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Research Paper

Development of an Edible Coating from Okra Mucilage to Preserve the Crispiness in Soft Dough Biscuits Upon Storage

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Abstract

Baked food products are considered to be one of the most popular processed foods in the world. Among all the bakery products, biscuits are the most frequently consumed snack food item. There is a vast and diverse market for biscuits as a leader in ready-to-eat baked goods. Biscuits have long shelf life than other bakery products when stored under proper conditions. But immediately after exposure to the air by opening or damaging the package, biscuits absorb moisture from the air and reduce its crispiness of the biscuits. According to the market survey results, the highest number of respondents (53.7 %) suggested developing an edible coating for biscuits to prevent the loss of crispiness in biscuits upon storage. As well as 98.5 % of respondents prefer edible coatings developed using natural sources. Polysaccharide-based edible coatings maintain the physicochemical, microbiological and sensorial properties of the food. Therefore, okra mucilage was used as the main ingredient for edible coating preparation for biscuits. The coating was applied on biscuits with different coating methods, different baking stages and stored in different environmental conditions to identify the efficiency of the coating. According to the results, a coating applied before the baking stage displayed better moisture barrier properties than that of the coating applied after baking in controlled, semi-controlled, and normal atmospheric environmental conditions. It's responsible for the reduction of moisture absorption of biscuits upon storage.

Keywords: Biscuits, edible coating, moisture, okra mucilage, shelf-life

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Introduction

According to Klunklin et al [1] baked food products are considered as one of the most familiar processed food items in the world. Among all the bakery products, biscuits are the most popular snack food. Smith [2] mentioned that the word "biscuit" is derived from the Latin "biscocuts" meaning twice baked. People have been using biscuits as their snacks for hundreds of years. As discussed by Polytechnic et al [3] in ancient times, biscuits have been produced at a household level with a few ingredients. But nowadays, biscuits are produced on large scale with automated plants. Adeola et al [4] described there is a very broad, globally spread market available for biscuits as a prominent ready-to-eat baked snack. Food and Agriculture Organization of the United Nations [5] indicates different varieties, sizes, flavors, colors and shapes have been introduced by the manufacturers to enhance its quality as well as attractiveness to consumers. According to Polytechnic et al [3], consumers consider the nutritional quality of biscuits which plays a major role in this variation.

Lauterbach et al and Chauhan et al [6,7] mention that, main ingredients such as fat/oil, sugar and flour are used in biscuit production. According to the biscuit varieties, ingredients can differ. These Unique functions of these biscuit varieties vary with the ingredients used in production. As discussed by Klunklin et al and the Food and Agriculture Organization of the United Nations [1,5] biscuits have fairly a long shelf life when stored under proper conditions. The quality deterioration of biscuits has a positive linear relationship with the shelf life. Kahve [8] indicated the main factor that affects the shelf life is moisture. According to Saranraj et al [9], like most other processed foods, baked products are subjected to physical, chemical, and microbial degradation. Physical and chemical deterioration limits the lifespan of low- and intermediate-moisture baked products, while microbial deterioration from bacteria, yeast, and mold is associated with higher moisture ranges. Commercially produced and properly handled bread often does not have enough moisture for the growth of spoilage microorganisms. High moisture content can lead to microbial spoilage due to their increased growth, mainly in baked goods.

Krystyjan et al and Alabakan [10,11] indicated freshly baked biscuits have a moisture content of 1-5 % and a water activity (aw) of about 0.1. When the biscuits are packaged, the moisture in the biscuit product reaches an equilibrium with the moisture in the space

in the package. However, when packaged with a high-moisture barrier or when the sealing quality is not sufficient, moisture enters the package and results in loss of the crispiness of the biscuits. As well as Theóphilo et al [12] mentioned that immediately after exposure to the air by opening or damaging the package, biscuits absorb moisture from the air and reduce the crispiness of biscuits. Almost all the manufacturers mainly use packaging material to address this problem. If the biscuits are coated with an edible coating, the moisture deterioration can be reduced.

As discussed by Yimtoe et al [13,] the edible coating is a film that is formed or placed on or between the food components. It is responsible for the preservation of the food item.

Also, edible coatings act as moisture and gas barriers that preserve the texture, color and moisture of the product as described by Kokoszka et al [14]. Edible coatings can be manufactured with different ingredients. According to the food variety, those coating ingredients can be varied. The edible coatings can be developed from a variety of biopolymer molecules, such as polysaccharides, proteins, and lipids. Chen et al [15] described that pullulan, chitosan, carrageenan, starch, alginate, cellulose, pectin, gellan gum, and xanthan gum as polysaccharide-based edible coatings. The main advantages of polysaccharides are abundance, availability, low cost, non-toxicity, and heat processing ability.

Porta [16] indicated that fruits and vegetables lose weight during post-harvest handling and storage due to transparency, and as a result, texture changes and surface shrinkage affect their shelf life. So edible coatings are often familiar to fruits and vegetables. Yai [17] discovered that novel edible packaging /coating technology has provided good results in extending the shelf life of pizza, pies, and other bakery products. Various probiotic coatings (dispersed or multi-layered) were also applied to the surface of the semi-baked bread to increase coating. Cantaloupe et al [18] indicated that the polysaccharide-based edible coatings maintain the physicochemical, microbiological and sensory properties of the food.

Okra mucilage is an ingredient that can be used in coating preparation. The development of an edible coating from okra mucilage for biscuits is a good solution to extend the shelf life of the biscuits without reducing their crispiness. According to Weerasekera et al [19], okra (*Hibiscus esculentus)* is an annual vegetable that belongs to the family of Malvaceae. Commonly they are known as Ladies finger or gumbo. Okra is widely grown from Africa to Asia, South Europe and America. It is a greenish capsule vegetable with a length of 10-

30 cm long and a diameter of 1-4 cm as indicated by Chowdhury [20]. Maturity indices of okra can be described under the main 3 categories. They are light green colored with soft texture, light green colored with hard, green whitish or green yellowish with the hard texture and its end is not easily broken.

Durazzo et al [21] discussed the fresh immature seed pods of okra are consumed as vegetable and mucilage extracted from pods are used in soups, sauces like recipes to make them thicker. According to Noorlaila et al, [22] okra plays a major role in the human diet by providing many nutrients. As well as it is an antioxidant-rich vegetable. Vitamin A, protein, sugars, deity fibers are some of the constituents contain in the okra. As discussed by Chowdhury et al, [20] okra mucilage/ gum contains sugar residues such as exopolysaccharides and protein called glycoproteins. Actually, it is a mucilaginous plant. Immature pods, seeds, leaves, stems, bark and cell wall of the okra capsule contains the different composition of mucilage. This mucilage displays pseudoplastic rheological characteristics. When heat is applied the viscosity of the mucilage increases.

Usage of okra mucilage as a coating also provides many additional advantages to the biscuit. Therefore, the preparation of edible coating with okra mucilage is a more suitable solution to overcome the above-mentioned issue of loss of crispiness due to the absorption of moisture. In this research, soft dough biscuits were selected to test the efficiency of coated biscuits.

Materials and Methods

Okra was collected from the local market of Awissawella in Colombo district, Sri Lanka (6.9504080, 80.2139470).

All reagents used for the study were in analytical grade.

Marketing Survey

A market survey was conducted through google forms to get an idea about customer preferences for edible coated biscuits. A random sample consists of university undergraduates, employed, unemployed and retired personnel representing different regions of Sri Lanka was selected for this survey. The questionnaire consisted of gender, age group, profession-like questions for screening purposes.

Preparation of Okra Mucilage

The matured okra was thoroughly washed with potable water after confirming its initial quality. Then the okra was cut into small pieces. The cut pieces were boiled with distilled water to the ratio of 1:1 with low flame for about 5-10 minutes. Then the mucilaginous solution was filtered through a strainer with a 250 μm sieve. The solution was mixed with 95 % ethanol (20 % v/v) and filtered through filter paper to collect extracted gum. For further clarification, the solution was heated with a low flame to about 50 ^{0}C for ethanol precipitation.

Application of Okra Gum on Biscuits

The extracted gum layer (4 g) was applied on each biscuit surface with the dipping and brushing method. The gum layer was applied on biscuits at different stages as in the oven end (baked biscuits) and the cutter section (raw biscuits).

Sample Storage

Prepared Coated biscuits were stored in different storage conditions as,
Controlled environment - wrapped/sealed packages (Metalized Wrappers)

Semi-controlled environment – package opened and then sealed

Open environment – normal atmospheric environment

Determination of Physical Properties of Coated Biscuits

Baked biscuit weight, height, diameter-like physical parameters were analyzed for each biscuit coated at different stages of biscuit processing.
Baked Biscuit Weight: Baked biscuit weight was measured using calculating the average weight of ten biscuits.

Baked Biscuit Height: Baked biscuit height was measured using calculating the average height of ten biscuits using a vernier caliper.

Baked Biscuit Diameter: Baked biscuit diameter was determined by using a vernier caliper.

Sensory Evaluation

Sensory evaluation was conducted using 15 untrained panelists. During the panel test, the panelists were asked to wash their mouth with water to remove any traces of residual food. Each panelist was asked to rate the liking of quality attributes according to Taste,

colour, flavor, texture, and overall acceptability on the 9-point hedonic scale (1= dislike very extremely and 9 = like very extremely). Environmental conditions like temperature (18-22^{0}C) and relative humidity (40-50 %) were maintained during the test procedure.

Determination of Moisture Content

Determination of moisture was carried out once within two days for each biscuit which coated at different stages of biscuit processing. Biscuits will be taken and grounded using mortar and pestle. A sample of 5 g of grounded biscuits will be analyzed using a moisture meter (Model- HB43-S Halogen, USA).

Statistical Analysis

One-way ANOVA is used for the statistical analysis.

Results and Discussion

Market Survey

Changes in lifestyles and changes in the eating habits of consumers were expected to lead to the biscuit market forecast period. According to the survey results, biscuits have a high demand in the market. Most of the respondents purchase biscuits once in 2-3 days, daily, and once a week. It's a good hint to identify the purchasing pattern of biscuits. Figure 1 indicates the biscuit purchasing pattern of respondents.

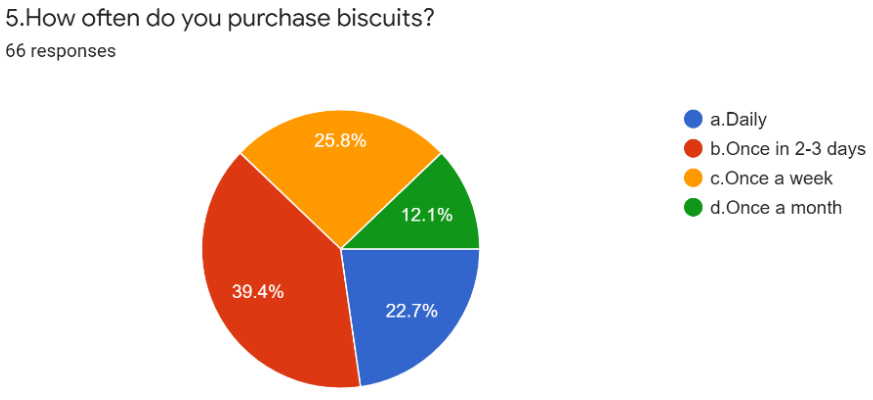

Figure 1. Purchasing pattern of biscuits

Biscuits are an easy meal and can be transported, stored, and eaten anywhere. These convenient features of biscuits are key factors in the demand and growth of the global biscuit market. Most of the respondents consume biscuits whenever hungry and during the tea breaks. As well as a high percentage of respondents consume biscuits as a snack.

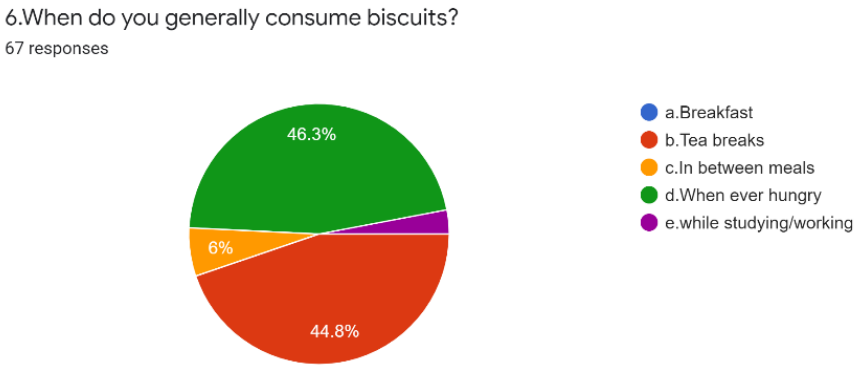

Figure 2. Consumption pattern of biscuits

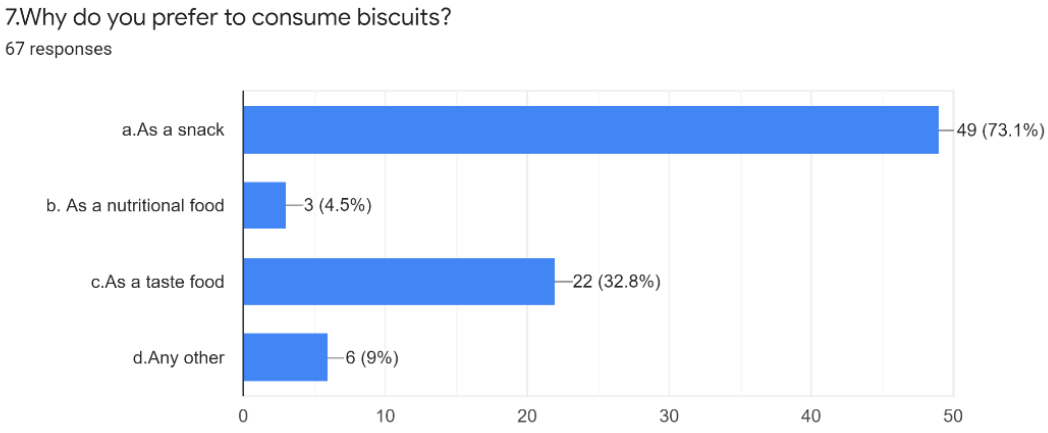

Figure 3. Preferences of biscuits

Biscuits are one of the most popular and preferred packaged foods in the world. Biscuits are available in the market with a variety of flavors, shapes, and tastes. As well as biscuits are available in the market with different weight ranges for the convenience of the consumers.

According to the survey results, the highest number of respondents like to purchase 85 g packets of biscuits. It's about 49.3% of the total responses. The least number of respondents like to consume 1 kg packet of biscuits. Figure 4 indicates the consumer preference on weight ranges of biscuits.

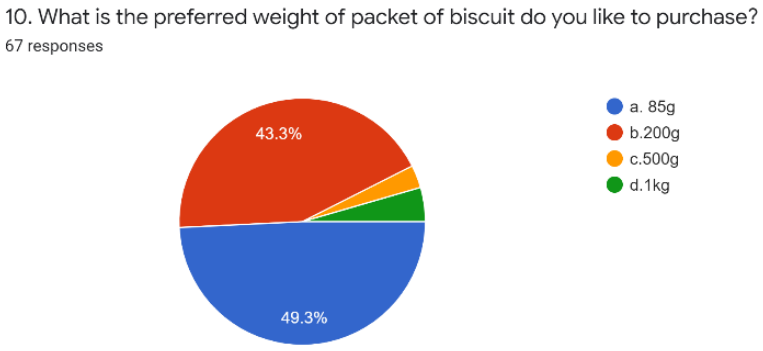

Figure 4. Preference weight ranges of biscuits

When considering the bulk consumption pattern of biscuits, most of the consumers didn't prefer to purchase biscuits in bulk because a large wastage of biscuits occurs due to moisture absorption. Therefore, the highest number of respondents prefer biscuits with edible coatings. They suggested that edible coatings with natural sources are better for the application.

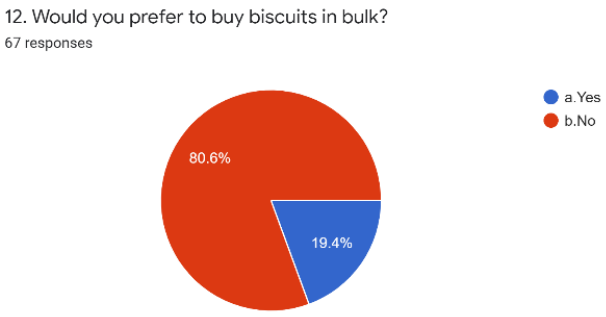

Figure 5. Bulk consumption patten of biscuits

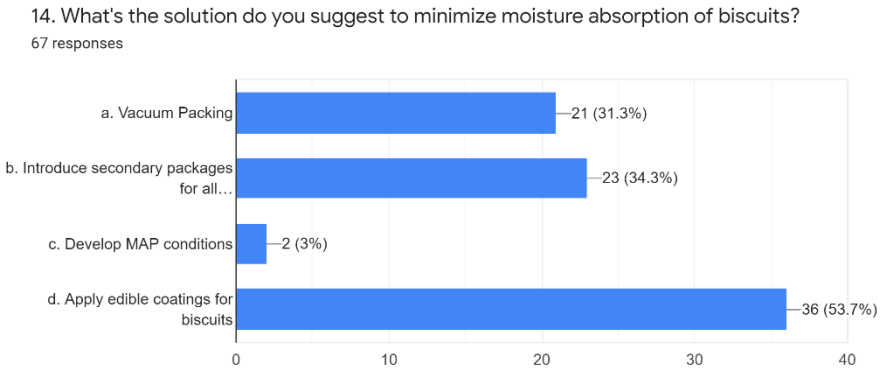

Figure 6. Consumer suggestion to minimize moisture absorption of biscuits

Baked Biscuit Weight

The results of the baked biscuit weight values were presented in Table 1. The weights of baked biscuits of coated biscuit samples also indicate the weight ranges which were closer to the normal uncoated biscuits (control sample).

The baked biscuit weight values of samples were comparatively analyzed according to the ANOVA test procedure at a 95 % confidence level. However, both of the treated samples were not significantly ($p>0.05$) different from the control sample.

Table 1. Baked Weigh of Biscuits

Sample	Average Weight
S1	58.8
S2	59.4
S3	59.8

S1 – Controlled Sample S2 – Coating Applied Before Baking Sample S3 – Coating Applied After Baking Sample

Baked Biscuit Height

The values for height of baked biscuits of coated biscuits samples elicited similar values as the controlled sample. The application of coating from okra did not appears as a thick layer. The baked height of biscuit samples was indicated in Table 2.

The baked biscuit height values of samples were comparatively analyzed according to the ANOVA test procedure at a 95 % confidence level. However, both of the treated samples were not significantly ($p>0.05$) different from the control sample.

Table 2. Baked Biscuit Height

Sample	Average Weight
S1	60.6
S2	61.0
S3	60.8

S1 – Controlled Sample S2 – Coating Applied Before Baking Sample S3 – Coating Applied After Baking Sample

Baked Biscuit Diameter

Baked biscuit diameter is also within the same ranges as the normal uncoated biscuit sample (control sample). It means the application of an edible coating using the brushing method has not changed the shape of the biscuits. It's a better method for coating on biscuit surfaces. The baked biscuit diameter values are indicated in Table 3.

Table 3. Baked Biscuit Diameter

Sample	Average Diameter
S1	47
S2	47
S3	47

S1 – Controlled Sample S2 – Coating Applied Before Baking Sample S3 – Coating Applied After Baking Sample

Moisture Content of Biscuits

According to these readings, the coating applied before baking samples displayed good moisture barrier properties than the controlled sample. Coating applied after baking samples also displayed comparatively better moisture barrier properties. However, it's not strong as the coating applied before baking samples.

The coating applied before the baking sample indicated a good barrier property under a controlled and semi-controlled environment. But it also not enough to avoid moisture migration in the normal atmospheric environment with the storage time. Moisture analysis results are displayed in Table 4.

Table 4. Moisture Content of Biscuits

Date	Sample	Environment		
		Controlled Environment	**Semi-Controlled Environment**	**Normal Atmospheric Environment**
Initial	S1	2.77	2.77	2.77
	S2	2.51	2.51	2.51
	S3	3.12	3.12	3.12
Day 3	S1	2.82	2.96	4.25
	S2	2.69	2.69	3.00
	S3	3.42	3.42	5.80
Day 6	S1	2.87	3.72	9.34
	S2	2.72	2.90	4.50
	S3	3.48	3.59	7.42

Sensory Analysis

A group of 15 semi-trained panelists evaluated various sensory attributes such as color, taste, texture, crispness, and overall acceptability. Panelists were asked to assign values on the scorecards according to their cognition. The data were analyzed statistically, and the best product was found. The statistical representation of sensory analysis is shown in Figure 7.

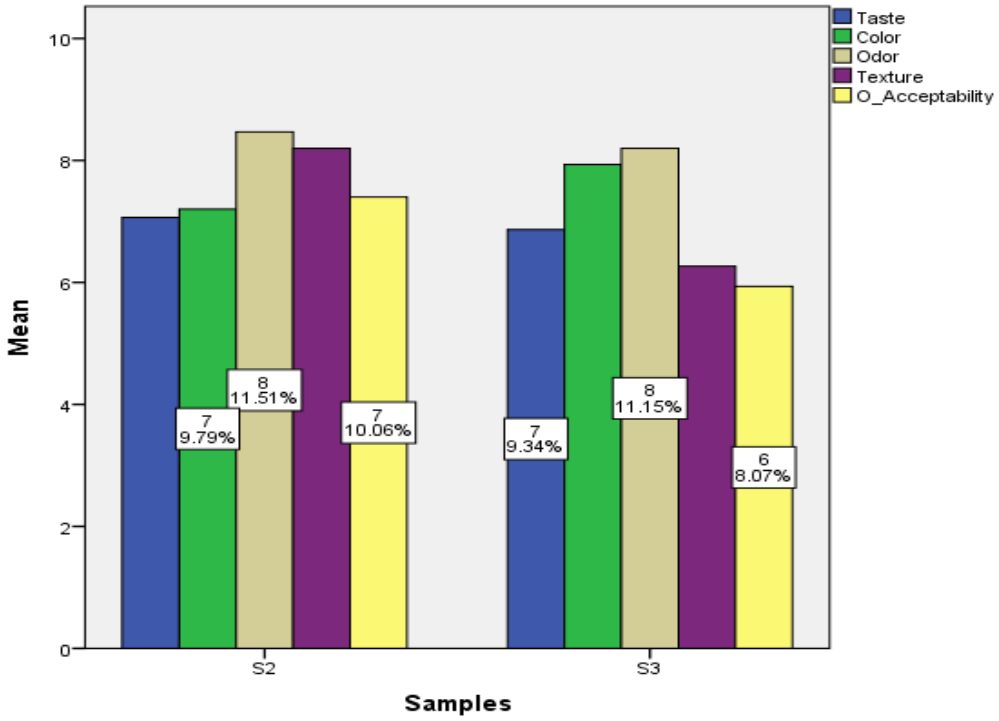

Figure 7. Sensory Analysis

Both samples (a coating applied before the baking stage samples and coating applied after baking samples) obtained similar scores. Coating applied before the baking stage sample achieved a higher number of ratings in taste, texture, odor, and overall acceptability like parameters. However, according to the results most preferred colour was obtained for coating applied after baking biscuits.

Conclusion

The application of an edible coating for biscuits is a better solution to control the loss of crispiness of biscuits upon storage. The present research involves a preliminary study on determining the effect of okra mucilage as an edible coating in reducing the loss of crispiness in biscuits upon storage.

Polysaccharide-based edible coatings maintain the physicochemical, microbiological and sensory properties of the food. Both samples which were coated at different stages obtained similar quality parameters in physical and sensory attributes. It's good positive progress in this research procedure.

Edible coating applications can be done using different coating application methods. According to the results of the present study, the brushing method was selected as the most suitable method for coating applications for biscuits. Because it maintains the external biscuit quality parameters like shape, appearance, etc. Further analysis such as shelf analysis and microbiological analysis is required to determine the efficiency of the developed edible coating.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgment

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