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Comparison of sterilization methods and bags placement positions on biological and nutritional performance of oyster mushroom

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Abstract

A research study “Comparison of sterilization methods and bags placement positions on biological and nutritional performances of oyster mushroom, was carried out at Nuclear Institute of Food and Agriculture (NIFA) Peshawar during spring, 2014. The experiment comprised of two factors that is sterilization methods (heat & chemical) and bags placement positions (ground, hanging and shelf). Experiment was laid out in completely randomized design (CRD) and was replicated three times. Analysis of variance revealed that sterilizing methods, bags placement positions and their interaction significantly affected the biological and nutritional performances of oyster mushroom. Heat sterilization method caused early spread of mycelia (43.3 days), early pin head development (45.4 days), early days to flowering (50.9 days), maximum mushroom size (22.2 cm), yield (1.8 kg), moisture content (85.4 %), minimum ash (0.7%), protein (3.1 %), fat (0.4 %), fiber (3.7 %) and carbohydrates (6.7 %). Among bag placement method early spread of mycelia (46 days), early Pin head development (48 days), early days to Flowering (53.5 days), maximum mushroom size (23 cm), yield (1.9 kg), moisture content (80.3 %), with lowest ash (0.6 %), protein (2.7 %), fat (0.4 %), fiber (3.5 %) and carbohydrates (6.6 %) were observed in ground bag placement positions. Thus from the present study, it is concluded that heat sterilization method and ground bag placement showed best results and hence recommended to enhance the biological and nutritional performance of Oyster mushroom.

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Introduction

Mushrooms are edible fungi and are cherished all over the world for their unique aroma, texture and nutritional values. These are considered as being rich in protein and having low levels of cholesterol and fats. These also contain amino acids, fiber, vitamins and can be used as a food (Ramzan, 1982). Oyster mushroom is a very famous crop, which may grown by different substrates as a supporting media such as wheat straw, cotton, saw dust and paddy straw. It requires temperature of 23 to 28°C and moisture of 80-85% for spawn running, 12-18°C for pin head development and maturity of fruiting bodies (Bhatti, 1984). *Pleurotus ostreatus* commonly known as Oyster mushroom, is a type of mushroom that is used all over on the earth and can be grown in Asia, India, all countries of Europe and lands of Africa. It species are known as a big source of protein, which ranging between 30- 40%, when dried well (Sharma and Madan 1993).

Mushroom fruiting bodies contain 5-15% dry matter and 19 to 35% protein. They are a big source of vitamins, mostly B₁, B₂, C and D₂ (Manzi, 1999). Apart from this, the mushrooms have high productivity per unit area. The mushroom is considered to be an excellent food source for Pakistan and other third world countries, where the Malnutrition is a problem. The bag placement method is used for Oyster mushrooms cultivation in Zimbabwe, in which bulk substrate of 20-25 kg bag⁻¹ used for cultivation (Tiffin, 2000).

Mushroom cultivation on industrial level can one of the vital options to meet the challenges. Apart from food and nutrition related challenges, utilization of crop residues is another challenge. Mushroom being an edible fungus has the capability of converting lignocelluloses wastes into protein containing hygienic food through natural recycling. In addition to sufficient amount of digestible protein it is low in calories. It contains non-starch polysaccharides and good source of total dietary fiber (TDF), which is the sum of the non-digestible carbohydrates, called chitin (Vetter, 2007).

Oyster mushroom production now a day's carried on many substrates such like wheat straw, paddy straw, sugarcane bagasse, rice bran etc. Oyster mushroom is well adopted mushroom, because of its strong genetic ability towards formation of different types of organic substances (Tajudeen, 2012).

The world's present annual production of mushrooms is around 1.5 million tons. Pakistan's export of mushroom to Europe is about 90 tons (Shah *et al.*, 2004).

The Oyster mushroom cultivation has been recorded various treatment application in order to destroy the harmful pathogen and promote mycelia growth (Chang, 2008). Different sterilization methods can be used for cultivation of oyster mushroom production and its yield improvement (Khan, 2002). Normally the sui gas and wooden fuel is used to sterilize the substrate for mushroom cultivation which are sometime unavailable or costly for the growers. In order to find some alternate and economical method of sterilization, this study was done to explore the techno-economical feasibility of two sterilization methods. Keeping in view, the nutritional and economic importance of mushroom, the present study was carried out with the following objectives. To find out the suitable and economical method of compost sterilization in oyster mushrooms. To compare growth and nutritional parameters of mushroom on sterilization (heat, chemical) and bag placement methods.

Materials and methods

An experiment was conducted under controlled environment (lab condition) at Nuclear Institute of Food and Agriculture (NIFA) Peshawar during spring season 2014. The experiment was laid out in Randomized Complete Design (CRD) and was replicated three times. The experiment was comprised of two sterilization methods (Heat sterilization, Chemical sterilization) and three bags placement positions (hanging, ground and shelf bags). The Material used in experiment for Oyster Mushroom cultivation includes. Wheat straw as substrate, Drum, Transparent Plastic bags.

*Factor A**Sterilization Methods*

Two methods of sterilization were used during experiment.

i. Heat Sterilization

Water was boiled in a steel drum and the filled bags of substrate were kept in the hot water for about 30 minutes at 100°C. After heat sterilization, the bags were taken and placed on plastic sheet for cooling at room temperature. When the heat sterilized substrate was cooled down at ambient condition, then spawning were made. The substrate moisture content was about 70% during growth.

ii. Chemical Sterilization

Wheat straw (substrate) was dipped in 10% formalin solution for half an hour, which killed all pathogen, which may cause infection to bags. Thus fill wheat straw with normal spawn, bag made of transparent plastic (both in form of Square and cylindrical) were used for its cultivation.

*Factor B (bag placement)**Bags Placement positions*

Both heat and chemical sterilized bags were placed in three ways.

Hanging bags

Substrate and spawn was filled in plastic bags and hang in Mushroom farm. Humidity was between 80 to 90% and room temperature 12 to 35°C during experiment.

Ground bags

Substrate and spawn were filled in plastic bags and kept on ground. Temperature ranging from 12 to 35°C and 80 to 90% humidity.

Shelf bags

Spawned compost bags were placed on shelves and temperature ranging from 12 to 35°C and 80 to 90% humidity.

*Parameters Studied**A) Growth Parameters**Early Spread of Mycelia (days)*

Early spread of Mycelia was counted in days and their average was calculated.

Pin head development (days)

After mycelia growth, duration of pin head development was recorded and their average was calculated.

Flowering (days)

Duration of flowering and its average was calculated.

Size of mushrooms (cm)

Size of oyster mushroom was recorded in all treatments and their average was noted.

Yield (kg)

Yield was recorded in all treatments and their average was noted.

B) Nutritional Parameters

Following parameters was tested

Determination of Moisture (%)

Moisture (%) was recorded in all treatments and their average was measured.

Moisture was determined by using following formula:

$$\% \text{Moisture} = \frac{\text{loss in weight sample}}{\text{weight of sample}} \times 100$$

Total Protein (%)

Protein (%) was recorded in all treatments and their average was measured

$$\% \text{N} = \frac{\text{titre-blank} \times \text{normality} \times 0.014}{\text{weight of sample}} \times 100$$

Crude fat (%)

Fat (%) was recorded in all treatments and their average was measured

Crude fat was tested by following formula:

$$\% \text{Crude fat} = \frac{\text{weight of ether extract}}{\text{weight of sample}} \times 100$$

Total ash (%)

Ash (%) was recorded in all treatments and their average was measured

Calculate the percent ash by following formula.

$$\% \text{ Ash} = \frac{\text{weight of ash}}{\text{weight of sample}} \times 100$$

Crude fiber (%)

Fiber (%) was recorded in all treatments and their average was measured

Finally weigh the samples again and percent fiber by the following formula.

$$\% \text{ Crude fiber} = \frac{W_1 - W_2}{W_0} \times 100$$

Total Carbohydrates (%)

Carbohydrates (%) was recorded in all treatments and their average was measured was tested by following formula.

$$\% \text{ Carbohydrates} = 100 - \% \text{ Fat} + \% \text{ Ash} + \% \text{ Protein} + \% \text{ Fiber} + \% \text{ Moisture}$$

Statistical analysis

An experiment done on two factor factorial Randomized Complete Design .To study the effect of three Bags placement and two sterilization methods on the yield of Oyster Mushroom in RCD with Three Replications. The data collected was analyzed statistically through M. Statistics package and (0.05%) Least Significant Difference (LSD) test was used for any significant difference among the factors.

Results and discussions*Growth Parameters**Early Spread of Mycelia (days)*

The data regarding early spread of mycelia is given in Table 1. The statistical analysis showed that both sterilization methods, bags placement methods significantly affected the early spread of mycelia and their interaction was no significant affect on early spread of mycelia.

In sterilization methods, early spread of mycelia (43.33 days) were recorded in heat sterilization methods, while late spread of mycelia (53 days) were noted in chemical sterilization methods.

The early spread of mycelia in heat sterilization methods might be due to the killing of microorganisms which would delay the spread of mycelia. Iqbal (2005) reported that spawn running completed on sugarcane bagasse 20, 37 and 20 days, respectively in local, exotic varieties of *Pleurotus ostreatus* and *Pleurotus sajarcaja* follow the cotton waste. Best period was required by the substrate of wheat straw for all the test types. It was 41, 46 and 43 days, respectively.

Among Bags placement methods, early spread of mycelia (46 days) was recorded in bags which were placed on ground, while late spread of mycelia (50.5 days) were noted in bags kept on shelf. In case of interaction the maximum value 55 was noted for shelf and chemical combination and minimum value 41 for Heat sterilization method with ground bag placement method. The result is in agreement with findings of Iqbal *et al.*, (2005) which reported those 37 days for colonization completion in exotic strains of *mushroom* on sugarcane bagasse.

Table 1. Duration of Early spread of Mycelia (days) as affected by sterilization and bag placement positions.

| Treatment | Bags Placement | | | Mean |
|---------------------------|------------------|-------------------|-----------------|--------|
| | Ground (days) | Hanging (days) | Shelf (days) | |
| Heat sterilization | 41 | 43 | 46 | 43.33b |
| Chemical sterilization | 51 | 53 | 55 | 53 a |
| Mean | 46 c | 48 b | 50.5 a | |

LSD for sterilization methods = 0.86, LSD for bags placement methods = 1.05

LSD for sterilization x bags placement methods = 1.49

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Pin Head Development (days)

The data regarding pin head development is given in Table 2. The statistical analysis showed that both sterilization methods, bags placement methods was significantly affected the pin head development and their interaction was no significant affect on pin head development.

In sterilization methods, early pin head developments (45.44 days) were recorded in heat sterilization methods, while late pin head development (55 days) were noted in chemical sterilization methods. The early pin head developments in heat sterilization methods might be due to the killing of microorganisms which would delay the pin head development. Iqbal, (2005) observed that time taken for first appearance of pin head after spawning of the substrate was 16, 18 and 23 days, respectively in the local and exotic strains of *Pleurotus ostreatus* and *Pleurotus sajarcaju*. It was followed by cotton waste i.e., 27, 33 and 32 days, respectively for the test species. Maximum time (43.7, 49 & 46.3 days) was taken in case of wheat straw.

Among Bags placement methods, early pin head development (48 days) was recorded in bags which were placed on ground, while late pin head developments (52.5 days) were noted in bags kept on shelf. In case of interaction the maximum value 57 days was noted for shelf and chemical combination and minimum value 43 days for Heat sterilization method with ground bag placement method. The result is in agreement with findings of several workers reported different timings for pin head formation of different mushroom species. For example, Rangaswami *et al.*, (1975) reported pin heads of *P. sajarcaju* in 20-25 days after inoculation. Khan *et al.*, (1981) got pin heads of *P. ostreatus* (Strain,-467) in 36 days, the same of *P. sajarcaju* and *P. ostreatus* in 40 and 46 days, after spawning. Tan, (1981) got fruiting bodies after 23-26 days. Ramzan, (1982) obtained pin heads of five strains of *P. ostreatus* on two substrates. Wheat and rice straw between 20-40 days Mehdi, (2013) recorded 20-24 days on paddy straw.

Table 2. Duration of Pin head development (days) as affected by sterilization and bag placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|------------------|-------------------|-----------------|---------|
| | Ground (days) | Hanging (days) | Shelf (days) | |
| Heat sterilization | 43 | 45.33 | 48 | 45.44 b |
| Chemical sterilization | 53 | 55 | 57 | 55 a |
| Mean | 48 c | 50.17 b | 52.5 a | |

LSD for sterilization methods = 0.81, LSD for bags placement methods = 0.99

LSD for sterilization x bags placement methods = 1.49

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Flowering (days)

The data regarding flowering is given in Table 4-3. The statistical analysis showed that both sterilization methods, bags placement methods and their interaction significantly affected the flowering.

In sterilization methods, early flowering (50.89 days) was recorded in heat sterilization methods, while late flowering (60 days) were noted in chemical sterilization methods. The early flowering in heat sterilization methods might be due to the killing of microorganisms which would delay the pin head development. The result is in agreement with findings of Iqbal, (2005) observed that time taken of flowering after spawning of the substrate was 53.3 days strains of *Pleurotus ostreatus* (local) while in *Pleurotus ostreatus* (exotic) taken 58.3 days.

Table 3. Duration of Flowering (days) as affected by sterilization and bag placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|------------------|-------------------|-----------------|----------|
| | Ground (days) | Hanging (days) | Shelf (days) | |
| Heat sterilization | 49 | 51.33 | 52.33 | 50.889 b |
| Chemical sterilization | 58 | 60 | 62 | 60.000 a |
| Mean | 53.500 c | 55.667 b | 57.167 a | |

LSD for sterilization methods = 0.46, LSD for bags placement methods = 0.56

LSD for sterilization x bags placement methods = 0.79

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Among Bags placement methods, flowering (53.5 days) was recorded in bags which were placed on ground, while late flowering (57.17 days) were noted in bags kept on shelf. The interaction was no significant affect on duration of flowering. The maximum value 62 days was noted for shelf and chemical combination and minimum value 49 days for Heat sterilization method with ground bag placement method.

The result is in agreement with findings of Shah *et al.*, (2004) stated that Saw dust wheat straw, sawdust+ leaves, sawdust, wheat straw+ leaves, wheat straw and Leaves were completed fruiting body formation 27,27, 35, 28.33, 33.67, 27 and 34 days respectively.

Size of Mushrooms

The data regarding size of mushroom is given in Table 4. The statistical analysis showed that both sterilization methods, bags placement methods significantly affected the size of mushroom while their interaction was no significant affect on size of mushroom.

The sterilization method indicated that the maximum time was taken mushroom when that exposed with heat sterilization method that is 22.222 cm, while the minimum 20.333 cm were taken in chemical sterilization method.

Table 4. Size of mushroom as affected by sterilization and bag placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|----------------|--------------|------------|---------|
| | Ground (cm) | Hanging (cm) | Shelf (cm) | |
| Heat sterilization | 24 | 22 | 20.67 | 22.22 a |
| Chemical sterilization | 22 | 21 | 18 | 20.33 b |
| Mean | 23 a | 21.5 b | 19.33 c | |

LSD for sterilization methods = 1.01, LSD for bags placement methods = 1.23

LSD for sterilization x bags placement methods = 1.75

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

In case of Bags placement methods mean the highest 23 cm value was observed for ground and the lowest 19.333 cm found for shelf. In case of interaction, there was no significant affect of interaction on size of mushroom. The maximum value 24 cm was noted for ground and heat sterilization method combination and minimum value 18 cm for chemical sterilization method with shelf bag placement method.

The result is in agreement with findings of Rina, (2012) observed that, the significant differences of size of mushroom cap as affected by experimental treatments consisted of PDA and leguminous trees F1 based substrates as culture media for mother and planting spawn of *V. volvacea*. (PDA) based substrate was 10.59 cm, Morunga based substrate 11.12 cm and Madre de cacao based substrate 8.76 cm.

Yield

The data regarding yield is given in Table 5. The statistical analysis showed that both sterilization methods, bags placement methods were significantly affect the yield while their interaction was no significant affect on the yield.

The highest mean was obtained from heat sterilization (1.8 kg) and lowest from chemical sterilization (1.41kg) Bags Placement has also a significant effects on the yield of Oyster mushroom, maximum (1.93) yield obtain from ground bag placement and minimum yield value from shelf bag placement method (1.65). In case of interaction, no significant affect on yield of oyster mushroom. The result is in agreement with findings of Mehdi, (2013) revealed that the oyster mushroom grown on wheat straw showed low result that was 1238.2kg and barley was highest 1388.3 kg. Smita (2011) recorded that the significant difference between 6, 8 and 10 was not found and at 8 percent showed maximum biological efficiency. Spawning rate speeding the colonization and improved yield.

Table 5. Yield kg⁻¹ of Oyster Mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement Method | | | Mean |
|------------------------|-----------------------|---------|-------|-------|
| | Ground | Hanging | Shelf | |
| Heat sterilization | 2.07 | 2.03 | 1.30 | 1.8a |
| Chemical sterilization | 1.80 | 1.40 | 1.03 | 1.41b |
| Mean | 1.93a | 1.71b | 1.65c | |

LSD for sterilization methods = 0.23, LSD for bags placement methods = .013

LSD for sterilization x bags placement methods = 0.19

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Nutritional Parameters

Fresh and dried mushroom samples were tested for moisture, Ash, Protein, Fat, Fiber and Carbohydrates content using various formulas given in materials and methods.

Moisture (Contains)

The data regarding Moisture is given in Table 6. Statistical Analysis showed that percent moisture is significantly affected by Sterilizing methods and bag placement methods. The interaction between them was also significant.

The sterilization method means indicated that the maximum moisture (85.43 %) was recorded in mushroom when exposed to heat sterilization, while the minimum moisture percentage (80.33 %) were found in chemical sterilization method.

In case of Bags placement methods the highest moisture (86.48 %) was observed in ground bag placement method and the lowest moisture (80 %) was found in shelf bag placement. In case of interaction the maximum Value for moisture (90.63 %) was noted with ground bag placement method and was heat sterilization method, while minimum moisture (79 %) was recorded in shelf bag placement method with chemical sterilization method.

Table 6. Moisture (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|----------------|-------------|-----------|---------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 90.63 a | 82.33 c | 84.67 b | 85.43 a |
| Chemical sterilization | 79.67 | 81. d | 79 e | 80.33 b |
| Mean | 86.48 a | 82.17 b | 80 c | |

LSD for sterilization methods = 0.52, LSD for bags placement methods = 0.64,

LSD for Sterilization Methods x Bags Placement Methods = 0.91

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Abrar, (2009) reported that the moisture percentage value was 92.45% and percent fiber 8.10% was highest in paddy straw while protein level shown best value 23.5% in soybean straw. Soybean and paddy straw combination result were best in fat (2.60%). Shah (2011) stated that moisture content in grey mushroom on wheat straw was reported 87.5% as compare to paddy straw was 77.5%. Pink mushroom result on wheat straw was 92%, it remain higher.

Ash (Contains)

The data regarding Ash % is given in Table 7. Statistical Analysis showed that sterilizing methods, bags placement methods and their interaction all significantly affected the Ash % of oyster mushroom. The sterilization method means indicated that the maximum percent was taken mushroom with chemical sterilization method that is 0.76%, while the minimum 0.67% percent value was observed in heat sterilization method.

In case of Bags placement methods mean the lowest 0.63 % value was observed for ground and the highest 0.78 % found for shelf. In case of interaction the minimum value 0.65 % was noted for ground and heat sterilization method combination and maximum value 0.77 % for chemical sterilization method with shelf bag placement method.

Table 7. Ash (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|----------------|-------------|-----------|--------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 0.5 b | 0.77 | 0.7 a | 0.67 b |
| Chemical sterilization | 0.73 | 0.8 a | 0.77 a | 0.76 a |
| Mean | 0.63 b | 0.72 ab | 0.78 a | |

LSD for sterilization methods = 0.09, LSD for bags placement methods = 0.10

LSD for sterilization x bags placement methods = 0.15

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Shah (2011) revealed a result which showed the total Ash found in grey mushroom on wheat straw was 81.8 (g/100) that on paddy straw recorded 57.3 gm/100. Pink mushroom resulted 7.4 gm/100 by wheat straw was and that was 47.3gm/100 on paddy straw. Sharma, (2013) stated that ash percent was 7.69% in wheat and rice mix straw while highest 10.34% in rice straw and paper.

Protein (Contains)

The data regarding Moisture is given in Table 8. Statistical Analysis which reported that sterilizing methods was no significant effect on protein while bags placement methods and their interaction all significantly affected the Protein %. The sterilization method means indicated that the maximum percent was found out in mushroom with heat sterilization method that is 3.09%, while the minimum 3.07% were taken in chemical sterilization method. In case of Bags placement methods mean the lowest 2.73 % value was observed for ground and the highest 3.4% found for shelf.

Table 8. Protein (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean (%) |
|------------------------|----------------|-------------|-----------|----------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 2.57 c | 3.1 b | 3.6 a | 3.09 |
| Chemical sterilization | 2.9 bc | 3.1 b | 3.2 b | 3.07 |
| Mean | 2.73 c | 3.1 b | 3.4 a | |

LSD for sterilization methods = 0.21, LSD for bags placement methods = 0.26

LSD for sterilization x bags placement methods = 0.37

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

In case of interaction the minimum value 2.57 % was noted for ground and heat sterilization method combination and maximum value 3.6 % for heat sterilization method with shelf bag placement method. Shah, (2011) observed that the protein percentage in mushroom significantly affected by paddy straw.

Amount of protein in wood scarp was 21 mg/ml and protein contain for wheat straw from the graph was 15 mg/ml. Abrar, (2009) studied that moisture (92.45%) and fiber content (8.10%) were highest in paddy straw while maximum protein level (23.5%) in soybean straw. Soybean and paddy straw combination result were best in fat (2.60%). Sharma *et al.*, (2013) studied that protein content was 25.38% in wheat and rice mix straw and best was 24.72% rice straw and paper.

Fat (Contains)

The data regarding Fat % is given in Table 9. Statistical Analysis that sterilizing methods, bags placement methods affect significantly fat percent while their interaction was no significant affect on the Fat percentage. The sterilization method means indicated that the maximum percent was taken mushroom when that exposed with chemical sterilization method that is 0.4 %, while the minimum 0.57 % were taken in heat sterilization method. In case of Bags placement methods mean lowest the 0.38 % value was observed for ground and the highest 0.58 % found for shelf. In case of interaction the minimum value 0.23 % was noted for ground and heat sterilization method combination and maximum value 0.6 % for chemical sterilization method with shelf bag placement method. Abrar, (2009) revealed the percent moisture (92.45%) and fiber percent value (8.10%) and concluded that both was highest in paddy straw while best protein percentage (23.5%) in soybean straw.

Soybean and paddy straw combination result were best in fat (2.60%). Shah, (2011) worked on fat content of mushroom and tested that the amount of fat in grey mushroom wheat straw was 0.710gm and it was reported 1.27gm in paddy straw. The pink mushroom 2gm in wheat straw which suggest best evaluation. Martinez-Carrera (2000) stated that moisture, ash, fat, Carbohydrates, Protein were 81.8%, 15.2%, 1.8%, 29.9%, 29.9 and 21.5% respectively. Sharma, (2013) stated that Fat % was 1.03% in wheat and rice mix straw while highest was 1.03% rice straw and papper.

Table 9. Fat (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|----------------|-------------|-----------|--------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 0.23 | 0.4 | 0.57 | 0.4 b |
| Chemical sterilization | 0.53 | 0.57 | 0.6 | 0.57 a |
| Mean | 0.38 b | 0.48 ab | 0.58 a | |

LSD for sterilization methods = 0.19, LSD for bags placement methods = 0.12

LSD for sterilization x bags placement methods = 0.17

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Fiber (Contains)

The data regarding fiber % is given in Table 10. Statistical Analysis showed that Sterilizing methods, bags placement methods and their interaction was no significant affect on the Fiber %. The sterilization method means indicated that the maximum time was taken mushroom when that exposed with chemical sterilization method that is 3.75 %, while the minimum 3.67 % were taken in heat sterilization method.

In case of Bags placement methods mean the highest 3.95 % value was observed for shelf and the lowest 3.46 % found for ground. In case of interaction the maximum value 3.9 % was noted for chemical sterilization method with shelf bag placement method and minimum value 3.27 % for ground and heat sterilization method combination.

Shah, (2011) done research on fiber content of mushroom and result 0.81gm gave grey mushroom on wheat straw. It was higher in Pink mushroom recorded 1.260gm fiber. Sharma (2013) stated that fiber % was 13% in wheat and rice mix straw while highest was 12% rice straw and papper. Abrar, (2009) studied that moisture (92.45%) and fiber content (8.10%) were highest in paddy straw while maximum protein level (23.5%) in soybean straw. Soybean and paddy straw combination result were best in fat (2.60%).

Table 10. Fiber (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean |
|------------------------|----------------|-------------|-----------|------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 3.27 | 3.75 | 4 | 3.67 |
| Chemical sterilization | 3.65 | 3 | 3.9 | 3.75 |
| Mean | 3.46 | 3.72 | 3.95 | |

LSD for sterilization methods = 0.45, LSD for bags placement methods = 0.55

LSD for sterilization x bags placement methods = 0.78

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Carbohydrates (Contains)

The data regarding Carbohydrates % is given in Table 11. Statistical Analysis shown that Sterilizing methods, bags placement methods and their interaction all significantly affected the carbohydrates percent of oyster mushroom. The sterilization method means indicated that the maximum time was taken mushroom when that exposed with heat sterilization method that is 11.83 %, while the minimum 6.73 % were taken in chemical sterilization method. In case of Bags placement methods mean the highest 11.58 % value was observed for shelf and the lowest 6.57 % found for ground. In case of interaction the maximum value 12.84 % was noted for chemical sterilization method with shelf bag placement method ground and heat sterilization method combination and minimum value 2.67 % for ground and heat sterilization method combination.

Shah, (2011) stated that Carbohydrates content was found in wood scarp 86.6(g/100g) and wheat straw was 66.7(g/100g). Sharma, (2013) stated that Carbohydrates % was 30.25% in wheat and rice mix straw while highest was 32.650% rice straw and papper. Martinez-Carrera, (2000) stated that moisture, ash, fat, Carbohydrates, Protein were 81.8%, 15.2%, 1.8%, 29.9%, 29.9 and 21.5% respectively.

Table 11. Carbohydrates (%) content of Oyster mushroom as affected by sterilization and bags placement positions.

| Treatment | Bags Placement | | | Mean (%) |
|------------------------|----------------|-------------|-----------|----------|
| | Ground (%) | Hanging (%) | Shelf (%) | |
| Heat sterilization | 2.67 e | 7.2 d | 10.33 c | 6.73 b |
| Chemical sterilization | 10.48 c | 12.19 b | 12.84 a | 11.83 a |
| Mean | 6.57 c | 9.69 b | 11.58 a | |

LSD for sterilization methods = 0.23, LSD for bags placement methods = 0.29

LSD for sterilization x bags placement methods = 0.40

Values followed by different letters are significantly different at 0.05% level of probability using least significant difference (LSD) test.

Conclusions

During the experiment the heat treatment method showed best result as compared to chemical treatment. Similarly the ground bag placement position proved better than the hanging bags, and shelf bags placement positions. The combination of heat sterilization method and ground bags placement position has significant impact on the biological and nutritional performance of Oyster mushroom. Heat sterilization and ground bag placement position combination can increase the yield of Oyster mushroom, resulting in the increased growth and productivity. Hence Combination of heat treatment and ground bag placement is recommended for best production of Oyster Mushroom. Further research is needed.

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