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RESEARCH ON USING GINGER ESSENTIAL OIL TO EXTEND THE SHELF-LIFE OF TRADITIONAL STICKY RICE CAKES WITH RAMIE (*Boehmeria nivea* L. Gaudich) LEAF

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ABSTRACT

In this study, in order to solve the problem of the short shelf life of sticky rice cakes with ramie leaf (SCRL), a typical traditional product of Binh Dinh province, ginger essential oil (GEO) was added to cake recipes to increase the shelf life. To evaluate the effectiveness of this method, five cake recipes containing different concentrations of GEO were studied. Parameters related to product quality, including moisture content, structure, and total aerobic microorganisms, were determined according to a storage time of six days. The results showed that the addition of GEO at a concentration of 4 mL/Kg of glutinous rice flour prolonged the shelf life of SCRL by 6 days. This research can be applied to increase the commercial value and preserve the diversity of traditional local products.

Keywords: Sticky rice cakes, ramie leaf, *Boehmeria nivea* L. Gaudich, ginger essential oil, shelf-life.

1. INTRODUCTION

Food safety has become a major public health concern in recent years. If not properly controlled, food spoilage can cause food poisoning and even death. Infection and growth of microorganisms are considered to be the main causes of food spoilage. Many preservation methods have been introduced to prevent microorganisms from spoiling the food. However, the abuse of synthetic preservatives has led to several health hazards in humans. The use of natural substances with antibacterial, antifungal, and antioxidant properties for food preservation is gaining attention from the community.

Sticky rice cake is popular in many Asian countries. This food can be made from basic ingredients such as glutinous rice, sticky rice, sugar, and some types of beans, coconuts, or sesame. The common methods for making this cake include steaming, frying, and boiling.

In Vietnam, the sticky rice cake with ramie leaf (SCRL) is a typical traditional specialty of the Binh Dinh province and has historical, cultural, and spiritual values typical of the people here. However, this product can usually only be administered for a short period of 2 – 3 days due to the nature of the raw materials and the manufacturing process of the media system, without the use of additives. Subsequently, the cake was damaged quickly. To solve this problem, some studies have used natural substances such as cinnamon, anise, and cardamom essential oils to preserve SCRL. However, there are no in-depth studies on the use of essential oils to prolong the shelf life of sticky rice cakes in general, and SCRL in particular.

Natural preservatives, such as essential oils, flavonoids, phenolic compounds, and microbial metabolites, are chemical agents of plants, animals, and bacteria that can preserve food by against fungal and food-borne bacteria. They prevent product breakdown by inhibiting microbial growth, oxidation, and the enzymatic reactions that occur in food [1].

Ginger is an herb that has been used for millennia in Ayurvedic, Chinese, and Tibb Unani medicine. Currently, ginger oil is produced commercially from dried or fresh ginger rhizomes. GC-MS analysis of GEO showed that the main active compounds in ginger are zingiberene, ar-curcumene, citral, Β - bisabolene, geranial, and camphene. These compounds exhibit antibacterial, anti-inflammatory, pain-relieving, anticancer, antioxidant, and cough-suppressing properties. In addition to its medicinal properties, GEO is currently being used to develop new active packaging materials for use in the food industry. These include chitosan-carboxymethyl cellulose films combined with GEO and cinnamon oil [2]. Biogenic nanocomposite materials of chitosan/montmorillonite combined with thyme and ginger essential oils can reduce lipid oxidation and microbial contamination, and extend the shelf life of fresh poultry meat [3]. Souza et al. (2023) further evaluated the activity of biogenic nanocomposites combined with thyme essential oil to preserve fresh poultry meat [4]. Moreover, the many advanced techniques developed to date have led to the discovery of different ginger cultivars that can improve GEO production. Many ongoing studies are analyzing the chemical and medicinal effects of GEO [5].

Some studies have used cinnamon, clove, and star anise essential oils to preserve glutinous rice cakes. Although the results prolonged the shelf life of the cakes, the flavor combination did not seem to satisfy consumer sensory requirements. There has not been a comprehensive study on the use of ginger essential oil in preserving rice cakes, especially sticky rice cakes with ramie leaves. Furthermore, the traditional production method of adding ginger to the filling has increased the flavor of cakes. Therefore, we believe that incorporating ginger essential oil into pie crust ingredients can meet the taste and sensory requirements of cake consumers. Therefore, "A research on using ginger essential oil to extend the shelf life of traditional sticky rice cakes with ramie leaf" is practical and meaningful. The results of this study provide major economic and social benefits to the food industry and local consumers.

2. MATERIALS AND METHODS

2.1. Raw materials

The research materials included GEO extracted by Hilltown Essential Oil Co. Ltd. B. Ramie leaves and glutinous rice were sourced from the Binh Dinh Province. Peeled mung beans, shredded coconuts and banana leaves were purchased from the Go Vap market. Refined sugar (sucrose (Pol) > 99.8%, moisture < 0.05%) was obtained from TTC Bien Hoa-Dong Nai Sugar One-Member Limited Company, Vietnam. In addition, D-glucose (AR, Xilong, Cas 5996-10-1) is a product of the SBC Vietnam Science Trading Service Co., Ltd.

2.2. Sample preparation method

2.2.1. Prepare the cake filling

In this study, the preparation sequence of the filling was as follows: 350 g of mung beans were soaked in water for 30 mins. Then, the beans were cooked in a 20 cm stainless steel pot Sunhouse Mama SH784 using a single Sunhouse SHD6803 induction cooker at a power level of 800 W until they were softened. Next, we mashed the cooked mung beans and mixed them with 300 g of sugar before cooking the mixture until it became dry and non-sticky. After that, 350 g of shredded coconut was added and mixed well before forming the mixture into 20 g balls.

2.2.2. Prepare the cake crust

The sample of sticky rice flour was prepared as follows: First, 1 kg of sticky rice was weighed and ground into flour using an 1800 W dry milling machine from OEM, Vietnam. Next, the sticky rice flour was sifted through an 80-mesh (0.125 mm) sieve to remove any lumps and smooth the flour. After the Ramie leaves were preprocessed and cleaned, they were ground into a puree. Ramie leaves were cooked at a ratio of ramie leaves: water = 1:2 (w/w) for 50-60 mins using an electric stove (Sunhouse SHD6803, 2000 W) at 600 W power level until there is no more water left. Next, add glutinous rice flour, ground Ramie leaves, sugar, water with GEO corresponding to 4 levels of 2 mL, 3 mL, 4 mL, 5 mL/1 kg of flour, respectively for the formulas MF2, MF3, MF4, MF5. CS means control samples without any GEO. The mixture was kneaded until it formed a smooth and non-sticky dough and then allowed to rest for 15 mins. Finally, the dough was divided into 40 g balls using an electronic scale platform.

2.2.3. Prepare for sample cake

The wrapping and steaming process of the SCRL is carried out as follows: First, the cake wrapper is rounded, flattened, and the filling is placed in the middle and then wrapped. The dough ball was rounded and coated with a layer of soybean oil to prevent the cake from sticking to the banana leaves. The cake was then placed on banana leaves and wrapped on two sides. The cakes were then stacked in an Inox HT Cook steaming basket and steamed using a single Sunhouse SHD6803 electric stove at 800 W for 30 mins. Once the cakes were steamed, they were cooled off and drained with excess water.

2.3. Methods of determining the shelf life of SCRL supplemented with GEO

The expiration date is the maximum time that a product can be stored and used without compromising its quality. Based on Kilcast and P. Subramaniam (2000), to determine the shelf life, one needs to consider parameters such as moisture content, texture, total microbial count, and product sensory so that it is compatible with the product requirements. When a product shows signs of deterioration, the storage process should be stopped, and the shelf life of the product should be recorded [7]. In this study, five SCRL recipes were used, and each recipe consisting of seven cakes was stored stably in an incubator (Model INCO246MED, MEMMERT) at 30ºC and 87% RH (Relative Humidity). Periodically, every 24 hours, SCRL samples were sampled to determine texture (hardness, cohesiveness, chewiness, gumminess), moisture, and total aerobic microorganisms to predict the shelf life of SCRL samples in this study.

2.4. Analytical Methods

2.4.1. Method for Moisture Determination

The water content in the product is determined by the method of drying to a constant weight at a temperature of 105°C according to TCVN 4069:2009 with adjustments. It is calculated using the following formula:

$$X_{H_2O} = \frac{G_1 - G_2}{G_1 - G} \times 100\ (\%) \qquad (2\text{-}1)$$

where:

X_{H2O} : Moisture content of the food ingredient (%).

G_1 : Weight of the drying cup and the sample before drying (g).

G_2 : Weight of the drying cup and the sample after drying (g).

G : Weight of the drying cup (g).

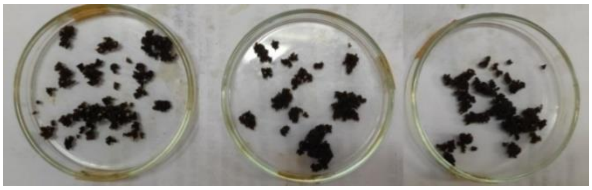


Figure 1. Sample cake is less ground before drying

2.4.2. Method for Determining the Texture of the SCRL

The texture of the SCRL was determined following the method described by Chuang and Yeh (2006) [6], with modifications. To determine the TPA (Texture Profile Analysis) for the samples, the molds prepared to accommodate the sample are described as follows: the molds are 21 mm diameter plumbing caps with a height of 20 mm. The crusts of the samples were prepared and placed into the molds in the following order: the middle part of the crust was placed in one mold and the two edges of the crust on the sides were placed in the other two molds. This process was performed uniformly for all the samples. TPA measurements were performed using a structural gauge with a maximum force of 5 kg and a TA39 probe of 2 mm diameter and 20 mm length, placed 20 mm from the sample, operating at a speed of 30 cm/min. The probe penetrated the sample after contact, and the probe penetrated 10 mm deep.

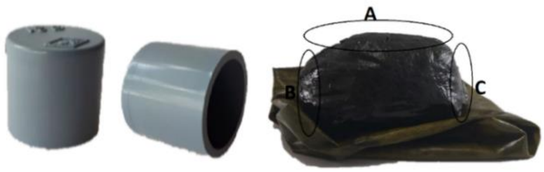


Figure 2. The illustration of the mold containing the sample and the cake in the order of sampling A, B, C (A is the middle of the crust, B and C is the edge of the crust)

2.4.3. Method of determining microbiological criteria

The identification of microorganisms contained in SCRL was carried out according to Vietnamese standards TCVN 4884-1:2015 (ISO 4833-1:2013). Microbiological enumeration was used to count colonies at 35 °C using the pour-plate technique. The total aerobic bacteria of the SCRL samples were determined on days 3, 4, 5, and 6 of cake storage. The pour plate technique was applied to count colonies on agar after the samples were incubated aerobically at (35 ± 1)°C for a period of 24 to 48 hours. The number of aerobic bacteria in 1 g or 1 mL of the test food product sample was calculated by counting the colonies on culture plates at different dilutions. All counted values are expressed as log CFU/g.

2.5. Data analysis

Each experiment was arranged in a randomized design with three replications, and the data are presented as mean ± SD. Analysis of variance (ANOVA) and treatment for differences between treatments by LSD (Least Significant Difference (LSD) test at the significance level $\alpha = 0.05$, using Statgraphics Centurion XV.I software.

3. RESULTS AND DISCUSSION

3.1. Influence of GEO on the physical properties of SCRL

Moisture (%) indexes of SCRL are shown in Table 1 below:

Table 1. Change of moisture (%) of SCRL over time and surveyed GEO concentration

Storage time (Day)	Moisture (%)				
	CS	MF2	MF3	MF4	MF5
0	35.51^{fA}±1.34	35.85^{fB}±1.52	36.38^{fC}±0.80	37.12^{fD}±1.96	38.06^{fE}±1.27
1	34.45^{efA}±0.53	35.18^{efB}±1.44	35.74^{efC}±1.12	36.53^{efD}±0.96	37.55^{efE}±1.01
2	34.02^{eA}±1.94	34.47^{eB}±0.64	35.08^{eC}±0.27	35.93^{eD}±1.41	36.97^{eE}±0.77
3	31.17^{dA}±0.67	33.62^{dB}±0.79	34.28^{dC}±0.43	35.24^{dD}±1.18	36.33^{dE}±0.92
4	29.75^{cA} ±0.62	32.72^{cB}±0.54	33.47^{cC}±0.91	34.60^{cD}±0.64	35.20^{cE}±0.66
5	28.66^{bA}±1.19	30.86^{bB}±0.73	31.91^{bC}±1.01	33.19^{bD}±0.51	34.48^{bE}±1.38
6	27.75^{aA}±1.55	29.32^{aB}±0.89	30.89^{aC}±0.61	32.21^{aD}±1.18	33.52^{aE}±0.44

The mean values with the indices in the above table (a – f) over time and (A – C) according to the GEO content are significantly different (at the significance level α ≤ 0.05).

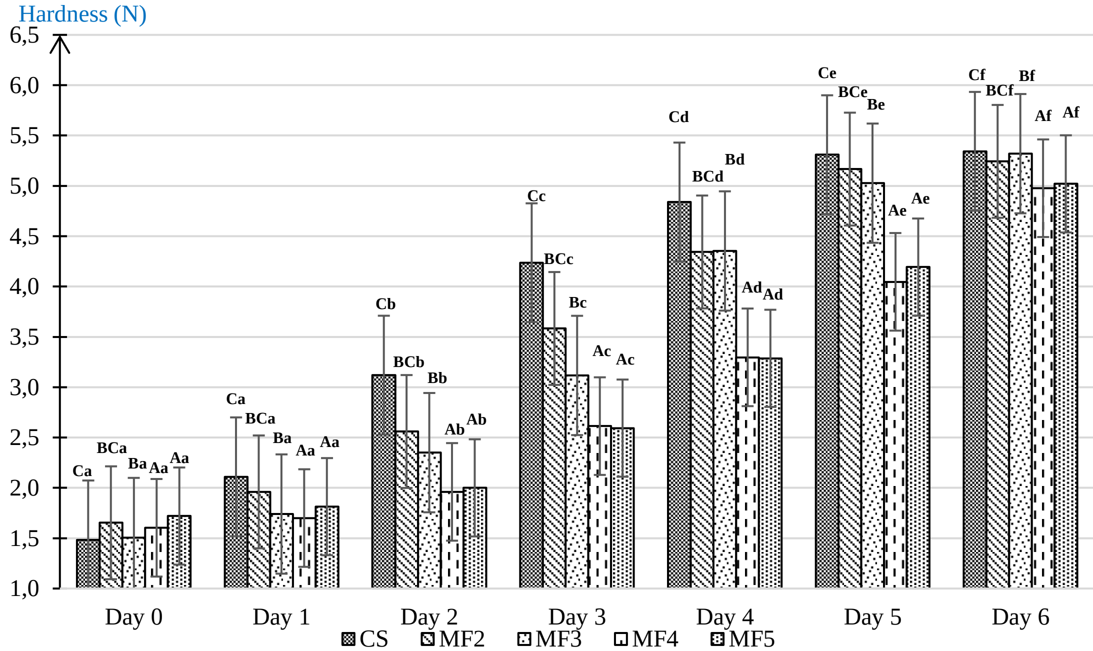
Although the limited number of publications on SCRL but the data obtained in this study are consistent with many published studies on processed rice cakes. Specifically, Cao et al. (2022) confirmed that moisture significantly affects the sensory and physical quality of steamed rice cakes [13]. In addition, in Ji's (2007) study on Migao cake made from glutinous rice, all samples showed a significant reduction in moisture content during storage [9]. Over time, the moisture content of the samples decreased significantly ($p < 0.05$), in which CS had the strongest decrease, and the sample with more GEO had a slower decrease in moisture value than CS ones. The GEO-supplemented samples also showed a strong decrease in moisture content on storage day 4 and 5, which, MF2 had the strongest decrease, followed by MF3, MF4, and MF5 had similar decreases, and CS decreased slowly.

Moisture plays an important role in the quality and hardening of the cakes. The more the GEO content increases, the more the moisture content increases. The phenomenon that GEO addition increases the moisture content can be explained based on a study of Korean rice cakes by Park et al. (2021). These authors confirmed that, for cakes made from steamed glutinous rice, the surface can hold more water than the holes in the middle because steam is transferred to the edges during the steaming process. Redistribution and dehydration can occur during rice cake storage. The reduction in cake moisture may have been due to evaporation from the surface into the surrounding air. SCRL supplemented with GEO showed less moisture loss than the control ones. This result indicates that GEO can reduce water evaporation and the binding capacity of GEO to water ejected from the starch chain during storage, thereby improving cake moisture retention [14].

Starch degradation is due to the loss of moisture in the dough mass, and the hardness increases with storage time. Thus, the hardness value and moisture content have an inverse relationship.

Carrying out the TPA measurement according to the method of Chuang and Yeh (2006) [6], the hardness value of the cake samples was determined and compared according to the storage time and the GEO content.

The results presented in Figure 3 show that after six days of storage at 30 ºC, the hardness of the SCRL samples slightly increased ($p < 0.05$). Significant differences between the SCRL samples were recorded in the hardness value over the storage time, especially between day 1 (24 hours) and day 5, as expressed by index (a-e); meanwhile, there was no significant difference between the hardness value of SCRL samples after 5 and 6 days of storage.



The mean values of the above indices (a – f) over time and (A – C) according to GEO content were significantly different (at a significance level α ≤ 0.05).

Figure 3. Graph showing the change of Hardness of the samples over time and according to different stored GEO content.

According to Hongwei Wang and colleagues (2019), glutinous rice flour creates a softer and more elastic structure for cakes. Glutinous rice flour is composed of many amylopectin branches, which, when cooked (gelatinized), create a cohesive and highly elastic mass [8]. The SCRL shell is mainly made from glutinous rice flour; therefore, it has a soft and flexible structure when the cake is steamed. The hardness value of the SCRL samples on the first day of storage is low that indicates the softness and ductility of the SCRL sample. CS has the lowest hardness value (1.48 ± 0.33 N), indicating a sample with the most softness and ductility, while MF5 has the highest hardness value (1.72 ± 0.54 N). The experimental results showed no significant difference between the freshly prepared SCRL samples (measured for 1h after steaming). However, during storage, the hardness values of the SCRL samples changed markedly and were influenced by the amount of GEO used.

The hardness of the control (non-GEO) sample increased significantly from day 0 to day 4, with the value increasing more than 3 times. Meanwhile, the hardness values of MF4 and MF5 did not increase significantly by time, and the distance between their equivalent hardness values (indices A-C) did not differ significantly. Over the last two days, the hardness of the SCRL increased slowly. The data in Table 1 show that the moisture content of all cake samples decreased significantly with storage time, which is similar to the results found by Ying Ji (2007) in a study on glutinous rice cakes. It was found that all sticky rice samples had a marked decrease in moisture content and an increase in hardness when stored, which was due to starch degradation [9]. Starch often contains two components, amylose which contains only α(1→4) glycosidic bonds, and amylopectin which contains α(1→4) glycosidic and α(1→6) glycosidic bonds. Amylose has an unbranched vascular structure, so it degrades faster than amylopectin [10]. Since glutinous rice flour is a starch with a high amylopectin content (~90%) [8], the degradation of the SCRL sample containing glutinous starch is slow. The hardness value increased rapidly from day 1 to day 4, followed by the degradation of saturated starch; thus, the hardness value increased more slowly. The change in the hardness of the cake samples according to the variation in GEO content can be explained by oxidation, which mutates the cake structure [11]. Cake samples supplemented with GEO, owing to their antioxidant and antibacterial activities, create a protective surface film, thereby reducing the amount of water lost in the cake and increasing its moisture content. This resulted in a decrease in the hardness of the samples with added essential oils; however, the mutation in hardness differed depending on the essential oil dose [12].

Next, the cohesiveness, toughness and gumminess indexes are shown in Table 2.

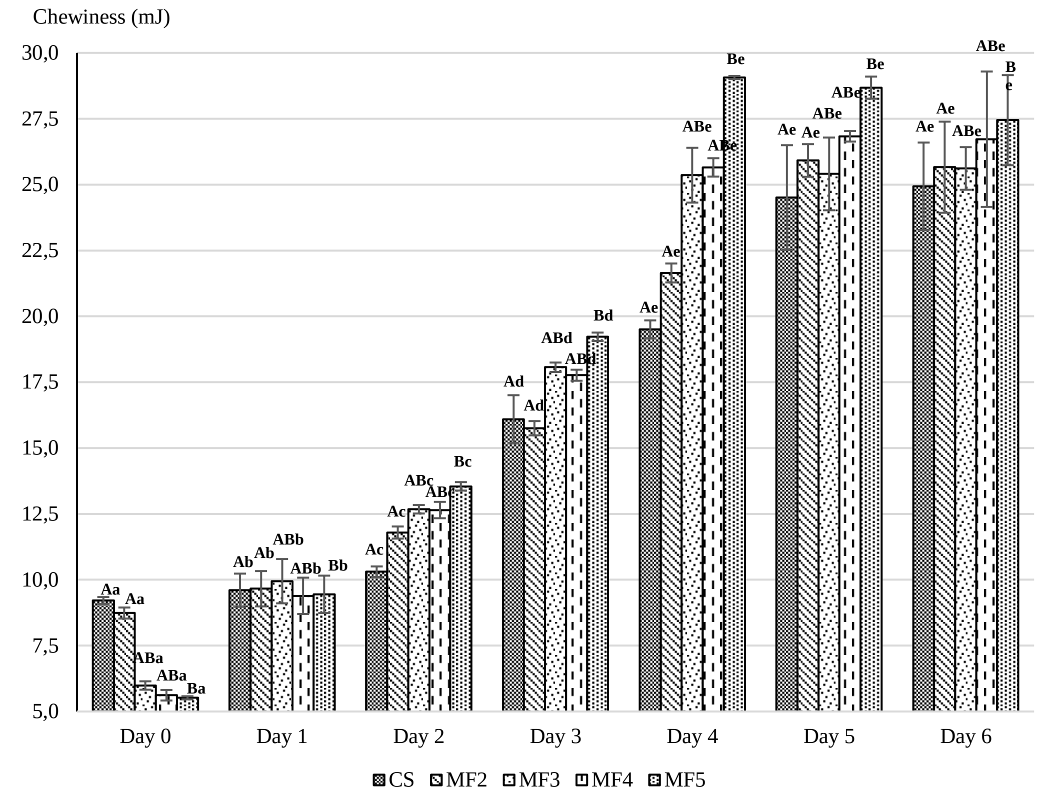
Table 2. Change of samples cohesiveness with storage time

Storage time (Day)	Cohesiveness				
	CS	MF2	MF3	MF4	MF5
0	$0.87^{e} \pm 0.06$	$0.73^{e} \pm 0.05$	$0.70^{e} \pm 0.21$	$0.67^{e} \pm 0.04$	$0.64^{e} \pm 0.04$
1	$0.67^{d} \pm 0.09$	$0.59^{d} \pm 0.16$	$0.61^{d} \pm 0.12$	$0.63^{d} \pm 0.02$	$0.62^{d} \pm 0.07$
2	$0.62^{c} \pm 0.06$	$0.56^{c} \pm 0.02$	$0.54^{c} \pm 0.03$	$0.51^{c} \pm 0.02$	$0.50^{c} \pm 0.03$
3	$0.53^{bc} \pm 0.02$	$0.52^{bc} \pm 0.02$	$0.52^{bc} \pm 0.02$	$0.50^{bc} \pm 0.01$	$0.50^{bc} \pm 0.01$
4	$0.44^{ab} \pm 0.03$	$0.45^{ab} \pm 0.02$	$0.43^{ab} \pm 0.04$	$0.46^{ab} \pm 0.02$	$0.51^{ab} \pm 0.04$
5	$0.35^{a} \pm 0.02$	$0.40^{a} \pm 0.03$	$0.42^{a} \pm 0.04$	$0.44^{a} \pm 0.03$	$0.47^{a} \pm 0.03$
6	$0.37^{a} \pm 0.07$	$0.43^{a} \pm 0.02$	$0.39^{a} \pm 0.14$	$0.45^{a} \pm 0.15$	$0.42^{a} \pm 0.13$

The mean values of the indexes in the above table (a – f) over time have significant differences (at the significance level $\alpha \leq 0.05$).

According to the storage time at 30 ºC, the value of cohesiveness in days between samples was recorded as significantly different ($p < 0.05$) and decreased significantly by days (a – f). When compared according to the additional GEO content, the value of cohesiveness between samples recorded for 6 days was not significantly different ($p > 0.05$). Because the molecular structure of glutinous rice flour contains a variety of sugars and starches, it is considered a complex starch. When cooking glutinous rice flour, the starch in the flour breaks down into simple sugars, creating sweetness and plasticity in the glutinous flour. On the first day, the cohesion of the cake samples was high. Starch degradation contributes to changes in textural properties (increase in hardness and decrease in cohesiveness) [9]. Although the adhesion decreased after 7 days, there was no difference in the reduction rate between the days. From this, it can be concluded that the added GEO content had no significant effect on the cohesiveness of SCRL.

Chewiness/toughness is an important structural parameter that ensures the machinability of SCRL. As shown in the chart in Figure 4, the chewiness value was significantly reduced after adding powdered ramie leaves (GEO) to the cake, whereas the sample without GEO increased when stored. This reduction can be explained by the reduced starch content and homogeneity between GEO and glutinous flour, which affect the adhesiveness of the cake [14]. However, when compared according to the preserved GEO content, the chewiness values of the samples recorded within 6 days were not significantly different ($p > 0.05$). Therefore, it can be concluded that GEO has no significant effect on the chewiness of the SCRL.



The mean values with the above indexes (a – f) over time and (A – C) according to GEO content are significantly different (at the significance level α ≤ 0.05).

Figure 4. The change of samples chewiness over time and according to different preserved GEO content

Table 3. Change of samples gumminess over time and according to different preserved GEO content

Storage time (Day)	Gumminess				
	CS	MF2	MF3	MF4	MF5
0	1.12^{aB}±0.01	1.12^{aB}±0.03	0.96^{aA}±.03	0.92^{aA}±0.01	0.90^{aA}±0.05
1	1.40^{aB}±0.4	1.29^{aB}±0.42	1.11^{aA}±0.39	1.06^{aA}±0.29	0.99^{aA}±0.23
2	1.85^{bB}±0.02	1.77^{bB}±0.34	1.46^{bA}±0.4	1.34^{bA}±0.5	1.10^{bA}±0.18
3	2.27^{cB}±0.58	2.15^{cB}±0.64	2.23^{cA}±0.31	2.09^{cA}±0.46	2.06^{cA}±0.16
4	2.37^{dB}±0.61	2.51^{dB}±0.48	2.45^{dA}±0.51	2.68^{dA}±0.02	2.61^{dA}±0.59
5	2.74^{dB}±0.53	2.71^{dB}±0.04	2.40^{dA}±0.24	2.33^{dA}±0.19	2.27^{dA}±0.11
6	2.56^{dB}±0.5	2.63^{dB}±0.82	2.28^{dA}±0.59	2.36^{dA}±0.37	2.33^{dA}±0.42

The mean values with the indexes in the above table (a – f) over time and (A – C) according to the GEO content are significantly different (at the significance level α ≤ 0.05).

The results in Table 3 show that the gumminess value increased within 6 days. However, in a study by Park et al. (2021) on Korean rice cakes, the gumminess of steamed cakes with a natural essential oil addition was lower than that of the control cakes. This result can be explained by the unevenness between glutinous rice flour and GEO added to the cake, which affects the springiness and weak adhesiveness of the cake [14]. Interestingly, the stickiness of the rice cakes decreased during storage, while the gumminess increased after one day of storage and remained at that level from one day to two days. This shows that there is a regular correlation between the gumminess of SCRL and rice cakes. In summary, GEO did not significantly affect the gumminess of SCRL.

In conclusion, GEO did not significantly affect the gumminess of SCRL, and the difference in gumminess between samples with and without GEO can be explained by the heterogeneity between GEO and glutinous rice flour.

3.2. Determination of some spoilage criteria of cakes according to storage time

The spoilage criteria of the finished cake according to the storage time were determined based on the total number of aerobic microorganisms developed on the finished cake samples over the storage time (shown in Table 4).

Table 4. Total aerobic microorganisms (CFU/g) on cake samples by storage time

Day	CS	MF2	MF3	MF4	MF5
4	$41x10^5$	$24.5x10^5$	$15.5x10^5$	$5.5x10^5$	$2.5x10^5$
5	$129.5x10^5$	$81.5x10^5$	$77x10^5$	$38x10^5$	$14.5x10^5$
6	$244.5x10^5$	$150.5x10^5$	$119.5x10^5$	$90.5x10^5$	$41.5x10^5$

The mechanism of action of GEO mainly occurs on the cell membrane by disrupting its structure, causing cell death, blocking membrane synthesis, and inhibiting cellular respiration. Owing to its highly volatile and hydrophilic properties, GEO readily penetrates cell membranes and exerts its biological effects [15]. Earlier studies reported that GEO exhibited inhibitory effects against a variety of pathogenic bacteria and fungi. Their effects are due to active components such as zingeberene, endo-borneol, and gingerol present in GEO [16].

During the first two days, the SCRL samples showed no deterioration. However, after that, CS began to exhibit viscous flow, whereas the GEO sample began to harden. The results of the microbiological analysis of the SCRL samples showed that, according to the storage time, the SCRL samples started to appear as yeast and mold on the fourth day. The control sample had the fastest and greatest increase in total aerobic microorganisms over the storage period compared to the other four SCRL samples using GEO. MF5 showed the slowest increase in total aerobic microorganisms with storage time. On the fifth day, the total number of aerobic microorganisms increased rapidly and exceeded the allowable limit according to the standard TCVN 12941:2020, with the total number of aerobic microorganisms in the control sample reaching $12.95x10^6$ (CFU/g). This means the control sample can not be used as food because of the risk to human health.

The previous study by Noori et al. (2018) demonstrated the antifungal activity of GEO against molds and yeasts. This study demonstrated the antibacterial and antioxidant efficacy of an edible coating based on a nano emulsion containing GEO (*Zingiber officinale*), which had a strong antibacterial effect comparable to that of the antibiotic gentamicin. In addition, GEO is resistant to molds and yeasts, as confirmed by the survey results of this study [17]. These results suggest that the addition of GEO to SCRL reduces the total number of aerobic microorganisms, molds, and yeasts, as demonstrated by the survey.

In summary, the results of the structural and microbiological analyses of SCRL samples show that MF4 and MF5 always have better structure and microbiological indicators than traditional SCRL samples. To achieve economic efficiency and reduce the pungent nature of SCRL, it is necessary to select a lower GEO concentration.

3.3. Images illustrating the effect of prolonging the shelf life of GEO on ramie leaf cake

This study recorded the external state of MF4, which was stored continuously for six days with a change in GEO content. The images were recorded periodically, and the following results were obtained.

After 3 days of storage, the cake samples showed deterioration, typically viscous on the outer surface of the cake, and the characteristic smell of Ramie leaves gradually disappeared. Meanwhile, the cake samples with added GEO slightly increased the hardness, and the outer surface remained dry and retained the aroma of the ginger essential oil.

After 4 days of storage, CS became hard, no longer chewy and soft like on the first day, and had a strange smell instead of the smell of ramie leaves. The cake began to appear slimy and slightly moldy on the outside of the banana leaf, which is not safe to use. The cakes added with GEO become firmer, and the outer surface remains dry and retains the aroma of GEO.

However, on the 5th day of storage, CS and MF2 appeared moldy on the surface of the banana leaves, and the cake was completely damaged. CS lost the smell of ramie leaves, whereas MF2 no longer had the smell of GEO. Other cakes also gradually lost the smell of GEO, except for MF4 and MF5, which retained the smell of GEO and ramie leaves. However, the outer surface of the banana leaf showed mold.

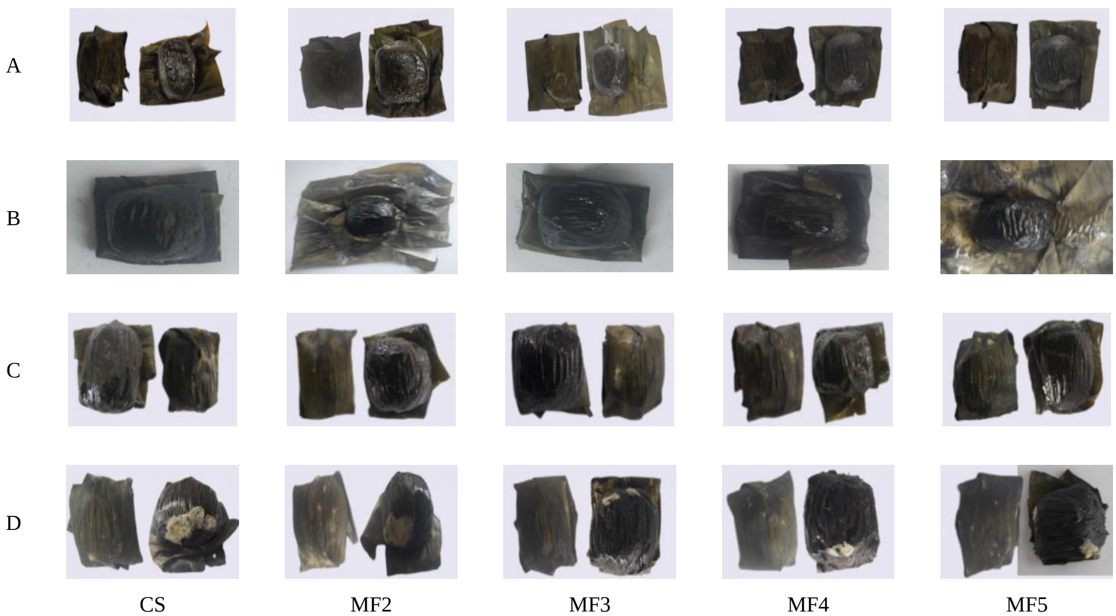


Figure 5. SCRL samples after 3 days (A), 4 days (B), 5 days (C), 6 days (D) of preservation

After 6 days of storage, the surface of the banana leaves and the crust of the cake samples appeared moldy (see Figure 5). The microbiological results showed that the CS had the highest total CFU, meanwhile MF4, and MF5 had similar low bacteria density. All cake models were completely damaged and no longer safe to use. Instead of the aroma of ramie leaves and GEO, by the end of the preservation process, the cake samples had only a rotten smell.

The results of structural analysis and microbiological index in SCRL samples showed that during storage, MF4 and MF5 had better structure and microbiological index than other samples. Based on these analyses, together with the economic efficiency and reduction of the pungent of ginger essential oil on the product sensory, we recommend a concentration of 4 mL GEO/kg powder to extend the shelf life of SCRL up to 6 days but still keep the product quality close to the traditional product.

4. CONCLUSIONS

Research has shown that the addition of GEO to glutinous rice flour affects the preservation process of cakes. The best effect was achieved when using 4 mL of GEO per kilogram of glutinous rice flour. The cake could be stored for six consecutive days at 30ºC and RH of 87% without mold. The preservation process also leads to the gradual hardening of the Ramie leaf cake. The amount of GEO added to the SCRL sample was correlated with the hardness of the cake. As the additional GEO content increased, the moisture content decreased slowly, and the hardness increased slightly. Microbial spoilage was also significantly reduced. Based on these results, it is possible to use GEO as a natural preservative with antibacterial and antioxidant properties to prolong the shelf life of SCRL.

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TÓM TẮT

NGHIÊN CỨU SỬ DỤNG TINH DẦU GỪNG ĐỂ KÉO DÀI THỜI HẠN SỬ DỤNG CỦA BÁNH ÍT LÁ GAI TRUYỀN THỐNG

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Trong nghiên cứu này, nhằm giải quyết vấn đề về hạn sử dụng ngắn của bánh ít lá gai - một sản phẩm truyền thống đặc trưng của tỉnh Bình Định, tinh dầu gừng được bổ sung vào các công thức bánh với mục đích làm tăng thời gian bảo quản. Để đánh giá hiệu quả của phương pháp này, 5 công thức bánh với nồng độ tinh dầu gừng khác nhau đã được nghiên cứu. Các thông số liên quan đến chất lượng sản phẩm, bao gồm độ ẩm, cấu trúc và tổng số vi sinh vật hiếu khí, đã được xác định theo thời gian bảo quản trong 6 ngày. Qua đó, kết quả cho thấy rằng bổ sung tinh dầu gừng với nồng độ 4 mL/kg bột nếp có khả năng kéo dài hạn sử dụng của bánh ít lá gai được 6 ngày. Nghiên cứu này có thể áp dụng để gia tăng giá trị thương mại và bảo tồn sự đa dạng của sản phẩm truyền thống địa phương.

Từ khóa: Bánh nếp, lá gai, *Boehmeria nivea* L. Gaudich, tinh dầu gừng, hạn sử dụng.