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APPLICATION OF G/CHNF/ZnONPs NANOCOMPOSITE FILM IN CHEDDAR CHEESE TO EXTEND SHELF-LIFE

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ABSTRACT

Cheese is a product that is susceptible to dangerous microorganisms during the handling or storage process. Producing cheese packaging that can stop the growth of harmful microorganisms is necessary to extend cheese's shelf life. Cheddar cheese was packed with G/CHNF/ZnONPs and then stored for 90 days in the refrigerator. Fat, protein, carbohydrate, and mineral (especially calcium) content decreased during storage time. Cheese samples packaged using G/CHNF/ZnONPs film packaging showed antibacterial activity so the shelf life of the cheese was extended. This shows the potential of G/CHNF/ZnONPs films as packaging for cheese, especially cheddar cheese.

Keywords: Packaging, Cheddar Cheese, Antibacterial, Shelf Life.

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INTRODUCTION

Packaging of cheese needs to be paid attention to to prevent the growth of dangerous bacteria which can shorten its shelf life.[1] To increase the cheese's shelf life, it is crucial to create cheese packaging that inhibits the growth of harmful germs. An affordable and effective method is needed to maintain the nutritional value of cheese, eco-friendly, and biodegradable packaging materials with robust antioxidant properties.[2] One of the biopolymers, gelatin (G), is frequently utilized as a basis material for films because of its biodegradable qualities.[3] However, gelatin film has limitations in its use because it has high water solubility and low tensile strength, so it is necessary to combine it with other biopolymer materials, such as chitosan to cover these shortcomings.[4] Chitosan nanofiber (CHNF) is a biopolymer that has wide potential for use in food technology because it has biodegradable properties, low toxicity, biocompatibility, and good film-forming ability.[5] For their photocatalytic activity, ZnO nanoparticles (ZnONPs) have been the focus of in-depth investigation. In addition, ZnONPs have strong antibacterial properties and are more biocompatible and safe than AgNPs so they can inhibit bacterial growth to extend shelf life.[6] In this research, we will Examine how applying nanocomposite coatings affects the shelf life and antibacterial activity of cheddar cheese and of course on maintaining the nutritional value of cheddar cheese.

EXPERIMENTAL

Material

Gelatin sourced from commercial cowhide with a gel strength of 225 g bloom (type-B), acetic acid at a concentration of 2%, glycerol with a purity of ≥99.5%, distilled water, polyvinyl alcohol (PVA), hydrochloric acid (HCl) at 0.1 N and 25%, and petroleum ether (PE) were all procured from Sigma-Aldrich in Singapore. Chitosan (BCB-Chitin) with a purity of 99% was obtained from Shaanxi, China. The zinc oxide nanoparticle (ZnONPs) powder supplied by Peter ShiZengou Farm-Reaching Biochemical Co. S. aureus (ATCC®12600TM), *E. coli* (ATCC®8739TM), and *P. aeruginosa* (ATCC®10145TM) were obtained from IBRC.

Methods

A film with a thickness of 1.4 mm was made using the casting knife technique. A 4% gelatin solution with distilled water as a solvent was dissolved Using a magnetic stirrer for 30 minutes at a temperature of 45 °C

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and 350 rotations per minute. Then the 4% gelatin solution was added to the CHNF solution, ZnONPs solution, and glycerol in a ratio of 8:1:1:0.08. The resulting film solution underwent degassing through sonication for 30 minutes at 30°C, with the goal of removing air bubbles in the solution. The prepared film solution was then printed into an acrylic mold measuring 20 x 20 cm2 and allowed to stand for 72 hours. The film is used to package cheddar cheese and store it in the refrigerator for 90 days. The cheddar cheese's nutritional value, antimicrobial efficacy, and shelf life will next be examined.

RESULTS AND DISCUSSION

Fat Content

From Table-1, it can be seen that there was a diminish in the fat substance of cheddar cheese amid the packaging and storage preparation. This is due to the fat content in cheese diminished amid the capacity time due to the breaking of the triglyceride atomic bonds and turned into free greasy acids[7]. This will be seen from the most reduced diminish in the fat substance of cheddar cheese after being put away for 90 days with diverse bundling, to be specific LDPE + cardboard bundling > G/CHNF/ZnONPs bundling > LDPE bundling > without bundling.

Table-1: The Nutritional Content of Packaged Cheddar Cheese Varies

No	Packaging Types	Fat Content (%)		Protein Content (%)		Calcium content (mg/100g)		Carbohydrate content (%)	
		0 days	90 days	0 days	90 days	0 days	90 days	0 days	90 days
1	G/CHNF/ZnONPs	21.88	18.99	23.19	21.08	784.90	768.50	13.07	11.46
2	LDPE packaging		18.79		20.80		765.10		10.29
3	LDPE + cardboard packaging		20.51		22.68		780.15		12.90
4	Without packaging		17.80		20.26		747.80		10.23

Protein Content

Past research has established that the crude protein concentration diminishes as time progresses during storage, as protein molecules are degraded to serve as an energy source in metabolic reactions.[8] The comes about appeared that the protein substance of cheese diminished amid the capacity period where the results were 21.08%, 20.80%, 22.68%, and 20.26% individually for cheese with G/CHNF/ZnONPs film, LDPE bundling, LDPE + cardboard bundling, and unpackaged cheese. This result is consistent with earlier studies on how choices in packaging and temperature conditions during storage resulted in fat content being disrupted, causing the cheese to become acidic and leading to protein denaturation.[7]

Mineral Content

Table-1 displays the outcomes of the examination of mineral content, with a specific emphasis on calcium levels, in cheddar cheese that has undergone various treatments. Storing cheese in a brine solution results in a more pronounced reduction in calcium content compared to cheese stored in a vacuum environment.[9] Furthermore, the calcium content of cheddar cheese wrapped with the G/CHNF/ZnONPs film was 768.50 mg/100g, according to the data, while cheese packaged with LDPE, LDPE + cardboard, and cheese without any packaging had calcium contents of 765.10 mg/100g, 780.15 mg/100g, and 747.80 mg/100g, respectively.

Carbohydrate Content

Carbohydrates are composed of three primary elements: carbon, hydrogen, and oxygen, with each element occurring in a proportion of 1:2:1. The body's metabolism can use or transform some dietary carbohydrates into glucose or oxidize that to pyruvate, and some sugar alcohols, such as sorbitol[10]. The Luff Schoorl technique was used to determine the carbohydrate content. The test was carried out on four samples of cheddar cheese that had been packaged in different packages and stored in the refrigerator for 90 days. Table-1 displays the test results for the carbohydrate content of the various cheese samples. The data clearly indicates that the duration of storage leads to a reduction in carbohydrate content.

Microbiological Activity

Figure-1 shows that cheese with G/CHNF/ZnONPs packaging had higher antimicrobial activity than the negative control (unpackaged cheese) but it was still lower than the positive control (cheese with LDPE + cardboard packaging). This antimicrobial activity is due to the synergistic relationship between ZnONPs and CHNF contained in the G/CHNF/ZnONPs nanocomposite film. The antimicrobial activity of ZnONPs occurs due to their photocatalytic capacity and the production of reactive oxygen compounds. The antimicrobial mechanism of chitosan can occur when the negatively charged membrane of microbial cells interacts with the positively charged amine groups in chitosan, causing leakage of intracellular contents and causing microbial cells to die.[11,12] Youssef dkk. (2019) stated that the use of chitosan/PVA-based bio-nanocomposites can prevent fungal growth during the storage period.[12]

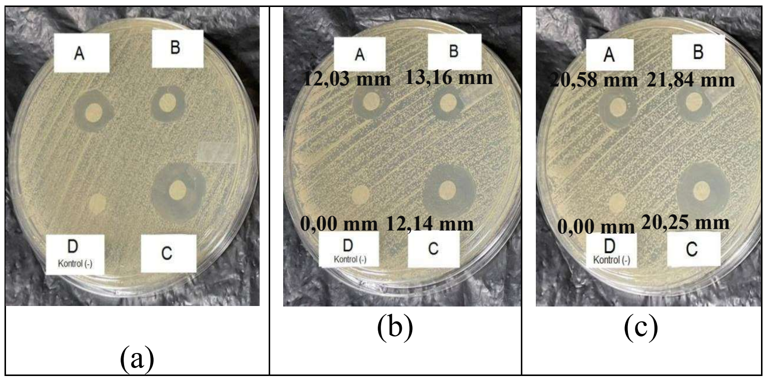

Fig.-1: The Determination of the Inhibitory Region Size for (a) *S. aureus*, (b) *P. aeruginosa*, and (c) *E. coli* Bacteria was Performed on Cheese Samples Identified as A (encased in G/CHNF/ZnONPs), B (Contained in LDPE Packaging), C (in LDPE + Cardboard Packaging), and D (without Packaging)

Shelf Life

According to the conducted shelf-life assessment, The cheese's G/CHNF/ZnONPs film-enclosed shelf life was found to be 118 days. In comparison, cheese packaged with LDPE, LDPE + cardboard, and cheese without packaging had shelf lives of 109 days, 128 days, and 94 days, respectively. This data suggests that the G/CHNF/ZnONPs coating greatly increases the cheese's shelf life. This indicates that the packaging method employed can enhance the cheese's shelf life. Another study reported that the use of nanocomposite films had extended the length of time cheese lasts in storage (30 days).[12,13,14]

CONCLUSION

Nanocomposite films containing G/CHNF/ZnONPs were fabricated and used for packaging cheddar cheese for 90 days. The assessment of the cheese's biological properties of cheese as well as its microbiological activity revealed that the nanocomposite film exhibited excellent packaging capabilities. Moreover, the assessment of the shelf life for cheddar cheese stored for 90 days revealed an extension to 118 days.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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