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Crisp Bhutan Oyster Mushroom (*Pleurotus pulmonarius*): A Potential Innovative Product for Commercialization

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Abstract

This research was undertaken to create therapeutic mushroom products and disseminate knowledge to entrepreneurs. The researchers along with a community created product design and distribution channels and developed a brand for medicinal mushroom products based on the community's identity. Bhutanese oyster mushrooms were used to create mushroom products that consisted of Bhutanese oyster mushroom (88%), sugar (5%), vegetable oil (3%), soy sauce (2%), coriander seeds (1%) and salt (1%).The production method was conducted by to washing the mushrooms thoroughly, squeezing the water out and setting them aside; then mixing all ingredients together and dry in a hot air oven at 60°C for 90 min. Then the batter was fried in hot oil at 90-95°C for 5 min, and then placed in the oven at 150°C for 20 min to crisp and reduce the surface moisture of the product. The sensory preference (7.80 – 8.80 points) was at a high level. Moreover, the knowledge can be transferred to entrepreneurs to implement in real production. It is a product that has the potential to be marketed for distribution as a health food with an emphasis on semi-premium marketing which can be differentiated by demonstrating the value and nutrients of Bhutanese oyster mushrooms. This research included designing aesthetic, outstanding and unique packaging to create the identity for the community. Furthermore, a brand of medicinal mushroom products called "Hed Khik Khak or Giggling Mushrooms" was created. The feedback acceptance (99%) was at a high level. The product has been registered under the trademark for Klong Chik Sub-district Community Enterprise to be used with therapeutic mushroom products in the future.

Introduction

Bhutanese oyster mushrooms are similar to grey oyster mushrooms as both are able to adapt to the environment as well as resistant to a relatively wide temperature range. Bhutanese oyster mushrooms grows and blooms well, produces high yields, can be planted in every season and is popular among consumers and

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mushroom growers. According to this study's findings on a model mushroom farm the production rate consisted of 300-500 kilograms of fresh mushrooms per week that were usually sold in the market as fresh mushrooms. However, the shelf life of fresh oyster mushrooms is relatively short, causing a high rate of perishable fresh mushrooms and effecting the income of sellers to earn less. Therefore, there is a need to develop products from fresh mushrooms in order to add value and help generate income. Prior research on developing healthy food products from mushrooms focused on three types of mushrooms: shiitake, straw mushrooms and oyster mushrooms. It was found that oyster mushrooms increased the proportion of protein and dietary fiber while reducing the amount of carbohydrates (Chantarakan, 2012). It is important information for product development of oyster mushrooms. Furthermore, previous research on oyster mushrooms has developed a variety of food products such as shredded mushrooms, crispy oyster mushrooms and deep-fried oyster mushrooms. Products also include mushrooms that are processed into foods such as mushroom chili paste, mushroom juice and mushroom buns, which are considered fresh foods and have a short or limited shelf life. This research was undertaken in order to aid mushroom farmers to develop products made from mushrooms that have a long shelf life that could be sold as souvenirs and are unique to the community. The purpose of this study was to research and develop medicinal mushroom products and transfer the knowledge to entrepreneurs to acquire the capability to produce the products in actual production, suggest patterns and distribution channels for Medicinal Mushroom Products, design therapeutic mushroom products to be aesthetic, outstanding and unique to the community and create a brand of therapeutic mushroom products.

Materials and methods

1. The development of the traditional flavored therapeutic mushroom recipe(s)

The ingredients consisted of the following: Bhutanese oyster mushroom (88%), sugar (5%), vegetable oil (3%), soy sauce (2%), coriander seeds (1%) and salt (1%). The production method started by washing the mushrooms thoroughly and then squeezing the water out and set aside. Mixed the oyster mushroom meat, sugar, vegetable oil, soy sauce, coriander seeds and iodized salt together. The mixture was dried in a hot air oven at 50 - 60°C for 60, 90, 120 and 150 min. The dehydrated mushrooms were fried in hot oil at 90 - 95°C for 5 min. The cooked mushrooms were baked to make them crispy and reduce the moisture on the surface of the products. The samples were oven-dried at 150°C for 20 min.

The time taken to dry mushrooms before frying at 60 ± 2°C for 60, 90, 120 and 150 min were studied and the physical quality i.e. color value was analyzed. Color value was evaluated by Hunter lab colorimeter (Chroma Meter CR 300 Series, Japan) by measuring L* a* b* C* (Chroma) and h_o (Hue angle). The replication experiment was done twice. The values were evaluated 3 times and in each replication, 10 positions of color values were analyzed. Chemical quality analysis consisting of water activity value (a_w) was conducted. a_w was randomly sampled from the dried shredded mushrooms. The water activity value (a_w) was measured by using the water activity meter (Aqua Lab, USA). The total moisture content (Infrared Moisture Analyzer, MA150) was used to find the weight loss due to the evaporations of the water and volatile matter at the specified temperature by randomly selecting the fried and dried shredded mushrooms from the experimental samples (AOAC., 2000). Two replicates of the experiment were performed and each replicate was measured 3 times.

The dried therapeutic mushroom samples were analyzed at 60 ± 2°C, fried and dehydrated. The color values were analyzed by sampling the fried and dried shredded mushrooms. According to the mushroom samples, color values were analyzed with a Hunter lab colorimeter (Chroma Meter CR 300 Series, Japan) by measuring L* a* b* C* (Chroma) and h_o (Hue angle). The replication experiment was done twice. The values were evaluated 3 times. In each replication, 10 positions of color values were analyzed. The quality was analyzed, i.e. Water Activity (α_w) (Aqua Lab, USA). According to the mushroom samples, α_w was analyzed using a water activity meter. The fat value was evaluated for fat content analysis according to the method (AOAC., 2000). The amount of oil absorbed during frying reduction (% oil reduction) was calculated by comparing it with the fat content of shredded mushrooms (Kaikaew et al., 2016). Total moisture content (Infrared Moisture Analyzer, MA150) was conducted to find the weight loss due to evaporation of water and volatile matter within the specified temperature by randomly selecting the fried and dried shredded mushrooms from the experimental samples. Fat oxidation analysis was evaluated by the TBARS (Thio barbituric acid reactive

substances) method. Fried and dried shredded mushrooms were randomly sampled for lipid oxidation analysis by the TBARS (Thio barbituric acid reactive substances) method, adapted from Wei et al. (2011) and Wrostad et al. (2005) by measuring the amount of Malondialdehyde substance with Thiobarbituric acid (TBA). Absorbance was measured with a spectrophotometer (Libra S11 Biochrom, USA) at a wavelength of 532 nm, reported in milligrams of malondialdehyde per 1 g of each sample. Two replicates of the experiment were performed and each replicate was measured 3 times.

The selected food experts had experience and direct positions in food processing and developments from 10 community enterprises to assess the characteristics of the Medicinal mushroom products in the terms of appearance, color, scent, taste and texture by using the focus group method with the scaled scores from 1 to 9 (i.e. 1 is the most disliked and 9 is the most liked).

2. The study of the nutritional values (selected recipe(s))

A centrifuge was used to grind the chosen samples of shredded mushrooms. Then, using the contents of moisture, lipids, proteins, fiber, ash and carbohydrates were examined according to the experiment (AOAC., 2000) the experiments were done twice with each replicate being measured three times.

3. The study of consumer acceptance (selected recipe(s))

The selected shredded mushrooms samples (Bhutanese oyster mushroom (88%), sugar (5%), vegetable oil (3%), soy sauce (2%), coriander seeds (1%), and salt (1%) or the samples of the traditional flavored shredded mushrooms that had been fried and dehydrated for 90 min) were tested for consumer acceptance by the Central Location Test (CLT) method through the questionnaire which was conducted with 200 consumers (market test) using non-purposive sampling, that is, the research team recruited consumers who had consumed shredded mushrooms. They were designated as a sample group. Data Collection in Lampang Province was conducted in August 2021. According to testing the confidence of the questionnaire, it was discovered that Cornbrash's alpha was at 0.8816 (Cronbach, 1951). It was greater than 0.70. It infers that the questionnaire was reliable and could be used to collect data.

4. The study on shelf life (selected recipe(s)) after 6 months of storage

In the study of the shelf life of the product at the room temperature, the analyzed qualities were as follows: (1) physical quality such as color value, solubility and viscosity, (2) chemical quality such as pH value, a_w value, moisture content, (3) microbial quality such as total microbial count, numbers of yeasts and molds, *E. coli, S. aureus* and *Salmonella* spp. according to the method (AOAC., 1995).

5. The study of the packaging design and marketing channels of therapeutic mushroom products

Two parts were considered regarding package design: (1) Aesthetic aspect by including the identity of the community in order to make it stand out and recognizable, such as the local tree, local culture, etc. and selecting the color group and art components to suit the consumer group and (2) Functionality aspect by choosing materials that are suitable for products and food storage and designing packaging to make it easy to eat and clearly communicates the brand's value and uniqueness.

6. Statistical analyses

All experiments were triplicated, and the data was analyzed by using IBA SPSS Statistics for Windows version 20 (IBA, Armonk, NY, USA.). The differences between the values were considered significant at $p \leq 0.05$. The averages were calculated by Duncan's new multiple range test. The completely randomized design was applied for the determination of the physical quality and chemical properties of the mushroom recipe, while the randomized complete block design was applied for the sensory evaluation. All analyses were also executed by using IBM SPSS Statistic version 20 software.

Results and discussion

1. Researching and developing the medicinal mushroom products, and transferring knowledge to entrepreneurs to enable the capability of production

The ingredients are as follows: Bhutanese oyster mushroom 88%, sugar 5%, vegetable oil 3%, soy sauce 2%, coriander seeds 1% and salt 1%. The production method are as follows; wash the mushrooms thoroughly, squeeze the water out, set them aside, then take oyster mushroom meat, sugar, vegetable oil, soy sauce, coriander seeds and iodized salt and mix them together, dry in a hot air oven at 50-60°C for 60, 90, 120 and 150 mins. Take the dehydrated mushrooms and fry them in hot oil at 90-95°C for 5 min. Bake the cooked mushrooms to make them crispy and reduce the moisture on the surface of the product. The samples were oven-dried at 150°C for 20 min. The results of physical and chemical analysis of dried mushroom samples at 60 ± 2 °C are shown in Table 1.

Table 1 Results of physical and chemical analysis of dried mushroom samples at 60 ± 2 °C

Baking time (mins)	Water activity (α_w)	Humidity (% w.b.)	Color value (CIE-Lab)				
			L*^{ns}	a*	b*^{ns}	C*^{ns}	h^{ns}
60	0.79±0.01^a	44.49±1.56^a	54.62±1.84	3.95±0.55^c	12.20±1.25	17.71±0.50	65.80±0.84
90	0.58±0.01^b	28.00±0.17^b	51.92±1.11	6.11±0.31^b	12.93±0.41	18.03±0.11	66.83±1.46
120	0.55±0.00^b	24.62±0.33^c	51.19±1.88	6.28±0.25^a	12.49±0.37	17.82±0.45	67.45±1.49
150	0.55±0.02^b	22.22±0.40^c	51.49±1.20	6.40±0.55^a	12.85±0.40	17.92±0.60	67.58±1.20

Remark: Mean ± Standard Deviation was calculated from the analysis of two replicates
Different letters in columns indicate significant differences ($p \leq 0.05$)
ns means no significant difference ($p > 0.05$) in each column

From the results of samples prepared at the medicinal mushroom products preparation step to analyze the physical values after drying at 60°C for 60, 90, 120, and 150 min, respectively, it was found that samples dried for a long time had a higher amount of humidity and α_w were statistically significantly decreased. The samples incubated for 60 minutes had the highest 44.49% of moisture content and α_w of 0.79, which are the levels of water content that are easy for microbial growth and chemical changes, causing easy deterioration due to chemical reactions. The preservation process before frying the mushrooms is to store them in a sealed container that helps prevent cross-contamination during refrigeration to prevent spoilage and deterioration. The samples that had been incubated for 90, 120 and 150 mins had moisture content and α_w between 22.22 and 28.00 percent and 0.55 to 0.58, respectively; the values are the amount of free water in the food that is within the dry food standard. While waiting for the frying process, the mushrooms could be stored at room temperature. However, storing in a sealed container protects the mushrooms from oxygen humidity and light, and allows the raw material to be stored for a longer time during the frying process (Fellow, 2000).

When considering the color values (CIE-Lab) of the aforementioned samples, namely L*, a*, b* C*, and h, the results showed that with the longer drying time, the brightness (L*) value decreased which was inversely proportional to a redness (a*) due to a shift to more brown color which comes from the non-enzymatic browning reaction, that is, Maillard reaction; it is a reaction caused by the combination between reducing sugars and amino acids in mushrooms. The product was a ring derivative that polymerizes rapidly, yielding a nitrogen-containing and insoluble brown substance. This reaction needed to take place in the condition that had been heated with water at the α_w level greater than 0.20. This reaction not only resulted in browning and a reduction in lightness (L*) but also affected the scent and taste of the food in both positive and negative ways (Rattananon, 2008; Fennema, 1996). This reaction could also occur during storage, resulting in the darkening of the product. No significant changes were observed from the b*, C*, and h values.

The drying of mushroom samples were prepared at 60, 90, 120 and 150 min to fry in oil at 150°C until they were well-cooked. The physical and chemical values were then analyzed (Tables 2 and 3). The results showed that the samples fried for longer tended to have lower moisture content and α_w values. For the samples that were baked for 120, 90 and 60 mins. The moisture content was 11.29, 11.41 and 15.45% and the α_w values were 0.37, 0.38 and 0.39 respectively. In order to consider the α_w value compared to the standard of ready-to-eat seasoned mushroom community products, the experimental results showed that all 3 samples of

Table 2 Results of physical analysis of therapeutic mushroom samples dried at 60 ± 2°C and then fried and dehydrated

Baking time (min)	Water activity (a_w)	Humidity (% w.b.)	Color value (CIE-Lab)				
			L*^{ns}	a*	b*^{ns}	C*^{ns}	h^{ns}
60	0.39±0.01^a	15.45±0.12^a	32.89±1.44	17.14±0.27^b	12.99±1.34	18.64±0.81	41.98±0.20
90	0.38±0.00^a	11.41±0.04^a	30.91±0.49	18.46±0.14^a	13.50±0.72	19.45±1.29	42.56±0.79
120	0.37±0.01^b	11.29±0.01^b	30.64±b0.02	18.99±0.15^a	13.64±0.31	18.98±0.58	42.64±0.67
150	0.36±0.01^b	11.90±0.01^b	31.40±b0.05	18.89±0.18^a	12.84±0.52	18.65±0.55	42.44±0.87

Remark: Mean ± Standard Deviation was calculated from the analysis of two replicates
Different letters in columns indicate significant differences ($p \leq 0.05$)
ns means no significant difference ($p > 0.05$) in each column

therapeutic mushroom products were produced within the standard level, that is, having a_w value not more than 0.60, which the humidity at this level is a safe level for dry food due to its low chemical transformation and microbial growth (Rattananon, 2008) allowing the mushrooms to be stored at room temperature. It is a condition that reduces the burden of storage and transportation and is suitable for businesses without the requirement of high investment in product management.

Based on the values of colorimetric analysis (CIE-Lab), the results showed no difference in b*, C*, and h values. Only the illuminance (L*) values in the samples had a higher tendency when baked for a shorter time. This is inversely proportional to redness (a*) as when products were baked longer, redness (a*) value increased as a result of the change by non-enzymatic browning as in the baking process. However, differences appeared in the preparation step at temperature 60°C, resulting in the browning change by the Maillard reaction. In the frying process, the high heat (about 160°C) caused the Maillard reaction at the beginning of frying. When the temperature increases, the sugar in the sample will gradually change to brown. In this phenomenon, the water will be removed from the structure and there will be caramel formation in this process which helps improve the flavor of food products. However, if there is too much chemical reaction generated, it will cause mushrooms to have a bitter taste and burn. Moreover, there are reports that substances obtained from the process of caramel formation produce substances with antioxidant effects. If there is too much of this process, it can cause carcinogens. Hence, it is crucial to regulate the production process in order to be the most appropriate (Tolgahan & Vural, 2019; Cedric et al., 2021).

Table 3 Chemical analysis results of therapeutic mushroom samples dried at 60 ± 2°C and then fried and dehydrated

Baking time (minutes)	Oil reduction (% w.b.)	Oil reduction (% d.b.)	TBA (mg/kg)
60	48.24^{a}±6.94	52.91^{a}±7.54	0.48^{a}± 0.00
90	41.83^{ab}±2.11	44.34^{ab}±2.35	0.47^{a}± 0.00
120	26.62^{b}±4.92	27.74^{b}±5.27	0.45^{b}± 0.01
150	25.22^{b}±5.20	26.50^{b}±6.70	0.45^{b}± 0.01

Remark: Mean ± standard deviation was calculated from the analysis of two replicates
Different letters in columns indicate significant differences ($p \leq 0.05$)
ns means no significant difference ($p > 0.05$) in each column

When the samples were analyzed for oil content, it was discovered that the samples prepared with the shortest baking time of 60 min, had the highest oil reduction, followed by the samples baked at 90, 120 and 150 min, respectively. These results are consistent with the work of Rattanathammawat et al. (2003) which was caused by different initial water loss rates and different moisture content reduction rates (Sirilert & Silalai, 2016). During frying, water is lost from the product and replaced by the absorbed oil. These results varied with the trend of fat oxidation analysis results (Thiobarbituric acid, TBA). The oil content that was examined was abundant and entirely from the frying process. Lipid oxidation is accelerated by light during storage, high heat from frying, and oxygen concentration. More peroxides of aldehydes obtained from unsaturated fatty acids were obtained from unsaturated fatty acid, causing the mushroom to rapidly and easilybe rotten (Rattananon, 2008; Noiduang et al., 2015; Fennema, 1996) As a result, the product needs to be kept in a container that is sealed as a method to ensure no light penetration, oxygen, or water vapor and as a method to extend the product's shelf life.

For the sensory quality assessment, 10 food experts were used as testers. They all participate in community enterprises. This was to evaluate the characteristics of medicinal mushroom products in terms of appearance, color, scent, taste and texture using a focus group method by tasting 4 samples of therapeutic mushroom products (where 9 = most liked and 1 = most disliked). The results showed that 90 min of traditional flavored medicinal mushroom products that were fried and dehydrated had the highest overall liking preference score of 8.5 ± 0.4. Regarding the evaluation of the sensory quality test of the medicinal mushroom products dried at 60°C for 60, 90, 120 and 150 min, respectively, the results showed that samples that were dried longer time of 90 min had the characteristics of the medicinal mushrooms in the terms of appearance, color, smell, taste, texture and liking. The overall liking scores were 7.9±0.3, 7.9±0.5, 7.8±0.5, 8.8±0.8, 8.4±0.5 and 8.5±0.4, respectively. The flavored mushroom products had consistent colors and no rancid smell. The products had the aroma of the coriander seeds. The natural colors of the ingredients were used. The products had a sweet and salty taste. The texture was not sticky or hard. In addition, there are the recommendations for product developments from the experts. That is, the products should have light color in order to make it appealing. White sesame seeds and cannabis leaves should be added to the products in order to add more value and nutrients. The scores are shown in Table 4.

Table 4 Sensory quality assessment scores

Attributes	Samples of traditional flavored medicinal mushroom products that have been fried and dehydrated			
	1 (60 Min)	2 (90 Min)	3 (120 Min)	4 (150 Min)
Appearance	6.4±0.5^{c}	7.9±0.3^{a}	6.9±0.5^{b}	6.8±0.5^{b}
Color	6.8±0.8^{c}	7.9±0.5^{a}	6.8±0.3^{c}	7.3±0.5^{b}
Odor	7.1±0.7^{b}	7.8±0.5^{a}	6.9±0.4^{c}	7.0±0.5^{b}
Taste	7.1±0.8^{c}	8.8±0.8^{a}	7.7±0.4^{b}	7.2±0.6^{c}
Texture, such as soft, crispy	7.0±0.5^{c}	8.4±0.5^{a}	7.4±0.5^{b}	7.6±0.6^{b}
Overall liking	7.0±0.4^{d}	8.5±0.4^{a}	7.6±0.7^{b}	7.4±0.8^{c}

Remark: Differences letters in rows indicate significant differences ($p \leq 0.05$)

2. Nutrition analysis results (selected recipe(s))

The centrifuge was used to grind the chosen samples of medicinal mushroom products. Then, the (AOAC., 2000) technique was used to find the contents of moisture, fat, protein, fiber, ash and carbohydrate. The findings are shown in Table 5.

Table 5 Nutrient content test results

Test item	Result	Unit
Ash 3.75	g/100g	
Moisture	5.90	g/100g
Total Energy	450.90	Kilocalories/100g
Energy from fat	161.10	Kilocalories/100g
Total Fat	17.90	g/100g
- Total saturated fatty acid	7.58	g/100g
Cholesterol	Not Detected	mg/100g
Protein	7.30	g/100g
Total carbohydrate (include fiber)	65.15	g/100g
Total dietary fiber	12.85	g/100g
Total sugar	49.7	g/100g
Sodium (Na)	850	mg/100g
Calcium (Ca)	33.4	mg/100g
Iron (Fe)	1.94	mg/100g
Total Vitamin A	Not Detected	µg/100g
Vitamin B1	0.21	mg/100g
Vitamin B2	0.20	mg/100g

3. Consumer acceptance study results (selected recipe(s))

The selected shredded mushrooms samples were tested for consumer acceptance by the Central Location Test (CLT) through the questionnaires that were administered with 200 consumers (market test) by using the non-purposive sampling. It was found 67.50% (135 people) of the respondents were females and the majority were between the ages of 31 and 45, representing 34.50% (or 69 people). They had a bachelor's degree or above, making up 52.50% (or 105 people), 42.50 percent were business unit employees (85 people). According to the sample's occupation, their monthly income ranged between 3,001 and 10,000 baht (84 people). When considering the therapeutic mushroom purchasing behavior of consumers, it was discovered that 97 percent of respondents answered that they loved medicinal mushroom products, but almost half of them had a frequency of consumption only 1-2 times a month (42%), showing a small purchase volume.

Seventy-two Percent of consumers typically purchase 1 to 5 packs, whereas 74% of the sample group purchases medicinal mushroom products for personal use, followed by souvenir shopping. Few respondents purchased with the intention of resale. Therapeutic mushroom products are most often bought in convenience stores, followed by department stores, markets, souvenir shops, exhibition halls, direct producers and others such as internet or vegetarian eateries, respectively. The participants would purchase medicinal mushroom products based on taste and nutritional value at a similar level, followed by price, packaging, product brand, being recommended by someone to buy therapeutic mushroom products and marketing promotion, respectively. The marketing strategy for healthy drinks needs to focus on nutritional value. However, the taste also needs to be delicious. The price of the product must be suitable for the quality as well.

When evaluating factors that affect product purchases, it was found that the majority of the sample group approved of the products at the highest level of preference (The average score was 8.12). The majority of customers concentrated on safety and cleanliness with the highest preference level (the average score was 9.28). The taste was the second most important factor for consumers to buy at the highest level of preference (The score was 8.89). The findings of the testing on factors influencing the purchase of therapeutic mushroom products, however, received the most favorable level in all aspects. These results displayed how items have evolved and improved over time in the research as shown in Table 6.

Table 6 Factors affecting the purchase of therapeutic mushroom products

Attributes	Liking score
Color	7.67±2.29
Visual appearance	8.19±2.02
Taste	8.89±2.29
Odor	8.10±2.29
Texture	7.95±2.01
Packaging, Labeling	8.52±2.03
Price	8.36±1.82
Promotional advertising	7.83±2.31
Brand	7.89±2.49
Safety, Hygiene	9.28±1.42

When considering the characteristics that the participants liked from the therapeutic mushroom product tasting test, it was discovered that overall preference was at a high level. According to Table 7, they preferred the taste the most, followed by the appearance, scent, color and texture.

Table 7 Test results of therapeutic mushroom products

Sensory attributes	Liking score
Physical appearance	7.91±0.93
Colour	7.70±1.14
Scent	7.73±1.26
Taste	8.23±1.02
Texture	7.28±1.59
Total preference	8.12±0.98

Ninety-nine Percent of the sample group approved of the entrepreneurs' therapeutic mushroom products. For the price level that the sample group expected to pay for the item, more than half of the respondents selected the price of 35 baht per size of 40 grams, which was followed by 30 baht and 40 baht. The sample group believed that the pricing would be in line with similar products available in the market. Given the range of such pricing, the respondents may not yet be fully aware of the product's benefits. Within such a price range of 30-35 baht for each size of 40 grams, there is still a possibility in the market as shown in Fig. 1.

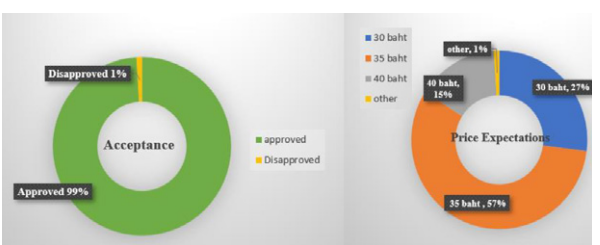

Fig. 1 Product acceptance and product price expectations of the sample group

4. Finding the product shelf life

The study of the product shelf life was conducted within 6 months and the product quality was analyzed. It was found that it was in accordance with the criteria specified by the law as shown in Table 8.

Table 8 Product quality test results after 6 months storage

Test Item	Result
Potassium sorbate	Not detected
Sodium benzoate	Not detected
Lead (Pb)	Not detected
pH	5.97
Water activity (at 25°C)	0.448 (threshold <0.6)
Net weight	40.06 g
Total Plate Count at 35°C	3.2 x 10^2 (Criteria Compliant) CFU/g
Coliforms	<3.0 (Criteria Compliant) MPN/g
Staphylococcus aureus	Not detected
Salmomella spp.	Not detected
Yeast and Molds	10 (Criterion 100) CFU/g

Consequently, the knowledge gained from the study and development of therapeutic mushroom products can be transferred to local entrepreneurs who have the ability to manufacture the products. The research team developed traditional flavored therapeutic mushroom products that resulted from the community participation of the community enterprise of Klong Chik Sub-district, Bang Pa-in District, Phra Nakhon Si Ayutthaya Province as souvenirs to generate income for the community and to create the community's identity.

5. The study of the packaging design and marketing channels of therapeutic mushroom products

An envelope made of aluminum foil was chosen for the package design to keep the product fresher and readily available for consumption. The front's graphic emphasizes the community enterprise's pride in the business that cultivates fresh Bhutanese mushrooms and turns them into medicinal mushroom products to be consumed with rice which is good for health and can be easily consumed by just opening the sachet.

A checklist to highlight the product's advantages was used in green and yellow vegetarian icons to convey the message directly to consumers who are health-conscious and added a premium look with a silver line. On the back, nutrition tables were arranged for easy reading and in order, including picking a font that is smooth and large. The icons and details were added to convey the details per category. The 'Hed Khik Khak or Giggling Mushrooms' logo is on the side which was designed to have natural tones with fun lined designs with a hidden smiley meaning to boost sweetness and create a memorable identity along with the amusing brand named 'Hed Khik Khak or Giggling Mushrooms' that includes numerous varieties which are to be invented in the future, as shown in Fig. 2.

Fig. 2 Therapeutic mushroom products

In terms of the branding, the trademark of therapeutic mushroom products has been registered with the Department of Intellectual Property with the product name 'Hed Khik Khak or Giggling Mushrooms' by designing a mark/symbol (Logo) as shown in Fig. 3.

Fig. 3 Trademark symbol

In addition, for therapeutic mushroom products' branding, the community and the researcher(s) collaborated to perform an acceptance survey for the created brand of Giggling Mushrooms. It was approved with a high score (7.89 points). The trademark has been registered for Khlong Chik Community Enterprise to be used to develop new products under the brand name.

In the aspect of marketing channels and guidelines for marketing the products, the channels for health stores and restaurants are suitable for the product characteristics. However, when considering the main distribution channels for health foods that focus on herbs, it was found that online marketing and contemporary shops that house regional civic organizations need to be targeted by highlighting the range of products to entice customers to purchase. Customers who purchase goods through these platforms typically acquire the products in small volumes but they may purchase them more frequently. Additionally, entrepreneurs like to organize promotional activities through these large retailers. Convenience stores serve as a distribution route for small goods which customers can opt to purchase and eat right away. Also, most consumers tend to consume mushroom products with steamed rice or boiled rice. Distributing the products in convenience stores satisfies customer demand in this sense.

The distribution channels directed to the target market could be divided into 3 ways, namely through sales representatives through a health store and through restaurants. For each channel, appropriate distribution costs need to be taken into consideration. The entrepreneurs must consider the appropriateness, namely the cost of sales through various stores using the company's salesperson, the cost of distribution through health stores and the cost of distribution through restaurants. Furthermore, a proper marketing plan must be planned for the implementation of marketing activities using marketing mix strategies to create awareness and to meet the needs of customers in order to achieve marketing results appropriately and achieve the market goals as specified. In addition, the design of therapeutic mushroom products needs to be aesthetic, outstanding and unique to represent the identity of the community. The researcher(s) worked on product design with the community along with conducting an acceptance questionnaire on the designed packaging and label with the highest acceptance score (8.52 points).

Conclusion

It was determined through the analysis of conventionally flavored therapeutic mushroom products that they could be successfully marketed and distributed. The utilization of locally cultivated Bhutanese oyster mushrooms is the product's standout feature. It is healthy for the body because it is organic and delightfully seasoned and it is ideal for those who care about their health. It is good for the working/school age group who wants nutritious food and the elderly who wants the benefit as it can help them relax. It is a healthy food that can be consumed daily. Based on these benefits, the community can create good popularity for the product with an emphasis on semi-premium marketing using

social media channels, health stores and restaurants, including various booths to showcase products by concentrating on marketing strategies regarding product differentiation (Differentiated strategy) to demonstrate the value and nutrients of the Bhutan oyster mushrooms. The products are available in sachet sizes, priced at 30-35 baht per sachet per 40 grams and come in a box size of 7 sachets with the price of 199 baht per box. Another strategy is to allow people to taste the products at product exhibitions. The promotion at the point of sale is for boosting the interest in the products.

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