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EFFECTS OF DRYING AND GRINDING IN PRODUCTION OF HEALTHY VEGETARIAN SOUP MIX

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Abstract: The healthy vegetarian soup recipe is full of veggies, it can be made with dried mushrooms, legumes and vegetables. The investigations were carried out to study the effect of drying method (hot air drying temperatures ranging from 50 to 70°C and freeze-drying) on colour and nutritional content of oyster mushroom (Pleurotus otreatus), which is the most widely cultivated in Viet Nam. To describe the hot air drying process, eight mathematical drying models were applied. Soup powder was passed through a sieve shaker for obtaining three different grades (0.25, 0.5 and 1 mm sieve sizes). The method of Principle Component Analysis (PCA) was used to describe the sensory attributes of samples. The results showed that mushroom dried at 70°C was the highest quality as compared to the other temperatures. The colour and nutritional content of freeze-dried samples (moisture content3%, protein31.98%, carbohydrate52.88% and phenolic content 31.13mgGAE/g) favourable in comparison to hot air drying. To establish drying models for mushroom, Wang and Smith model was selected (R^2>0.9). The PCA was represented 86% of the total variance in the sensory attribute data. The soup mix powder having particle size of 1 mm was found better sensory quality among all other sizes.

Keywords: vegetarian soup mix, sensory attributes, dehydrated mushroom, particle size, legume.

1. Introduction

Soup is liquid which is prepared from vegetables or animals, seasoning and mix together by using water, juice or stock and some food additive to improve the soup body; depending on the desired end product. The function of soup can become an alternative food for breakfast because a lot of nutrients could fulfill the adequacy body requirement, very practical in preparation and take an only short time to serve. Supplement additive and their functional attributes, proportion are major concerns for the good quality of the dried soup.

Instant soup and its functional attributes provide health benefits. Due to the limitation of plant proteins as deficiency of amino acids, can be maintained by mixing legume, mushroom and vegetable flours together (Upadhyay *et al*., 2017). Mushroom and legume are the most widely cultivated in Viet Nam, it is considered as an available sources to supply a good ingredients to produce vegetarian soup powder. Moreover, the nutritional function of mushroom and legume are content high percentage of protein, fiber, minerals, and bioactive compounds and contain a low amount of fat that are necessary for body functioning. Legumes are vital food resources which contribute to the nutritional well-being of diverse human diets. They provide essential nutrients and high levels of protein with moderate levels of energy and dietary fiber. Mushroom is considered to be a complete and safest food, suitable for all age groups. This nutrient dense versatile food can be taken as a substitute of meat, fish, fruits, and vegetables (Kakon *et al*., 2012), it also represents an excellent source of protein, vitamins (B1, B2, niacin, C, folic acid), dietary fibers, minerals (P, K, Na, Ca, and Fe) and is low in fat and contain an abundance of essential amino acids like lysine and leucine(Kurtzman, 2005). During processing to prepare the mushroom for soup the maintaining their quality in term of physical and chemical compounds should be mentioned. Dehydration is one of the efficient methods of preservation to prevent types of spoilage for mushrooms to be used as ingredients for soups.Celen*et al*. (2010) reported that drying temperature has a significant effect on the moisture evaporation from mushrooms. Drying method have been reported to effect on colour and texture of various products. Chemical pretreatment on mushroom are common used to prevent the mushroom before drying at high temperature, especially is sodium metabisulfite, this chemical solution are saidto offer considerable advantages over the use of gaseous additives in better controlling the amount taken up, greatly reducing time for the treatment and decreasing desorption losses during drying(Stafford *et al*., 1972). Moreover, the improvement quality of vegetarian soup powders, the particle size of soup powder are important. The structure of soup and its physical characteristic have significant effect in the mouth and, thus, on the sensory perception. Considering the above points, the present research work had been aimed to prepare the main ingredients to produced dried vegetarian soup with dried oyster mushroom, legumes and some vegetarian to investigate the effect of drying method on quality of oyster mushroom and particle size of soup powder on sensorial properties.

2. Materials and Method

2.1 Raw materials and ingredients

The raw materials and ingredients are includes of pules green pea (*Vignaradiata)*, red kidney bean (*Phaseolus vulgaris*), black turtle bean (*Phaseolus vulgaris)*, Dutch pea (*Pisumarvensesativum*), oyster mushroom (*Pleurotus ostreatus*), tomatoes, carrot, onion, garlic, white pepper, coriander, barley (in flake form), potato powder, pumpkin, sugar, seasoning, non-dairy creamer, full cream milk powder. All of ingredients were purchased from the local market and supermarket in Can Tho city (Vietnam).

2.1.1 Preparation and processing of raw materials

Carrots, pumpkins, tomatoes and potatoes were sorted, washed, peeled and sliced in cubic form (carrot and tomato) and soaked in sodium metabisulphite ($Na_2S_2O_5$) solution(300 ppm/L of water) for 30 min, then steaming in microwave 5 min and dipped into cold water. For legumes (green pea, red kidney bean, black turtle bean and Dutch pea) were washed, soaked in water 1 hour and boiled. After that, all of vegetables and legumes hot air flow drying were performed at 65^{o}C in 7 hours till completely drying.

2.1.2 Dehydration of grey oyster mushroom (*Pleurotus otreatus*)

The preparation of mushroom was divided into two techniques for drying including by hot-air drying and freeze-drying. For freeze-drying, the initial weight of mushroom is 500g. The freezing temperature and time were -80^{o}C and 24 hours, respectively. The temperature and vacuum pressure of the freeze-dryer was kept at -80^{o}C and 0.001 mBar for four different *time* intervals (12, 18, 24 and 30 hours). For hot-air drying mushrooms were sorted, washed, weighed 500g and followed by dipping in 400 ppm sodium metabisulphite ($Na_2S_2O_5$) solution for 5 min and hot-air dried at air temperature of 50, 60 and 70^{o}C. Air heated electrically before entering the heater. Mushrooms spread in a single layer on the tray. During air drying, weight and temperature of the samples were record at regular interval of times. The initial moisture content of the mushroom was ranged from 92% to 93% (w.b.) and the final moisture content was at 6-8 % (w.b) determined by the AOAC method (AOAC, 2005). To select a suitable model for describing the drying process of mushroom by using hot-air drying, drying curves fitted with 08 thin-layer drying equations were applied (Table 1).

Table 1: Thin layer drying models given by various authors

Model name	Model
Newton	$MR = exp^{(-kt)}$
Henderson and Pabis	$MR = aexp^{(-kt)}$
Page	$MR = exp^{(-kt^n)}$
Wang and Smith	$MR = 1 + at + bt^2$

Logarithmic	$MR = a\exp(-kt) + C$
Two term model	$MR = a\,exp^{(-kt)} + c\,exp^{(-gt)}$
Midili and others	$MR = a\,exp^{(-kt)} + bt$
Modified Midili and others	$MR = a\,exp^{(-kt)} + b$

Source: Hii et al. (2008); Onwude et al. (2016)
The non-liner regression analysis was using Microsoft Excel Software (Microsoft office, USA, version 2013).

2.1.3 Preparation of soup powder
The ingredients (green pea, red kidney bean, black turtle bean, Dutch pea, pumpkin, tomato, onion, garlic and potato) were weighed 100g and milled base on particle size using a sieving machine with three mesh sizes in different particle size 1.0, 0.5 and 0.25 mm. The samples were placed on the top sieve with the largest mesh size follow by the smaller ones and shake for 10 min, disassemble and stir lightly, then shake for an additional 5 min. After that, all the ingredients were mixed by following the ratio in Table 2.

Table 2: Mixing ratio of the dried vegetarian soup (g/100g)

Ingredients	Content (g/100g)	Ingredients	Content (g/100g)
Grey oyster mushroom	4	Carrot	3.8
Green bean	8	Garlic	0.5
Red bean	8	Onion	1
Black bean	8	Seasoning	5.1
Dutch pea	8	Sugar	1.8
Barley	10	Coriander	0.2
Potato powder	20	White pepper	0.2
Tomato	3.8	Non-dairy creamer	12
Pumpkin	3.2	Full cream milk powder	2.4

2.2 Evaluation of product quality
The proximate composition of the dried vegetarian soup with some legumes will analytical according to the methods of AOAC (AOAC, 2005).

Colour measurement: external colour of dried mushroom and vegetarian soup mix powder were evaluated in a Hunter-Lab colourimeter uses three values (*L*, *a*, and *b*) to describe the samples (dried mushroom and vegetarian soup mix powder). The measurements were displayed in *L*, *a*, and *b* values, where *L* is black (0)/white (100), *a* is red (+)/green (-) and *b* is yellow (+)/blue (-) scales.

Scanning Electron Microscopy (SEM): Scanning Electron Microscopy gives information about the size, shape and arrangement of particles in the mushroom matrix (Tudorică *et al.*, 2002). Dried mushrooms were cut using a razor blade and the sample was mounted onto brass stubs using double-sided carbon conductive adhesive tape. A gold coating (0.5 nanometer thick) was then applied under 8-9 pascal vacuum. Bulk samples were examined at 15 kV, the sample distance to the 7cm ejection glass, 35x magnification using a JOEL model J550 scanning electron microscope (Japan).

Sensory evaluation: Quantitative Descriptive Analysis (QDA) was applied for sensory evaluation. Nine panelists were selected based on the screening criteria including no allergic to food, availability and interest in participating in the descriptive analysis panel. The panelist was tested to determine their ability to discriminate different intensities of basic taste solutions and the intensity rating scale from 0 to 5 (where 0 = attribute not detected and 5 attribute extremely strong).

2.4 Statistical Analysis
The obtained data were analyze using Analyzed of variance (ANOVA) and consequently Duncan's Multiple Range Tests (DMRT) have to use to determine significant difference between samples (P<0.05). Data will analyze using the STATGRAPHICS CENTURION XV.I software. PCA was applied using XLSTAT (2007, Addinsoft, New York).

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3. Results and Discussion

3.1 Effect of temperature on the colour and nutritional compounds under hot air drying

Colour measurement

Colour is an important quality parameter for the dried mushrooms. Dehydrations at 50, 60 and 70°C were completed in 4.5, 4.25 and 3.5 hours, respectively. The colour indicated that the white colour increased with increased drying temperatures of mushrooms, so the browning is more pronounced at lowest temperatures and during the drying operation may be brought about by the action of polyphenol oxidase enzyme or by non-enzymatic (Maillard reactions between reducing sugar and amino acids at elevated temperature). Table 3 displays the colour values (*L*, *a*, and *b*) for dried mushrooms at 50, 60 and 70°C. The colour measurement indicated that the *L* values increased with increased drying temperatures of mushrooms, possibly due to inactivation of PPO. Elevated temperatures have been reported to deactivate PPO (Akyildiz and Didem Öcal, 2006). According to the results, mushrooms dehydrated at 60 and 70°C had the highest *L* values (75.11, 75.13), whereas mushrooms dehydrated at 50°C had the lowest (67.01) due to polyphenol oxidase is very active between the temperatures at 30-50°C. Changes in *a* values during dehydration of mushrooms are shown that the mean *a* value at 60°C had the highest (-4.84.), while the mushrooms dehydration at 50°C and 70°C the average *a* values were -2.40, -3.90, respectively. The average *b* value of samples dehydrated at 50°C and 60°C were 13.30and 13.52 were non-significant different (p>0.05).

Table 3: Effect of temperature on the colour under hot-air drying

Temperature (°C)	L	a	b
50	67.01 ± 0.39^{a}	-2.40 ± 0.07^{a}	13.30 ± 0.35^{a}
60	75.11 ± 0.80^{b}	-4.84 ± 0.15^{b}	13.52 ± 0.19^{a}
70	75.13 ± 0.04^{b}	-3.90 ± 0.18^{c}	14.61 ± 0.16^{b}

Values are expressed as mean±SD. Values with different superscripts are significantly different (P<0.05).

Nutritional compounds of grey oyster mushrooms

Nutritional compounds of grey oyster mushrooms manufacture with different drying temperature under hot air drying are shown in Table 4. The protein, carbohydrate and lipid contents of mushrooms were significant difference (p<0.05) between three temperatures (50, 60 and 70°C). Table 4 showed the proximate composition of dried mushroom samples of *Pleurotus ostreatus* by hot air drying in different temperatures ranging from 50, 60 to 70°C. The moisture content was found to be highest in the sample dried at 50°C (8.61%) while the least in sample dried at 70°C (6.48%), the moisture content was reduced gradually when the temperature increased. With this regards, the removal of moisture in the mushroom will reduce the risk of microbial spoilage or deleterious effects caused by enzyme (Yuen *et al*., 2014). Moreover, the protein, carbohydrate and lipid contents at 70°C was highest (23.59%, 48.57%, 0.06%) among treated samples. This results is in agreement with Audrey *et al*. (2004), which stated that protein content increased when heat is applied. The rise of nutritional values after treated by different drying temperatures might due to during drying, moisture removed, while oil, protein and carbohydrate content were increased. According to Bernart (2005), in their studies, *Pleurotus sp*. has protein content (23.9%) and carbohydrate (61.1%) were nearly when compare to this study. The lipid content was shown to be 0.057, 0.062 and 0.065%. Mushrooms are generally cholesterol free and have low fat. They contain unsaturated fatty acids which are less hazardous to health than the saturated fatty acids of animal fats (Yehia, 2012). Mushrooms are a good source of protein and carbohydrate that complement to our daily intake for various nutrients. Simultaneously, oyster mushrooms are suitable used as food ingredients for low-calorie diets by reason of its low amount of fat.

Table 4: Effect of temperature on the nutritional compounds of grey oyster mushroom flour under hot-air drying

Temperature (°C)	Moisture Content (%)	Protein (%)	Carbohydrate (%)	Lipid (%)	Total phenolic content (mgGAE/g)
50	8.61 ± 0.31^{b}	18.20 ± 0.30^{a}	42.10 ± 0.11^{a}	0.057 ± 0.005^{a}	19.26 ± 0.35^{c}
60	8.24 ± 0.11^{b}	21.29 ± 0.01^{b}	45.40 ± 0.45^{b}	0.062 ± 0.000^{ab}	12.63 ± 0.35^{b}
70	6.48 ± 0.30^{a}	23.59 ± 0.37^{c}	48.57 ± 0.34^{c}	0.065 ± 0.000^{b}	7.519 ± 0.29^{a}

Values are expressed as mean ±SD. Values with different superscripts are significantly different (P<0.05).

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Phenolic compounds in mushrooms are the most plentiful antioxidants in human diet. The concentration of total phenols in the dried Grey oyster mushrooms was determined, and the results are shown in Table 4 it could be seen that these antioxidative properties of the dried mushrooms suddenly decreased when dried mushrooms at a higher temperature. At 50°C, the amount of total phenolic content was 19.26mgGAE/g and was significantly decreased ($p<0.05$) when increasing the temperature at 60 to 70°C (12.63 to 7.519mgGAE/g). The drying temperature is very important variable in the mushrooms dehydration (Wijitra and Vachiraya, 2018). These results are in agreement with the results found by Choycharoen *et al.* (2016) that the cooking process had changed the properties of the active ingredient and the amount of antioxidant phenolic compounds in Shiitake, Eryngii, oyster mushrooms. Moreover, Ismail *et al.* (2004) reported that thermal treatment decreased the total phenolic content in all vegetable such as kale, spinach, cabbage, swamp cabbage, mushroom and shallots and antioxidant activity in some of them. Previous researchers demonstrated by several factors such as drying temperature, oxygen concentration and storage time (Saci *et al*., 2015). Temperature is one of the most important factors affecting on antioxidant activity.

Drying curve model of grey oyster mushroom under hot-air drying.

The effect of three temperatures on the drying curve of mushroom is shown in Figure 1. It can be seen that the moisture ratio decreases with drying time. The effect of temperature on drying is significant in case of hot air drying. By increasing the temperature from 50 to 60°C, drying time is decreased 25 min and 50 to 70°C drying time is reduced 1 hour, moisture ratio (MR) decreased exponentially with time, which shows a typical drying trend.

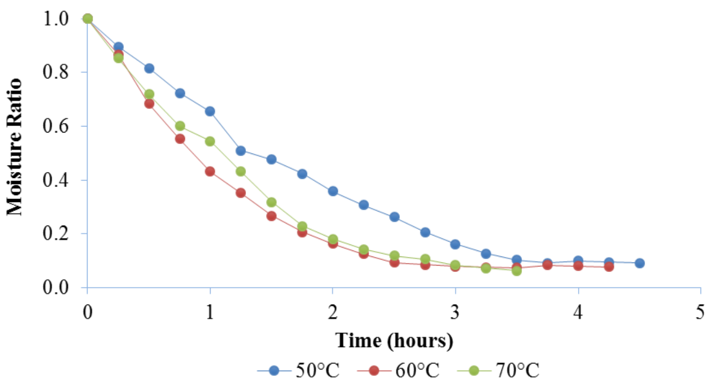


Figure 1: Variation of MR (M/M_o) of Grey oyster mushroom with drying time in different temperature (50, 60 and 70°C)

Note: $MR=M/M_o$, M is the moisture content at time and M_o is the initial moisture content.

The time required to reduce the moisture ratio any given level was dependent on the drying condition, being highest at 50°C and lowest at 70°C. With drying, the time taken to reduce the moisture content of mushrooms from the initial 87.86% to a final 6.48%. The effect of hot air drying temperature was most dramatic with moisture ratio decreasing rapidly with increased temperature. Several researchers reported considerable increases in drying rates when higher temperatures were applied for dehydration various vegetables such as carrot, garlic, and eggplant (Doymaz, 2004).Eight drying models have been used to describe drying kinetics. The model constants coefficients of these models used for moisture ratio change with time are presented in Table 5, 6, 7. The acceptability of the model is based on a value for coefficient of determination (R^2) which should be close to one, and low values for chi-square (X^2). According from the result the values of R^2 of the Wang and Smith model are almost equal with one (Equations 4, 5 and 6) and low parameters of X^2. Consequently, it can be stated that the Wang and Smith model gives an adequate description of the drying characteristic. The high values of R^2 (≥0.9979, 0.9906 and 0.9968) and low parameters of X^2 (≤0.0035, 0.0041 and 0.0115) indicated that the calculated results were in good agreement with the experimental data. Therefore, this model can be proposed for predicting changes in moisture ratio with time.

For drying at 50°C: $MR = 1+ (-0.4172t) + 0.0468t^2 \quad (R^2 = 0.9979, X^2 = 0.0035) \quad (4)$

For drying at 60°C: $MR = 1+ (-0.6110t) + 0.0962t^2 \quad (R^2 = 0.9906, X^2 = 0.0115) \quad (5)$

For drying at 70°C: $MR = 1+ (-0.5938t) + 0.0963t^2 \quad (R^2 = 0.9968, X^2 = 0.0041) \quad (6)$

Table 5: Results of the fitting statistics of various thin layer models at 50°C drying temperature

Model name	Coefficients and constants	R^2	X^2
Newton	k = 0.5355	0.9922	0.0237
Henderson and Pabis	a = 1.0523, k = 0.5644	0.9903	0.0174
Page	k = 0.4592, n = 1.2117	0.9969	0.0051
Wang and Smith	a = -0.4172, b = 0.0468	0.9979	0.0035
Logarithmic	a = 1.1410, k = 0.4413, c = -0.1171	0.9949	0.0083
Two term model	a = 0.5261, k = 0.5643, c = 0.5261, g = 0.5643	0.9903	0.0174
Midili and others	a = 1.0264, k = 0.4848, b = -0.0171	0.9945	0.0091
Modified Midili and others	a = 1.1410, k = 0.4413, b = -0.1171	0.9949	0.0083

Note: k is the drying rate constant; a, b and n: model constant

Table 6: Results of the fitting statistics of various thin layer models at 60°C drying temperature

Model name	Coefficients and constants	R^2	X^2
Newton	k = 0.8385	0.9925	0.0122
Henderson and Pabis	a = 1.0312, k = 0.8648	0.9933	0.0105
Page	k = 0.8203, n = 1.0672	0.9937	0.0105
Wang and Smith	a = -0.6110, b = 0.0962	0.9906	0.0115
Logarithmic	a = 1.0173, k = 0.9330, c = 0.0252	0.9943	0.0085
Two term model	a = 0.5156, k = 0.8648, c = 0.5156, g = 0.8648	0.9933	0.0105
Midili and others	a = 1.0434, k = 0.9162, b = 0.0070	0.9948	0.0077
Modified Midili and others	a = 1.0173, k = 0.9330, b = 0.0252	0.9943	0.0085

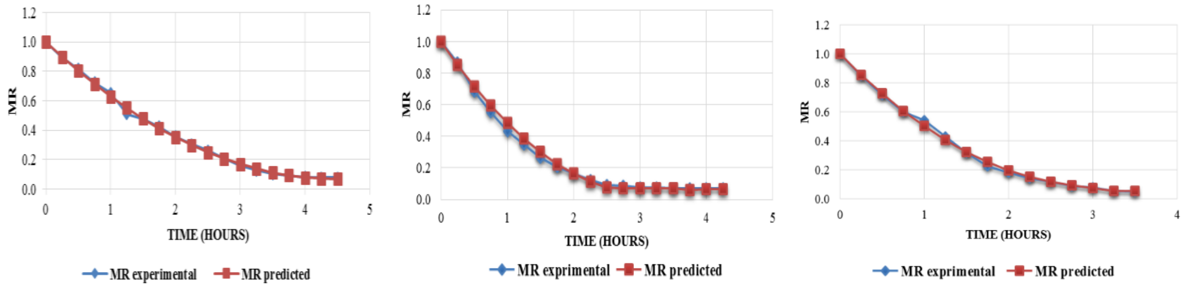
Note: k is the drying rate constant; a, b and n: model constant

Table 7: Results of the fitting statistics of various thin layer models at 70°C drying temperature

Model name	Coefficients and constants	R^2	X^2
Newton	k = 0.7470	0.9896	0.0168
Henderson and Pabis	a = 1,035, k = 0.7739	0.9891	0.0145
Page	k = 0.7014, n = 1.1537	0.9931	0.0092
Wang and Smith	a = -0.5938, b = 0.0963	0.9968	0.0041
Logarithmic	a = 1.063, k = 0.7051, c = -0.0393	0.9899	0.0131
Two term model	a = 0.5176, k = 0.7739, c = 0.5176, g = 0.7739	0.9891	0.0145
Midili and others	a = 1.026, k = 0.7367, b = -0.0071	0.9896	0.0136
Modified Midili and others	a = 1.063, k = 0.7051, c = -0.0393	0.9899	0.0131

Note: k is the drying rate constant; a, b and n: model constant

The comparison between the experimental data and the model for hot air drying (Wang and Smith model) is shown in Figure 2. There is a good agreement between the experimental and the model-predicted values for Wang and Smith model. Consistency between MR experimental data and MR predicted (Wang and Smith) is shown the $R^2 \geq 0.9909$. Figure 3 shows the plot of the experimental data of moisture ratio versus the predicted values of moisture ratio.



a. 50°C b. 60°C c. 70°C

Figure 2: Comparison between MR $_{experimental}$ and MR $_{predicted}$ of Wang and Smith model in different temperatures

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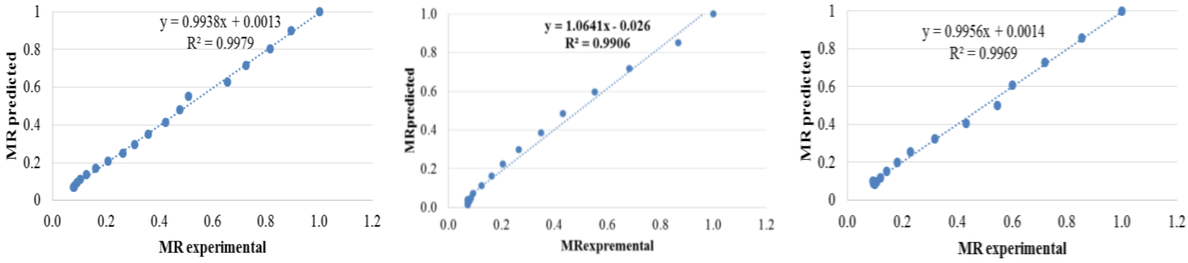

a. 50°C b. 60°C c. 70°C

Figure 3: Correlation between MR_{exp} and MR_{pre} (Wang and Smith model) at drying temperature of grey oyster mushroom

3.2 Effect of freeze-drying on colour and nutritional compositions of grey oyster mushrooms

Colour measurement

Mushrooms dehydrated the colour is an important quality parameter, the influence of the different drying times (12, 18, 24 and 30 hours) the colour measurements were taken after drying mushroom. The drying time had a significant difference on colour of mushrooms. A decrease in lightness (*L* value) or increase is considered as an indicator of colour degradation for mushrooms as they relate the sensitivity of mushrooms to dehydration time. It was found that the samples dried in period times at 12, 18, 24 hours were darker than the drying at longest time (30 hours). The average values of the colour parameters for mushroom in various times during freeze drying are presented in Table 8. The mushroom dried at 12 hours a values of *L*, *a*, and *b* equal to 79.54, -8.46 and 15.52, respectively. The results show an increase of *L* values with the increasing of time drying might be due to the moisture content reduced with time and the cause of operations on freeze drying (low temperature dehydration) could not damage the colour on surface of mushroom when increase the duration time for drying. Recently, Argyropoulos *et al*. (2011) reported that the *L* value of freeze-dried mushrooms was slightly increased during drying and the moisture loss, colour development is the most important factors for describing the quality of freeze-dried food products. Freeze drying is low-temperature dehydration process which involves freezing the product, lowering pressure, then removing the ice by sublimation, so the brown colour is not formed due to vacuum pressure and lower temperatures in drying (Thuy *et al*., 2019). Comparing the four levels of various time drying it is possible to conclude that the lightest dried mushroom was obtained at 30 hours (85.43). From the values of hunter colour for dried mushrooms is possible to see that increase of time from 12 to 30 hours increased the lightness colour (79.54, 81.3, 84.64, and 85.43).

Table 8: Effect of drying time on the colour of the freeze-dried grey oyster mushroom

Time (hour)	L	a	b
12	79.54 ± 0.34^{a}	-8.46 ± 0.13^{ab}	15.52 ± 0.30^{a}
18	81.3 ± 0.38^{b}	-8.18 ± 0.05^{c}	15.43 ± 0.14^{a}
24	84.64 ± 0.08^{c}	-8.54 ± 0.10^{a}	15.42 ± 0.25^{a}
30	85.43 ± 0.07^{d}	-8.32 ± 0.09^{bc}	15.32 ± 0.26^{a}

Values are expressed as mean ±SD. Values with different superscripts are significantly different (P<0.05).

Nutritional compositions

The preservation of nutritional compounds is essential for accessing quality of processed food products, and in particular for the case of mushrooms, which very much used for culinary preparations because of their nutrients. Freeze-drying, being a low temperature causes less deterioration in the chemical compositions of food products. In this process water is eliminated by sublimation from a frozen state, and the temperature of product remains very low during the operation (Kompany and René, 1995). In this case the duration for drying was applied in four levels to compare the chemical compositions in dried mushrooms. Table 9 shows the results of the nutritional compounds analysis to the mushroom after freeze-drying in different period times were significant different ($p<0.05$). It could be seen that the moisture content of dried mushrooms at 12 hours had highest moisture content (15.24 %) and the freeze-drying operation reduced the moisture content with time at 18, 24 and 30 hours to 10.51, 5.24 and 3.00 %, respectively. The duration of drying influenced the protein, carbohydrate and lipid contents of dried mushrooms. The increase in nutrient contents were observed with increasing the time from 12 to 30 hours for drying (Table 9).

Table 9: Effect of drying time on the nutritional compounds of freeze-dried grey oyster mushroom

Time (hour)	Moisture content (%)	Protein (%)	Carbohydrate (%)	Lipid (%)	Total phenolic content (mgGAE/g)
12	15.24±0.08[d]	12.31±0.27[a]	12.63±0.35[a]	0.024±0.001[a]	30.10±0.40[a]
18	10.51± 0.23[c]	26.38±0.06[b]	37.90±0.33[b]	0.056±0.001[b]	30.60±0.30[a]
24	5.24±0.08[b]	31.73±0.25[c]	47.13±0.11[c]	0.060±0.007[b]	30.92±1.00[a]
30	3.00±0.00[a]	31.98±0.00[c]	52.88±1.25[d]	0.069±0.002[c]	31.13±0.81[a]

Values are expressed as mean ±SD. Values with different superscripts are significantly different (P<0.05).

The lowest nutrient contents of dried mushrooms were observed in the samples dried at 12 hours while the samples dried at 30 hours recorded the highest value of (31.98, 52.88 and 0.069%). These results are in agreement with Thuy *et al.* (2019), the chemical components of freeze-dried chicken increased when drying time increased from 12 to 48 hours. During drying, heat and moisture transfers are coupled. It is a simultaneous heat and moisture transfer process where moisture leaves the food in the form of vapor, while oil is not significantly changed. Regarding to Piskov *et al.* (2018), in their studies, recorded that the conditions of freeze drying were optimal in terms of ensuring the preservation of the nutrient contents and the antioxidant capacity of oyster mushrooms.

Grey oyster mushrooms are rich source of nutrition and contain various bioactive compounds, such as phenolic, flavonoid, ascorbic acid, glycosides, tocopherols, polysaccharides, ergthioeine, and carotenoids (Gupta *et al.*, 2017). During processes such as drying might affect the phenolic compounds. The results from the study (Table 9) showed that total phenolic contents of freeze-dried mushrooms in different drying times did not varied significantly (p>0.05) where is the time increased from 12 to 30 hours the TPC was slightly increase 30.10, 30.60, 30.92 and 31.13mgGAE/g, respectively. Freeze-drying is known to extend the shelf-life of foods by preventing the microbial growth and retarding lipid oxidation. Freeze dried products are believed to have the same characteristics as those of fresh ones. As such, preservation and retention of the attributes in term of nutrients and biological activity of fresh samples makes this technique one of the most fascinating and applicable process for drying food materials (Shofian *et al.*, 2011). According to Minatel *et al.* (2017), total phenolic compounds were either unaffected or actually increased in concentration and extractability after high-pressure treatments preservation during freeze-drying, total phenolic in vegetables were retained at high levels that in those vegetables than were air-dried. Interestingly, when total phenolic levels at microwave vacuum preservation is compared to freeze-drying, the results showed that freezing-drying is a better dehydration method than microwave vacuum drying. In this case it was observed that the drying time and freeze-drying method could maintain the total of phenolic compounds on mushrooms when increased the time.

Effect of drying methods on physical structure of oyster mushrooms

The physical structure of hot air drying mushroom and freeze-drying mushrooms samples as viewed under scanning electron microscope is given in Fig. 4. The structure of the particles of hot air dried mushrooms and freeze-dried mushroom were different. The particles in hot air dried samples were irregularly broken pieces or had a flake like structure. Freeze-dried samples had shrunken with porous or honey comb like structure. The porous structure is due to sublimation of ice in the freeze-dried samples. The sublimation process is likely to result in the formation of voids. The dried mushrooms prepared by freeze drying showed smoother microstructure than the dried mushrooms under hot air drying. However, the less-dense structure with higher porosity was noticed for samples dried by hot air drying.

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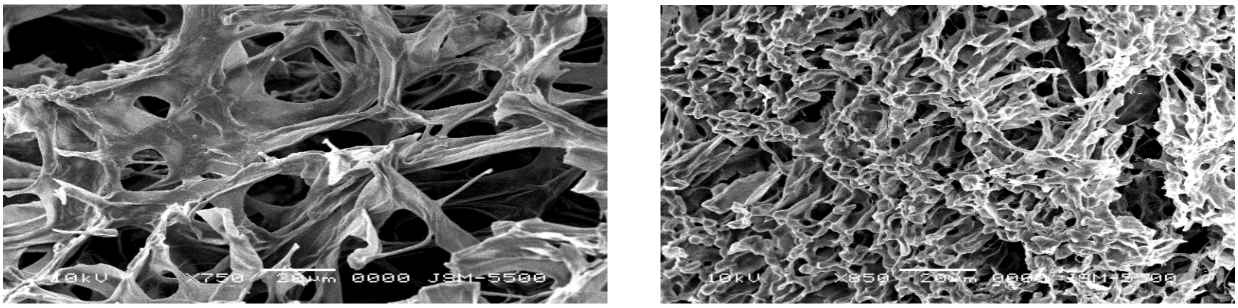

a. Hot air dried (70^{o}C) b. Freeze-dried (30 hours)

Figure 4: Scanning electron microscopic (SEM) photographs of (a) hot air dried mushroom at 70^{o}C and (b) freeze dried mushrooms at 30 hours**.**

The structure of freeze-dried mushrooms was clearly different than the hot air dried samples. The hot air dried material (Fig. 4a) was large porous, while the morphology of the dried sample (Fig.4b) was relatively dense. The pore development after hot air drying is presumably because of tissue expansion from the internal water evaporated. During freeze-drying, the original dimensions of the product are maintained first by freezing. The ice is then sublimed, usually under a high vacuum. Since there is no aqueous phase, there is no migration of water to the surface but instead a receding interface of frozen and layer. The effects of shrinkage and concentration of water soluble components due to the mobility of the aqueous phase are thereby prevented and the resulting product is not shrunken but has a small porous (Li and Jelen, 1987).

3.2 Effect of particle size of soup powder on sensory characteristics of vegetarian soup

The particle size of the three grades of soup powders obtained by the sieve of the mesh. The particle size for the powder samples passing through the 1, 0.5, and 0.25 mm respectively. The method of principle Component Analysis (PCA) was used to describe the sensory attributes of these samples (Figure 5). The Principal Component (PC) was represent 86% of the total variance (Figure 5). The particle size of soup powders were characterized based on their similarities and differences in sensory characteristics. Principal Component was described mainly by the Aroma, Taste, texture, and mouth-feel attributes such as cooked beans aroma, umami, bitter, viscosity, smoothness, etc. It can be seen that in three particle sizes of soup powder (1, 0.5 and 0.25 mm) were included of difference attributes after tasting by panellists. According to Kitsawad and Tuntisripreecha (2016), particle size had a significant effect on sensory parameters *viz.* appearance, flavour, mouth feel, taste, and overall acceptability. The sample size 1 mm was shown several attributes in term of smoothness, viscosity, umami, sweet, denseness, cohesiveness, onion, other aroma, pepper. In addition, sample size 0.5 mm was included oily mouth coating, salty, grittiness. The sample size 0.25 mm was contained of sour, bitter, and cooked. However, all of attributes that occurred in sample size 1 mm can be described the sample is the most preference among all of the samples due to the attribute of soup powder should be had smoothness, viscosity, sweet, and umami after cooking. Particle size is an important sensory property of powder and can relate to various powder characteristics. Complete knowledge of sensory properties of any food powder has a decisive importance for the realization of many technological processes, especially for monitoring their quality and consumer acceptance (Kurozawa *et al.*, 2009). Regarding to results, all of small particle sizes (0.5 and 0.25 mm) disassociated with the attribute of viscosity, smoothness due to the particles are small, soft, and are able to roll over each other, they contribute to creaminess perception. However, when the particles are too small, they are thought to be unable to provide a so-called "substantialness" impression, and might instead contribute to "watery" perception. Particle size is an important physical property of powder and can relate to various powder characteristics.

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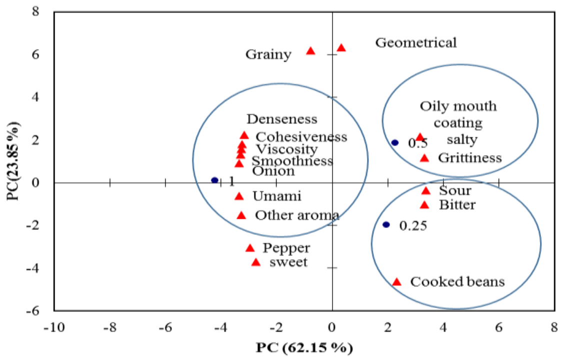

Figure 5: Principal component analysis (PCA) of particle size of powder samples

4. Conclusion

The present study revealed that the quality of dried oyster mushrooms depends significantly on the type of drying method. Hot air drying was shown that the best drying temperature to preserve its physical and nutritional value is at 70°C in term of colour, moisture, protein and carbohydrate content is well prevented. Besides, this temperature is more negative effect on total phenolic compounds as compared to other temperatures. Moreover, the effect of freeze-drying are shown that the drying time can be effect on nutritional compounds when increased the time the nutrient of dried mushrooms were increased, dried mushroom at 30 hours had the highest quality such as colour, moisture content, protein, carbohydrate, lipid and total of phenolic compounds. In conclusion, freeze-drying method is recommended in reducing moisture content and increasing proximate contents. Freeze-drying gave better quality in dried mushroom than hot-air drying, with respect to physical and chemical attributes. The particle size of 1 mm of soup powder was shown the most preference among all of the samples due to high sensory score in term of smoothness, viscosity, sweet, and umami after cooking.

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