

Development of Crispy Spicy Snack from Bhutan Oyster Mushroom by-Product with Narok Chili Paste

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Abstract— The aim of this study is to develop a crispy spicy snack from Bhutan oyster mushroom by-product and Narok chili paste. It was rejected from the mushroom house with an evaporation system at Wat Jampee school, Suphan Buri province. The methodology of this study is the preparation of three different sizes of oyster mushroom by-products; shredded, medium, and whole mushrooms. They were then blanched in hot water, cooled in cold water, soaked in 1% Calcium Chloride (CaCl₂) for 15 min., drained and dipped in batter, and deep fried at 160 °C in vegetable oil. The shred and medium size of mushrooms took 8 min. and 10 min. for the whole mushroom. It was then, baked at 90°C for 50 min. It was found that the shred and medium-sized oyster mushroom by-products had the exact overall liking at 6.90 at a slightly liking level. To select the standard recipe for Narok chili paste and the most appropriate size of mushroom by target customer for further product development. The experiment found that shredded mushrooms with Narok chili paste recipe 1 (T1S1) from six samples received the highest overall preference score of 6.10.

As for the sensory evaluation with a 9-point Hedonic Scale found that the shredded mushroom with the first recipe chili paste got moderate overall liking (7.06), the color of the mushroom (7.09), crispiness (7.04) chili paste color (7.49), spiciness (6.90), saltiness (6.52). The consumer acceptance was 77%. Hence, the study of the development of a crispy spicy Bhutan Oyster Mushroom by-product snack from the mushroom house with an evaporation system at Wat Jampee School, Suphan Buri province, add value to the by-product until the country's economic sustainability in the future.

Index Terms— Oyster Mushroom, Chili Paste, Snack

I. INTRODUCTION

Snacks can be sweet or savory. It will be processed and ready to eat immediately [1]. The main component of the snack is flour, mainly sugar and fat. There are also MSG, salt, artificial food flavors, colorings, seasoning, and little nutritional value [2].

In 2017, the total market value was as high as 35 billion baht, growing 5.3% higher than the previous year. Snack products are products with market value and there is high competition between operators in developing healthy snack products to be suitable and safe for consumers and successful in commercial distribution. Operators and related practitioners know the product development technology required, market demand, and the requirements of the Ministry of Public Health [3]. Snacks that use healthy processing methods such as baking, using natural flavors, colors, and ingredients, and local flavors such as Tom Yum flavor, basil, etc. are still in demand by consumers [4].

Wat Jampee School, Suphan Buri province crops Bhutan Oyster Mushroom with an evaporation system, which must control humidity, temperature, and water spray to adjust the environment to suit the mushrooms all the time. The mushrooms from this condition can bloom by 15-20%, more than the traditional method, this method can save energy and extend the shelf life of the mushroom lumps for longer storage time by 10-25% [5]. The school harvests mushrooms to make some dishes for students' lunch and sells as fresh. There are still some by-product mushrooms left from fresh sales that cannot be sold as fresh mushrooms because the quality does not meet the standards like mushrooms blooming too small mushroom which is often sold at low prices.

Bhutan Oyster Mushroom is the *Pleurotus eous* species which is similar in appearance to abalone and dark color. Due to the variety of properties of this mushroom, people are popular to use it to prepare dishes such as crispy fried mushroom salad, tom yum soup, mushroom salad, and mushroom chili sauce.

Accordingly, Thai people are more active in exercising and eating nutritious food and have an urgent life, the business of healthy food and beverage products tends to continue to improve. And it is also a trend that entrepreneurs pay attention to, especially healthy snack products. Because consumers pay more attention to healthy snacks. It plays an important role in the growth of the health food business. The snack market in Thailand can be considered. It is a market with potential and continuous growth.

Therefore, the purpose of this research is to develop the Bhutan Oyster Mushrooms by-product to be the crispy spicy snack. And add a new transformation with the taste of Narok chili paste to make it be a nutritious snack. So it can enter the healthy snack market. It also adds value to the Bhutan Oyster Mushrooms that are left over from sales and are of substandard quality. And the research results can also be useful to generate income for the local community and those who are interested in adding value to mushrooms as well.

II. LITERATURE REVIEW

A. Oyster Mushroom

Bhutan Oyster mushroom [6] has a shape and appearance similar to oyster mushrooms and is classified in the same family by the name “Bhutan Mushroom” is the name that was established in Thailand. Because this mushroom was first found in Jammu, in the foothills of the Himalayas in India. In 1975, Dr. Siripong Boonlong, Institute of Applied Science Research of Thailand Cultivated experiments in Thailand and found that Oyster mushrooms grow well in the climate of central Thailand. Later, Kasetsart University brought to experiment and culture in different mediums and conditions. It was found that Bhutanese fairy mushrooms grow well in many kinds of weather conditions, that is, when the weather is normal, the incubation takes about 20-25 days, but if it is during the winter, it takes only 15-20 days of incubation, and in the cold weather will bloom quickly. The flower color is dark. But if the summer blooms late, the flower color will fade. The picture of oyster mushroom was shown in Fig. 1 [7]. After that in 1977, the Plant Disease Research Division Department of Agriculture conducted an experiment to expand the results to farmers. Therefore, Oyster mushrooms are cultivated for commercial purposes more widely. Scientific name: *Pleurotus Sajor-caju* (Fr.) Sing Generic name: Phoenix mushroom, Indian oyster mushroom, Sajor-caju mushroom, Bhutan oyster mushroom.

Class : Basidiomycetes
Subclass : Holobasidiomycetidae
Order : Agaricales
Family : Tricholomataceae
Genus : *Pleurotus*
Species : *Pulmonarius*



Fig. 1. Oyster Mushrooms

Source: National Bureau of Agricultural Commodity and Food Standards (2012)

Table I shows nutrition facts of the amount of nutrients and essential amino acid that beneficial to health [8].

Nutrition	Unit
Calcium	20 mg/100g
Phosphorus	760 mg/100g
Potassium	3260 mg/100g
Ferrous	124 ppm
Cadmium	0.3 ppm
Zinc	12 ppm
Copper	12.2 ppm
Plumbum	3.2 ppm
Isoleucine	78 mg/g of crude protein nitrogen
Leucine	68.1 mg/g of crude protein nitrogen
Methionine + Cysteine	62.5 mg/g of crude protein nitrogen
Phenylalanine + Tyrosine	137.8 mg/g of crude protein nitrogen
Threonine	88 mg/g of crude protein nitrogen
Tryptophan	91 mg/g of crude protein nitrogen
Valine	76.1 mg/g of crude protein nitrogen

Source: Available from: <http://mdc.library.mju.ac.th/ebook/335131.pdf>

B. *Narok Chili Paste*

Narok chili paste made from dried chilies which is generally red color and spicier than chili paste made from fresh chilies. Dried chilies are used as a seasoning ingredient. Some chili pastes may contain water as an ingredient, texture will be semi-liquid. Chili pastes made from dried chilies such as Ta Daeng Chili Paste, Ong Chili Paste, Galangal Chili Paste, Laab Chili Paste, Narok Chili Paste, etc. The standard chili paste recipe compose with fresh chili, garlic, shrimp paste, dried shrimp, palm sugar, lime juice, and fish sauce which can be applied with other type of chili paste [9]. Narok chili paste is adapted from the standard recipe but has strongly hot and spicy taste. Using Bird chili will give the most spiciness. Thai pepper looks like large chili seeds, dark red color, moderately spicy, strong aromatic, and little seeds. Narok chili paste is nutritious. Because it contains many herbs such as chili, shallots, garlic, etc. These ingredients could find in local area. [10].

C. *Frying*

Frying means cooking food by using vegetable oil or animal fat. It acts as a carrier for heat exchange and helps lubricate food from sticking to the pan. Frying temperatures is in the range of 170-210°C. The fried food has different unique characteristics such as crispness, color, smell, flavor, and texture. Frying is divided into 2 categories, namely deep frying and shallow frying.

Firstly, deep frying is the basic method of food preparation to get the desired sensory characteristics in terms of flavor, golden brown and crispy texture. The process of deep-frying involves immersing food in hot oil. The temperature of the surface rises rapidly. The oil on the surface is cooled. This oil will seep into the food by convection. This method was used in the research product with palm oil.

Secondly, shallow frying is a frying process by using less oil which is suitable for household frying or frying some foods that do not require uniformity of color such as roti and burgers. The quality of fried food depends on the type of oil used. The frying oil must be appropriate quality. Because the frying oil is a carrier to transfer heat to the food and cook the food.

The factors affect the quality of fried food such as food moisture, oxygen, type of oil, temperature and time of frying, package and storage those are effect on product texture, color, shelf-life, preference, and acceptance score [11].

D. *Drying*

Drying is the heating to cook the food. To expel water from food to the least amount remaining. The dried food will have water or moisture content about 2 to 3 percent, less water activity (aw) in the food to

prolong the shelf life. Because it inhibits the growth of microorganisms and reduced enzyme activity. Drying is divided into two processes, the first process is natural drying that is the lowest cost and easiest process by sun drying but the dried product is low quality and temperature is uncontrollable. Secondly, drying by dryer with convection or conduction. The process will give the good product quality and can control the temperature. This experiment choose the second drying method after frying to reduce product moisture that impact to shelf-life and produce browning from maillard reaction to create product color properly [12].

III. MATERIALS AND METHOD

Materials and methods were divided into three parts: population and samples size, sensory assessment, and methodology respectively. This research is mainly experimental and survey research in the last part of the research. To explore the consumer acceptance of the crispy spicy Bhutan oyster mushroom snack from mushroom by-product to increase the value and remain from distribution to be able to be used.

A. *Population and Sample size*

Population, general consumers who eat crispy mushroom products and Narok chili paste in Bangkok and its vicinity, aged 19 years and above. The sampling method was randomly selected by purposive sampling method in 3 groups as follows:

First group, thirty untrained sensory participants were randomly selected by convenience sampling as in-house panels [13] into two replications for studying of the optimal size of crispy Bhutan oyster mushrooms.

Second group, thirty untrained sensory participants were randomly selected by convenience sampling as in-house panels [13] into two replications for studying of the preferences and adequacy of crispy spicy Bhutan oyster mushroom products.

Thirdly, one hundred untrained sensory participants were randomly selected by convenience sampling as in-house panels [13] into two replications for studying of consumers' preferences and acceptance of the developed crispy spicy Bhutan oyster mushroom snack.

B. *Sensory Assessment*

The research instrument for collecting this research data, consist of three assessment. Firstly, the sensory assessment of the crispy Bhutan oyster mushrooms which is divided into three parts; demography, sensory tests by a preference rating (9-Point Hedonic Scale) and a product-developed adequacy test (Just About Right: JAR) and recommendation respectively.

Secondary, the sensory assessment of the crispy spicy Bhutan oyster mushroom which is divided

into three parts; demography, sensory tests by a preference rating (9-Point Hedonic Scale) and a product-developed adequacy test (Just About Right: JAR) and recommendation respectively.

Thirdly, the sensory assessment of preference and acceptance of the developed crispy spicy Bhutan oyster mushroom snack which is divided into three parts; demography, sensory tests by a preference and acceptance rating (9-Point Hedonic Scale) and recommendation respectively by one hundred participants.

C. Methodology

The preliminary preparation of Crispy spicy Bhutan oyster mushrooms, Harvesting mushrooms by collecting them from planting bag then selected the rejected mushrooms which have a flaw such as defect cap and over blooming cap to the develop to be snack. Mushrooms were washed and drained. After that prepared by cutting into different sizes as shown in Fig. 2:

T1: stem size 4x0.2 cm and cap size 1x3 cm (shredded mushroom)

T2: stem size 4x1 cm and cap size 2x3 cm (medium-sized mushroom)

T3: stem size 4x1 cm and cap diameter 3 cm (whole mushroom)



Fig. 2. Cutting size of mushroom (T1) shredded mushroom, (T2) medium-sized mushroom, and (T3) whole mushroom

They were blanched in boiling water for 10 seconds, cooled with ice-cold water and drained. All of them were immersed in calcium chloride solution at a concentration of 1% (weight/volume) to reduce browning reaction for 15 minutes and drained on a sieve [14].

The prep mushrooms were dipped in wheat flour and deep-fry at 160°C, 8 min for sample T1 and T2, 10 min for T3 then rest on a wire rack to drain the oil. Frying is the processing method to improve

and preserve the product quality by elimination of pathogenic microorganisms, enzyme and reduction of food moisture to prolong shelf-life. The all fried mushrooms were dried in a hot air oven at 90 °C for 50 minutes in order to reduce the moisture content and excess oil of the mushrooms [15]. After the process, all crispy mushrooms were analyzed on physical qualities such as moisture content and sensory test by thirty untrained sensory participants aged 19 years and above. Thirty untrained sensory participants were randomly assigned sampling to use in-house panels [13] into two replications to select the optimal size.

The experiment was prepared for Narok chili paste by roasting chili and pounding with the rest of ingredients then braising and seasoning. Next, mixed with dried shrimp and stirred in low heat until they were dried and well combined to be powder. Narok chili paste was divided into 3 recipes as the following table II and the picture of Narok chili paste Recipe were shown in Fig. 3.

First recipe [16] was prepared by roasting dried chili peppers, dried chilli and pounded fried shallots, fried garlic thoroughly. After that braised old galangal, tamarind paste, fish sauce and palm sugar until homogeneous on low heat. Then stirred well with dried shrimp powder until well combined. Second recipe [17] was prepared by pounding fried shallots, fried garlic, tamarind paste, dried chili, dried shrimp paste and dried shrimp powder, seasoning with fish sauce. Stirring the pounding mixture until well combined.

Third recipe [18] was prepared by roasting dried chili with dried cayenne pepper then blended with fried shallots and fried garlic thoroughly. Added dried shrimp powder in the mixture on the pan by stirring on low heat and seasoning with salt and sugar.

TABLE II
SHRIMP NAROK CHILI PASTE RECIPE

Ingredient	Recipe		
	1	2	3
Dried shrimp powder (g)	150	90	75
Dried chili (g)	15	40	30
Dried Cayenne pepper (g)	10	-	-
Fried Shallots (g)	35	90	63
Fried garlic (g)	50	15	150
Old Galanga (g)	10	-	-
Tamarind paste (g)	15	30	75
Fish sauce (g)	30	45	75
Palm sugar (g)	25	-	-
Dried shrimp paste (g)	-	10	10
Sugar	-	-	-



Fig. 3. The Narok chili paste recipe 1, 2, and 3 from left to right

The final step, mix the Narok chili paste and fried mushrooms by a ratio of 1:3 by weight for every treatment to assess the sensory of preferences and adequacy of crispy spicy Bhutan oyster mushroom products by factorial in balance incomplete block (BIB) design to get the best product by thirty participants. Then adjust the experiment according to the interpretation of the net score. After developing product, the product was assessed the sensory of preferences and adequacy by one hundred participants.

All experimental data were analyzed by Analysis of Variance (ANOVA). Significantly different means were separated according to the method of Duncan's New Multiple Rang Test (DMRT) according to the procedure described in [19].

At the end of the experiment, the developed product was analyzed color with CLE ($L^*a^*b^*$) system by Spectrophotometer. The meaning of L^* parameter is the lightness value between 0-100, a^* is the red shade for positive value and green shade for negative value, b^* is the yellow shade for positive value and blue shade for negative value. Moreover, moisture content analysis was analyzed with infrared radiation by moisture analyzer and the nutritional and chemical properties by AOAC (2019) method.

IV. RESULT AND DISCUSSION

A. Bhutan Oyster Mushroom Size

The results of color showed that all 3 samples were significantly different ($P < 0.05$) (Table III).

The sample T3 got the highest value of the lightness parameter (L^*) at 58.16, and sample T1 got the highest redness value (a^*) at 5.01 and (b^*) yellowness value at 12.56. In this research, mushrooms have less brown color and moisture after processing which conform to a previous study that reported that blanching before processing eliminates Polyphenol oxidase that can reduce oxidation reaction in mushrooms [14]. Moreover, immersion in a calcium chloride solution can dehydrate the mushrooms. That effect on color and moisture content from different sizes, the sample T3 (whole mushrooms) got the highest percentage of moisture content because the bigger surface area can absorbed more moisture while sample T1 (shredded mushrooms) got the least moisture content at 1.47 %.

TABLE III
THE ANALYSIS OF COLOR AND MOISTURE

Sample	L^*	a^*	b^*	Moisture (%)
T1	57.08±1.46	5.01±1.04	12.56±0.88	1.47±0.21
T2	51.44±0.66	3.70±1.12	9.59±1.90	2.01±0.18
T3	58.16±1.81	2.94±0.91	8.9±3.42	2.53±0.25

Data are shown as average ± standard deviation

Note: T1 = shredded mushrooms, T2 = medium-sized mushrooms, T3 = whole mushrooms

From the preference test, thirty consumers was attracting by the shredded (T1) and medium-sized (T2) that got the similar scores and were not significantly different ($P > 0.05$) as shown in Table IV and Fig. 4. Therefore, they were the selected appropriately size for further study [20].

TABLE IV
THE PREFERENCE SCORE

Sample	Average Liking Score					
	Appearance	Color	Flavor	Crispiness	Texture	Overall
T1	7.23±1.19 ^a	6.97±1.33 ^a	6.83±0.95 ^a	6.33±1.45 ^a	6.37±1.19 ^a	6.90±0.92 ^a
T2	6.83±1.23 ^a	7.00±1.11 ^a	6.87±1.07 ^a	6.93±1.36 ^a	6.63±1.47 ^a	6.90±0.85 ^a
T3	6.87±1.07 ^a	6.37±0.99 ^b	6.37±1.27 ^a	5.23±1.27 ^b	5.07±1.05 ^b	4.97±1.19 ^b

Data are shown as average ± standard deviation

^{a,b,c} The means followed by same letter are significantly different in the same column ($p < 0.05$)

Note: T1= shredded mushrooms, T2 = medium-sized mushrooms, and T3 = whole mushrooms



Fig. 4. Sample T1= shredded mushrooms, T2 = medium-sized mushrooms, and T3 = whole mushrooms

B. Consumer Preference and Adequacy Score of Product

According to the results of the preference and adequacy test of shredded mushrooms (T1) and medium-sized mushrooms (T2) with 3 types of chili paste which were Narok chili paste Recipe 1 (S1), Recipe 2 (S2) and Recipe 3 (S3) as shown in Table V. To select the standard recipe for Narok chili paste and the most appropriate size of mushroom. It was tested by 100 persons of target consumers according

to the procedure described in [13]. It was found that the shredded mushrooms with Narok chili paste Recipe 1 (T1S1) received the highest overall score of 6.10. In addition, other factors are still higher than other samples. For the adequacy value was in range of 60-90%. Spiciness and saltiness of the product were 60 and 63% when considering the net score on both sides, it was less than 20%. Therefore, shredded mushrooms were selected with Narok chili paste Recipe 1 (T1S1) for further product development.

TABLE V
THE PREFERENCE SCORE OF 6 SAMPLES OF CRISPY BHUTAN OYSTER MUSHROOMS

Sample	Average Liking Score					
	Crispy Mushroom Color	Crispiness	Chili Paste Color	Spiciness	Saltiness	Overall
T1S1	6.47±1.76	7.10 ^a ±1.21	7.17 ^a ±1.18	6.10 ^a ±1.88	6.03 ^a ±1.40	6.10 ^a ±1.97
T1S2	5.57 ^{ab} ±1.76	6.30 ^{abc} ±1.24	4.43 ^d ±2.10	5.47 ^a ±1.68	4.67 ^{bc} ±1.67	5.10 ^a ±1.85
T1S3	6.23 ^{ab} ±1.31	6.97 ^{ab} ±1.13	6.17 ^b ±1.70	5.53 ^a ±1.99	5.37 ^{ab} ±1.92	5.73 ^a ±2.05
T2S1	6.47±1.74	5.23 ^{cd} ±2.50	7.00 ^{ab} ±1.41	5.90 ^a ±2.09	5.43 ^{ab} ±2.11	5.53 ^a ±2.08
T2S2	6.47±1.22	5.13 ^d ±2.70	6.20 ^b ±1.96	5.90 ^a ±1.88	5.60 ^{ab} ±2.27	5.53 ^a ±2.30
T2S3	5.33 ^b ±2.29	5.97 ^{bcd} ±2.50	4.60 ^e ±1.87	5.17 ^a ±1.80	4.27 ^c ±1.67	5.10 ^a ±1.47

Data are shown as average ± standard deviation

^{a,b,c} The means followed by same letter are significantly different in the same column ($p < 0.05$)

Note: T1= shredded mushrooms, T2 = medium-sized mushrooms with Narok chili paste, S1 = Recipe 1, S2= Recipe 2, and S3= Recipe 3

C. Consumer Preference and Acceptance

The 100 target consumers rated their overall preference and acceptance score at a moderate level,

7.06 as shown in Table VI and 77% as shown in Table VII which is the highest score. From the data can interpret that consumers are willing to buy the final product (Fig. 5).

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