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Effect of Different Agro-wastes Substrates on the Growth and Productivity of the Oyster Mushroom in Upper Egypt

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A B S T R A C T

Pleurotus cystidiosus (Oyster mushroom) was grown using various agro-wastes substrate as: sugarcane (ScB), wheat straw (WS) and rice straw (RS), The ScB, RS and WS agro-wastes substrates were selected as the most favorable lignocellulosic sources. *P. cystidiosus* can efficiently degrade the agro-wastes and grow at wide range of temperatures. The effects of growing the type of Oyster mushroom on agro-wastes as substrates were chosen through evaluating the parameters in the growing mycelium including carbohydrates, protein, fiber, moisture, fat, ash, and minerals. The WS showed the highest yield (97% Bio efficiency), maximum crude protein (23%), and phosphorus content of (890 mg/ 100 g of dry mushroom). The ScB recorded minimum moisture (88%) and crude fiber content (9%). However, the maximum moisture (91%) and highest fruiting bodies size (10 cm) are recorded on RS cultivation. The combination of substrates formula ScB+ WS+ RS expressed the highest carbohydrate content (58 %), ash (7.1%), phosphorus (585 mg/ 100g of dry mushroom), and calcium (320 mg/ 100g of dry mushroom) content. Finally, we concluded that the *P. cystidiosus* of Upper Egypt can be cultivated under temperature variation and substrates mainly on WS, then RS, and ScB. The aim of the current research was studying the effect of the agro-wastes substrates and some nutritional conditions on the mycelial growth of *P. cystidiosus*, during winter season in the Upper Egypt.

Introduction

Recently, the problem of wastes accumulation and the challenges of food production are the most important problems facing the world, especially with the interest of growing and environmental awareness. There is a great interest to biodegradation of the agricultural wastes in the developing countries. In addition, all the cellulosic residues of the fields are currently used along with the other food wastes to increase the development and production of mushrooms. After *Agaricus bisporus, Pleurotus cystidiosus* is the most widely grown mushroom in the world (Kues & Liu, 2000). The Upper Egyptian region is the most popular and widely cultivated region for *P, cystidiosus.* The conditions of the Upper Egypt region mainly high temperature are suitable for *P. cystidiosus* growth, in addition to the technology that is low-cost and biologically-efficient (Mane *et al.,* 2007). *P. cystidiosus* (Family Tricholomataceae) composed of about fourty species that are cultivated in different parts of Egypt. It can grow well on different types of lignocellulosic substrates and at different temperature conditions. Chang *et al.* (1989) reported that *P. cysticidiosus* grows well throughout the year in a variety of tropical regions and ranks next to *A, bisporus* as one of the world's most productive and profitable mushrooms. Jandiak *et al.* (1995) reported that As an efficient degrader of lignin, *P. cystidiosus* grownup on a vast array of farming wastes as well as at a wide range of temperatures. This Oyster mushroom has high economical and medicinal values, due to its chemical composition and\or nutrition. As powerful antioxidants, oyster mushrooms play an important role in medicine (Li *et al.,* 2007). When experimentally induced diabetics are treated with *P. cystidiosus*, hypoglycaemia is accentuated (Chorvathova *et al.,* 1993). As a result of its ability to colonize and degrade a wide variety of lingocellulosic materials and other waste products, oyster mushrooms are widely used in agriculture, forest products, and food processing (Gracha *et al.,* 1993). Previously, Tesfaw *et al.,* (2015) pointed out that it contains 91% of water and 10% of dry matter; in addition, its nutritional value can be compared with milk, eggs and meat. Kurtzman, (1967); Hayes Haddad, (1976); Szabova *et al.,* (2013) added that Oyster mushroom is rich in organic components including: vitamins (thiamine, riboflavin, folic and niacin), proteins and minerals, and is believed as intermediary of vegetables and animals. Moreover, all nine amino acids are present in it. Mushrooms of this type contain a high potassium-to-sodium ratio, so they are ideal for treating hypertension and heart disease (Dehariya *et al.,* 2013). According to Bano *et al.,* (1993); Cohen *et al.,* (2002), in order to degrade agro-lignocellulosic wastes, oyster mushrooms are the most viable and economic method. By using these biodegradable technologies, we can also reduce air pollution and environmental pollution caused by burning agriculture waste. The purpose of the current study was to determine the optimal nutritional conditions for the development and production of oyster mushrooms in Upper Egypt under the conditions described above.

Materials and Methods

Substrate preparation and inoculation

Two agro wastes substrates including (ScB) and (WS) were obtained from Qena governorate farms, Egypt. The RS and WS were dried and made into pellets (0.5-2 cm in length), followed by soaking in water over 2 h. For the purpose of determining the most suitable substrates for mushroom cultivation, three substrates were tested: RS, WS, and ScB, while the next substrate combination was prepared with the total combination at a proportion of 1:1, following the method of

Bano *et al.,* (1982) with slight modifications. Inoculating the bags with mushroom spawn was done in three replicates for each substrate formula.

Mushroom spawn cultivation

Sterilized agro-substrates were packed into polyethylene bags of 30 x 50 cm, and multilayered techniques were applied to the growth of mushroom spawns (Baysal *et al.,* 2003). About 5 kg of dry substrate was filled in each bag. To maintain 25 °C and 80-90% humidity in the greenhouse, the bags were inoculated with spawn and kept for 20 days under sufficient light. The polyethylene bags were tear-off after the incubation period, and the spawn runs was completed within 18 d. It took 35 days after spawning for the third flush to be harvested.

Biological efficiency and moisture content

Mushroom yield was calculated by adding the weights of all the fruiting bodies collected from all three pickings. The biological efficiency (B.E.) was calculated adopting the following formula (Chang *et al.*, 1981):

B.E. (%) = (Fresh mushroom wt./Dry substrate wt.) × 100

Based on the data presented by Syed et al (2009), the moisture content (MC) of mushrooms was calculated and also expressed as percentage:

M.C (%) = (Fresh wt. of mushroom – wt. of mushroom/ Fresh wt. of mushroom) × 100

Analysis of nutrients

The protein, total carbohydrates, fat, ash and content were established by procedure mentioned by Wankhede *et al.,* (1976); AOAC. (1995). The crude fibers and Ca were established according to Ranganna, (1986). Whereas the mineral contents (K, Mg and Zn) were analyzed by the flam and spectrophotometer in reference to Ezeibekwe *et al.,* (2009), after extraction of the elements in 0.1N HCl acidic solutions.

Mushroom incubation and harvest

According to Tesfaw *et al.,* (2015), the substrates which inoculated were reserved in incubator at 28ºC & 70-80% humidity (RH) underneath darkness conditions. When surface was covered entirely with the mushroom mycelium, they transfer to an incubator at 24ºC and kept at RH of about 90% or above.

After harvest, the length (mm), diameter of cap (cm), and weight (g) were measured, along with the means. In order to calculate the total yield and B.E., these accumulated data were used.

Statistical analysis

There were three replicates in each experiment that were randomized complete block designs.

To compare the mean significant differences (p0.05) among the treatments, ANOVA was performed using Duncan's multiple range tests to determine whether there was a significant difference in the amount of changes between the two treatments.

Results and Discussion

There are differences recorded concerning the cap diameter of *P. cystidiosus* growth the different substrates' formula (Table 1). The cap diameter is the highest (10 cm) on RS and substrate formula Ws+ Rs, conversely the lowest cap diameter (8 cm) is recorded on using ScB. The WS is recorded to be the

superior over other agro-wastes in mushroom production parameters in agreement with Philippoussis, (2003). Moreover, mixing the agro-wastes at different ratios enhanced productivity. Figure 1 demonstrates that the lengths of the Oyster mushrooms steps are changed with the use of the different agro-waste substrates. The stipe length ranged from 32- 43 mm, while the lowest stipe (32 mm) is recorded on using the substrate formula RS+ ScB (Table 1). The values of the stipe lengths of the Oyster mushroom grown on the different substrate formulas are almost the same or lower than those of other experimental substrates (ScB, RS and WS agro-wastes), while the thickness values are the same or higher, according to Dehariya *et al.*, (2013).

The data in Table 2 show that the fresh weight of each picking of the Oyster mushrooms on the lignocllulosic agro-wastes WS- Rs- ScB substrates is lower than that of the other substrate formulas. The total yields of the Oyster mushroom on using the formula of Ws+ RS+ ScB are of good remarkable quantities. The WS presents the maximum number of fruiting bodies and fresh weights, followed by ScB, whereas the lowest number is recorded by RS. These variations are probably attributed to the difference of the bulk density and constituents of the agro-waste substrates. The yields of mushroom are correlated positively with the cellulosic content, but negatively with the lignin and phenoloic contents, in agreement with the findings of Sivaprakasm (1986).

The maximum yield of *P. cystidiosus* is obtained on using WS (970 g/ 5kg straw) with B.E. of 97%, followed by the yield on WS+ ScB (850 g/ 5kg straw) with B.E. of 85%, while the least yield is recorded on using WS+ RS agro-waste (770 g/ kg straw).

The maximum moisture content is recorded using the ScB (91%), followed by WS (90%). It is noteworthy, however, that moisture content differs slightly between the other substrates. As evidence of their performance, the three substrates also had elevated B.E. values when the WS was used, followed by the RS (Table 2). In WS, the RS or RS combination always precedes the harvested fruiting body harvest time. Variable levels of B.E. have been observed when *P. cystidiosus* is cultured on similar by-products. According to Mane *et al.*, (2007), a major reason for these variations is the spawn rate, the species of fungal growth, and the type of supplements added to the substrate. Among the recorded BEs for the Oyster mushrooms on common substrates like RS, Sharma *et al.*, (2013) pointed out that it was 85.5% for common substrates such as RS, whereas it was 103.8% for leguminous plants. There is no significant difference between the harvest of oyster mushrooms recorded now and earlier studies (Raina *et al.*, 2009; Patil, 2012).

Figure 2 shows the protein, fat, carbohydrates, crude fiber, and ash content of developed fruiting bodies. Based on dry weight, WS-grown mushroom fruiting bodies were found to have a 23% protein content, followed by WS+RS (22%). The highest fat content of the Oyster mushroom is recorded on using the WS+ RS combination (3.9%), followed by ScB (2.5%). The current protein and fat contents are similar to the earlier studies of Patil and Dakorem, (2007).

The high content of carbohydrate mushrooms is 67% in fruiting bodies cultivated on ScB, whereas the least is 51% on cultivation on the WS + ScB, which is consistent with the results of Patil *et al.*, (2008). High record of fiber is observed on ScB (702%), followed by WS formula (6.9%). There is no disagreement between these results and those from earlier studies of Bhattacharjya *et al.*, (2014). Depending on the dry weight of the food, the

protein content will usually range from 20 to 30%. Patil *et al.*, (2008) revealed that enhanced yields and quality of mushrooms can be attributed to substrates rich in usable nitrogen.

Maximum content ash of Oyster is found on using the combination of Ws+ Rs+ ScB (7.5%), followed by mushroom which grow on WS+ RS (6.5%), similar results were reported by Patil et al., (2001). In a previous study, Quimio, (1987) reported that cellulose rich organic substances are valuable substrates for the development of mushroom. Agro-waste with high content of phenolic and lignin decrease activity of cellulose, however less lignin content would enhance the enzyme activity and thus ensure higher yield of the mushroom (Sivaprakasam, 1980).

Table.1 Represent the data of caps diameter, length of stipes and the fresh weights after 3 flushes at the winter season

Agro-waste substrates	Cap diameter (cm)	Fresh weight (g)/ bag dry straw	Length of the stipe (mm)
WS	9.5	410	35
RS	10	355	33
ScB	8	380	34
ScB+ WS+ RS	10	390	36
WS+ RS	10	370	43
RS+ ScB	9	395	32
ScB+ WS	9	400	41

Table.2 influence of the agro-waste substrata on the total produce, B.E-moisture content of Oyster

Agro-waste substrates	1 picking	2 picking	3 Picking	Total yield (g)/	Bio efficiency (B.E)	Moisture %
(WS)	440	230	200	970	97	90
(RS)	355	275	150	780	78	88
(ScB)	380	260	170	810	81	91
WS+ RS+ ScB	390	240	160	790	79	89
RS+ ScB	395	230	155	780	78	89
ScB+ WS	400	310	140	850	85	88
Ws+ Rs	370	240	160	770	77	89

Fig.1 The oyster mushroom growth bag

Fig.2 Effects of the different agro-wastes on the protein, carbohydrates, fat, fiber and ash contents of the Oyster mushroom

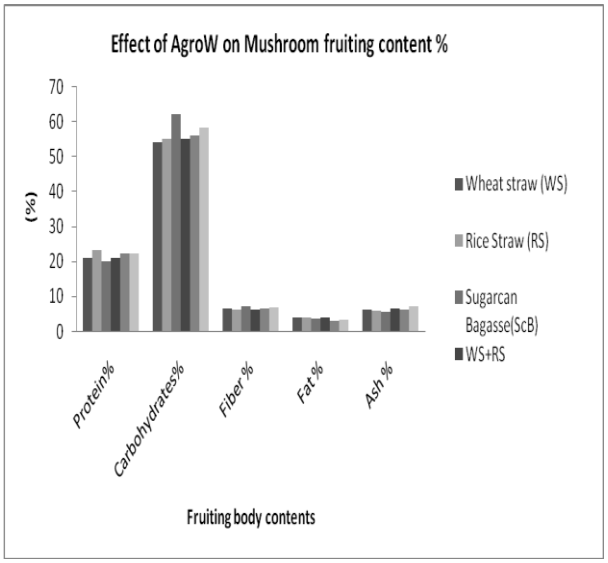
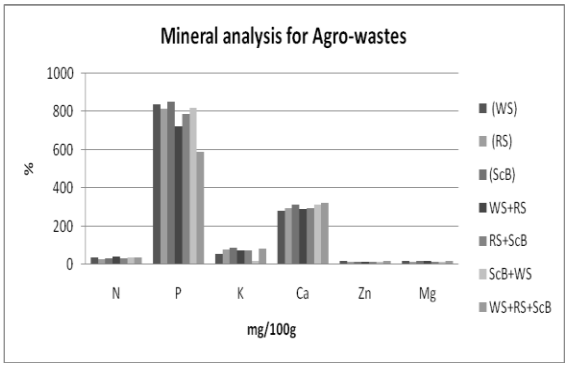


Fig.3 Effects of the agro-wastes substrates on the N, P, K Mg, Zn and Ca contents (mg/ 100g) of the Oyster mushroom



The highest calcium (Ca) content is recorded when Oyster is grown on substrate formula of Ws + Rs (310 mg/ 100g), followed by ScB +WS (280mg/ 100g), as clear in Figure 3. The phosphorus (p) content is maximum on using the ScB (850mg/ 100g), whereas the lowest content is observed in the formula of RS+ WS (722mg/ 100g), recorded by Caglarirmak (2007). Higher contents of Zink (Zn) and Magnesium (Mg) in the mycelium of Oyster mushroom is achieved on WS (18mg/ 100g) substrate. The lowest potassium (K) value is observed from the formula of WS+ RS and is significantly lower than the other substrates formula. In the case of nitrogen (N), the maximum content is achieved on using the substrate formula WS+ RS (39 mg/ 100g). These current results for the K, P and Ca contents are in consistent with the previous studies of Ahmed *et al.,* (2009); Patil *et al.,* (2010); Patil *et al.,* (2012),

According to the data of all agro-wastes estimated in this study, it can be concluded that *P. cystidiosus* in Upper Egypt grow up in a widespread temperature, & on several substrates. The best growth is recorded on WS then RS, and then on ScB. Accordingly, growing the Oyster mushroom on WS or ScB is less expensive, due to the availability of these agro-wastes in the surrounding environment. The use of the agro-wastes such as; ScB, RS and WS for Oyster mushroom cultivation is a new way of handling the plantations wastes.

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