Natural Resources And Food Security: A Case Study Of Effect Of Supplements On The Growth And Fruiting Body Of Oyster Mushroom (Pleurotus Sajorcaju)

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***Abstract*—This study investigated the effect of supplement on the yield of Pleurotus sajor-caju cultivated on rubber sawdust (Havea brasiliensis Mull. Arg.). The substrates were prepared into five different treatments and each treatment was replicated five times, as follows: (T_1) Consisted of wheat bran, lime and sugar, (T_2) Consisted of wheat bran and lime, (T_3) Consisted of wheat bran only, (T_4) Consisted of lime only and (T_5) Consisted of wheat bran and sugar respectively. The result of the proximate analysis conducted on the mushroom showed that the overall nutritional value of the mushroom were good. In spite of differences in term of supplement composition, all the five treatments attained 100% ramification rate on the fourth week. In term of fructification, the length of stipe, diameter of the pileus and Mushroom height obtained were found to be of sizeable and marketable sizes. The analysis of variance conducted for the Mushroom yield across the treatments showed significant difference. The highest yield were produced by T_1 followed by T_2,T_4,T_3 and T_5 with yield value of 108.74 ±7.87, 60.76 ± 4.62, 58.66 ± 3.48, 32.15 ± 2.19 and 19.04 ± 2.02 (g) respectively. The low performance of T_3 and T_5 were attributed to the absence of lime hence the implications was discussed. Since the nutritive values of the mushroom were good not minding the substrate used, T_1 (wheat bran, lime and sugar) is recommended for the high yielding proportion of mushroom while the least treatment in terms of yield which is T_5 (wheat bran and sugar) should be ignored or discouraged.**

Keywords—Supplement, Food security, Natural resources, Pleurotus sajorcatu, mushroom yield

I INTRODUCTION

Oyster Mushroom has good nutritional potential and very lucrative in Nigeria markets [1]. Cultivation of Mushroom can be taken up on a large scale by individual entrepreneurs. The agro-climatic condition as well as local availability of raw materials makes mushroom cultivation an economically viable proposition [2]. Mushrooms, also called 'white vegetables' or 'boneless vegetarian meat' contain ample amounts of proteins, vitamins and fibre apart from having certain medicinal properties [3]. Mushroom contains 20-35% protein (dry weight) which is higher than those of vegetables and fruits and is of superior quality. Mushrooms are now getting significant importance due to their nutritional and medicinal value and today, their cultivation is being done in about 100 countries [4]. At present, world production is estimated to be around 5 million tonnes and is ever increasing [5]. All Mushrooms are fungi, but not all fungi are mushrooms, though 20 Mushroom varieties are domesticated about half a dozen varieties such as: button, shitake, oyster, wood ear and paddy straw Mushrooms contribute 99% of the total world production [6]. Mushroom offers prospects for converting lignocellulosic residues from agricultural fields and forests into protein rich biomass. Such processing of agro waste not only reduces environmental pollution but the by-products of mushroom cultivation are also a good source of manure, animal feed and soil conditioner [7]. Mushrooms are important constituents of minor forest produced that grow on the most abundant biomolecule of this biosphere, known as cellulose [8]. Presently, Mushrooms are regarded, as macro fungi with a distinctive fruiting body, which can either be epigeous or hypogenous and large enough to be seen with the naked eyes and picked by hands [9]. The forests is a complex mass biodiversity, it is also rich with the production of fungi, among which are Mushroom fungi, nucleated, spore-bearing, achlorophyllous organisms, which reproduce sexually and asexually, they are filamentous, branched somatic structures; typically surrounded by cell walls containing cellulose and chitin or both [10]. Many authors [11] [12] [13] [14] have worked on the use of sawdust such as *Gmelina arborea, Triplochiton scleronxylon, Tectona grandis, Ceiba petandra* but little or nothing was found reported on the use of rubber sawdust (*Havea brasiliensis*) for cultivation of Mushroom. Hence, this present study investigated the effect of supplements on the yield of *Pleurotus sajor-caju* cultivated on rubber (*Havea brasiliensis*) sawdust. *Pleurotus* spp is one of the edible Mushrooms, which can be cultivated in the tropics. The genus has been studied in various parts of the world, because most species are edible, fast growing and capable of rapid degradation of wood. [14; [15] *Pleurotus* spp are from the super kingdom Eukaryota, kingdom Mycetae (a distinct kingdom of fungi), division Amastigomycota, family Agaricacea, class Basidiomycetes, subclass Homobasidiomycetidae and order Agricales [17]. They include; *Pleurotus squarrosulus* (Mont) Singer, *Pleurotus opuntiae (*Dumen and Leveille) Saccardo, *Pleurotus ostreatus, Pleurotus tuber – reguim* and a host of other species. They grow well on different types of lignocellulosic material converting the materials into digestible and protein rich substances suitable for animal feed [18]. .*Pleurotus* spp grow and fruit easily on media, they have therefore become a useful tool for the investigation of fungal physiology. The physiological aspects most studied have been its response to light, temperature, gravity and allergenic properties of its spores. [19][20] [21]. *Pleurotus sajur caju*, is a tropical sclerotial mushroom which has been gaining some interest [22] (Ekpo and Aluko, 2002). This species produces a sclerotium or underground tuber, as well as, a mushroom, both of which are edible. The sclerotium is produced towards the end of the growing season (April to September) when, conditions are not favourable, and new fruits are formed from these tubers during the next growing season [23] [24] [25] stated that, a lot of energy is stored in the sclerotium that Nigerians only have to plant them and give sufficient water to grow Mushroom. The sclerotium is the fine aggregation of vegetative hyphae which determine growth. They contain reserved food materials and after maturity are capable of independent persistence for a long period of time. On germination, they form either mycelial or reproductive structures (fruit bodies) at the expense of the reserve materials. [26]. It is a hard resting body, resistant to unfavourable conditions and may remain dormant for long periods sclerotia are composed of small cells, termed macrocysts, which vary in size from 10-25µ and in the number of nuclei they contain (0-14), each macrocyst is surrounded by a membrane [27]

II. MORPHOLOGY OF MUSHROOM

Mushrooms can be defined as “a macro-fungus with distinctive fruiting bodies, epigeous or hypogeous, large enough to be seen with naked eyes and picked up by the hands”. The Mushroom fruiting body may be umbrella like or of various other shapes, size and colour. Commonly it consists of a cap or pileus and a stalk or stipe but others have additional structures like veil or annulus, a cup or volva. Cap or pileus is the expanded portion of the carpophore (fruit body) which may be thick, fleshy, membranous or corky. On the underside of the pileus, gills are situated. These gills bear spores on their surface and exhibit a change in colour corresponding to that of the spores, as in figure 1.

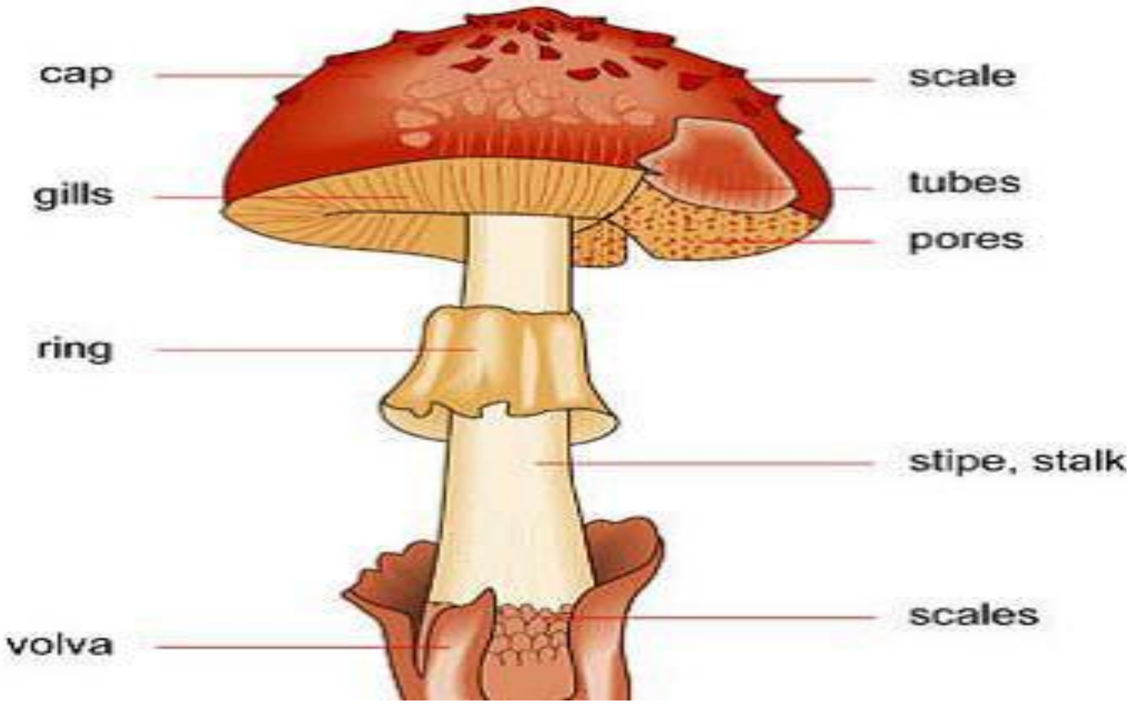

Figure 1: Morphology of Mushroom (Kendrick, 1992) [28]

The main objective of this study is to examine the effect of varying supplements on the yield and fruiting body produced from *Pleurotus sajor-caju* cultivated on rubber (*Havea brasiliensis)* saw dust. The specific objective is to evaluate: i). anticipated significant different in the yield production of *Pleurotus.sajor-caju* cultivated using varying supplement. ii). Yield performance of mushroom grown on sawdust of rubber (*Havea brasiliensis*) iii). The nutritive values of the fruit bodies of *Pleurotus.sajor-caju produce* from different supplement level. This is shown in the reports of [29] as below.

Table 1 Proximate protein content (dry weight) of edible mushrooms

Species	Protein Content (%)
Volvariella volvacea	21.32
Agaricus bisporus	27.8
Pleurotus ostreatus	27.4
Pleurotus florida	37.19
Pleurotus sajor-caju	36.94
Lentinula edodes	17.5
Auricularia auricular-judae	8.1
Flammulina velutipes	21.9

Source: Singh and Chaube 1995 [29]

III. MATERIALS AND METHODS

STUDY AREA

The research was carried out at the School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology Owerri, Imo state, Nigeria. Owerri is the capital of Imo State (Nigeria). Imo State lies within latitudes 4°45'N and 7°15'N, and longitude 6°50'E and 7°25'E with an area of around 5,100 sq km. The rainy season begins in April and lasts until October with annual rainfall varying from 1,500mm to 2,200mm. An average annual temperature above 20 °C (68.0 °F) creates an annual relative humidity of 75% with humidity reaching 90% in the rainy season.

EQUIPMENT AND MATERIALS FOR MUSHROOM CULTIVATION

1 Small room to serve as mushroom house.
2 Shelves to serve as growing beds as needed
3 Containers made of plastic, metal or wood in the form of trays.
4 Polypropylene bags
5 Water tank/water container. These are plastic or metal to store water for all activities and watering of mushrooms.
6 Water sprayer: used in sprinkling water on mushrooms Sprayers such as the type used for insecticide or plastic sprayers are also used. Knapsack sprayers are utilized for larger quantities.
7 Drum or big pots: for boiling or pasteurization substrates.
8 Heat source: Fuel-wood, gas, electric cooker.
9 Buckets, basins, bowls used in transferring materials and water
10 Substrate material (consumable items) - cotton waste, sawdust, rice straw, corncobs and calcium carbonate or lime powder. Dettol or formaldehyde which can be diluted to a very low concentration for sterilizing the mushroom house. Others are Polythene bags; wooden box for moulding substrates, for pasteurization, metal stands.

PROCEDURES

Fresh sawdust of rubber (*Hevea brasiliensis)* were collected from sawmill at Naze, Owerri_West Local Government of Imo State, Nigeria. The sawdust was heaped thoroughly, watered and allowed to drain to about 65% moisture content. The sawdust was composted for 30 days and sun dried, and as well being turned over every five days until the rancid odour disappears and 65-70% moisture content is attained. Thereafter, five different treatments were used in the experiment. Each consisted of 5kg of the substrate was mixed with supplements (wheat bran, lime and sugar) at 12% wheat bran, 1% sugar and 1% lime respectively. The first treatment (T_1) was consisted of wheat bran, lime and sugar, second treatment (T_2) was consisted of wheat bran and lime, third treatment (T_3) was consisted of wheat bran only and the fourth treatment (T_4) was consisted of lime only while the fifth treatment (T_5) was consisted of wheat bran and sugar respectively as shown below

Table 2 of experimental treatment

Treatments	Content
T_1	Wheat bran, lime, and sugar
T_2	Wheat bran and lime
T_3	Wheat bran
T_4	Lime only
T_5	Wheat bran and sugar respectively

MUSHROOM CULTIVATION PROCEDURE

Substrate preparation and composting takes the following sequences –Turning - Mixing and bagging - Pasteurization or Sterilization - Inoculation of substrate or Spawning - Incubation of substrate bags in the dark - Exposure of fully ramified bags to light and watering - Harvesting of Mushroom and finally packaging.

SUBSTRATE PREPARATION

Several Agro-industrial waste materials have been found useful for mushroom cultivation. These include cotton waste, sawdust, wood chips, sugarcane bargasse, different types of straws e.g. rice wheat, corn cobs banana leaves, oil palm waste etc. Any of the above listed wastes could be used as substrate grinded to sawdust like size or chop into 0.2-0.5mm. Hence, prepared rubber sawdust from sawmill was used in this study.

Composting

Composting is the period whereby the materials are allowed to break down (ferment), making the substrate suitable for the growth of the mushroom. Sawdust composting may take longer depending on wheat bran should again be added when using the composted sawdust, mixed with adequate water before packing in polypropylene bags. Block can be made from the composted substrate or the material can be spread on nets for pasteurization in drum if it is to be spread directly on shelves later.

the time of collection. The substrate material most available to the grower can be used to grow mushroom; depending on the substrate, there is usually composting variable length of time. Cotton waste for example with fast decomposition rate can be composted for only 3 to 4 days. Rice bran (20%) and lime are added to the substrate after composting and water mixed together. Turning of the substrate involved turning of the block by scattering to allow air in and also to mix all the nutrients together, thereafter, the block is moulded again. This is done twice after every two days. Sawdust is very much used in South East Asia for mushroom cultivation. To compost sawdust, mix with 10% rice bran or 5% wheat bran and lime 1%. The sawdust is then made thoroughly wet, mixed and stacked into a heap. This heap is turned every 4-5 days for 30 days. This composting period allows the fresh sawdust to soften but may not be required for older and more weathered sawdust. After composting, the substrate can be loaded into bags for pasteurization or sterilization. 10-20% rice bran or 5-10%

Mixing: This is the first stage or step of making the substrate, various supplement are added to the saw dust such as: lime, sugar, and wheat brown and are mixed thoroughly with the rubber (*Hevea brasiliensis*) saw-dust.

Plate 1: Mixing of substrate

Plate 2: Barged Substrate

Fully composted sawdust is weighed, mixed with supplements and water. This is then filled into nylon bags and arranged in a drum for pasteurization.

Pasteurization

This involves passing hot steam from boiling water into the composted substrate for several hours to eradicate or kill organisms which can affect the growth of the mushroom. Pasteurization temperature gets rid of these organisms that are dangerous for growth while sterilization kills all the organisms within the composted materials.

Plate 3: Local pasteurization process

Inoculation or Spawning

This is the process of planting the mushroom seed (spawn) obtained from the research Institute or University laboratories into the prepared pasteurized or sterilized substrate. This must be done in a clean environment to avoid contamination.

Plate 4: Sterilizing the table for inoculation

Incubation

After inoculation, the substrate is covered with black polythene sheet in a dark environment and left for some weeks for growth to occur and this period is called incubation period.

Plate 5: Incubation process

Exposure

When the whitish growth has passed through the substrate, up to the base the container is then exposed to light and air is allowed to circulate while adequate watering or humidification of the environment is done to stimulate the flushing of the mushrooms.

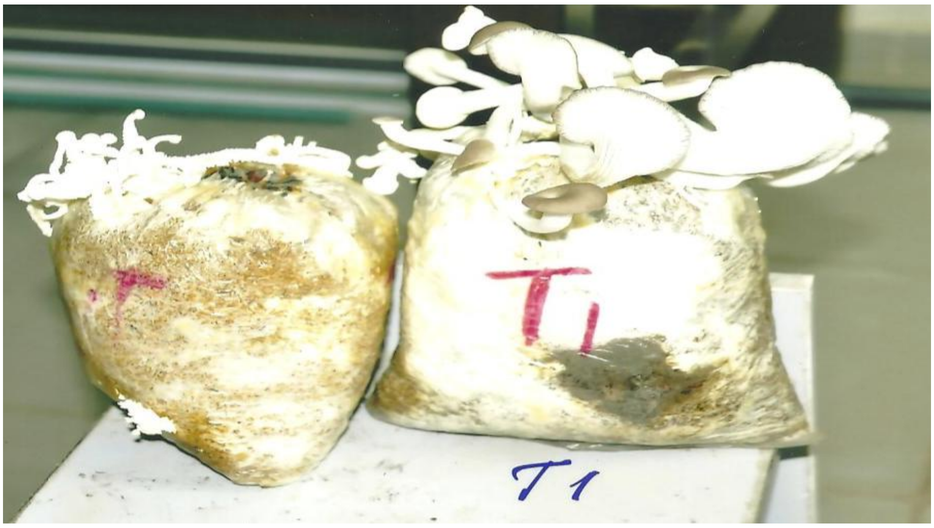

Plate 6 Flushed mushroom

Harvesting

The Mushroom that grows should be left to attain good steady growth for 4-5 days and then should be harvested. Watering should however be continued as 2nd and 3rd flushing can come after some days' interval.

Packing

Harvested Mushroom can be packed in polythene bags after appropriate weighing for proper costing. Bags of fresh Mushrooms should be puncture in a few places to allow aeration of the Mushrooms. Harvested Mushrooms that are not immediately needed can be thoroughly dried and packed for sales in the dried form.

Plate 7 well packaged mushroom

RESULTS AND DISCUSSION

Table 3: The Proximate analysis of fruiting body of *Pleurotus.sajor-caju* grown on rubber sawdust

Proximate	Composition (100%)
Moisture	75.74
Protein	29.61
Fat	0.77
Ash	5.71
Fibre	7.42
Carbohydrate	69.22

Table 4: The mean mycelia growth (%) exhibited by substrates on weekly basis

Treatments	Week 1	Week 2	Week 3	Week 4
T1	35.20	63.46	86.35	100
T2	28.40	54.52	78.50	100
T3	27.52	51.68	65.14	100
T4	24.02	48.60	72.55	100
T5	22.82	47.25	61.59	100

Table 5: The mean length of stipe (cm) per flush

Treatment	flush 1	flush 2	flush 3	flush 4	flush 5
T1	6.4	7.1	5.7	6.2	6.0
T2	5.8	6.3	6.1	7.2	6.8
T3	3.8	4.5	4.8	-	-
T4	6.0	6.3	6.8	7.1	7.2
T5	4.2	4.7	-	-	-

Table 6: The mean diameter of pileus (cm)

Treatment	**Flush 1**	**Flush 2**	**Flush 3**	**Flush 4**	**Flush 5**
T1	6.0	6.4	7.3	5.2	6.2
T2	6.3	5.8	6.5	6.2	6.3
T3	5.4	6.2	5.3	-	-
T4	6.1	6.8	7.0	6.1	6.3
T5	5.6	6.1	-	-	-

Table 7: The mean mushroom height (cm)

Treatment	Flush 1	Flush 2	Flush 3	Flush 4	Flush 5
T1	8.2	9.3	7.9	8.6	8.2
T2	7.4	8.4	8.1	9.0	8.6
T3	7.1	7.4	7.6	-	-
T4	8.1	8.2	8.4	9.2	8.4
T5	7.0	7.5	-	-	-

Table 8: Analysis of variance (ANOVA) to show the significant different in the yield of the fruiting body of *Pleurotus sajor-caju* cultivated on rubber sawdust

Source of variation	sum of squares	df	mean square	F	Sig
Treatment	16770.72	4	4192.68	26.19	0.00
Error	3200.60	20	160.03		
Total	19971.32	24			

Significant at p≤0.05

Table 9: The follow up test using Duncan Multiple Range Test (DMRT) to show the significant different in the yield of the fruiting body of *P.sajor-caju* cultivated on rubber sawdust

Treatments	Mean (g)	S.E	Duncan rating
T1	108.74	7.87	a
T2	60.76	4.62	b
T3	32.15	2.19	c
T4	58.66	3.48	b
T5	19.04	2.02	d

Mean with same alphabet are not significantly different from each other

DISCUSSION

The effect of supplement on the yield and nutritional value of *Pleurotus sajor – caju* cultivated on rubber (*Havea brasiliensis*) sawdust

Table 1, showed the proximate analysis of the fruiting body of *Pleurotus sajor- caju* cultivated on rubber sawdust. The results reveal that Moisture, Protein, Fat, Ash, Fibre and carbohydrate obtained were found to be noteworthy with values of 75.74, 29.61, 0.77, 5.71, 7.82, and 69.22% respectively. The protein content obtained in my study established the fact that Mushroom is high in protein. These results are confirmed with the findings of other studies confirming that protein content of *Pleurotu sajor –caju* fruiting bodies grown on different substrates ranged from 20.33 to 32.50%. Hence, the protein obtained in my study were found within this range .This is an indication that *pleurotus sajor –caju* could be rank highest in terms of protein among other vegetables. The percentage content of fat and fibre were similar as reported by [30] who observed the crude fibre of *Pleurotus sajor-caju* fruiting bodies was range from 6.78-7.82% when grown on different substrates. Based on these results the overall nutritional status of the fruiting bodies of *Pleurotus sajor – caju* was found to be good. The mean mycelia growth (%) exhibited by substrate on weekly basis were shown in table 2. The result indicated that all the substrates across the five treatments attained 100% ramification on the fourth week. This is an indication that the sawdust used supported the growth of *Pleurotus sajor-caju* as evidenced by completed and heavy colonization of substrates, forming a compact white mass of mycelium within four weeks of inoculation. Consequently, in term of fructification the overall performance were good .Hence ,the length of stipe (Table 3) shows that treatment one (T_1),treatment two (T_2) and treatment four (T_4) performed exceptionally good as harvest was recorded up to five times and the length of stipe recorded were of sizeable and marketable sizes. The mean diameter of pileus (Table 4) ranged from 5.3-7.3cm while the highest value were found in treatment one of flush three and the mushroom height (table 5) obtained ranged from 7.0-9.3cm while the highest value were found in treatment one of flush two. Though, they were found to be good, sizeable and marketable. Similar finding were recorded by [31] who reported the good sizeable and marketable size of mushroom height to be ranged between 5.5-12.0cm in size. Hence, the sizes obtained in this study exist between these ranges. The analysis of variance conducted to establish the significant difference in mushroom yield across the treatments revealed that significant difference exist in the yield of mushroom across the treatment (Table 6). The follow up test was conducted to separate the mean yield of the mushroom across the treatment. T_1 consisted of wheat bran, lime and sugar had the highest yield, follow by T_2, consisted of wheat bran and lime ,T_4 consisted of lime only ,T_3 consisted of bran only and T_5 consisted of wheat bran only and T5 consisted of wheat bran and sugar with the yield value of 108.741± 7.87,60.76 ± 4.62,58.66 ±3.48.32.15±2.19 and 19.04 ± 2.02 respectively. The highest yield obtained in T_1 can be attributed to the combination of supplement (wheat bran lime and sugar) added to it .This could be attributed to the fact that supplements aids sporophore emergence thus, aids the mushroom yield.

CONCLUSION

The effect of supplements on the yield and fruiting body production of *Pleurotus sajor-caju* cultivated of rubber sawdust was established. The observation of the present investigation suggests that the edible mushroom (*Pleurotus sajor-caju)* attained 100% ramification on the fourth week. This is an indication that ramification rate is independent of varying supplements. The nutritional composition of the mushroom obtained showed that the overall nutritional values of the mushroom were good. Consequently, the yield encountered across the treatment suggest that lime is an important supplement in mushroom cultivation and thus cannot be ignored or substituted by any means or for any other supplements as it aids the neutralization of the acidity or alkalinity of the substrate and this in turn enhance the sporophore emergence during mushroom growth. The treatment comprising of lime as part of their supplements (T_1,T_2 and T_4) were found producing good yield compared to those without lime (T_3 and T_5). The cultivation of edible mushroom offers one of the most feasible and economic method for the bioconversion of the lignocellulosic wastes thus can also limit air pollution associated with burning lignocellulosic waste as well as decrease environmental pollution due to unutilized wood wastes. Nutritional attributes of the oyster mushroom is being increasingly accepted at recent times as source of food for man. This can help in bridging the gap of malnutrition among low income earners and also serve as means for job creation in the society. This practical study is considered innovative at this level while supporting the exploitation of non-forest products [32a,b,c].

RECOMMENDATIONS

The nutritive values of the mushroom have been confirmed in this study not minding the substrate used, T_1 (wheat bran, lime and sugar) is recommended for the high yielding proportion of mushroom while the least treatment in terms of yield which is T_5 (wheat bran and sugar) should be discouraged. Further research should be conducted on the suitability of different lignocellulosic wastes as well as other agricultural wastes as substrate for mushroom cultivation. Government should encourage practical research by investing more funds into research and institutions while supporting and aid commercial cultivation of edible mushroom thereby enhance scientific breakthrough. There is the need for improved procurement of modern laboratory equipments for commercialization of nutritive food value and enhance food security.

REFERENCES

[1] Nurudeen T.A, Ekpo E.N and Dania V.O (2012): Effect of supplements on the yield and fruiting body production of oyster mushroom (*Pleurotus sajor –caju*). Proceedings of 2ND annual conference of association of women in forestry and environment (AWIFE). Held at FRIN Conference hall ,Jericho, Ibadan Nov. 30th,2012, 68-74pp.

[2] NABARD (2007): National Bank for Agricultural and Rural Development NABARD's Bankable Project 2007.

[3] Ajayi (1997): Cultivation of *Pleurotus tuber-regium* (Fries) singer on Rice straw and wood wastes of some economic trees pp. 7 – 22.

[4] Thomas, V.K. (1965): Cultivation mushrooms; America Mushroom Institute pamphlet. United state department of agricultural 189. Mushrooms National Agricultural Statistics service. Washington D.C. pp.14.

[5] FAO. (1990): Technical guideline for mushroom growing in the tropics by Quimio, S.T. Chang and D.J. Royse; Food and Agricultural organization of the United Nations, Rome 1990. (FAO plant production and protection paper).

[6] Ajayi (1997): Cultivation of *Pleurotus tuber-regium* (Fries) singer on Rice straw and wood wastes of some economic trees pp. 7 – 22.

[7] NABARD (2007): National Bank for Agricultural and Rural Development NABARD's Bankable Project 2007.

[8] Chang S.T. and P.G. Miles (1999): Historical Records of the Early Cultivation of *Lentinus* in China. Mushroom J. Topics 7. Pp.31-37.

[9] Chang S.T. and P.G. Miles (1999): Historical Records of the Early Cultivation of *Lentinus* in China. Mushroom J. Topics 7. Pp.31-37.

[10] Alexopoulous, C.J. (1962): Introductory Mycology 2nd edition. John Wiley and sons Inc. New York, London, Sydney. Pp. 4 – 21, 505-517.

[11] Ekpo. E.N. and A.P. Aluko (2002): Cultivation Strategy and Nutritive Values of Edible Mushroom (*Pleurotus tuber- regium*) as a component of sustainable livelihood. In: Abu. J.E, Oni, P.I. and L. Popoola (2002); proceedings of the 28th Annual Conference of the Forestry Association of Nigeria, Akure Ondo State. Pp. 114-118.

[12 Nurudeen T.A, Ekpo E.N and Dania V.O (2012): Effect of supplements on the yield and fruiting body production of oyster mushroom (*Pleurotus sajor –caju*). Proceedings of 2ND annual conference of association of women in forestry and environment (AWIFE). Held at FRIN Conference hall ,Jericho, Ibadan Nov. 30th,2012, 68-74pp.

[13] Oso. B.A. (1975); Mushrooms and the Yoruba people of Nigeria. Mycologia 67. Pp.271 – 279.

[14] Okhuoya, J.A. and J.E Etugo (1992): Studies of the cultivation of *Pleurotus tuber- regium* (Fries) Singer. An edible Mushroom, Bioresource Technology 44. Pp.1-3.

[15] Oei, P. (1991): Manual on mushroom cultivation techniques, species and opportunities for commercial applications in developing countries. TOOL/CTA Amsterdam and Wagningen. Pp.177-30, 77-104.

[16] Okhuoya, J.A. and J.E Etugo (1992): Studies of the cultivation of *Pleurotus tuber- regium* (Fries) Singer. An edible Mushroom, Bioresource Technology 44. Pp.1-3.

[17] Alexopoulous, C.J. (1962): Introductory Mycology 2nd edition. John Wiley and sons Inc. New York, London, Sydney. Pp. 4 – 21, 505-517.

[18] Oei, P. (1991): Manual on mushroom cultivation techniques, species and opportunities for commercial applications in developing countries. TOOL/CTA Amsterdam and Wagningen. Pp.177-30, 77-104.

[19] Block, S.S, G. Tsao and L. Han (1959): Cultivation of *Pleurotus ostreatus.* Mushrooms science 4. Pp. 308-325.

[19] Block. S.S, G. Tsao and L. Han (1958): Production of Mushrooms from sawdust J. Agriculture, Food Chemistry 6. Pp.923-927.

[20] Zadrazil, F. (1974): The Ecology and Industrial production of *Pleurotus cornuciepiae* and *P eryngii.* Mushroom science 9. Pp.621 – 652.

[21] Schulze B.A, Axeir S.R.A, Telek L.I, Block O.L (1974): The effect of tannin content of the nutritive value of some leaf protein concentrates. Human Nutri. Food Sci. Nutr. 41F:41 – 46.

[22] Ekpo. E.N. and A.P. Aluko (2002): Cultivation Strategy and Nutritive Values of Edible Mushroom (*Pleurotus tuber- regium*) as a component of sustainable livelihood. In: Abu. J.E, Oni, P.I. and L. Popoola (2002); proceedings of the 28th Annual Conference of the Forestry Association of Nigeria, Akure Ondo State. Pp. 114-118.

[23] Ekpo. E.N. and A.P. Aluko (2002): Cultivation Strategy and Nutritive Values of Edible Mushroom (*Pleurotus tuber- regium*) as a component of sustainable livelihood. In: Abu. J.E, Oni, P.I. and L. Popoola (2002); proceedings of the 28th Annual Conference of the Forestry Association of Nigeria, Akure Ondo State. Pp. 114-118.

[24] Okhuoya, J.A. and J.E Etugo (1992): Studies of the cultivation of *Pleurotus tuber- regium* (Fries) Singer. An edible Mushroom, Bioresource Technology 44. Pp.1-3.

[25] Oei, P. (1991): Manual on mushroom cultivation techniques, species and opportunities for commercial applications in developing

countries. TOOL/CTA Amsterdam and Wagningen. Pp.177-30, 77-104.

[26] Sussman. A.S. (1966): The Fungi (An advanced treatise) edited by Ainsworth. G.C. vol.II. The Fungal organism. Academic press, New York, San Francisco, London. Pp. 101 – 103.

[27] Alexopoulous, C.J. (1962): Introductory Mycology 2nd edition. John Wiley and sons Inc. New York, London, Sydney. Pp. 4 – 21, 505-517.

[28] Kendrick, B. (1992): The fifth kingdom. Focus group, Newbury port. M.A.

[29] Singh M.P and Chaube V.K (2011): Yield performance and nutritional analysis of *Pleurotus citrinopileatus* on different agrowastes and vegetable wastes. Proceedings of the 7th International Conference on Mushroom Biology and Mushroom Products (ICMBMP7). Held at Convention Centre, Arcachon, France, October 4-7,2011.

[30] Syred, A.A., Kadam, J. A., Mane, V. P., Patil, S. S., and Baig, M. M. (2009). Biological efficiency and nutritional contents of *Pleurotus florida (Mont.)* Singer cultivated on different agro-wastes. *Nature and Science*, 7(1), 44-48.

[31] Nurudeen T.A, Ekpo E.N and Dania V.O (2012): Effect of supplements on the yield and fruiting body production of oyster mushroom (*Pleurotus sajor –caju*). Proceedings of 2ND annual conference of association of women in forestry and environment (AWIFE). Held at FRIN Conference hall ,Jericho, Ibadan Nov. 30th,2012, 68-74pp.

[32a] FAO (1995): Report of the International Export Consultation of Non-wood Forest Products. Yogyarkarta, Indonesia, January 1995. Pp. 17 – 22.

[32b] FAO (1996): Domestication and Commercialization of Non-timber Forest Products (NTFP's) IN Agroforestry systems, FAO, Rome (9). Pp. 32-39.

[32c] FAO (2000): Non-wood News, Information on Non-wood forest products (7). March 2000, FAO Rome. Pp.40.