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# Characterization and Optimization of the Processing Potential of Pleurotus ostreatus (Jacquin) P. Kummer Mushroom Powder in Loaf Bread Production

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**Abstract**

With the popularity of mushrooms as functional foods, its demand and consumption also increases. However, the perishable nature of mushrooms causes difficulty in their distribution and marketing as fresh produce This study was conducted to evaluate the effects of different colors of oyster mushroom, drying time and drying temperature on the physico-chemical, physical and proximate composition of powdered mushroom through Response Surface Methodology; determine the acceptability of powdered mushroom made from different strains of oyster mushroom, drying time and drying temperature in loaf bread production; determine the physical characteristics of loaf bread with oyster mushroom powder; and identify the optimum processing conditions for oyster mushroom powder production as ingredient in loaf bread production. The study was arranged in a 33 fractional factorial following the central composite design. Oyster mushroom powders were analyzed for its physico-chemical characteristics, moisture, fat and protein contents. Loaf bread was subjected to sensory evaluation and loaf height increase was evaluated. Results showed that powder made from white oyster mushroom with longest drying time had the highest TSS and pH. The color analysis of powdered oyster mushroom revealed that drying time significantly affected the browning index and moisture content. However, fat content was not significantly affected by the three variables considered. Appearance of loaf bread with mushroom powder was significantly affected by drying temperature. Bread height increase was significantly affected by the drying temperature. Optimum process for the preparation of oyster mushroom powder for loaf bread production was pink oyster mushroom with 6 hours of drying and 520C drying temperature.

Keywords: Oyster mushroom, browning index, Response Surface Methodology,

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## Introduction

Oyster mushroom is a common edible mushroom long cultivated in different countries, with China as the world's largest producer. It is one of the most gregarious of the cultivated mushrooms due to its wide adaptability in terms of environment and growing substrate. It is a saprophyte that acts as primary decomposer of woods especially deciduous trees (Chukwurah et al., 2012). The oyster mushroom is frequently consumed as soup, tea and pepper soup. The genus Pleurotus comprises some of the popular edible mushrooms due to their favorable organoleptic and medicinal properties. It is medicinal because it contains statins such as lovastatin which reduce cholesterol levels (Gunde- Cimerman and Cimerman, 1995).

Oyster mushrooms are more valuable source of protein that makes up 5% of the weight of fungus, which is equivalent to 20-40% by weight of dry matter. They are considered richer than either cattle or fish on a dry weight basis and are good source of almost all the essential amino acids when compared with most vegetables and fruits (Chukwurah et al., 2013; Matilla et al.,2002). They are also a good source of non-enzymatic antioxidant and high content of vitamin C and B complex (Ahmed et al., 2013).

With the popularity of mushrooms as functional foods, its demand and consumption also increases. However, the perishable nature of mushrooms causes difficulty in their distribution and marketing as fresh produce (Li et al., 2013). Prevention of browning or discoloration after harvest has been studied for more than a decade now but still finding the most appropriate method of control is still not established. This may be because of the sensitivity of mushroom to its environmental factors of which it is grown, the morphological and cultural characteristics of various strains and the substrate from which it is cultivated. Also, once oyster mushroom deteriorated, its fruiting body can cause severe gastrointestinal discomfort when consumed (Hassan and Medany, 2012). Thus, extending postharvest storage is a constant quest for the production and supply chain of mushrooms. One way of extending its shelf life is drying the commodity and converting it to powder.

There are existing bakery products with mushroom powder as one of its ingredients. The closest prior arts include CN107198101, which disclosed the preparation method of an intestine moistening bread. The process of producing such bread made use of mushroom powder but the method of cooking is through steaming and the mushroom powder was made from spirulina. Similarly, CN106614895 also discloses the method of preparation of straw mushroom bread. In addition, RU2670515 (C1) also disclosed the composition of dough for production of wheat bread with mushrooms. In this invention, the mushroom powder was made from chaga mushrooms. Of the different mushroom powders developed, none of them comes from oyster mushroom. Hence this study was conducted.

Generally, this study aimed to evaluate the processing potential of powdered oyster mushroom using different strains of Pleurotus ostreatus spp. as affected by varying levels of drying time and temperature. Specifically it aimed to: 1. Evaluate the effects of different colors of oyster mushroom, drying time and drying temperature on the physico-chemical, physical and proximate composition of powdered mushroom through Response Surface Methodology; 2. Determine the acceptability of powdered oyster mushroom made from different strains of oyster mushroom, drying time and drying temperature in loaf bread production; 3. Determine the physical characteristics of loaf bread with oyster mushroom powder made from different strains of oyster mushroom, drying time and drying temperature; 4. Identify the optimum processing conditions for oyster mushroom powder production as ingredient in bakery products.

## Methodology

### Experimental Design and Treatments

The study will be arranged following the central composite design (CCD) with 15 experimental treatment combinations. The variables will be the color of oyster mushroom, drying time (hours) and drying temperature (oC). The treatment combinations are presented in Table 1.

Table 1. Experimental treatment combinations of the three variables arranged in central composite design

| Treatment | Color of Oyster Mushroom | Drying Time (hours) | Drying Temperature (oC) |
|---|---|---|---|
| 1 | yellow | 4 | 41 |
| 2 | yellow | 4 | 63 |
| 3 | yellow | 8 | 63 |
| 4 | yellow | 8 | 41 |
| 5 | white | 4 | 41 |
| 6 | white | 4 | 63 |
| 7 | white | 8 | 63 |
| 8 | white | 8 | 41 |
| 9 | Pink | 4 | 52 |
| 10 | Pink | 6 | 63 |
| 11 | Pink | 8 | 52 |
| 12 | Pink | 6 | 41 |
| 13 | white | 6 | 52 |
| 14 | yellow | 6 | 52 |
| 15 | Pink | 6 | 52 |

### Raw Material Selection and Preparation

Different strains of oyster mushroom (gray, white and pink) were procured from Mushroom Research Center of CapSU Burias. The samples were trimmed and blanched at a temperature of 70oC for 1 minute prior to drying.

**The Dehydration and Powdering of Oyster Mushroom**

Different mushroom samples were dried according to specified temperature and drying time per treatment. Dried samples were ground finely, packed in a foil laminate packaging material and stored for analysis and evaluation.

**Physico-Chemical Properties of Oyster Mushroom Powder**

**TSS and pH**

The total soluble solids content will be determined directly using a handheld refractometer while pH will be determined using a portable pH meter.

**Color Analysis**

The Hunter L*, a* and b* values of powdered oyster mushroom will be measured using a Konika Minolata color reader CR-10 tri-stimulus colorimeter. Browning index will be calculated following the formula of Mohapatra et al (2010):

$$BI = 100 \times \frac{X-0.31}{0.17}$$

Where:

$$X = \frac{a^* + 1.75L^*}{(5.645L^* + a^* - 3.012b^*)}$$

**Nutritional Content of Oyster Mushroom Powder**

The proximate analysis (moisture, ash, protein, fat and fiber contents) of freshly harvested oyster mushroom at different stages of fruiting body maturity was done following the standard methods described in AOAC (2000). Carbohydrate content was calculated by subtracting the amount of moisture, ash, protein, fat and fiber content from 100.

**Oyster Mushroom Powder Application and Evaluation**

**Loaf Bread Preparation**

Loaf bread preparation followed the standard formulation. To determine the processing potential of oyster mushroom powders prepared from fifteen different treatments, it was added to the loaf bread formulation substituting the amount of wheat flour with 30% oyster mushroom powder. The composite flour therefore was made of 70% wheat flour and 30% oyster mushroom powder.

### Loaf Bread Height Increase

Height of the bread samples was measured before and 30 minutes after baking. Measurements were taken on different sides for thickness of the bread and the average measurement was recorded. Thickness was measured using vernier caliper.

### Sensory Evaluation of Loaf Bread

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### Attaining the Optimum Experimental Combinations

Data that were gathered from the physico-chemical tests and biochemical tests for all experimental treatments will be analyzed employing the response surface regression with the use of Statistical Analytical Software (SAS v. 6.12). Using the Statistica version 6, a graphical presentation of the contour plots were generated for all analyses of each run condition. Contour plots were superimposed to identify the optimum region of the experiment.

### Statistical Tools and Analysis

Data gathered from the experiment was analyzed using statistical analysis software (SAS) v. 9.13 and statistica v.6 software.

## Results and Discussion

### Physico-Chemical Characteristics of Oyster Mushroom Powder

Results of the physico-chemical characteristics of oyster mushroom powder showed that Total Soluble Solids (TSS) ranged from 2.0 to 5.01 oB while pH ranged from 5.89 to 6.55 (Table 2). Highest TSS was observed from powder prepared from white oyster mushroom dried for 4 hours at 41oC drying temperature. Likewise, highest pH was observed from treatment prepared from gray oyster mushroom dried for 6 hours at 52oC drying temperature. Response surface plots for TSS showed that at constant drying temperature, powder made from white oyster mushroom with longest drying time had the highest TSS (Figure 1). On the other hand, at constant mushroom color, TSS was at its highest at lowest drying temperature. In terms of pH, Figure 2 shows that the longer the drying time, the higher is the pH.

Table 2. Physico-chemical properties of powdered oyster mushroom as affected by varying colors, drying time and drying temperature

| TREATMENT | OM COLOR | DRYING TIME(HRS) | DRYING TEMP(OC) | TSS (°B) | pH |
|---|---|---|---|---|---|
| 1 | Gray | 4 | 41 | 3.06 | 6.24 |
| 2 | Gray | 4 | 63 | 2.33 | 6.35 |
| 3 | Gray | 8 | 63 | 3.00 | 6.35 |
| 4 | Gray | 8 | 41 | 4.00 | 6.49 |
| 5 | White | 4 | 41 | 5.01 | 5.89 |
| 6 | White | 4 | 63 | 3.00 | 6.09 |
| 7 | White | 8 | 63 | 5.00 | 6.38 |
| 8 | White | 8 | 41 | 3.00 | 6.46 |
| 9 | Pink | 4 | 52 | 5.00 | 6.10 |
| 10 | Pink | 6 | 63 | 3.68 | 6.46 |
| 11 | Pink | 8 | 52 | 4.00 | 6.34 |
| 12 | Pink | 6 | 41 | 3.00 | 6.39 |
| 13 | White | 6 | 52 | 3.03 | 6.20 |
| 14 | Gray | 6 | 52 | 3.39 | 6.55 |
| 15 | Pink | 6 | 52 | 2.01 | 6.38 |

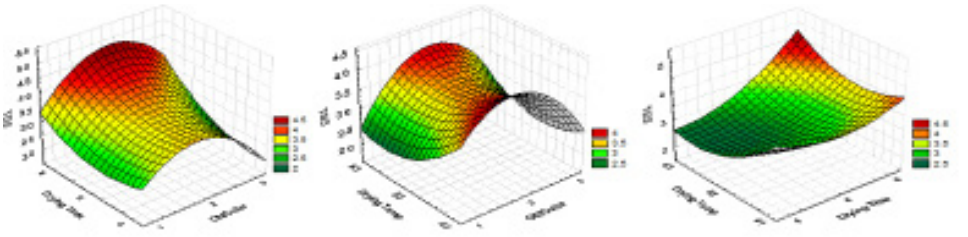


Figure 1. Response surface plots for TSS of oyster mushroom powder prepared from different strains of oyster mushrooms with varying levels of drying time and drying temperature

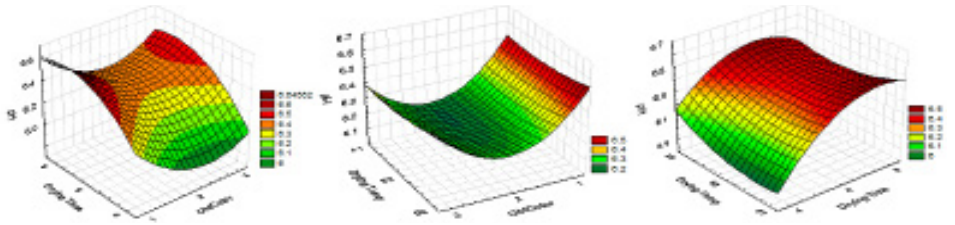


Figure 2. Response surface plots for pH of oyster mushroom powder prepared from different colors of oyster mushroom with varying levels of drying time and drying temperature.

## Color Analysis

The L a b color model is an international standard for measuring color. L values consists of a luminance or lightness ranging from 0-100, a value (from green to red) and b value ranged from blue to yellow (Bautista and Esguerra, 2007).

The color analysis of powdered oyster mushroom is presented in Table 3. The Table shows L value ranged from 47.58 to 72.35. On the other hand, a value ranged from -2.20 to 5.77 while b value ranged from 15.25 to 23.96 with powder made from pink oyster mushroom with 6 hours drying time and 63oC drying temperature the highest. The browning index measures the degree of browning of powdered oyster mushroom after drying. The data revealed that oyster mushroom powder made from gray color mushroom had the lowest browning index value. Statistical analysis however revealed that drying time significantly affected the browning index of oyster mushroom powder.

Table 3. Color analysis of powdered oyster mushroom as affected by varying colors, drying time and drying temperature

| TREATMENT | OM COLOR | DRYING TIME(HRS) | DRYING TEMP(OC) | L | a | b | BI |
|---|---|---|---|---|---|---|---|
| 1 | Gray | 4 | 41 | 47.81 | 2.22 | 15.25 | 42.40 |
| 2 | Gray | 4 | 63 | 68.72 | -1.81 | 18.48 | 26.85 |
| 3 | Gray | 8 | 63 | 72.35 | -2.20 | 18.15 | 24.07 |
| 4 | Gray | 8 | 41 | 47.58 | 2.16 | 15.39 | 42.91 |
| 5 | White | 4 | 41 | 58.83 | 2.95 | 22.66 | 52.88 |
| 6 | White | 4 | 63 | 53.95 | 3.04 | 18.47 | 47.43 |
| 7 | White | 8 | 63 | 73.99 | -0.74 | 22.63 | 33.75 |
| 8 | White | 8 | 41 | 61.99 | 2.42 | 22.83 | 48.83 |
| 9 | Pink | 4 | 52 | 56.92 | 3.57 | 17.22 | 42.20 |
| 10 | Pink | 6 | 63 | 67.96 | 5.77 | 23.96 | 52.34 |
| 11 | Pink | 8 | 52 | 57.12 | 5.02 | 21.27 | 55.66 |
| 12 | Pink | 6 | 41 | 56.49 | 5.39 | 21.17 | 57.01 |
| 13 | White | 6 | 52 | 57.34 | 3.98 | 22.60 | 56.81 |
| 14 | Gray | 6 | 52 | 58.78 | 0.59 | 18.83 | 38.18 |
| 15 | Pink | 6 | 52 | 58.96 | 5.07 | 22.02 | 55.64 |

## Nutritional Content of Oyster Mushroom Powder

The proximate composition of oyster mushroom powder is presented in Table 4. The moisture content of oyster mushroom powder decreased with an increase in drying time and drying temperature with gray oyster mushroom dried for 8 hours at 63oC had the lowest. In contrast, dry matter content of the latter was the highest. In terms of fat content, oyster mushroom powder prepared from white oyster mushroom dried for 4 hours at 63oC had the lowest with a fat content of 0.98 likewise, oyster mushroom powder prepared from white mushroom with drying time of 8 hours and drying temperature of 63oC. Response surface regression analysis for moisture content revealed that color of oyster mushroom and its drying time

significantly affected the moisture content of powder. However, crude fat content was not significantly affected by the three variables considered.

Table 4. Nutritional properties of powdered oyster mushroom as affected by varying colors, drying time and drying temperature

| TREATMENT | OM COLOR | DRYING TIME(HRS) | DRYING TEMP($^{O}$C) | MC (%) | DM (%) | CF (%) |
|---|---|---|---|---|---|---|
| 1 | Gray | 4 | 41 | 23.50 | 76.47 | 1.50 |
| 2 | Gray | 4 | 63 | 14.93 | 85.07 | 1.82 |
| 3 | Gray | 8 | 63 | 8.92 | 91.08 | 2.32 |
| 4 | Gray | 8 | 41 | 25.34 | 74.66 | 1.91 |
| 5 | White | 4 | 41 | 27.52 | 72.48 | 1.66 |
| 6 | White | 4 | 63 | 11.06 | 88.94 | 0.98 |
| 7 | White | 8 | 63 | 9.95 | 90.05 | 3.35 |
| 8 | White | 8 | 41 | 12.71 | 87.29 | 1.77 |
| 9 | Pink | 4 | 52 | 9.13 | 90.87 | 3.31 |
| 10 | Pink | 6 | 63 | 9.56 | 90.44 | 3.17 |
| 11 | Pink | 8 | 52 | 22.67 | 77.33 | 2.58 |
| 12 | Pink | 6 | 41 | 17.71 | 82.29 | 2.72 |
| 13 | White | 6 | 52 | 9.79 | 90.21 | 2.98 |
| 14 | Gray | 6 | 52 | 9.58 | 90.42 | 2.84 |
| 15 | Pink | 6 | 52 | 11.24 | 88.76 | 2.75 |

MC- Moisture Content DM- Dry Matter CF- Crude Fat

**Sensory Evaluation**

Result of the sensory evaluation is presented in Figure 4. Loaf bread prepared with oyster mushroom powder prepared from pink oyster mushroom which was dried for 4 hours at 52oC drying temperature had consistently highest acceptability ratings in terms of appearance, color, aroma, taste, texture, aftertaste and general acceptability while loaf bread prepared from gray oyster mushroom which was dried for 4 hours at 63oC drying temperature had the lowest ratings in terms of color, texture and general acceptability.

Response surface regression analysis ( Table 5) revealed that the appearance of loaf bread with mushroom powder prepared from different colors of Pleurotus ostreatus with varying levels of drying time and drying temperature was significantly affected by drying temperature. Color and texture were not significantly affected by the different variables. Likewise, the square of oyster mushroom significantly affected the aroma, taste and after taste. Loaf bread with powder prepared from pink oyster and dried for 4 hours at 52oC had the highest mean acceptability ratings due to its finer texture and pinkish bread color (Figure 4). On the other hand, the interaction effect between drying time and color of oyster mushroom highly significantly affected the general acceptability.

Table 5. Mean sensory acceptability ratings of loaf bread with mushroom powder

prepared from different colors of Pleurotus ostreatus with varying levels of drying time and drying temperature.

| Trt | A | B | C | Appea | Color rance | Aroma | Taste | Texture | After taste | General Accept. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Gray | 4 | 41 | 7.14 | 7.36 | 6.82 | 7.07 | 6.82 | 6.54 | 7.18 |
| 2 | Gray | 4 | 63 | 6.89 | 6.71 | 6.71 | 6.68 | 6.61 | 6.64 | 6.64 |
| 3 | Gray | 8 | 63 | 6.93 | 7.00 | 7.18 | 7.07 | 7.29 | 7.21 | 7.46 |
| 4 | Gray | 8 | 41 | 7.46 | 7.00 | 7.21 | 7.14 | 7.21 | 7.21 | 7.39 |
| 5 | White | 4 | 41 | 6.82 | 7.04 | 6.39 | 6.50 | 6.46 | 6.32 | 6.96 |
| 6 | White | 4 | 63 | 6.50 | 6.89 | 6.25 | 6.57 | 6.64 | 6.54 | 6.86 |
| 7 | White | 8 | 63 | 7.21 | 7.11 | 6.54 | 6.46 | 6.89 | 6.89 | 7.14 |
| 8 | White | 8 | 41 | 7.50 | 7.46 | 7.04 | 7.54 | 7.46 | 7.11 | 7.71 |
| 9 | Pink | 4 | 52 | 7.89 | 8.04 | 7.36 | 7.75 | 7.46 | 7.57 | 8.21 |
| 10 | Pink | 6 | 63 | 6.61 | 6.86 | 6.61 | 6.61 | 6.64 | 6.93 | 7.32 |
| 11 | Pink | 8 | 52 | 7.43 | 7.25 | 7.11 | 6.79 | 7.14 | 6.96 | 7.39 |
| 12 | Pink | 6 | 41 | 7.50 | 7.71 | 7.39 | 7.14 | 7.36 | 7.14 | 7.61 |
| 13 | White | 6 | 52 | 6.93 | 6.93 | 6.68 | 6.68 | 6.86 | 6.57 | 7.04 |
| 14 | Gray | 6 | 52 | 7.46 | 7.75 | 7.43 | 7.64 | 7.46 | 7.68 | 8.00 |
| 15 | Pink | 6 | 52 | 7.32 | 7.39 | 6.96 | 7.39 | 7.29 | 7.43 | 7.54 |

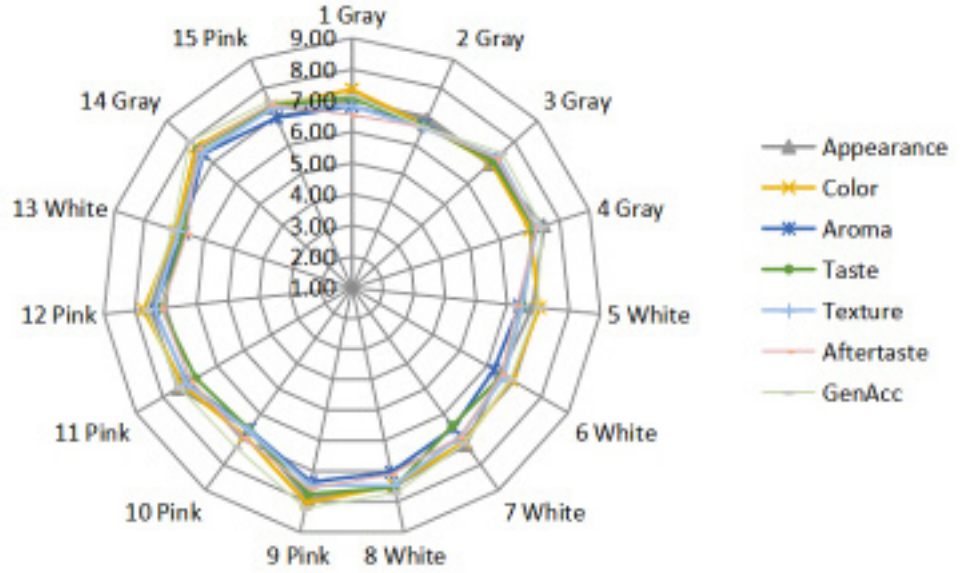



Figure 3. Sensory acceptability of loaf bread with mushroom powder prepared from varying colors, drying time and temperature

Table 6. Summary of effect estimates of sensory attributes of loaf bread prepared from different colors of Pleurotus ostreatus with varying levels of drying time and drying temperature.

| Parameter | EFFECT ESTIMATES | | | | | | |
|---|---|---|---|---|---|---|---|
| | Appearance | Color | Aroma | Taste | Texture | After taste | General Accept. |
| Intercept | 0.9477 | 2.0142 | 1.2011 | -1.9316 | 0.9090 | -1.8726 | 0.3755 |
| OMC | -0.1523 | 0.3146 | -0.6241 | 0.1969 | 0.3622 | -0.4118 | -0.0653 |
| DT | -0.5092 | -0.2180 | 0.2719 | 0.3728 | 0.3015 | 0.6553 | 0.2012 |
| DTEMP | 0.3146* | 0.23414 | 0.2178 | 0.3306* | 0.2621 | 0.2746 | 0.2547 |
| OMC* OMC | 0.2484 | 0.17698 | 0.4559* | 0.3143* | 0.2163 | 0.3778* | 0.2746 |
| DT*OMC | -0.0501 | -0.0676 | -0.0714 | -0.1199* | -0.0886 | -0.1339* | -0.1435** |
| DTE*DT | 0.06151 | 0.016865 | 0.00149 | 0.00893 | 0.00794 | -0.01389 | 0.00645 |
| DTEMP* OMC | -0.0092 | -0.0100 | -0.0155 | -0.0076 | -0.0133 | -0.0056 | -0.0017 |
| DTEMP* DT | -0.0014 | 0.00244 | -0.0016 | -0.0047 | -0.0026 | -0.0030 | 0.0008 |
| DTEMP* DTEMP | -0.0029* | -0.0024 | -0.0019 | -0.0030* | -0.0023 | -0.0024* | -0.0026 |

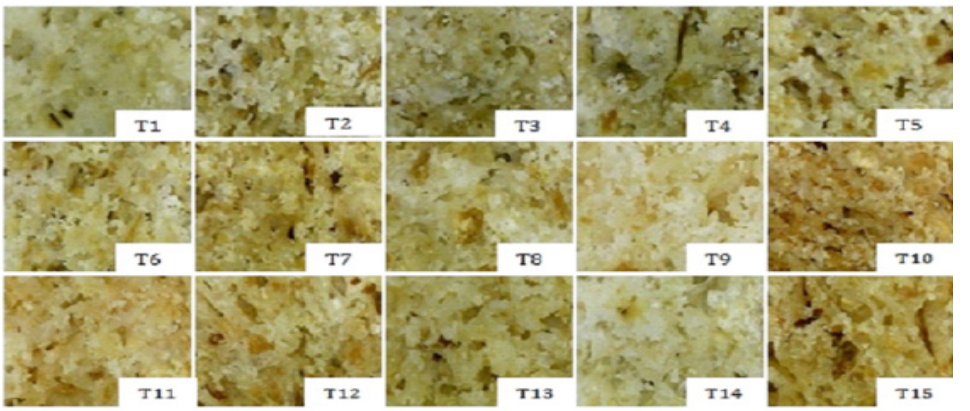



Figure 4. Microstructures of loaf bread with powdered oyster mushroom prepared from different colors of Pleurotus ostreatus with varying levels of drying time and temperature(Magnification: 1000x)

**Bread Height Increase**

The bread height increase of loaf bread with powdered oyster mushroom prepared from different colors of Pleurotus ostreatus with varying levels of drying time and drying temperature is shown in Figure 5 and presented in Table 7. The data shows that loaf bread prepared with pink oyster mushroom powder dried for 8 hours at 52oC had the highest bread height increase.

Response surface regression analysis revealed that bread height increase was significantly affected by the drying temperature and the interaction effect between the drying temperature and oyster mushroom color.

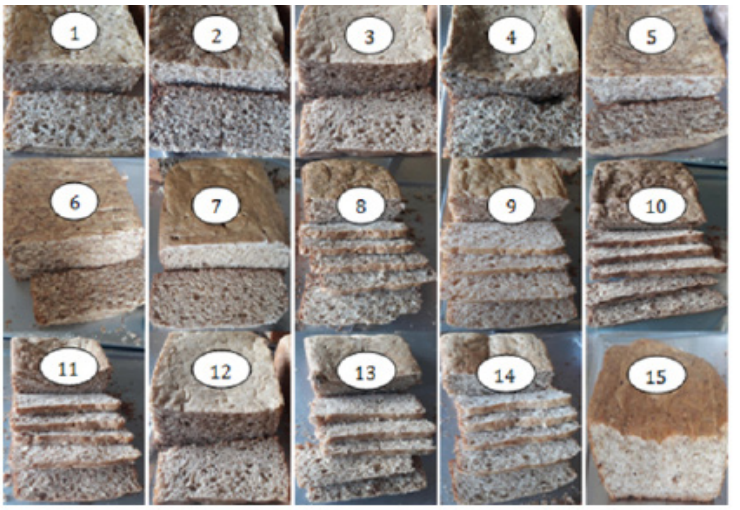



Figure 5. Appearance of loaf bread with oyster mushroom prepared from different colors of oyster mushroom at varying drying time and drying temperatures

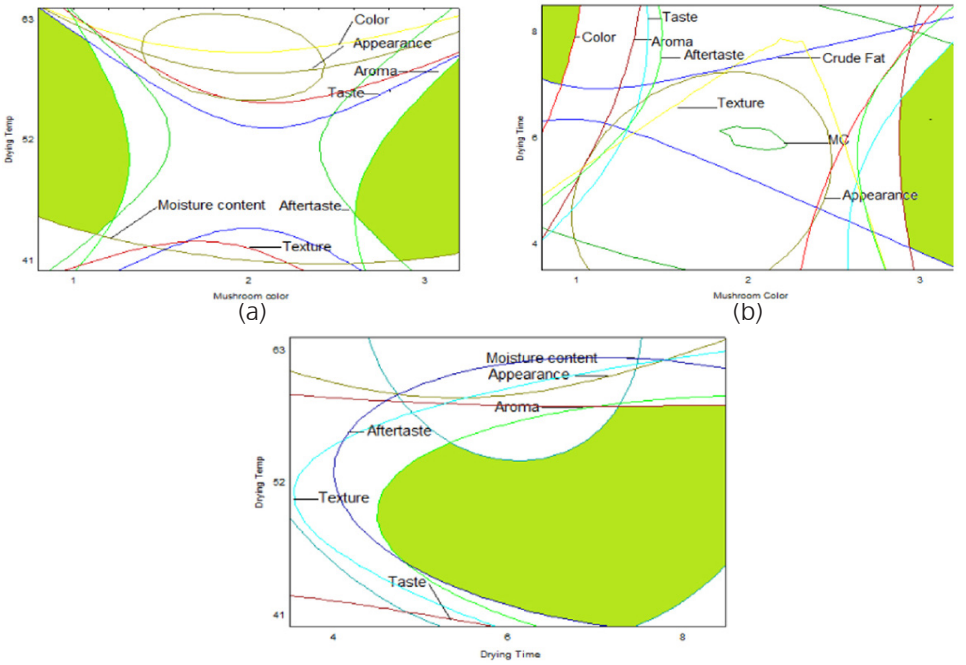
Table 7. Height increase and weight of loaf bread with mushroom powder prepared from different colors of Pleurotus ostreatus with varying levels of drying time and drying temperature

| TREATMENT | OM COLOR | DRYING TIME(HRS) | DRYING TEMP(OC) | Bread Height Increase (%) |
|---|---|---|---|---|
| 1 | Gray | 4 | 41 | 123.15 |
| 2 | Gray | 4 | 63 | 141.68 |
| 3 | Gray | 8 | 63 | 186.31 |
| 4 | Gray | 8 | 41 | 160.59 |
| 5 | White | 4 | 41 | 103.81 |
| 6 | White | 4 | 63 | 117.99 |
| 7 | White | 8 | 63 | 147.01 |
| 8 | White | 8 | 41 | 171.17 |
| 9 | Pink | 4 | 52 | 211.94 |
| 10 | Pink | 6 | 63 | 105.80 |
| 11 | Pink | 8 | 52 | 271.60 |
| 12 | Pink | 6 | 41 | 212.22 |
| 13 | White | 6 | 52 | 159.20 |
| 14 | Gray | 6 | 52 | 204.28 |
| 15 | Pink | 6 | 52 | 80.76 |

**Attaining the Optimum Processing Condition for the Production of Oyster Mushroom Powder**

The optimum processing condition for the production of oyster mushroom powder was determined by superimposing the contour plots of the sensory results and proximate composition. A cut off score of 7.0 for all sensory attributes and 10-20% for moisture content were set. Figure 7 shows the shaded portions of the graph representing the optimum region of the experiment. At constant drying time (Figure 7a), drying temperature ranged from 52 to 63oC while the mushroom color could be gray or pink. However at constant drying temperature (Figure 7b) the optimum was narrowed down to pink oyster mushroom and drying time of 6 to 8 hours while at constant oyster mushroom color (Figure 7c), the optimum was at drying temperature of 520C and drying time of 6-8 hours.

Considering all these conditions, the optimum process for the preparation of oyster mushroom powder for loaf bread production was pink oyster mushroom with 6 hours of drying and 520C drying temperature.




Oyster Mushroom Color: 1- Gray 2- White 3- pink

Figure 6. Optimum region at constant (a) drying temperature, (b) drying time and (c) mushroom color. Cut-off score for sensory attributes 7.0; MC≤10.

## Conclusions

Color of oyster mushroom significantly affected the pH, moisture and crude fat content; drying time significantly affected the moisture, crude fat and browning index while drying temperature significantly affected the bread height increase, appearance and taste of loaf bread.

Loaf bread prepared from pink oyster mushroom powder with 4 hours drying time and 52oC drying temperature had the highest acceptability rating in terms of appearance, color, aroma, taste, texture, aftertaste and general acceptability.

Loaf bread with oyster mushroom powder prepared from pink oyster mushroom with 8 hours drying time and 52oC drying temperature had the highest bread height increase.

The optimum process condition for the preparation of oyster mushroom powder for loaf bread production was pink oyster mushroom with 6 hours of drying and 520C drying temperature .

## Recommendations

Optimize the level of substitution of mushroom powder in loaf bread formulation. Same study be conducted utilizing oyster mushroom powder in other bread products. Conduct physiological test on oyster mushroom powder to determine its antioxidant activity.

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