membranes of fungal cells and completely destroy their cell wall. Interestingly, Suhr & Nielsen, 2003 reported the impact of oils such as thyme, clove and cinnamon aids in fungal spoilage whereas orange, sage and rosemary oils showed limited effectiveness in bread. Researches have concluded promising results for the use of marjoram and sage essential oils for their ability to inhibit bread mold growth. However, they are often overlooked due to their less favourable flavour and odor (Horváth et al., 2016).

Conclusion

Bread remains an essential dietary staple worldwide for its accessibility, affordability and versatility across cultures. However, its inherent perishability challenges the maintenance of its quality and freshness. The bread industry has shown substantial growth due to the rising consumer demand. Despite growth in production volumes, the industry generated significant global revenue, highlighting soaring market growth.

The need of innovative preservation strategies and their permissible limits, as outlined by FSSAI 2010, are essential to address bread staling caused by both physical and microbiological spoilage. The baking industry's adoption of natural and synthetic additives has been crucial in enhancing bread's organoleptic properties and improving its shelf life. This review examines the roles and impacts of various additives in bread production, emphasizing their contribution to quality maintenance and meeting consumer demands. The findings underline the role of acidity regulates, emulsifiers, polyols and hydrocolloids which play crucial roles in maintaining freshness, texture and overall quality. Preservatives such as calcium propionate, sorbic acid, potassium sorbate, salt and essential oils are key to extend shelf life and prevent spoilage.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

References

1 AB, R., SM, S., & RV, S. (2012). Effect of Hydrocolloid (guar gum) Incorporation on the Quality Characteristics of Bread. Journal of Food Processing & Technology, 03(02). https://doi.org/10.4172/2157-7110.1000136

2 All India bread manufacturer association (AIBMA). (2024). No Title. https://aibma.com/industry.html

3 Alpers, T., Kerpes, R., Frioli, M., Nobis, A., Hoi, K. I., Bach, A., Jekle, M., & Becker, T. (2021). Impact of Storing Condition on Staling and Microbial Spoilage Behavior of Bread and Their Contribution to Prevent Food Waste. Foods, 10(1), 76. https://doi.org/10.3390/foods10010076

4 Angioloni, A., & Collar, C. (2011). Physicochemical and nutritional properties of reduced-caloric density high-fibre breads. LWT - Food Science and Technology, 44(3), 747–

758. https://doi.org/10.1016/j.lwt.2010.09.008
5 Arus, V. A., Leonte, M., & Moroi, A. M. (2008). RESEARCHES REGARDING THE USES OF SOME EMULSIFYING AGENTS IN BAKERY INDUSTRY. 3, 19–22.
6 Azizi, M. ., Rajabzadeh, N., & Riahi, E. (2003). Effect of mono-diglyceride and lecithin on dough rheological characteristics and quality of flat bread. LWT - Food Science and Technology, 36(2), 189–193. https://doi.org/10.1016/S0023-6438(02)00201-3
7 Bhise, S., & Kaur, A. (2014). Baking quality, sensory properties and shelf life of bread with polyols. Journal of Food Science and Technology, 51(9), 2054–2061. https://doi.org/10.1007/s13197-014-1256-3
8 Bhise, S., & Kaur, A. (2017). Synergetic effect of polyols and fibres on baking, sensory and textural quality of bread with improved shelf life. Int. J. Curr. Microbiol. Appl. Sci, 6, 1-12.
9 Blanco, C. A., Ronda, F., Pérez, B., & Pando, V. (2011). Improving gluten-free bread quality by enrichment with acidic food additives. Food Chemistry, 127(3), 1204-1209.
10 Cauvain, S. (2015a). Bread: The Product. In Technology of Breadmaking (pp. 1–22). Springer International Publishing. https://doi.org/10.1007/978-3-319-14687-4_1
11 Cauvain, S. (2015b). Bread Spoilage and Staling. In Technology of Breadmaking (pp. 279–302). Springer International Publishing. https://doi.org/10.1007/978-3-319-14687-4_10
12 Dagdelen, A. F., & Gocmen, D. (2007). Effects of glucose oxidase, hemicellulase and ascorbic acid on dough and bread quality. Journal of Food Quality, 30(6), 1009–1022. https://doi.org/10.1111/j.1745-4557.2007.00156.x
13 Defloor, I., De Geest, C., Schellekens, M., Martens, A., & Delcour, J. A. (1999). Emulsifier and/or extruded strachin the production of breads from cassava. Cereal Chem, , ., 68(4), 323–327.
14 Ding, S., & Yang, J. (2021). The effects of sugar alcohols on rheological properties, functionalities, and texture in baked products–A review. Trends in Food Science & Technology, 111, 670-679.
15 Eveleva, V. V., & Cherpalova, T. M. (2019). Innovative decisions to improve food quality and safety. Food Systems, 2(4), 14–17. https://doi.org/10.21323/2618-9771-2019-2-4-14-17
16 Fadda, C., Sanguinetti, A. M., Del Caro, A., Collar, C., & Piga, A. (2014). Bread Staling: Updating the View. Comprehensive Reviews in Food Science and Food Safety, 13(4), 473–492. https://doi.org/10.1111/1541-4337.12064
17 Garcia, M. V., Bernardi, A. O., & Copetti, M. V. (2019). The fungal problem in bread production: insights of causes, consequences, and control methods. Current Opinion in Food Science, 29, 1–6. https://doi.org/10.1016/j.cofs.2019.06.010
18 Garzón, R., Hernando, I., Llorca, E., & Rosell, C. M. (2018). Understanding the effect of emulsifiers on bread aeration during breadmaking. Journal of the Science of Food and Agriculture, 98(14), 5494–5502. https://doi.org/10.1002/jsfa.9094
19 Ghanbari, M., & Farmani, J. (2013). Influence of hydrocolloids on dough properties and quality of barbari: An Iranian leavened flat bread. Journal of Agricultural Science and Technology, 15(3), 545–555.
20 Gomes-Ruffi, C. R., Cunha, R. H. da, Almeida, E. L., Chang, Y. K., & Steel, C. J.

(2012). Effect of the emulsifier sodium stearoyl lactylate and of the enzyme maltogenic amylase on the quality of pan bread during storage. LWT, 49(1), 96–101. https://doi.org/10.1016/j.lwt.2012.04.014

21 Gómez-Díaz, D., & Navaza, J. M. (2003). Rheology of aqueous solutions of food additives: Effect of concentration, temperature and blending. Journal of Food Engineering, 56(4), 387–392. https://doi.org/10.1016/S0260-8774(02)00211-X

22 Guarda, A., Rosell, C. M., Benedito, C., & Galotto, M. J. (2004). Different hydrocolloids as bread improvers and antistaling agents. Food Hydrocolloids, 18(2), 241–247. https://doi.org/10.1016/S0268-005X(03)00080-8

23 Horváth, G.; Jenei, J.T.; Vágvölgyi, C.; Böszörményi, A.; Krisch, J. Effects of essential oil combinations on pathogenic yeasts and moulds. Acta Biol. Hung. 2016, 67, 205–214.

24 Hussain, S., & Bashari, M. (2023). Shelf Life Enhancement of Bread by Utilizing Natural and Chemical Preservatives. Emerging Challenges in Agriculture and Food Science, 88.

25 IARC. (1986). Potassium bromate. Monogr Eval Carcinog Risks Hum., 40, 207–220.

26 Joint FAO/WHO Codex Alimentarius Commission. (2014). Codex Alimentarius : Food Additives. Journal of Chemical Information and Modeling, 53(9), 1689–1699.

27 Kohajdová, Z., & Karovičová, J. (2008). Influence of Hydrocolloids on Quality of Baked Goods *. ACTA Acta Sci. Pol., Technol. Aliment, 7(2), 43–49. https://www.food.actapol.net/pub/4_2_2008.pdf

28 Kohajdová, Z., Karovičová, J., & Schmidt, Š. (2009). Significance of emulsifiers and hydrocolloids in bakery industry. Acta Chimica Slovaca, 2(1), 46–61.

29 Miller, R. A., Maningat, C. C., & Hoseney, R. C. (2008). Modified wheat starches increase bread yield. Cereal Chemistry, 85(6), 713–715. https://doi.org/10.1094/CCHEM-85-6-0713

30 Pahwa, A., Kaur, A., & Puri, R. (2016). Influence of Hydrocolloids on the Quality of Major Flat Breads: A Review. Journal of Food Processing, 2016, 1–9. https://doi.org/10.1155/2016/8750258

31 Pareyt, B., Finnie, S. M., Putseys, J. A., & Delcour, J. A. (2011). Lipids in bread making: Sources, interactions, and impact on bread quality. Journal of Cereal Science, 54(3), 266–279. https://doi.org/10.1016/j.jcs.2011.08.011

32 Pourzafar, Z., Movahhed, S., Chenarbon, H. A., & Movahhed, S. (2013). Effect of addition of the emulsifier DATEM on sensory and staling characteristics of gluten- free Barbari bread. 4(3), 60–63.

33 Prem, J., Vazhacharickal, J. J., Mathew, S. N. K., & Prathap, P. (2015). Effect of concentration and pH on the preservative action of calcium propionate against black bread mold (rhizopus stolonifer) in Kerala. CIBTech Journal of Biotechnology ISSN, 4(2), 2319–38591.

34 Rahman M, Islam R, Hasan S, Zzaman W, Rana MR, Ahmed S, Roy M, Sayem A, Matin A, Raposo A, Zandonadi RP, Botelho RBA, Sunny AR. A Comprehensive Review on Bio-Preservation of Bread: An Approach to Adopt Wholesome Strategies. Foods. 2022 Jan 24;11(3):319. doi: 10.3390/foods11030319. PMID: 35159469; PMCID: PMC8834264.

35 Ravi, R., Sai Manohar, R., & Haridas Rao, P. (2000). Influence of additives on the

rheological characteristics and baking quality of wheat flours. European Food Research and Technology, 210(3), 202–208. https://doi.org/10.1007/PL00005512

36 Rosell, C. M., Bajerska, J., & El Sheikha, A. F. (Eds.). (2015). Bread and Its Fortification. CRC Press. https://doi.org/10.1201/b18918

37 Rosell, C. M., Rojas, J. A., & Barber, C. B. De. (2001). In ¯ uence of hydrocolloids on dough rheology and bread quality. 15.

38 Sahin, A. W., Axel, C., Zannini, E., & Arendt, E. K. (2018). Xylitol, mannitol and maltitol as potential sucrose replacers in burger buns. Food & function, 9(4), 2201-2212.

39 Salehifar, M., Adili, L., Tarzi, B. G., & Bakhoda, H. (2012). Effects of Lipase , Phospholipase and DATEM on some Quality Characteristics of Bugget. Annals of Biological Research, 3(11), 5236–5241.

40 Saranjay, P., Kumar, D. P., Jayanthi, M., & Karunya, S. K. (2015). Effect of Calcium Propionate on the Inhibition of Fungal Growth in Bakery Products. Asian Journal of Multidisxiplinary Research, 1(3), 273–279.

41 Sarkar, N., & Walker, L. C. (1995). Hydration-dehydration properties of methylcellulose and hydroxypropylmethylcellulose. Carbohydrate Polymers, 27(3), 177–185. https://doi.org/10.1016/0144-8617(95)00061-B

42 Shanmugavel, V., Komala Santhi, K., Kurup, A. H., Kalakandan, S., Anandharaj, A., & Rawson, A. (2020). Potassium bromate: Effects on bread components, health, environment and method of analysis: A review. Food Chemistry, 311, 125964. https://doi.org/10.1016/j.foodchem.2019.125964

43 Sluimer, P. (2005). Principles of Breadmaking: Functionality of Raw Materials and Process Steps. American Association of Cereal Chemists.

44 Stampfli, L., Nersten, B., & Nerden, B. (1995). Emulsifiers in bread making. Food Chemistry, 52(4), 353–360. https://doi.org/10.1016/0308-8146(95)93281-U

45 State-nigeria, I., & Umelo. (2014). Effect of Different Dough Improvers on the Proximate Composition , Minerals , Vitamins and. 1(3), 112–126.

46 statista. (2024). https://www.statista.com/outlook/cmo/food/bread-cereal-products/bread/india

47 Su, X., Wu, F., Zhang, Y., Yang, N., Chen, F., Jin, Z., & Xu, X. (2019). Effect of organic acids on bread quality improvement. Food Chemistry, 278, 267-275.

48 Suhr, K.I.; Nielsen, P.V. Antifungal activity of essential oils evaluated by two different application techniques against rye bread spoilage fungi. J. Appl. Microbiol. 2003, 94, 665–674.

49 Tarar, O. M., Mueen-ud-din, G., Murtaza, M. A., Rehman, S. ur, Mueen-ud-din, G., & Murtaza, M. A. (2010). Studies on the shelf life of bread using acidulants and their salts. Turkish Journal of Biology, 34(2), 133–138. https://doi.org/10.3906/biy-0803-20

50 Tebben, L., Shen, Y., & Li, Y. (2018). Improvers and functional ingredients in whole wheat bread: A review of their effects on dough properties and bread quality. Trends in Food Science & Technology, 81, 10–24. https://doi.org/10.1016/j.tifs.2018.08.015

51 www.thehindu.com/business/Economy/india-suffered-income-loss-of-159-billion-in-key-sectors-due-to-extreme-heat-in-2021-report/article66035523.ece

52 Vargas, M. C. A., & Simsek, S. (2021). Clean Label in Bread. Foods, 10(9), 2054. https://doi.org/10.3390/foods10092054