Received: September 18, 2023 | Revised: February 6, 2024 | Accepted: February 8, 2024

Development of Samed mushroom (*Boletus griseipurpureus* Corner) crackers and quality study during storage

Chompunooch Somalee[1*], Natta Kachenpukdee[1] and Amornrat Angajchariya[2]

[1]Department of Aquaculture and Fishery Product, Faculty of Science and Fishery Technology, Rajamangala University of Technology Srivijaya, Trang 92150, THAILAND

[2]General education, Faculty of Science and Fishery Technology, Rajamangala University of Technology Srivijaya, Trang 92150, THAILAND

[*]Corresponding author: chompunooch.s@rmutsv.ac.th

ABSTRACT

The objectives of this research were to develop cracker products using pre-treated Samed mushrooms in three variations (boiling water, brining, and soaking in herbal water), assess the proximate composition, evaluate their chemical and physical properties, and assess the quality of Samed mushroom crackers during storage. The proximate composition of fresh Samed mushrooms (per 100 g) revealed moisture of 92.08 g, carbohydrates of 2.60 g, protein of 3.37 g, ash of 0.81 g, fat of 0.23 g, and fiber content of 0.91g. The energy content was 29.59 kcal/100 g. The proximate composition of Samed mushroom crackers per 100 g indicated the following: carbohydrates 69.25 g, crude fat 24.08 g, protein 4.36 g, ash 1.82 g, and moisture 0.49 g. Additionally, the energy content was 511.6 kcal/100 g, with sugar and sodium contents measuring at 0.91 g and 552.3 mg/100 g, respectively. The study on the different types of pre-treatment solutions for Samed mushrooms demonstrated that pre-treatment by soaking in herbal water received the highest acceptance from consumers, with an overall liking score of 8.97. In the development of Samed mushroom crackers, the appropriate ratio of Samed mushroom to fish was 15 to 85. Regarding the microbiological quality changes during a 30-day storage period, the study revealed that the total viable count was <10 CFU/g, yeast count was 7.0 CFU/g, *Bacillus cereus* count was <100 CFU/g, *Staphylococcus aureus* count was <10 CFU/g, *Clostridium perfringens* count was <100 CFU/g, and *Escherichia coli* count was 3.0 CFU/g. In terms of chemical quality, the peroxide value was 0.57 meq/kg which is consistent with the Thai Community Product Standard (Cracker 107/2011). Storage for 30 days found that the condition of adding nitrogen gas resulted in the finding of less microorganisms than in a normal atmosphere, along with conditions for adding oxygen absorbers together with desiccant.

Keywords: Proximate composition, Pre-treatment Samed mushroom, Samed mushrooms crackers

INTRODUCTION

Crackers are a type of snack made primarily from flour, such as cassava flour, rice flour, or wheat flour. They consist of various ingredients including fish, shrimp, pumpkin, taro, black sesame, white sesame, mushrooms, salt, garlic, pepper, sugar, and water. These ingredients are mixed with water and seasonings to form a dough, which is then shaped, steamed until cooked, cut into thin sheets, and dried in the sun. The process of making fish crackers begins by thoroughly mixing all the ingredients with a mixer for 20 minutes. The mixture is then shaped into lumps with a diameter of 2.5 cm and a length of 15 cm, placed inside a container lined with banana leaves, and steamed for about 40-60 minutes. Afterward, it is left to reach room temperature for 30 minutes, followed by refrigerating at 4 degrees Celsius for 24 hours. Then, it is sliced to a thickness of 2 mm and dried using a hot air dryer at 60 °C for 3 hours [7].

The Samed mushroom, scientifically known as *Boletus griseipurpureus* Corner, is a type of mushroom that naturally grows in the sandy soil area of the Samed forest. Samed mushrooms typically emerge after a prolonged drought followed by heavy rainfall lasting 3-4 days, in other words, during the transition between the end of summer to the beginning of the rainy season. They are frequently found in regions where Samed trees or Acacia Thep trees grow. Due to their bitter taste, the primary method of processing involves boiling the mushrooms with tamarind leaves and applying salt. People relish them by either dipping them in chili paste or incorporating them into coconut milk curries. As there is a limited time for collecting fresh mushrooms, typically during April and May, processing is necessary to extend their shelf life and enhance their taste for variety.

Previous research revealed that Samed mushrooms had a lower carbohydrate content compared to other

DOI: 10.60101/jarst.2023.254159

JOURNAL OF APPLIED RESEARCH ON SCIENCE AND TECHNOLOGY

edible mushrooms, typically ranging from 6-11%. They are also low in fat, which is a common characteristic of edible mushrooms. Furthermore, Samed mushrooms have a relatively high protein and fiber content [9, 10], making them a suitable choice for individuals who are controlling their weight. The high fiber content aids in reducing constipation, improving the excretory system, and helping lower cholesterol and blood sugar levels [4, 6]. The development of Samed mushroom crackers involves studying and refining the cracker formula. The preparation of Samed mushrooms as a raw material aims to tackle the issue of mushroom bitterness through boiling, brining, and soaking in herbal water. Mixing Samet mushrooms into the process of making fish crackers serves to increase the proximate composition of the products and is accepted by consumers. This study focuses on cracker products, which are categorized as ready-to-eat food items but necessitate frying prior to sale. These products encounter specific challenges, notably rancidity, and a decrease in crispness when stored over extended periods. To mitigate these issues, extensive research has been conducted on appropriate packaging and storage conditions, aimed at extending the shelf life of these crackers. A significant advancement in this area is the implementation of a gas-flushing technique within the filling process, employing a modified atmosphere rich in nitrogen gas. This method has been proven to effectively prolong the shelf life of the products, thereby enabling extended storage durations without compromising quality prior to consumption. Additionally, the study encompasses a thorough quality analysis of various products, including an in-depth assessment of the proximate composition of Samed mushrooms and the final cracker products. Such analysis is crucial in ensuring the proximate composition and overall quality of the end products. The implications of this research extend to local community engagement. The findings and methodologies can be shared with local community groups, fostering the creation of new employment opportunities and aiding in the development of a unique product that is specific to the region. This approach not only utilizes local natural resources to their fullest potential but also aims at minimizing waste.

MATERIALS AND METHODS

The study was conducted in the laboratories of the Department of Aquaculture and Fishery Product at the Faculty of Science and Fisheries Technology, Rajamangala University of Technology Srivijaya, located in Trang province, southern Thailand. Fresh Samed Mushrooms (*Boletus griseipurpureus* Cor.) were procured from villagers who gathered them in the Samed forest area. Tapioca flour, fish meat, garlic, salt, and other ingredients were sourced from the local market.

1. Comparison of the proximate composition of fresh Samed mushrooms and three pre-treatment conditions for Samed mushrooms

The proximate composition of fresh Samed mushrooms and Samed mushrooms pre-treated in boiling water, brine, and herbal water was analyzed. The analysis examined the content of energy, protein, fat, carbohydrates, moisture, and crude fiber in 100 g, following AOAC (2016) standards. It includes moisture (methods 925.45 and TE-CH-357), protein (923.03), crude fiber (925.45 and TE-CH-122), crude fat (948.15), and ash (923.03). Total energy was calculated according to the following equations: (1) and (2).

$$\text{Energy (kcal)} = 4 \times (\text{g protein} + \text{g carbohydrate}) + 9 \times (\text{g lipid}) \quad (1)$$

$$\text{Carbohydrate content} = 100 - \{\text{moisture (g)} + \text{crude protein (g)} + \text{total fat (g)} + \text{crude fiber (g)} + \text{total ash (g)}\}; \text{ where (g) = grams per 100 grams} \quad (2)$$

2. Pre-treatment methods for Samed mushrooms

Selecting Samed mushrooms as raw materials for making Samed mushroom crackers involved three types of processed mushrooms including boiling water, brining, and soaking in herbal water as follows:

2.1 Samed mushrooms in boiling water

Samed mushrooms were prepared by trimming the roots, removing soil and any spoiled parts. Samed mushrooms were put into the boiling water with 2% salt. Boil them for 2 rounds to reduce the bitterness and mucilage from the mushrooms. The mushrooms were removed from boiled water using a strainer and placed in cold water immediately.

2.2 Samed mushrooms soaked in brine

Brine water was prepared by mixing 2% of salt into clean water. This brine was boiled and then poured into the bottle with mushrooms. Let its temperature drop to ambient before closing the lid. Submerge the Samed mushrooms in a brine solution for two hours before their utilization.

2.3 Samed mushrooms in herbal water

Prepare galangal (3%), lemongrass (3%), acetic acid (0.4%), salt (2%) and clean water (91.6%). Boil these ingredients for 5 minutes, then filtered. Take the mushrooms that have been boiled in water and place them in a glass bottle. Add the herbal water until the mushrooms are fully submerged. Wait for it to cool, and then close the lid. Submerge the Samed mushrooms in herbal water for two hours before utilization.

3. Ingredients and method for Samed Mushroom Crackers

Due to the bitterness of Samed mushroom, the fish cracker recipe was selected as a prototype for mixing with the mushroom. The previous formula of fish cracker was used as a fundamental recipe for the development of mushroom cracker [10], with tapioca

DOI: 10.60101/jarst.2023.254159

flour (52%), clean water (21%) fish meat (8%), wheat flour (7%), garlic (4%), pepper (4%), salt (1%), sugar (3%), and fish sauce (3%) weighed according to the levels of flour required per treatment and the formulation. Procedures for making crackers begin by weighing the ingredients for the crackers according to the specified proportions and various seasonings. Divide the dough into two parts. The 1st part was kneaded with boiling water until homogeneous. Part 2: Combine the ingredients in item 1 and massage together with part 1 and various ingredients until homogeneous. Take the dough and shape it into cylindrical pieces with a diameter of about 1.5 inches. Steam the dough until it fully cooked. This process usually takes approximately 1 hour and 30 minutes. Let the cooked dough cool at room temperature, then refrigerate it at a temperature between 4 to 10°C overnight. Cut the dough into thin slices, approximately 2 mm thick and proceed with drying the sliced dough, either through natural air drying or by using an oven.

Pre-treatment mushrooms in boiling water, brining, and soaking in herbal water. These mushrooms were chosen based on sensory testing to determine consumer acceptance regarding color, odor, flavor, texture, and overall liking.

4. Sensory evaluation of value-added products

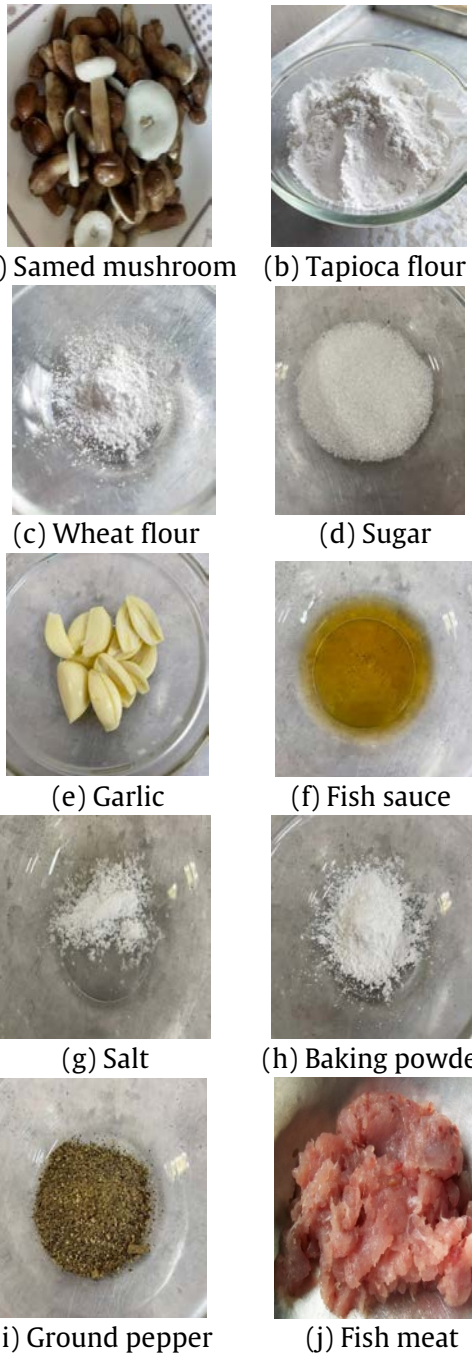
Sensory analysis was conducted on three variants of fish crackers, including those treated with pre-treated Samed mushrooms, by 30 panelists. The gender distribution was 34.28% male and 65.72% female, with ages ranging from 18 to 55 years. Of these, 33.33% were aged between 18-22, and 66.67% were between 30-55 years old. Twenty panelists resided within the university, while ten lived outside, all with prior experience in tasting crackers. The panelists independently evaluated the crackers, which were prepared in three distinct formulations, for various sensory parameters such as color, odor, flavor, texture, and overall liking. During the sensory evaluation, panelists were instructed to drink water or rinse their mouths after each assessment to cleanse their palates. The panelists were provided with a hedonic scale questionnaire to assess the value-added products, using a 9-point hedonic scale, from 1 (Extremely dislike) to 9 (Extremely like), ensuring comprehensive feedback on the sensory attributes of each cracker type.

4.1 Investigated the formula for fish cracker production

Fish crackers were prepared by mixing predetermined portions as required by the different formulations (Table 1). For selecting fish cracker recipes based on sensory tests, the study evaluated acceptance in terms of color, odor, flavor, texture, and overall liking. Using a 9-point hedonic scaling test. A minimum of 30 panels were selected from Table 1 to determine the accepted recipes based on the liking scores.

Table 1 Formulation of fish cracker with different ingredients.

Ingredient	Amount (g)		
	Formula 1	Formula 2	Formula 3
Tapioca flour	1000	1000	1000
Fish meat	300	300	300
Salt	10	5	30
Garlic	65	55	65
Pepper	20	30	20
Sugar	35	35	35
Fish sauce	20	25	0
Baking powder	10	10	10
Boiling water	40	40	40



(a) Samed mushroom (b) Tapioca flour (c) Wheat flour (d) Sugar (e) Garlic (f) Fish sauce (g) Salt (h) Baking powder (i) Ground pepper (j) Fish meat

Figure 1 Ingredient of Samed mushroom crackers.

DOI: 10.60101/jarst.2023.254159

JOURNAL OF APPLIED RESEARCH ON SCIENCE AND TECHNOLOGY

4.2 Study of the appropriate amount of Selected Samed mushrooms for cracker properties

Investigate the appropriate proportion of Selected Samed mushrooms (10%, 15%, 20%) to fish meat content in the production for cracker was used to study the suitable quantity of Samed mushrooms in three different sets of formulas:

Formula 1: Samed mushroom content of 10%, fish meat content of 90%.

Formula 2: Samed mushroom content of 15%, fish meat content of 85%.

Formula 3: Samed mushroom content of 20%, fish meat content of 80%.

The most widely accepted recipes for Samed mushroom crackers were chosen through sensory testing. Consumer acceptance of each formula of Samed mushroom crackers was evaluated, considering factors such as color, odor, flavor, texture, and overall liking, using a 9-point hedonic scaling test. A minimum of 30 panels were utilized for this assessment.

Figure 2 Samed mushroom crackers.

4.3 Proximate Composition Analysis of developed Samed mushroom cracker product of appropriate mushroom cracker

The proximate composition analysis includes energy (kcal), crude fat (g), protein (g), carbohydrates (g), cholesterol (mg), ash (g), moisture (g), sugar (g), sodium (mg) content per 100 g. Carbohydrate and energy percentages were calculated following the method in (1). Crude fat, protein, cholesterol, ash, moisture, sugar, and sodium content were determined using AOAC (2016) methods.

5. Product and qualities during storage for 30 days

5.1 Samples of Samed mushrooms with suitable pre-treatment for crackers prepared from recipes accepted by consumers were subjected to the frying process. These samples were then packed using the following three conditions: 1) Nitrogen gas filling condition (gas flushing), 2) Normal atmosphere (control), and 3) Oxygen absorber and desiccant to preserve and study changes in quality in various aspects, namely: 1) Study of chemical quality: Peroxide value (PV) was determined using the method given by AOAC (1969). To prepare the reagents, first mix three volumes of acetic acid (CH_3COOH) with two volumes of chloroform ($CHCl_3$) to create the acetic acid-chloroform solution. Next, make a saturated potassium iodide solution by dissolving excess KI in freshly boiled water, ensuring excess solid remains, and store this in a dark place, testing it daily. Additionally, prepare 0.1 M and 0.01 M sodium thiosulfate solutions according to the procedure in (AOAC 942.27) diluting the 0.1 M solution with freshly boiled and cooled water for the 0.01 M concentration. For the determination process in fats and oils, begin by weighing a 5 g sample and dissolving it in the acetic acid-chloroform solution. Add the saturated potassium iodide solution, followed by water, and titrate with 0.1 M sodium thiosulfate until the color change is observed. Record the volume of sodium thiosulfate used. PV was calculated using the formula given below:

PV (Meq/kg) = S x M x 1000/g test portion, where S = mL $Na_2S_2O_3$ (blank corrected) and M = molarity $Na_2S_2O_3$ solution [1], 2) Study of microbiological quality: Analysis of total viable count, yeast-mold quantity, *Staphylococcus aureus, Clostridium perfringen, Bacillus cereus*, and *Escherichia coli* in the microbiology laboratory according to the method [1], and 3) Study of chemical changes: Analysis for the value of a_w (Water activity).

5.2 Study the appropriate storage conditions and qualities during storage for 30 days of the product by storing it at room temperature (23-25°C). Random sampling was performed to analyze various aspects according to item (1) at random intervals of 0, 10, 20, and 30 days.

6. Statistical analysis

The research design also incorporated a Completely Randomized Design (CRD). One-way ANOVA tests were used to assess the differences in proximate composition between fresh Samed mushrooms and pre-treatment Samed mushrooms of three types. The data were presented as the mean ± standard deviation (SD). All significance tests were set at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

1. Proximate composition of fresh Samed mushrooms and three pre-treatment conditions for Samed mushrooms

The proximate composition of fresh Samed mushrooms, along with mushrooms subjected to three different pre-treatments, is presented in Table 2. Significant differences ($p \leq 0.05$) were observed in the proximate composition of the samples studied. Pre-treating Samed mushrooms in brine increased their carbohydrate and crude fiber content. However, all three pre-treatment conditions led to a decrease in crude fat and protein content. Among these, pre-treating with boiling water resulted in the highest moisture content. Pre-treatments with brining and soaking in herbal water increased the ash content of the mushrooms, while pre-treatment with boiling water and soaking in herbal

DOI: 10.60101/jarst.2023.254159

water reduced their energy content. Previous research has revealed that pre-treating Samed mushrooms with boiling water decreases their moisture content. While the ash and protein content increased, the crude fat content was not significantly different from that of fresh sed mushrooms [13]. Pre-treating Samed mushrooms in brine decreases their moisture, ash, crude fat, and protein content [14]. Samed mushrooms are known for their high protein and low-fat content, enriched with various health-promoting bioactive compounds such as phenols, flavonoids, and polysaccharides. Furthermore, processes like drying, storage, and cooking can significantly affect their physical, chemical, sensory, and biological characteristics [10].

Table 2 Proximate composition of fresh Samed mushrooms and pre-treatment Samed mushrooms.

Analysis results	Fresh Samed mush rooms	Pre-treatment Samed mushrooms		
		Boiling water	Brining	Soaking in herbal water
Carbohydrate (g)	2.60±0.02^{d}	1.98±0.03^{c}	3.78±0.04^{a}	3.25±0.03^{b}
Crude Fibre (g)	0.91±0.03^{c}	1.08±0.03^{a}	1.11±0.21^{a}	1.01±0.12^{b}
Crude Fat (g)	0.23±0.02^{a}	0.16±0.15^{b}	0.15±0.02^{bc}	0.13±0.31^{bd}
Moisture (g)	92.08±0.23^{b}	92.95±0.16^{a}	91.72±0.15^{c}	91.57±0.13^{d}
Protein (g)	3.37±0.30^{a}	2.92±0.30^{b}	2.16±0.15^{d}	2.77±0.12^{c}
Ash (g)	0.81±0.02^{c}	0.19±0.03^{d}	1.08±0.04^{b}	1.27±0.03^{a}
Energy (kcal)	29.59±0.01^{a}	28.24±0.03^{c}	29.55±0.01^{a}	29.29±0.02^{b}

Note: The different letters in each row indicate that there was a significant difference ($p \leq 0.05$)

2. Developing a suitable fish cracker product formula and studying consumer acceptance based on sensory perception

During the fish cracker production experiment, all three formulas were examined, and consumer acceptance of each cracker formula was evaluated through sensory testing to assess sensory perception quality. The outcomes of this evaluation are presented in Table 3.

Table 3 Sensory test results of the three formulas of fish crackers product.

Attribute	Average liking score		
	Formula 1	Formula 2	Formula 3
Color	8.83±0.38^{a}	7.07±0.25^{c}	7.90±0.31^{b}
Odor	8.47±0.51^{a}	7.70±0.56^{b}	7.50±0.50^{b}
Flavor	8.70±0.47^{a}	7.30±0.47^{b}	7.20±0.41^{b}
Texture	8.73±0.43^{a}	7.33±0.49^{c}	7.77±0.43^{b}
Overall liking	8.87±0.35^{a}	7.10±0.31^{c}	7.73±0.45^{b}

Note: The different letters in each row indicate that there was a significant difference ($p \leq 0.05$)

Therefore, when considering the liking scores in all aspects, it was observed that Formula 1 received the highest score. It consisted of 20.0% fish meat, 66.7% tapioca starch, 0.7% salt, 1.3% pepper, 4.3% garlic, 2.3% sugar, 0.6% baking powder, 1.3% fish sauce, and 2.7% boiling water. The ingredients used in each formula of rice cracker production vary, leading to differences in appearance, color, odor, flavor, texture, and overall liking. Specifically, the quantity of pepper has an impact on the smell, enhancing the product's aroma and helping to eliminate the fishy odor associated with the fish mixed in the rice crackers. In Formula 1, 20 g of pepper are added, as this amount provides the most acceptable level of aroma and taste to consumers. Fish sauce and salt are combined to enhance the taste and add saltiness. Additionally, the inclusion of 4.3 percent garlic in Formula 1 contributes to a pungent smell and a distinct spicy flavor. Garlic is known for its ability to deodorize the fishy smell of meat, enhance flavor, and add taste to food [7].

Table 4 Sensory test scores of various types of pre-treatment mushrooms utilized in Samed mushroom cracker production.

Attribute	Average Likability Score of Samed mushroom		
	Boiling water	Brining	Soaking in herbal water
Color	7.27±0.83^{c}	7.63±0.61^{b}	8.60±0.50^{a}
Odor	7.30±0.53^{c}	7.67±0.48^{b}	8.57±0.50^{a}
Flavor	7.43±0.57^{b}	7.70±0.53^{b}	8.53±0.57^{a}
Texture	7.27±0.52^{c}	7.83±0.46^{b}	8.73±0.52^{a}
overall liking	7.13±0.51^{c}	7.80±0.41^{b}	8.97±0.18^{a}

Note: The different letters in each row indicate that there was a significant difference ($p \leq 0.05$)

3. Acceptance of different pre-treatment mushrooms for Samed mushroom cracker production

Based on Table 4, the evaluation of sensory quality for Samed mushroom crackers made with different types of pre-treatments Samed mushrooms, namely those pre-treatments in boiling water, brining, and soaking in herbal water, revealed that formula 3 exhibited a statistically significant highest score ($p \leq 0.05$) for all attributes compared to formula 1 and formula 2. Furthermore, the use of herbal water; including galangal, and lemongrass for pre-treatment Samed mushrooms demonstrated that boiling the herbs in water resulted in an appealing aroma. Additionally, the mixture of acetic acid from fermented vinegar helped

DOI: 10.60101/jarst.2023.254159

reduce the bitterness of the mushrooms when combined with salt. Folk wisdom also suggests the use of sour tamarind leaves during blanching can mitigate the bitterness [8]. Furthermore, boiling Samed mushrooms in a solution of salt and citric acid helps reduce their bitterness. Using a 4% NaCl solution and a 0.3% (w/v) citric acid solution, boiling for 10 minutes affects the taste and texture of the Samed mushrooms, making them more palatable [11].

4. Optimal proportion of Samed mushroom to fish meat in cracker production

The experiment aimed to determine the suitable percentage of pre-treated Samed mushroom in herbal water for the production of Samed mushroom crackers. Consumers participated in a sensory test to evaluate sensory acceptance based on criteria such as color, odor, flavour, texture, and overall liking. The results of the selection process to determine the ideal percentage of Samed mushrooms used in the production of Samed mushroom crackers are presented in Table 5.

Table 5 Results of sensory test scores for Samed mushrooms in the proper amount of fish meat in Samed mushroom cracker production.

Attribute	Average liking score		
	Formula 1 (10 %)	Formula 2 (15 %)	Formula 3 (20 %)
Color	7.17±1.09^{b}	7.87±0.63^{a}	7.43±0.82^{ab}
Odor	7.53±0.90^{a}	7.82±0.97^{a}	7.53±1.04^{a}
Flavor	7.33±0.96^{b}	8.10±0.76^{a}	8.00±1.02^{a}
Texture	7.23±0.97^{b}	7.90±0.92^{a}	7.97±0.97^{a}
Overall liking	7.43±0.86^{b}	8.28±0.74^{a}	8.13±0.87^{a}

Note: The different letters in each row indicate that there was a significant difference ($p \leq 0.05$)

Based on the evaluation results of sensory quality from Table 5, Formula 2 with 15 percent of Samed mushroom received higher consumer acceptance compared to Formula 1 and 3. As a result, 15 percent of Samed mushroom content was selected for further study. Based on the findings regarding the inclusion of Samed mushrooms in cracker products, it was observed that Samed mushrooms possessed a bitter taste. To use them as an ingredient, it is necessary to boil them in hot water and add salt to mitigate the bitterness. Therefore, when merging bitter Samed mushrooms into the product, it is crucial to determine the appropriate quantity. The results of mixing blanched Samed mushrooms with herbs indicated that 15% was the preferred amount among consumers.

Furthermore, Samed mushrooms are highly regarded and widely consumed by villagers. These bitter mushrooms are believed to possess medicinal properties that can aid in reducing blood sugar levels and preventing diabetes [9, 10]. They are also considered delicious food items in both the Northeast and South regions [8].

5. Proximate composition of Samed mushrooms cracker

The analysis results of the proximate composition in Samed mushroom crackers revealed the following values per 100 g of samples: a total energy value of 511.16 kcal; crude fat of 24.08 g; cholesterol of 6.42 mg; protein of 4.36 g; carbohydrates of 69.25 g; sugar of 2.67 g; sodium of 552.308 mg; ash of 1.82 g; and moisture of 0.49 g. Mushrooms are known for their medicinal properties and their ability to support the functioning of vital organs such as the brain, heart, lungs, liver, and blood circulation system. In Chinese medicine, mushrooms are classified as cold medicine due to their properties that aid in reducing fever, enhancing vitality, cooling the body, healing bruises, nourishing the body, and regulating blood sugar levels. Additionally, mushrooms have been found to lower cholesterol levels, reduce blood pressure, act as diuretics, aid in alleviating irritability, nourish nerve cells, and even help inhibit the growth of cancer cells. Regular consumption of mushrooms has shown benefits for lowering blood sugar and reducing cholesterol levels in diabetic patients.

Table 6 Proximate composition of 100 g of Samed mushrooms in herbal water for cracker production.

Proximate composition	Amount	Unit
Energy	511.16	kcal
Crude Fat	24.08	g
Protein	4.36	g
Carbohydrate	69.25	g
Cholesterol	6.42	mg
Ash	1.82	g
Moisture	0.49	g
Sugar	2.67	g
Sodium	552.308	mg

Table 7 Results of the study on the quality of basic chemical and physical components of Samed mushroom crackers.

Type	Basic elements in various fields		
	Moisture (%)	a_w	Peroxide value (meq/kg)
Samed mushroom crackers	0.49	0.35	0.50

Note: Peroxide value unit = meq/kg. = milligram oxygen peroxide equivalent/kg.

6. Product quality changes in Samed mushroom crackers during storage

6.1 The results of various quality studies of Samed mushroom crackers

From the investigation of the basic components of ready-to-eat crackers, the experimental results are presented in Table 7. It was observed that Samed mushroom crackers had a moisture content of 0.49%, a peroxide content of 0.50 mg of peroxide oxygen equivalent/kg, and an a_w value of 0.35 (Community product standard, 1987). The report on the fundamental

DOI: 10.60101/jarst.2023.254159

constituents of ready-to-eat crackers indicated that the moisture content should not exceed 4.0%, and the peroxide content should not exceed 30 mg peroxide oxygen equivalent/kg. These basic components meet the criteria set by the Office of Community Product Standards for Crispy Crackers (CPS. 107/2011) [11].

6.2 Results of the initial study on the microbiological quality of Samed mushroom crackers

Result of microbiological quality: analysis of total viable count, yeast-mold quantity, *Staphylococcus aureus*, *Clostridium perfringen*, *Bacillus cereus*, and *Escherichia coli* in the microbiology laboratory according to the method [1] is presented in Table 8.

Based on the study of the microbiological quality of ready-to-eat Samed mushroom crackers, the experimental results are presented in Table 8. However, it was observed that microbial analysis values did not exceed the standards set by the Thai Industrial Standards Institute, 2530 (TIS 701-2530), or exceeded the community product standard (107/2011: Crispy Rice), as all analysis values were within the defined limits. Therefore, consumers can safely consume the product. The total variable count value was not more than $1x10^6$ CFU/g, yeast was not more than 100 CFU/g, *Bacillus cereus* was not more than $1x10^3$ CFU/g, *Staphylococcus aureus* was less than 10 CFU/g, *Clostridium perfringens* was less than $1x10^3$ CFU/g, and *Escherichia coli* was less than 3 CFU/g.

Table 8 Results of the microbiological analysis of Samed mushroom crackers.

Microbial analysis	Amount (CFU/g)	Community Product Standards (CFU/g)
Total variable count	<10	Not exceeding $<1\times10^6$
Yeast and Mold	7.0	Not exceeding 100
Bacillus cereus	<100	Not exceeding 1×10^3
Staphylococcus aureus	<10	<10
Clostridium perfringen	<100	Not exceeding 1×10^3
Escherichia coli	<3 MPN/g	<3 per 1 gram of each sample

Note: Bacillus cereus <100 = No Bacillus cereus colonies were found on the Petri dish.
Clostridium perfringen <100 = No *Clostridium perfringen* colonies were found on the petri dish.
Total variable count *<10 =* No total variable count colonies were found on the petri dish.
Staphylococcus aureus <10 = No colonies of *Staphylococcus aureus* on the petri dish

6.3 Proper packaging and packing conditions

From Table 9, the analysis results of the total microbial content of the Samed mushroom crackers in different packing and storage conditions are shown. It was observed that the microorganisms in the nitrogen gas filling condition had the lowest count at 1.2×10^2 CFU/g, at the end of storage. The oxygen absorber and desiccant conditions had counts of 1.8×10^2 CFU/g and the normal atmosphere had a count of 2.1×10^2 CFU/g, respectively. Throughout the 30-day period, the microbial quality remained within the standard for community products (107/2011: Crispy Rice), where the total microbial content should not exceed $1x10^6$ CFU/g [11].

Table 9 Results of analysis of total microorganisms of Samed mushroom crackers in different packing and storage conditions.

Duration (days)	Total microbial content (CFU/g)		
	Normal atmosphere (Control)	Add an oxygen absorber and a desiccant	Adjust the atmosphere with nitrogen gas
0	ND	ND	ND
10	ND	1×10	ND
20	1.2×10^2	1.2×10^2	7×10
30	2.1×10^2	1.8×10^2	1.2×10^2

Note: ND= Non Detected = no microbial content found

Table 10 Results of analysis of yeast-mold content in Samed mushroom crackers stored under various conditions.

Duration (days)	Yeast and mold content (CFU/g)		
	Normal atmosphere (Control)	Add oxygen absorber and desiccant	Adjust the atmosphere with nitrogen gas filling
0	ND	ND	ND
10	<10	<10	<10
20	<10	<10	<10
30	<10	<10	<10

Note: ND = Non Detected = no microbial content found

From Table 10, the analysis results of yeast and mold content in Samed mushroom crackers under different packing and storage conditions were obtained. It was observed that there was no difference in the yeast and mold counts among the various packing conditions. The count remained consistently below 10 to 30 days, in accordance with the standards set by the Thai Industrial Standards Institute in 2011. This was achieved by packaging the cracker products in aluminum foil bags during the shelf-life study.

CONCLUSION

The results of this study showed that using pre-treated Samed mushrooms with herbal water affected the physical properties of the Samed mushroom cracker product. However, Samed mushroom crackers could be produced with an optimal Samed mushroom to fish meat ratio, which was found to be 15:85. This ratio has been accepted by consumers. The nitrogen gas filling condition resulted in a decrease in microbial counts

DOI: 10.60101/jarst.2023.254159

compared to the normal atmosphere and oxygen absorbent filling conditions. This effect was strengthened by including oxygen absorbers and desiccants, ensuring sustained quality for up to 30 days. The findings from this research can be shared with local community groups to foster new employment opportunities and create a distinctive regional product. The study aims to optimize the utilization of local natural resources for maximum benefit while minimizing losses. However, the researcher did not consistently analyze peroxide values throughout the 30-day storage period in the study. It is crucial to monitor these values continuously until the end of the storage period for a thorough assessment of product stability and quality.

ACKNOWLEDGEMENT

The authors extend their sincere gratitude to Rajamangala University of Technology Srivijaya for providing research funding and support. We would also like to express our appreciation to all individuals and groups who contributed to this research, including research assistants, farmers' communities, and housewives in Sikao district. Their valuable assistance was crucial in various aspects, including data collection, analysis, sample preparation, and the overall success of the research. We are also thankful to the students who dedicated their efforts to this project, and we would like to express our gratitude to Dr. Anantanit Chumsri for editing the English version of this article. This research aimed to apply knowledge for the benefit of the community by leveraging existing natural resources, adding value, and generating income. Ultimately, this research has resulted in the development of innovative food products for the community.

REFERENCES

1. Official Method of Analysis of AOAC International. 17th ed. Virginia: AOAC international; 2000.
2. Tanner JT, Barnett SA, Mountford MK, Angyal G, Beare-Rogers JL, Boyer KW, et al. Analysis of milk-based infant formula. Phase V. Vitamins A and E, folic acid, and pantothenic acid: Food and Drug Administration-Infant Formula Council: Collaborative study. J AOAC Int. 1993;76(2):399-413.
3. Official Methods of Analysis of AOAC International. 20th eds. Gaithersburg: AOAC international; 2016.
4. Anderson JW, Baird P, Davis RH Jr, Ferreri S, Knudtson M, Koraym A, et al. Health benefits of dietary fiber. Nutr Rev. 2009;67(4):188-205.
5. Chanthep S. Study on factors affecting the fruiting of wild mushrooms and their utilization [dissertation]. Faculty of Science and Technology: Songkhla Nakarin University; 1993.
6. Chawla R, Patil GR. Characterization and potential application of blend of passion fruit peel with rice flour in an extruded product for fiber enhancement. Compr Rev Food Sci Food Saf. 2010;9(2):178-96.
7. Garlic: Nutritional Benefits and Medicinal Properties [Internet]. Honestdocs. 2019 [cited 2023 Sep 16]. Available From: https://www.honestdocs.co/herbal-garlic-help-disease
8. Khatun K, Mahtab H, Khanam P A, Sayeed MA, Khan KA. Oyster mushroom reduced blood glucose and cholesterol in diabetes subjects. Mymensigh Med J. 2007;16:94-9.
9. Khemthong C, Chamchan R, Suttisansanee U, Charoenkiatkul S, Chupeerach C, Nattira ON. Development of healthy snack from sa-med mushroom (*Boletus griseipurpureus* Corner). Walailak J Sci & Tech. 2020;17(11):1157-67.
10. Liu Q, Sun L, Ding Y, Zhuang Y. Chemical composition, health benefits, food processing effects and applications of Boletus: a review. Crit Rev Food Sci Nutr. 2023;1-23.
11. Miracle: "Bitter Mushroom" Found in Yucalipus Forest Reduces Diabetes [Internet]. Mgronline. 2019. [cited 2023 Sep 16]. Available From: https://mgronline.com/local/detail/9600000054978.
12. Community Product Standard for Crispy Crackers: M. Por. Chor.107-2554 [Internet]. Bangkok: Ministry of Agriculture and Cooperatives. 2011. [cited 2023 Sep 16]. Available From: https://www.xn--12ca9cdcza1fboh6b4ca0evmxcuh.com/certificate/view?product_id=509&code_certificate_id=18.
13. Phugan P, Pramai P, Inket S, Singsom S. Product development of TOM YUM PUMPKIN Cracker. PSRU Journal of Science and Technology. 2019;4(3):15-26.
14. Rana V, Bachheti RK, Chand T, Barman A. Dietary fibre and human health. Int j food saf nutr. 2011;4(2-4):101-18.

DOI: 10.60101/jarst.2023.254159