Development of seasoned gray oyster mushroom chips using vacuum frying process

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Abstract

To make a value-added product of crispy chips from gray oyster mushrooms a vacuum frying condition was developed. The objectives of this research were to optimize a vacuum frying condition (frying temperature, time, and spinning process) for making vacuum fried oyster mushroom chips, and to evaluate a suitable flavor for seasoning the mushroom chips. Results showed that the optimal vacuum frying process was frying temperature and time of 120°C for 15 min and spinning speed at 1200 rpm (under pressure -700 mmHg; vacuum gage). The obtained gray oyster mushroom chips had a low moisture content, fat content, and fracturability. For sensory evaluation scale of 9-point hedonic and 5-point just about right (JAR), seasoned chips (with 8% barbecue flavor) got the highest overall linking score compared the other treatments with different seasoning levels and flavors. The analysis of the final product showed that the chips had a high fiber (25.62%) and protein (17.47%) content and a low moisture content (2.15%), water activity (0.308) and microbial loads (total plate count = 1 x 10^3 CFU/g and yeast and mold content = 1 x 10^2 CFU/g).

Keywords: vacuum frying process, gray oyster mushroom, seasoned chips, value-added snack

1. Introduction

In recent years, the demand for savory snacks has increased by 15–20% of the current market value every year. Potato chips and potato based snacks, one of the major snacks in the market, accounted for 33% of the whole market value. Secondly, starch based snacks accounted for 33%. Other snacks made from sea weed, squid, and rice accounted for 34% (Department of Industrial Promotion, 2013). The snack food industry has been largely driven by the customer demand for snack vegetables. Increasing demand of organic and natural snack foods has been foreseen by snack food production industry, indicating that there is a tendency toward healthier snack options. Gray oyster mushroom is one of the commercial edible mushrooms that could be cultivated around the world. Gray oyster mushroom can be eaten raw and frequently used in Asian cookery in soups, stuffed or in stir-fry recipes.

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Like many mushrooms, gray oyster mushroom is rich sources of nutritive values such as proteins, fibers, vitamins and minerals, while it provides low calories and fat content. In addition, it is also an ideal diet for vegetarians, diabetic and heat patients (Ranogajec *et al.,* 2010).

Development of savory snack from gray oyster mushroom has been of great interest for many product development specialists. Thus, this research aimed to develop seasoned gray oyster mushroom chips using a vacuum frying process. Vacuum frying process is a cost-effective process, and provides high quality attributes of fried foods. In addition, suitable seasonings to flavoring gray oyster mushroom chips were also evaluated using 9-point hedonic scale and just about right (JAR) 5-point scale.

2. Materials and Methods

2.1 Preparation of gray oyster mushroom

Gray oyster mushroom was purchased from a local farm in Nakhonnayok, Thailand. Gray oyster mushroom was pre-washed by rinsing under running tap water for 5 min. Then, the stem part of mushroom was removed by cutting. Only the cap of the mushroom was selected, and then blanched under hot water at 80°C for 2 min. The mushroom was cooled down in a refrigerator at -40°C for 30 min before cooking process.

2.2 Effect of vacuum frying treatments on product quality

The prepared mushroom was fried using a vacuum fryer (model VP-20P, Owner, Thailand) under -700 mmHg (vacuum gage). The operating conditions were varied at 80, 100 and 120°C for 10, 15 and 20 min (under 1000 rpm spinning for 10 min). After the frying process, residual frying oil was removed from the product using a spinner (model VP-20P, Owner, Thailand) at different speeds (800, 1,000 and 1,200 rpm for 10 min). Various flavors of seasonings (Barbecue and Tom yum; Flavor&Aromatic aromatic group Co., LTD) were mixed into the product before packing them into an aluminum foil bag under a vacuum condition (heat level 6, vacuum level 2; Triton packaging, USA). The effect of varying operating conditions on the physicochemical and organoleptic properties of the product was determined. Sensory quality of the products with different seasonings was evaluated.

2.3 Determination of physicochemical properties

2.3.1 Texture analysis (fracturability)

Fracturability of the chips was carried out using a texture analyzer (TA.XT plus, Stable Macro, England). The chips were compressed with a spherical probe (P-0.25) at a speed of 1.0 mm/s until reaching 90% strain and post speed 10.0 mm/s. Compression data was recorded in newton of force. Fifteen replicates (n = 15) were performed for each treatment.

2.3.2 Color measurement

Color profiles of the chips were measured using a colorimeter (Color Flex, Hunter lab, USA). All samples were ground into small particles (15 g samples using speed level 2 of grounder machine for 30 s; model HR1393, Philips) before transferred into a quartz container. The color of the chips were presented in terms of L* C* h° color space. Five replicated samples were recorded per treatments.

2.3.3 Proximate analysis of the chips

The proximate analysis (moisture, protein, fat, fiber contents) of gray oyster mushroom chips with and without seasoning was done using the standard methods described in AOAC (2000). Protein contents of the chips were estimated from the determination of total nitrogen content by Kjeldahl method using a conversion factors of 6.25. Carbohydrate content was calculated by subtracting.

2.4 Determination of water activity (a_w)

All samples were ground into small particles. Approximately, 2.5 g of samples were used for the analysis using a water activity meter (Aqua Lab, Model. CX3TE, England). All determinations were performed in triplicates.

2.5 Microbiological analysis

Total plate count (TPC) and yeast and mold count of samples were analyzed to evaluate the effect of the process and microbial safety of the products. Briefly, the gray oyster mushroom chips 11 g were prepared by adding 99 mL of 0.1% peptone saline solution. Samples were homogenized for 2 min (400 rpm) at room temperature with stomacher (model 400 CIR, Seward, England). Subsequently decimal dilution series (10-fold) were prepared from the primary dilution using peptone solution and they were pour plate in plate count agar (PCA, HighMedia) and potato dextrose agar (PDA, Criterion^{TM}) to determine TPC and yeast & mold count, respectively. The plates were incubated at 37°C (48 h) for TPC and 30°C (72 h) for yeast and mold. The result was expressed as the number of colony-forming units (CFU) per gram of the sample.

2.6 Sensory analysis

The acceptance tests of the gray oyster mushroom chips were performed using 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). For investigating the effect of frying temperature and time, a balanced incompletely block design (BIB) was used with parameters of t=9, k=4, r=8, b=18 and λ=3 (Gacula *et al.,* 2007). Overall, seventy two untrained sensory panels for a triplicate experiment (n =3) were used for evaluation of several attributes including color, oiliness, flavor, crispiness, seasoning amount and overall liking of the products. For evaluating the effect of spinning and seasoning amount, a randomized complete block design (RCBD) was applied. Thirty untrained sensory panels evaluated products. A cup of drinking water for rinsing between the samples was prepared in the booth. The samples were served in a sealed aluminum foil bag, and labeled with a 3-digit random number and random order of sample presentation.

2.7 Statistical analysis

Physicochemical properties and sensory data were reported as mean ± standard deviation. An analysis of variance (ANOVA) was performed. When considered the effect of frying temperature and time, a 3×3 factorial in completely block design was applied. Duncan's multiple-range test was applied on the individual variables to compare the means and to assess their significant differences (at significant level, p<0.05). All calculations were performed by SPSS18 (http://www.spss.com; SPSS Inc., Chicago, IL).

3. Results and Discussion

3.1 Effect of frying temperature and time

Influence of vacuum frying conditions on physicochemical properties and sensory qualities of the chips was investigated at different frying temperatures and (80, 100 and 120°C) and times (10, 15 and 20 min). As shown in Table 1, frying temperature and time strongly impacted on moisture content, fat content (absorption), color and texture property (fracturability) of the product.

In general, it was noticed that an increase in the temperature and time decreased moisture content, fat absorption and fracturability of the chips. Results showed that there had no significant difference (p>0.05) in moisture content of the products heated at 80, 100 and 120°C for 10 min. However, when frying times was increased to 15 and 20 min, a significant moisture loss of the chips was observed (p<0.05). Furthermore, time considered for frying condition at 80°C for 10–20 min. Since the mushroom crust is in direct contact with the frying oil, it is a much higher temperature than the saturation temperature, therefore release moisture more rapidly than the core of the food. That means when fried at 10 min, the surface temperature of food placed in the hot oil. As the chip's internal moisture vaporized into steam but not long enough to vaporized water from the core. From Table 1, the vacuum frying treatment at 80°C/10 min showed higher moisture content than 15 and 20 min. The result was consistent with a previous report by Shyu and Hwang (2001).

For fat content, results showed that the product fried at 120°C had the lowest fat content (25–42% w/w) compared to the frying temperatures at 80°C (51–62% w/w) and 100°C (42–54% w/w). It is suggested that using higher frying temperature and time could minimize oil absorption into the product. This could be due to a lower frying oil density at high temperature may minimize the oil absorption into the product (Fan *et al.,* 2005). In general, increasing frying time would increase oil absorption into the product. However, in vacuum frying process, oil absorption is generally higher than conventional frying process. Without spinning process, the oil absorption of the product might be very high and shows an insignificant effect of an increase in frying time. Thus, spinning process is mandatory for vacuum frying process. The longer frying time, the lower oil absorption was observed in this study. It would be explained by changes in sizes and numbers of voids occurred food microstructure during cooking that would allow absorbed oils to be removed by centrifugal force.

As influenced by varying frying conditions, the longer frying time, the darker the color of the chips indicated by a decrease in L* (lightness) and an increase in C* (chroma) was observed. In addition, a decrease in h° (hue angle) suggested that the product turned more of a brownish color.

A decrease in breaking force (fracturability) of the chips was observed as a result of increased frying temperature and time. The lowest breaking force (379–485 N) was found at the treatment using 120°C for 20 min, while the chips treated at 80°C exhibited the highest fracturability (575–689 N). In addition, the chips obtained at 80°C for 10 min exhibited the highest moisture and fat contents. This indicated that the frying temperature at 80°C was not enough for the vacuum frying process.

For the overall quality, optimal condition for the vacuum frying process was at 120°C for 15 min based on low residual fat content in the chip and fracturability. Even though differences in physicochemical properties were observed, sensory analysis of the chips exhibited indifferences in all tested attributes (color, crispiness, oily and overall liking scores) of all treatments (data not shown). Thus, frying temperature at 120°C for 15 min was used for the further study on effect of spinning process for removal of residual oil content.

Table 1 Physicochemical properties of gray oyster mushroom chips obtained from various vacuum frying treatments

Treatments (°C: min)	Physicochemical properties					
	Moisture content (% w/w)	Fat content (% w/w)	L*	C*	h°	Fracturability (N)
80:10	3.05±0.47^{c}	62.44±6.63^{b}	27.81±1.72^{a}	15.35±0.97^{a}	80.74±0.62^{ab}	N/A
80:15	1.68±0.12^{a}	51.43±3.08^{b}	40.55±0.94^{b}	17.12±0.57^{b}	83.04±0.90^{b}	619.50±109.71^{b}
80:20	1.19±0.11^{a}	56.62±4.86^{b}	45.21±0.91^{b}	17.98±0.12^{b}	83.54±0.16^{b}	689.78±76.05^{b}
100:10	2.59±0.55^{b}	54.60±2.23^{b}	46.88±0.59^{b}	18.58±0.71^{b}	83.36±0.42^{b}	575.71±103.81^{b}
100:15	1.25±1.03^{a}	57.47±8.29^{b}	46.82±0.32^{b}	17.93±0.98^{b}	83.14±0.26^{b}	602.71±127.46^{b}
100:20	1.02±0.26^{a}	42.26±8.71^{b}	50.18±2.05^{c}	19.86±1.25^{b}	83.56±0.19^{b}	523.65±171.08^{b}
120:10	2.68±0.23^{bc}	42.32±6.75^{b}	48.81±2.53^{c}	19.74±1.25^{b}	82.24±0.38^{ab}	485.93±87.12^{b}
120:15	2.79±0.08^{bc}	25.12±4.43^{a}	47.87±1.48^{c}	21.03±1.03^{c}	81.62±0.08^{ab}	434.60±106.74^{b}
120:20	2.45±1.93^{b}	25.31±5.68^{a}	41.78±1.99^{b}	20.23±1.68^{bc}	78.98±0.26^{a}	379.85±37.92^{a}

Note: Mean with different superscript letters in the same column are significantly different (p<0.05)

3.2 Effect of spinning process

To optimize spinning condition to remove residual oils from the chips, spinning speeds were varied at 800, 1000 and 1200 rpm. Effect of spinning process on some physicochemical properties and sensory attributes was investigated. As illustrated in Table 2, spinning process had a strong impact on fat, moisture contents and fracturability, but the color property. Fat content of the chips was decreased from 32.86 to 27.00 (% w/w) in the treatments with 800 and 1200 rpm, respectively. In addition, spinning speed at 1200 rpm resulted in the lowest fracturability of the chips. However, for sensory aspects, no significant differences were observed as a result of spinning process. The average of overall liking score of all treatments was approximately 7.30 (data not shown).

Table 2 Effect of spinning process on physicochemical properties of gray oyster mushroom chips

Physicochemical properties	Spinning speed (rpm)		
	800	**1000**	**1200**
Moisture content (%)	2.61±0.75^{ns}	2.32±1.30^{ns}	2.07±0.07^{ns}
Fat content (%)	32.86±6.80^{b}	34.18±4.27^{b}	27.00±5.01^{a}
L*	56.48±0.35^{ns}	56.67±0.34^{ns}	57.68±1.36^{ns}
C*	18.42±1.08^{a}	17.90±1.44^{a}	20.40±0.49^{b}
h°	84.37±0.34^{ns}	84.34±0.28^{ns}	83.21±0.20^{ns}
Fracturability (N)	513.86±131.07^{ns}	494.58±127.34^{ns}	442.70±87.91^{ns}

Note: mean with different superscript letters in the same row are significantly different (p<0.05)

3.3 Development of seasoned gray oyster mushroom chips

Two different seasonings (barbecue and Tom-yum flavors) for gray oyster mushroom chips were evaluated using 9-point hedonic scale at two different levels (4 and 8% w/w) of seasoning compared to the control (without seasoning). Results showed that the chips seasoned with barbecue flavor at 8% obtained the highest flavor and overall linking score compared to other conditions (Table 3). The overall linking score of barbecue flavored gray oyster mushroom chips was 7.0 compared to 5.3 for the control and 6.3 for Tom yum flavored chips. In addition, the analysis of just about right (JAR) 5-point scales on 8% barbecue flavored chips showed that optimal levels of attributes (flavor, crispiness, oiliness and seasoning amount) of the product were obtained (data not shown).

Table 3 The comparison of preference mean score of gray oyster mushroom chips with/without seasoning.

Attributes	Control	4% BBQ flavor	8% BBQ flavor	4% TomYum	8% TomYum
Color	5.96±0.78^{ns}	5.76±0.73^{ns}	6.36±1.07^{ns}	6.13±1.15^{ns}	6.16±1.39^{ns}
Flavor	4.63±0.86^{a}	5.63±1.07^{b}	6.50±1.05^{b}	5.60±1.29^{b}	5.73±1.61^{b}
Crispy	6.16±0.72^{ns}	5.70±1.05^{ns}	6.43±0.86^{ns}	5.86±0.97^{ns}	6.06±1.26^{ns}
Oiliness	6.06±1.09^{ns}	6.23±1.03^{ns}	6.90±0.96^{ns}	6.16±0.78^{ns}	6.46±0.75^{ns}
Seasoning	3.53±1.08^{a}	5.33±1.08^{b}	6.73±1.50^{b}	5.50±1.65^{b}	5.76±1.61^{b}
Overall liking	5.06±1.60^{a}	6.03±1.04^{ab}	6.96±1.24^{b}	6.13±1.27^{ab}	6.33±1.26^{ab}

Note: mean with different superscript letters in the same row are significantly different (p<0.05)

Proximate analysis and some physicochemical properties of barbecue flavored gray oyster mushroom chips were shown in Table 4. Furthermore fiber was determined in term of crude fiber. The product contained high fiber (25.62%) content and protein (17.47%). In addition, the product had low moisture content (2.15%) and water activity (a_w = 0.308). For microbial analysis, total plate count, and yeast and mold count of the product were $1×10^3$ and 100 CFU/g, respectively.

Moreover, a customer acceptance test obtained from potential 100 customers suggested that 100% of the customers were interested on the product, and 99% of them want to purchase the product. The optimal price of 25 g product/pact was suggested at 20–25 baht (62% of the customers). For other price ranges, 25%, 5% and 3% of the customers accepted the price at 26–30, 31–35 and 36–40 baht, respectively.

Table 4 Proximate analysis and some physicochemical properties of barbecue flavored gray oyster mushroom chips

Characteristics	Mean±S.D
Proximate analysis	
Carbohydrate (%)	51.41±5.46
Fat content (%)	24.36±5.11
Protein (%)	17.47±5.03
Ash (%)	4.61±7.18
Moisture content (%)	2.14±0.48
Physico-chemical properties	
L*	51.18±2.06
C*	22.53±1.47
h°	76.55±14.23
Fracturability (N)	438.74±20.11
Water activity (a_w)	0.30±0.00
Microbiological analysis	
Total plate count (CFU/g sample)	$<1×10^3$
Yeast and mold count (CFU/g sample)	$<1×10^2$

4. Conclusion

Using frying condition at 120°C for 15 min and spinning speed at 1200 rpm resulted in optimal physicochemical properties. Barbecue flavored gray oyster mushroom chips (8% w/w) receiving the highest overall liking score could be a potential high fiber in the snack food industry.

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