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Effect of various packaging techniques on quality characteristics of mozzarella cheese

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ABSTRACT

Mozzarella cheese is the most popular cheese varieties in world known for its primary use in pizza preparation. It is white in color, soft with glossy surface with high moisture content (50-60%). Due to high moisture content, it has limited shelf life. Several preservation techniques are used to maintain the product quality and for extending the shelf stability of mozzarella cheese but, packaging is found to be the most promising technique. Modified atmosphere packaging, vacuum packaging and active packaging are the packaging techniques can be applied to extend the self stability of mozzarella cheese.

INTRODUCTION

Among the dairy products, cheese is the richest variety which can be consumed fresh. Cheese is produced by the coagulation milk with the effect of rennet enzymes or organic acids which are nonhazardous for human life. About 4000 types of cheese are produced worldwide that differs in texture as well as flavor and amongst these mozzarella cheese has a significant role among the cheese varieties (Akarca et al., 2015).

Mozzarella cheese is a pasta filata variety of cheese which has unique stretching and melting properties. It is classified into two different types depending on its moisture content i.e. high moisture mozzarella cheese (moisture content: 56-65%) and low moisture mozzarella cheese (moisture content: 45- 54%). High-moisture mozzarella cheese is commonly consumed fresh as a table cheese while low moisture mozzarella cheese is usually used as a condiment for bread or pizza. Due to its high moisture content, it has limited shelf stability of about 30 days at low temperature conditions (4 °C), soft texture and shows aggregation characteristics. However, mozzarella cheese

with low moisture content has longer shelf life, hard texture and shows elasticity as well as elongation properties.

The limited shelf life of mozzarella cheese is mainly due to contamination caused by microorganisms present in water used during the stretching process in manufacturing stage. Several preservation techniques as brining, addition of potassium sorbate are used to maintain the product quality and for extending the shelf stability of mozzarella cheese but, packaging is found to be the most promising technique (Calligaris et al. 2015). Modified atmosphere packaging, vacuum packaging and active packaging are the packaging techniques applied to extend the self stability of mozzarella cheese.

Modified atmosphere packaging

Modified atmosphere packaging (MAP) is becoming more common and is successfully applied to different processed dairy products. In this method, the product is placed into the pack, and the air is removed and replaced with a mixture of gases and is hermetically sealed. The most frequently used gases are oxygen, nitrogen and carbon dioxide, but other gases such as carbon monoxide, nitrous oxide and sulfur dioxide may also be used.

Modified atmosphere packaging (MAP) extends the shelf stability of cheeses as it protects against oxidation and dehydration along with the inhibition of undesirable microorganisms. The MAP helps in reduction of microbial growth and delays the enzymatic changes resulting in extension of shelf life of product. Films having low water vapour transmission and low oxygen permeability as well as the modified gaseous environment around the mozzarella cheese helps in shelf life extension. Many researchers have studied the effect of various modified gases in MAP for mozzarella cheese. Alves et al., (1996) revealed that the CO_2 has the bacteriostatic and fungistatic effect and significantly increases the shelf life of mozzarella cheese under modified atmospheres containing the gas compared with air (385% under 100% CO_2, 246% under of 50% CO_2 / 50% N_2). Eliot et al., (1998) found that inside the package, CO_2 was found to be effective in inhibiting undesirable microorganisms such as staphylococci, yeast and moulds whereas it was not as effective in inhibiting mesophilics. The most effective level of CO_2 was ≥0.75 for maintaining the microbiological quality of shredded Mozzarella cheese during 8 weeks. Also, atmospheres containing CO_2 and N_2 have been effective to inhibit the proliferation of undesirable microorganisms. The significant decrease in the development of microflora in mozzarella cheese samples packaged in the atmosphere of CO_2 was observed.

The shelf stability of mozzarella cheese under different atmospheres (air, 100% CO_2, 100% N_2, and 50% N_2/50% CO_2) was estimated by Alam and Goyal (2007) and packed in high-barrier bags then stored at low temperature conditions (−10 to −15 °C). The significant increase in shelf life was found in Mozzarella cheese under MAP conditions in comparison to conventional air package shelf life (14–16, 90, 75, and 65 days under air, 100% CO_2, 50% N_2/50% CO_2, and 100% N_2, respectively).

Akarca et al., (2015) reported that the acidity of mozzarella cheese packaged in MAP was increased during storage of 21 days and found to have acidity value of 2.28% as lactic acid. This may be the result of the lack of oxygen in the packaging, creating suitable conditions for thegrowth of lactic acid bacteria (LAB). It was also reported that the acidity increased with storage time for mozzarella samples stored for 28 days.

Vacuum packaging

The vacuum packaging process involves placing the product in a bag, and evacuating the air without addition of another gas. The bags used in vacuum packaging are typically made of a flexible plastic film that has low gas and water vapor permeability and the plastic film generally adheres closely to the product. It prevents growth of aerobic spoilage organisms, shrinkage, and oxidation. Vacuum packaging is a simple technique, but it can lead to undesirable changes in the structure and appearance of cheese.

Felfoul et al., (2017) reported the lowest sensory for mozzarella cheese packaged in vacuum packaging due to structure deterioration. It was also found to have shelf life of 100 days when stored at 10 °C in vacuum packaging.Vacuum packaged sample was the least favored sample in the sensory analysis (Akarca et al., 2015).

The vacuum packaged mozzarella cheese showed initial decrease in pH value. This might due to degradation of lactose to lactic acid and was associated with the formation of carbonic acid resulting fromthe dissolution of CO_2 in water as well as thedecrease in moisture in the cheese samples. After 4 weeks, the value of pH increased due to an intensive proteolysis during cheese samples storage.

The whiteness of mozzarella cheese samples decreased significantly during the storage. This might be due to decrease in value of pH during storage as at high pH protein network is less dense that allows more scattering of light which gives whiter color to cheese while as the pH decreased, the protein network becomes more compact and dense, the structure becomes more homogeneous that resist scattering of light and whiteness decreases.

The studies revealed that the significant decrease in yeast/mold counts in vacuum packaged sample. The majority of molds causing food spoilage require the presence of oxygen fortheir growth. The plastic film in the vacuum packaging bags had very low oxygen permeability that retards the growth of yeast and mold (Akarca et al., 2015). Total viable count of mozzarella cheese samples in vacuum packaging was found to be low due to anaerobic conditions created by complete removal of air from thepackaging material. This resulted in disturbance of homeostasis mechanism of the organisms, resulting in lower bacterial count in vacuum packaged iron fortified mozzarella cheese samples (Raquib et al., 2021).

Active packaging

An active packaging technology is based on the concept of incorporating components into the packaging systems that release or absorb substances so as to

prolong shelf life, sustain quality, safety and sensory characteristics of mozzarella cheese. Moisture absorbers, oxygen scavengers, carbon dioxide generators/absorbers, ethylene absorbers, antimicrobial agents, and ethanol emitters, are all examples of active packaging components.

An active packaging has been developed using different types of natural substances. The shelf life of mozzarella cheese was significantly increased by dissolving lysozyme and Na_2-EDTA in the packaging brine. Lysozyme is a lytic enzyme found in many natural systems, used in cheese manufacture to prevent the growth of lactate-fermenting and gas-forming *Clostridia* spp.. The antimicrobial spectrum of lysozyme could be enhanced when it is used with other substances, such as EDTA, disodium pyrophosphate, penta sodium tri-polyphosphate, caffeic acid, and cinnamic acid.

Cellulose polymer based antimicrobial films incorporated with nisin and natamycin showed the potential for preservation of sliced Mozzarella cheese. A novel antimicrobial film based on hybrid organic–inorganic material commonly called as "anionic clays", consisting of layered double hydroxide intercalated with salicylate and carbonate anions increased the storage life of Mozzarella to three weeks at a storage temperature of 18°C. A dye based ultraviolet light activated oxygen sensor was successfully developed and characterized for its oxygen sensitivity, oxygen dependent color change and mechanical properties. The developed indicator was integrated with MAP Mozzarella cheese as an integrity/oxygen indicator, which could be helpful for stakeholders in the entire supply chain.

Han et al., (2014) developed an antimicrobial sachet system containing microcellular foam starch embedding rosemary oil andthyme oil reduced the growth of L. monocytogenes, lactic acid bacteria, and total aerobic bacteria in mozzarella cheese during 15 day storage period. Lemon extract wasused as active agent, in combination with brine andwith a gel solution made of sodium alginate for shelf life extension of mozzarella cheese (Conte et al., 2007). It was found that active agent exert an inhibitory effect on the microorganisms responsible for spoilage phenomena without affecting the functional microbiota of the product that leads to extension of shelf stability of mozzarella cheese.

CONCLUSIONS

Mozzarella cheese, a nutritious dairy product, is a pasta filata variety of cheese which is well-liked worldwide and has unique stretching and melting properties. It has limited shelf life due to high moisture content which helps in the growth of microorganisms. Various preservation techniques have been used by researchers and packaging is found to be an efficient method for extending the shelf stability of mozzarella cheese. Out of all the preservation techniques vacuum packaging, modified atmosphere packaging and active packaging helps in reduction the growth of microorganisms that leads to shelf life extension of mozzarella cheese. Due to the absence of oxygen, vacuum packing is a suitable solution for increasing cheese's shelf life; nevertheless, it adversely affects texture of mozzarella cheese whereas in MAP and

active packaging samples retains its texture. Therefore, it can be recommended that modified atmosphere packaging as well as active packaging techniques helps in extending the shelf stability of mozzarella cheese as well as maintain the texture and quality characteristics**.**

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Table 1Application of various packaging techniques for shelf stability of mozzarella cheese

Type of packaging	Parameters	Results	References
Modified atmosphere packaging	Air, 100% N_2, 10 CO_2/ 90 N_2, 25 CO_2/ 75 N_2, 50 CO_2/ 50 N_2, 75 CO_2/ 25 N_2 and 100 CO_2	The most effective level of CO_2 was ≥0.75 for maintaining the microbiological quality of shredded Mozzarella cheese during 8 weeks.	Eliot et al 1998
	Air, 100% CO_2, 100% N_2, and 50% N_2/50% CO_2	The shelf life of mozzarella cheese increased upto 90 days under 100% CO_2 atmospheric conditions.	Alam and Goyal (2007)
	100% N_2, 100% CO_2, and 50% CO_2/50% N_2	No growth of yeast and mold was detected in Mozzarella cheese stored under 100% CO_2 during 58 days at 7 ± 1 °C.	Alves et al 1996
Vacuum packaging	Vacuum	Shelf life of 100 days when stored at 10 °C	Felfoul et al 2017
	Vacuum	Total viable count was found to be low	Raquib et al 2021
Active packaging	Lemon extract as active agent in conjunction with brine andwith a sodium alginate gel solution	Lemon extract showed an increase in shelf life of mozzarella cheese due to its inhibition effect on microorganisms.	Conte et al 2007
	Antimicrobial sachet system containing rosemary oil andthyme oil	Reduced the growth of L. monocytogenes, lactic acid bacteria, and total aerobic bacteria in mozzarella cheese	Han et al 2014