

# The effect of pretreatments on the moisture content, fat content, and acceptability of vacuum-fried white oyster mushroom (*Pleurotus ostreatus*) chips

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## Abstract

The study investigated the effect of pretreatments on the moisture content, fat content, and acceptability of vacuum-fried white oyster mushroom chips. Control and four different pretreatments (1) freezing, (2) osmotic dehydration with maltodextrin solution and freezing, (3) steam blanching, and freezing, and (4) steam blanching, osmotic dehydration, and freezing were used in the study. All samples were fried in coconut oil at 80°C at a vacuum pressure of -700 mmHg for 15 mins, followed by spinning at 1420 rpm for 10 mins. The results showed that pretreatments significantly ( $p < 0.05$ ) affected the moisture content, fat content, and acceptability of the vacuum-fried white oyster mushroom chips. Vacuum-fried white oyster mushroom chips pretreated with steam blanching, osmotic dehydration, and freezing were found to have the lowest moisture content (0.86%). Other pretreatments resulted in vacuum-fried white oyster mushroom chips with higher moisture contents, still below the standard level for microbial growth. The osmotic dehydration with maltodextrin solution and freezing pretreatment minimized the oil uptake (22.24% fat content) of the vacuum-fried white oyster mushroom chips and was the most acceptable in sensory evaluation. Therefore, the osmotic dehydration and freezing before vacuum frying was the most suitable pretreatment for vacuum-fried white oyster mushroom chips.

## 1. Introduction

The word “mushroom” refers to the fruit body of certain fungi. They belong to the class *Basidiomycetes*, order; *Agaricales* (Gamage and Ohga, 2018). Mushrooms are edible fungi of commercial importance and their cultivation has emerged as a promising agro-based land-independent enterprise (Shivhare *et al.*, 2014). They are increasingly being utilized as important food products for their significant role in human health, nutrition, and disease control (Chang and Miles, 1989). With their flavor, texture, nutritional value, and high productivity per unit area, mushrooms have been identified as an excellent food source to alleviate malnutrition in developing countries (Pathmashini *et al.*, 2009).

At present, oyster mushrooms (*Pleurotus* species) are the world’s third most common species of cultivated mushrooms after button and shitake (Fernandes *et al.*, 2015; Josephine, 2015). Oyster mushrooms got their name from their fan-shaped cap, which resembles an oyster shell, and has pronounced gills on the underside

(Motoviloff, 2014). They are rich in large amounts of essential nutrients such as carbohydrates, proteins, vitamins, amino acids, fiber, organic elements, lipid and volatile compounds. Thus, are considered one of the richest well-balanced sources of human nutrition and are widely used in the food and nutraceutical industries (Maftoun *et al.*, 2015).

Despite the high nutritional value of mushrooms, they are highly perishable and can be preserved only if properly processed (Martínez-Soto *et al.*, 2001). The mushrooms of the *Pleurotus* genus are delicate and sensitive, and start deteriorating within 1 day after harvest (Apati *et al.*, 2010). Thereby, causing difficulties in their distribution and marketing as fresh products (Ren *et al.*, 2018). Value-adding is a must to reduce post-harvest losses (Gamage and Ohga, 2018). One way of value-adding food is by vacuum frying. It is well known that fried products have consumer appeal in all age groups and in virtually all cultures. The process is quick and can easily be made continuous for mass production, and the food appears sterile and dry, with a relatively

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long shelf life (Ren *et al.*, 2018).

Vacuum frying is the processing of fruits and vegetables under pressures well below atmospheric levels, preferably below 8 kPa that can lower the boiling points of frying oil and moisture in food. Moisture can thus be removed from the fried food rapidly once the oil temperature reaches the boiling point of water (Ren *et al.*, 2018). Vacuum frying reduces the oil content in the fried product. Moreover, it can preserve the natural color and flavors of the product and has a less adverse effect on oil quality (Tagalpallewar *et al.*, 2015). It is a cost-effective process and provides high-quality attributes of fried foods. As a result, vacuum frying is a feasible option for the processing of white oyster mushrooms into chips. Inevitably, some quality deteriorations could also take place during the vacuum frying process. To improve the quality of vacuum-fried products, several pretreatment methods, such as blanching, pre-drying, osmotic pre-treatment, coating, and freezing have been applied to the frying of foods (Fan *et al.*, 2006). Hence, this study aimed to investigate the effect of pretreatments on the quality, specifically on the moisture content, fat content, and acceptability of vacuum-fried white oyster mushroom chips.

## 2. Materials and methods

### 2.1 Materials

Fresh white oyster mushrooms were purchased from a local mushroom cultivator from Legazpi City, Albay. Maltodextrin was purchased from a food ingredient supplier in Quezon City, Manila. Coconut oil and distilled water were purchased from a local supermarket in Legazpi City, Albay. Aluminum foil pouch was purchased from a food packaging supplies store in Ermita, Manila.

The vacuum fryer used was equipped with a spinner (model PD120S-220, Department of Science and Technology (DOST)), with a capacity of 5 kg and a maximum temperature and vacuum degree of 130°C and -700 mmHg, respectively, for an oil capacity of 64 L is from the Bicol Regional Food Innovation and Commercialization Center, Bicol University - East Campus, Legazpi City, Albay.

### 2.2 Pretreatment of white oyster mushroom

Fresh white oyster mushrooms were cleaned by wiping them with a clean white damp cloth. This was followed by the removal of the stipes of the cleaned white oyster mushrooms. White oyster mushrooms free from stipe were treated as follows: (1) untreated as control, (2) freezing, (3) osmotic dehydration with maltodextrin solution (50% w/v) at 25°C for 60 mins and

freezing at -18°C for 24 hrs, (4) steam blanching and freezing at -18°C for 24 hrs, and (5) steam blanching, osmotic dehydration with maltodextrin solution (50% w/v) at 25°C for 60 mins, and freezing at -18°C for 24 hrs. The steam blanching process involved steaming (95°C) for 5 mins and blanching the steamed white oyster mushrooms for 5 mins in ice bath (10°C). Pretreatments used were adapted from the study of Ren *et al.* (2018), with modifications.

### 2.3 Vacuum Frying

A batch of 2 KG of white oyster mushrooms, after the pretreatment, was fried in 64 L of coconut oil. The oil temperature used was 80°C, vacuum pressure of -700 mmHg, and frying time of 15 mins. After the frying process, residual frying oil was removed from the product using a spinner (1420 rpm for 10 mins). Spun mushrooms were packed in aluminum foil pouches under vacuum conditions before analysis. Vacuum frying process was based on the study conducted by Charoen *et al.* (2015), with modifications.

### 2.4 Determination of moisture and fat contents

To determine the effect of the pretreatments on the moisture and fat contents of the vacuum-fried white oyster mushroom chips, moisture content and fat content were determined according to AOAC 930.04, 21<sup>st</sup> Ed. and AOAC 948.15, 21<sup>st</sup> Ed. Methods (Latimer, 2019), respectively. Analyses were performed in triplicates.

### 2.5 Sensory evaluation

Nine-point hedonic scale was used to determine the acceptability of the white oyster mushrooms vacuum-fried at 80°C. The panelists were asked to assess the acceptability of the vacuum-fried white oyster mushroom chips using the following rating: nine (9) as Likely extremely, eight (8) as Like very much, seven (7) as Like moderately, six (6) as Like slightly, five (5) as Neither like nor a dislike, four (4) as Dislike slightly, three (3) as Dislike moderately, two (2) as Dislike very much, and one (1) as Dislike extremely. A total of fifty consumer-type panelists were utilized in the sensory evaluation and were asked to evaluate the level of acceptability of the vacuum-fried white oyster mushroom chips in terms of appearance, color, aroma, texture, taste, and general acceptability.

### 2.6 Data analysis

Data were analyzed using a one-way Analysis of Variance (ANOVA) and Tukey's Range Test. Mean values were considered significantly different when  $p < 0.05$ .

### 3. Results and discussion

#### 3.1 Effects of pretreatment on the moisture content of the vacuum-fried white oyster mushroom chips

The moisture contents of the vacuum-fried white oyster mushroom chips are presented in Table 1. Steam blanching, osmotic dehydration, and freezing pretreatment resulted in vacuum-fried white oyster mushroom chips with the lowest moisture content, 0.86%. Steam blanching and freezing pretreatment resulted in vacuum-fried white oyster mushroom chips with the highest moisture content, 2.01%, followed by the control (1.79%), vacuum-fried white oyster mushroom chips with freezing as pretreatment (1.62%), and vacuum-fried white oyster mushroom chips with osmotic dehydration and freezing as pretreatment (1.60%).

Steam blanching disrupts the cells and makes it easy for moisture to evaporate (Wickramasinghe *et al.*, 2020). Similarly, freezing could increase the cell membrane penetrability of the material and can cause water to more easily evaporate (Fan *et al.*, 2006). Despite these, vacuum-fried white oyster mushroom chips with steam blanching and freezing as pretreatment obtained the highest moisture content. Moisture may have been absorbed by the white oyster mushrooms during the ice bath process resulting in a higher initial moisture content prior to vacuum frying. However, in combination with osmotic dehydration, it resulted in vacuum-fried white oyster mushroom chips with the lowest moisture content. From the result, it can be inferred that pretreatments with osmotic dehydration yielded vacuum-fried white oyster mushroom chips with lower moisture content. Osmotic dehydration is the removal of water by immersing food in a salt or sugar solution of high osmotic pressure. In this study, immersion in maltodextrin solution. The water is transferred from the food to the solution by virtue of the difference in osmotic pressure (Berk, 2018). The moisture contents of the vacuum-fried white oyster

mushroom chips obtained in this study are lower than the moisture content (2.15%) of vacuum-fried gray oyster mushroom chips developed in the study of Charoen *et al.* (2015).

#### 3.2 Effects of pretreatment on the fat content of the vacuum-fried white oyster mushroom chips

The fat contents of the vacuum-fried white oyster mushroom chips are presented in Table 2. Osmotic dehydration and freezing pretreatment caused the highest reduction in fat content, 22.24%. This was followed by the vacuum-fried white oyster mushroom chips with steam blanching, osmotic dehydration, and freezing as pretreatment, 41.61%. This suggests that pretreatment with osmotic dehydration, just like in moisture content, resulted in vacuum-fried white oyster mushroom chips with lower fat contents. This is in agreement with the study on vacuum-fried potato chips by Song *et al.* (2007), low initial moisture content resulted in low final fat content, as seen in Tables 1 and 2. Likewise, the result is in agreement with the study of Ren *et al.* (2018), where osmotic dehydration reduced oil uptake in vacuum-fried shiitake mushroom slices. Osmotic dehydration enhances heat transfer and moisture removal rate (Su *et al.*, 2021), resulting in denser and smaller pores or damage to the cell structure (Isik *et al.*, 2016; Adedeji and Ngadi, 2017). This decreases pressure and area of penetration of oil after frying, hence reducing oil uptake (Jia *et al.*, 2018).

The untreated vacuum-fried white oyster mushroom chips obtained the highest fat content (63.87%). This shows that pretreatment helped in the reduction of fat content. Rapid freezing as a pretreatment before vacuum frying reduces oil absorption (Hariono *et al.*, 2018). On the other hand, blanching causes the expulsion of air between the cells (Xin *et al.*, 2015). This reduction of air can reduce the porous space that can be occupied by oil during the frying process (Garcia-Segovia *et al.*, 2016).

Table 1. Moisture content of the vacuum-fried white oyster mushroom chips.

Control	Freezing	Osmotic dehydration with maltodextrin solution + Freezing	Steam blanching + Freezing	Steam blanching + Osmotic dehydration with maltodextrin solution + Freezing
1.79±0.06 <sup>a</sup>	1.62±0.10 <sup>b</sup>	1.60±0.05 <sup>b</sup>	2.01±0.04 <sup>c</sup>	0.86±0.03 <sup>d</sup>

Values are presented as mean±SD in percentage. Values with different superscripts are statistically significantly different ( $p < 0.05$ ).

Table 2. Fat content of the vacuum-fried white oyster mushroom chips.

Control	Freezing	Osmotic dehydration with maltodextrin solution + Freezing	Steam blanching + Freezing	Steam blanching + Osmotic dehydration with maltodextrin solution + Freezing
63.87±3.70 <sup>a</sup>	55.46±0.13 <sup>b</sup>	22.24±0.26 <sup>c</sup>	57.91±2.56 <sup>ab</sup>	41.61±0.11 <sup>d</sup>

Values are presented as mean±SD in percentage. Values with different superscripts are statistically significantly different ( $p < 0.05$ ).

A typical potato chip has a fat content of 35-40% (Riaz, 2016). Vacuum-fried white oyster mushroom chips with osmotic dehydration with maltodextrin and freezing pretreatment are 12.76-17.76% lower in fat content.

### 3.3 Effects of pretreatment on the acceptability of the vacuum-fried white oyster mushroom chips

A sensory evaluation was performed to determine the acceptability of the vacuum-fried white oyster mushroom chips. A total of fifty consumer-type panelists were utilized in the evaluation. As shown in Figure 1 are the vacuum-fried white oyster mushroom chips.

Table 3 shows that the panelists find all samples as acceptable as indicated by the scores in the general acceptability. Significant differences ( $p < 0.05$ ) were observed in the attributes, appearance, color, texture, and taste, except in aroma. Vacuum-fried white oyster mushroom chips with osmotic dehydration with maltodextrin solution as one of the pretreatments resulted in higher acceptability in all attributes. Osmotic dehydration of fruits and vegetables results in an improvement in color, texture, flavor, nutrient retention, product stability, and prevention of microbial spoilage (Yadav and Singh, 2012).

The oxidative browning of mushrooms involves the actions of a group of enzymes referred to as polyphenol oxidase (Murniati *et al.*, 2018). Osmotic dehydration promotes the preservation of color and flavor by inhibiting polyphenol oxidase and preventing enzymatic browning. The product is immersed in the osmotic agent and not exposed to oxygen thereby retaining its color

better (Sravani and Saxena, 2021). A study by Ren *et al.* (2018) showed that pretreatment with osmotic dehydration with maltodextrin solution enhanced color perception of vacuum-fried shiitake mushroom slices. Freezing controls enzyme actions by slowing down enzyme activity. Steam blanching, an important step in freezing, slows or stops the action of enzymes. Underblanching stimulates the activity of some enzymes and is worse than not blanching at all. Overblanching, on the other hand, can result in a loss of color, flavor, vitamins, and minerals (Garden-Robinson, 2004). A study by Ndiaye *et al.* (2009) revealed that mango slices steam blanched for 5 mins and 7 mins inactivated peroxidase and polyphenol oxidase, respectively. Steam blanching in this study was carried out for 10 mins. This justifies the rating 8.12 (*like very much*) in terms of color for the pretreatment osmotic dehydration and freezing and 7.94 (*like moderately*), a lower rating, for the pretreatment steam blanching, osmotic dehydration, and freezing.

Aroma has a vital role in determining consumer's perception, acceptance, and choice of food. Compounds smelled by an olfactory are known as the aroma-active compounds in food (Yu *et al.*, 2021). No significant difference was observed in all the samples in terms of aroma. A study by Nyegue *et al.* (2002) identified the major odorous compounds in fresh *Pleurotus ostreatus* organic extract. These were C<sub>8</sub> components (mushroom odors) as octen-3-ol (59.3%), octan-3-one, octen-3-one, 3-octanol, (E)-2-octenal, n-octanal, and n-octanol. Other compounds detected include benzyl alcohol (sweet-spicy odor), phenylethanol (rose odor), and benzaldehyde

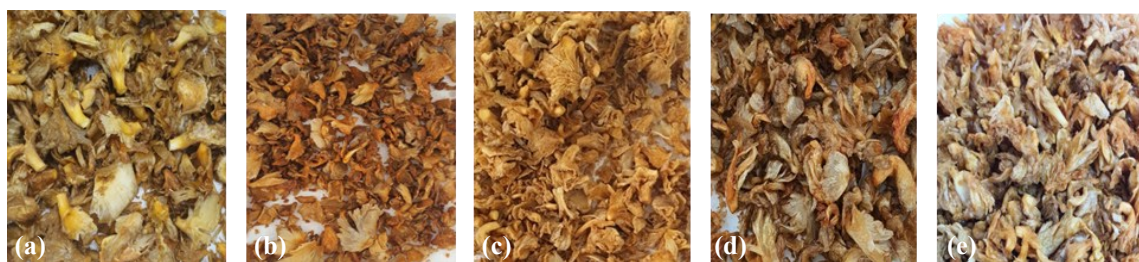


Figure 1. Vacuum-fried white oyster mushroom chips: (a) control, (b) freezing, (c) osmotic dehydration + freezing, (d) steam blanching + freezing, (e) steam blanching + osmotic dehydration + freezing.

Table 3. Acceptability of the vacuum-fried white oyster mushroom chips.

	Control	Freezing	Osmotic dehydration with maltodextrin solution + Freezing	Steam blanching + Freezing	Steam blanching + Osmotic dehydration with maltodextrin solution + Freezing
Appearance	7.34±1.364 <sup>b</sup>	7.78±1.148 <sup>ab</sup>	8.12±1.003 <sup>a</sup>	7.38±1.260 <sup>b</sup>	7.94±0.867 <sup>ab</sup>
Color	7.28±1.262 <sup>b</sup>	7.64±1.139 <sup>ab</sup>	8.02±0.979 <sup>a</sup>	7.30±1.199 <sup>b</sup>	7.80±1.178 <sup>ab</sup>
Aroma	7.10±1.199 <sup>a</sup>	7.58±1.247 <sup>a</sup>	7.64±1.139 <sup>a</sup>	7.40±1.195 <sup>a</sup>	7.62±1.064 <sup>a</sup>
Texture	7.32±1.406 <sup>b</sup>	7.70±1.249 <sup>ab</sup>	8.26±0.922 <sup>a</sup>	6.24±1.858 <sup>c</sup>	8.06±0.935 <sup>a</sup>
Taste	6.86±1.690 <sup>b</sup>	7.88±0.982 <sup>a</sup>	8.24±1.001 <sup>a</sup>	5.88±1.769 <sup>c</sup>	7.78±1.055 <sup>a</sup>
General Acceptability	7.24±1.287 <sup>b</sup>	8.00±0.904 <sup>a</sup>	8.30±0.735 <sup>a</sup>	6.58±1.605 <sup>c</sup>	7.92±0.877 <sup>a</sup>

Values are presented as mean±SD in percentage. Values with different superscripts are statistically significantly different ( $p < 0.05$ ).

(almond odor) as well as monoterpenes (linalool and linalool oxide) which may also contribute to its pleasant flavor.

A main sensory quality attribute affecting food acceptance, particularly in chips, is texture (Ikoko and Kuri, 2006). A study by Ren *et al.* (2022) reported that immersion in maltodextrin increased crispiness in *Pleurotus eryngii* chips. A study on the effect of osmotic treatment on mango chips exhibited that sugar uptake led to a firm structure, low porosity, and a loss in elasticity for the mango chips (Nunes and Moreira, 2009; Wang *et al.*, 2010; Tabtiang *et al.*, 2012). The combination of osmotic dehydration and freezing resulted in vacuum-fried white oyster mushroom chips with a rating in texture of 8.26 (*like very much*). The uptake of maltodextrin led to a firm texture of the white oyster mushroom chips. Research studies show that freezing before vacuum frying fruit or vegetables can improve the crispness and taste quality of the product (Hariono *et al.*, 2018). Freezing maintains the original color, flavor, and texture of foods (Garden-Robinson, 2004). Steam blanching leads to the softening of tissue cells (Wickramasinghe *et al.*, 2020), affecting texture.

White oyster mushroom has a savory taste (*umami*) (Rahmah *et al.*, 2020). Maltodextrin is a polysaccharide used as a food additive and flavor enhancer (Marcus, 2019). It is made from the hydrolysis of starch, comes in the form of a white powder, and has a sweet taste (Wang and Wang, 2000). This explains the 8.24 (*like very much*) rating of the vacuum-fried white oyster mushroom chips with osmotic dehydration with maltodextrin solution and freezing pretreatment, in terms of taste.

Osmotic dehydration with maltodextrin solution and freezing pretreatment had the highest rating in appearance, color, aroma, texture, taste, and general acceptability as seen in Table 3 indicating that this pretreatment was the most suitable for the vacuum-fried white oyster mushroom chips.

#### 4. Conclusion

The pretreatments significantly ( $p < 0.05$ ) affected the moisture content, fat content, and acceptability of the vacuum-fried white oyster mushroom chips. The osmotic dehydration with maltodextrin solution and freezing pretreatment minimized the oil uptake (22.24% fat content) of the vacuum-fried white oyster mushroom chips and is the most acceptable (8.30) in sensory evaluation. Therefore, osmotic dehydration and freezing before vacuum frying was the most suitable pretreatment for vacuum-fried white oyster mushroom chips. Texture and shelf-life analyses may be done to determine crispness and stability.

#### Conflict of interest

The author declares no conflict of interest.

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