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TECHNOLOGICAL AND ECONOMIC ASSESSMENT OF MUSHROOM CULTIVATION IN NIGERIA

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Abstract

*In this study, a cottage level technology has been proposed for the commercial exploitation of mushroom biotechnology in Nigeria. The profitability of the mushroom cultivation technology has been established at 2.5, 3.75 and 5.0 tonnes capacities per annum using investment options A or B for two mushroom varieties. Option C becomes relatively marginally profitable for **Pleurotus ostreatus** only at 3.75 tonnes capacity per annum. Option A entails the complete process of spawn production and mushroom cultivation. Option B involves purchasing the spawn from a separate organisation and then using the spawn for mushroom cultivation while Option C which is considered for only **P. ostreatus** involves purchasing the ready-to-fruit spawned bags for incubation and fructification. The engineering economy studies revealed that the venture could be profitable with selling price above one hundred and seventy four naira (₦174) and one hundred and fifteen naira (₦115) per kilogram of **Volvariella volvacea** and **Pleurotus ostreatus** respectively. The study also shows that investors should target the low income group by working towards being a "low-price producer". This could be achieved by adopting the option B with the proposed techniques at above 75% capacity utilization. Profitability and sensitivity analyses show option C to be a relatively risky investment which could easily be affected by competition and price instability. Option B is the most favoured for investors because of the lower capital investment requirement and favourable profitability indices. The business risk is also shared between the mushroom grower and spawn producers.*

Introduction

Mushrooms have been used by man for food and medicinal purposes since ancient times but they were not conspicuously cultivated

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as a crop until the 17th Century. China was one of the first countries to recognise the nutritional importance of mushrooms. The cultivation in China can be traced back to between 533 and 544 A.D. It was described by the Chinese as being well known, delicious dishes (Agricon, 1988).

The early cultivation of mushroom was reported in France in the 17th Century after which many other European countries and the United States of America followed suit. The methods of cultivation were guarded secrets for a long-time (Hill *et. al.*, 1960). Today, edible mushrooms are being cultivated all over the world (Europe, North and South America, Asia, Australia etc.) under different climatic conditions and with various degrees of sophistication (Zadrazil, 1988, Chang, 1988).

In Brazil for instance, the cultivation of *Agaricus species* began in the 1950s using precarious constructions and by 1988 the production had reached an estimated output of 5,000 - 6,000 tons per year. The substrate used was horse dung, rice straw and sugarcane begasse, a by-product of sugar and alcohol plants (Maziero, 1988).

The Guatemalan experience was initiated in the 1960s by employing very low technology using caves near Guatemala city. This was disrupted by the 1976 earthquake. Reports show that the industry had been reactivated by small producers bringing output by 1988 to 50 tons mushrooms per year. This was only about 30% of installed capacity and the poor performance had been attributed to inefficient methods, poor management and weak marketing strategies (De Leon and Rolz, 1988).

In the last decade, People's Republic of China and Taiwan became the second and third largest producers of mushrooms in the world. Korea and the above mentioned countries are the only tropical developing countries which have a strong influence on industrialised countries in the mushroom production economy (Park and Zadrazil, 1988). In 1984 Korea produced 769 tons of *Tricholoma matsutake* species with a value of US $24,000,000; 770 tons of *Lentinus edodes* fetching $9,015,000 and 2,400 tons of *Pleurotus ostreatus* which returned $5,280,000. Korea's production of *Agaricus bisporus* was 19,400 tons in 1984. Japan in 1983 produced 158,855 tons of *Lentinus edodes* while it was estimated that the world production of cultivated mushrooms in 1986 would have exceeded 2.2 million tons. The button mushrooms, *Agaricus bisporus* and *Agaricus bitorquis* are the most important cultivated mushrooms accounting for 70% of the world production (Chang, 1987).

The current growth of the mushroom industry is derived partly from the recent advances in mushroom biotechnology (Chang, 1988). It is however not encouraging that commercial cultivation of mushroom is yet to become popular in Nigeria.

Although cultivation of mushroom is not totally strange to our local farmers, the practice is still very low and nearly insignificant. Traditional farmers usually stock oil-palm pericarp wastes in an open space and cover with fresh palm-fronds. This gives room for chance inoculation of the substrate by wild spores through which mushrooms are grown. Farmers also harvest the "tuber" (sclerotia) of *Pleurotus tuber-regium* from the wild and plant it in a suitable environment. It is then watered for fructification and harvesting. Research activities have shown that some tropical mushrooms can be cultivated in Nigeria using modern knowledge system (Madunagu 1988, Fasidi and Kadiri 1990, 1993, 1995, Kadiri and Fasidi 1990, 1994, Okhuoya and Okegbo 1990, Ilori and Isikhuemhen 1995).

Attempts at commercial cultivation by using this modern knowledge system have been made by certain entrepreneurs in the country. However, most of these attempts have ended up because exotic mushroom species were cultivated by hired foreign experts and packaged technologies. Despite the high market potential (Adeniyi *et al*) very high costs of production were involved and this could not be sustained thus leading to the collapse of the ventures.

The purpose of this study is to carry out an engineering economic assessment of some mushroom cultivation technologies which had been proved technically viable (Chang 1988) at the Federal Institute of Industrial Research Osodi (FIIRO) Lagos.

Methodology

Both participatory and interview schedule were used for data collection on mushroom cultivation from researchers. The interview elicited information on technical problems
militating against the pioneer investors' performance and technology options that could be adopted to resolve some of these problems.

The list of facilities, raw materials and other inputs required for the technology options were also obtained from the researchers. Cost estimates were provided by equipment manufacturers, suppliers and direct market prices.

This piece of information was qualitatively reviewed and used in the design of technology options and process technology for mushroom cultivation. With reference to the design process technology, a list of facilities and civil structures for a minimum capacity producing 100kg of fresh mushroom per week (regarded as 100% in this study) was used to compute the capacity investment. Furthermore, the data on the mushroom cultivation project were subjected to engineering economic assessment. In developing the cash flow, the pre-production expenses was estimated at 10% of capacity investment (obtained above). The operating costs (fuel, energy, maintenance, labour, sales promotion and distribution costs) were estimated. The gradient series model was used to estimate annual maintenance cost over the life cycle (n) of the project. In this model, the maintenance cost of the project was assumed to be A_1 in the first year and G more naira for each additional year until the end of the 6th year. The present worth cost (PW_c) of maintenance was first estimated and thereafter converted to annual worth cost (AW_c) using the expression:

$$PW_c = A_1 (P/A, \ddot{\imath}, n) + G (P/G, \ddot{\imath}, n)$$

$$AW_c = PW_c (A/P, \ddot{\imath}, n)$$

where ï, is the minimum attractive rate of return (MARR); (P/A, ï, n), (P/G, ï, n) and (A/P, ï, n) factors were obtained from the interest table (De la Mare, 1991). A MARR of 10% was used for this study bearing in mind that bank interest rates have fallen below 10% recently. A_1 and G were estimated as₦ 30,000 and₦ 5,000 respectively for the project with electricity generating set operating at full capacity. For the project without electricity generating set operating at full capacity, A_1 and G were estimated as six thousand naira (₦6,000) and one thousand naira (₦ 1,000) respectively. As at the time of this study, one US dollar ($1) is equivalent to eighty Nigerian naira (₦80)

The market prices of raw materials (compost materials) and other operating supplies were used to estimate the costs. The number of employees required for the project at various capacity utilization of the different technology options and mushroom varieties were evaluated. Their wages were estimated on equal basis.

ales were calculated on the basis of the plant capacity. Both sales and salvage value at the end of project life will generate revenue. The salvage value at the end of 8 years was assumed to be zero and thus the book value at the end of project life (n = 6 years) was taken as the salvage value. The straight line method of computing depreciation was used. It assumes that the loss in value is directly proportional to the age of the asset.

Profitability Analysis:

The net present value (NPV) model was used to determine profitability of the project before tax. The NPV of a series of cash flows is the equivalence of a single sum of money to be received or disbursed at a time (t = o) if all future receipts and disbursements over the time are properly discounted to the present time and summed algebraically. The model is represented as

$$NPV = \sum_{t=o}^{n} A_{t,x} (1 + i)^{-n}$$

$$= \sum_{t=o}^{n} A_{t,x} (P/F, i, n)$$

where $A_{t,x}$ = net cash flow for project x at year t (t = 0,1,2,...n) *i* and n are as specified above, (P/F, , n) was obtained from the interest table.

The NPV as expressed above is based on the concept that all cash inflows and outflows are discounted to the base point at an interest rate ï which is the MARR (De Garmo *et al.*, 1979).

Sensitivity Analysis:

Analysis of sensitivity of the project to capacity utilization was made with the NPV model while the sensitivity to selling price and project useful life were made with the annual worth (AW) model. "Sensitivity" is the relative magnitude of change in the measure of merit (such as NPV or AW) caused by one or more change in the estimated study parameters.

The annual worth (AW) of a project is its annual equivalent receipts ($\underline{R}$) minus annual equivalent expenses ($\underline{E}$), less its annual equivalent capital recovery (CR) amount. The capital recovery cost for a project is the equivalent uniform annual cost of the capital invested which include depreciation and interest on invested capital (De Garmo *et al*, 1979). The relationships are expressed as

$$AW = \underline{R} - \underline{E} - CR$$

$$CR = I(A/P, i, n) - S\,(A/F, i, n)$$

where I = initial investment for project

S = salvage value at the end of study period.

i and n are as described above, and (A/P, *i*, n), (A/F, *i*, n) factors were obtained from the interest table.

In determining sensitivity of the project to capacity utilization, the designed minimum capacity based on the facilities and civil structures list was taken as 100%, while levels of utilization was hypothetically lowered stepwisely by 25% to test sensitivity to underutilization of plant capacity. The second assumption was that under the annual disbursement cost, maintenance and distribution costs remained constant as fixed cost while other costs varied in proportion to the capacity utilization. In the determination of the sensitivity to selling price, the AWs of project were calculated at fixed capacities (50, 75 and 100%) while reducing price stepwisely by ₦10. Only the selling price was varied while costs remained constant at the capacity utilization levels.

Finally, sensitivity to project useful life was determined at the various capacity utilizations while varying n, by ± 33% and the AW calculated as previously discussed. It was assumed that the salvage value remained constant while the only factor that changed during the analysis was the cost of capital recovery.

Technology Options And Scale Of Mushroom Production

As pointed out earlier on, some attempts have been made in the commercial cultivation of mushroom in Nigeria. Most of them did not last long because of some technical problems encountered by the pioneer investors. These problems as revealed by the interview schedule include:

- inability to sustain the imported technology
- high cost of producing the exotic varieties
- complete loss of culture due to frequent infrastructural failure.
- huge financial loss due to mass contamination of ready-to-fruit inoculated substrate
- managerial incapability accounted for by defective operational logistics reflected in the choice of cultivated varieties, inadequate technology option and scale of production.

The cultivation technology recommended by the researchers that could resolve some of the technical problem is the "indoor container system". The preference for indoor cultivation was hinged on the need to avoid external contamination which is more frequent in the outdoor method. Additionally, the indoor method gives a better yield because of the possibility to control the temperature, humidity and pest infestation.

The scale of investment would depend on available capital. A cottage level employing six people including the proprietor is however strongly recommended. Tropical species are favoured for cultivation in Nigeria as there would be no need for complex airconditional facility. Cultivation could be easily done with acceptable yield at 30± 2^{0}C (Fasidi and Kadiri, 1993).The recommended varieties and suitable substrates for cultivation are listed in Table 1. A successful mushroom cultivation business would require some good knowledge of the intricacies of managing the technology.

The process technology for mushroom cultivation is divided into (i) substrate preparation (ii) spawn production (iii) actual cultivation of the mushroom and (iv) sanitation and treatment of residues. The expert opinions indicated that farmers should obtain spawn from research stations or spawn producing companies when eventually established. The research stations are sufficiently equipped and competent in terms of know-how in accomplishing the highly technical process of spawn production.

Table 1: Recommended Varieties of Mushroom and Suitable Substrates for Cultivation

Mushroom variety	Suitable substrates
a/ *Lentinus subnudus*	Saw dust
b/ *Lentinus edodes*	Saw dust
c/ *Pleurotus ostreatus*	Saw dust, cotton waste
d/ *Pleurotus squarossulus*	Saw dust, cotton waste
e/ *Pleurotus tuber-regium*	Saw dust, cotton waste
f/ *Volvariella volvacea*	Rice straw, cotton waste
g/ *Volvariella esculenta*	Cotton waste

For optimum mycelial density in the mushroom spawn, the strain is carried on a suitable substrate like rice bran, maize, sorghum and milled cassava peel (Fasidi and Kadiri,1993). Spawn production usually involves four steps, namely pre-cooking of the substrate, filling, autoclaving, cooling down and inoculating with desired mushroom mycelia. Tissue cultures are recommended for isolating and propagating sporeless strains which are environmentally advantageous.

For the purpose of this study, composted blow-room cotton waste is the recommended substrate. The cotton waste is easily obtainable from the textile industry. Calcium carbonate (1%) is added to dry cotton waste (32%) and mixed properly with water (67%). This is pressed into stacks of about one cubic metre size and fermented for about 9 days. During the period, the compost is turned at 2-days interval.

After fermentation, the compost is pasteurized at 60°C for 6 hours once each day on two consecutive days in order to selectively eliminate competing microorganisms. The compost is then cooled down to about

30°C and spawned at 5% ratio. A cover of polythene sheet is applied to retain the moisture and provide condition for high CO_2/air ratio which favours the next mycelial running stage. After three days of mycelial running, the room is ventiliated, exposed to light and the culture moistened. Primordia formation (development of pin-head) is noticed after 3 days and mushroom could be harvested in another 3-4 days.

With blow-room cotton waste, a yield value of 25% fresh fruit-body is used in computation for *Volvariella volvacea* while 85% is used for *Pleurotus ostreatus*. The yield is calculated as wet weight of mushroom per wet weight of compost in percentage. Allowance is given for some loss of efficiency during the learning period in view of the fact that yield values for the two varieties are 30% and 100% respectively (Chang and Hayes, 1978).

Based on the information obtained from the mushroom researchers and participation in the mushroom cultivation workshop, three different investment options are proposed for this project at small enterprise level.

Option A:

This involves the complete process starting from spawn production, substrate preparation and spawning the substrate followed by incubation for fructification and harvesting. *Volvariella volvacea* and *Pleurotus ostreatus* are suitable varieties considered for this option. The cultivation technique recommended for *V. volvacea* is composted and pasteurized blow-room cotton waste direct on wooden shelves with wire mesh while *Pleurotus ostreatus* requires the composted and pasteurized cotton waste in fruiting boxes.

Option B:

With this option, spawn is obtained from research centres or such competent establishments. The substrate is composted, pasteurized and then spawned for incubation and fructification. Both *Pleurotus ostreatus* and *Volvariella volvacea* were considered for this option. The recommended cultivation technique is as in option A.

Option C:

This is the least involving option. It entails purchasing the "ready-for-cropping" spawned substrate bags. The cultivation technique entails incubating the already pasteurized, cooled and spawned subsrate in plastic bags in the mushroom house under suitable conditions for fructification and harvesting. *Pleurotus ostreatus* is the only variety considered for this option.

An investor can start with either of the options B or C depending on available capital and thereafter integrate backward as the business progresses.

Plant Hygiene, Pest and Disease Control

Whatever option the investor adopts, the importance of plant hygiene, pest and disease control cannot be overemphasised. This is necessary for good yield and pure mushroom harvest at all times. A hygienic farm environment is to be maintained by paying special attention to cleaning and heat treatment of the mushroom house. Good work practice using clean clothes and equipment would facilitate the hygienic condition. Regular disinfection and pesticide application regime at the end of each cultivation cycle would complement the efforts to put pests and diseases under control.

Engineering Economic Assessment

The mushroom house is to be built with laterite blocks and plastered inside with a washable finish. Provision is made for ventilation unit and removable flourescent lighting inside the mushroom house. An adjacent composting shed with half level walls is provided. Other facilities for the mushroom cultivation include among others a well furnished inoculation room, deep well, water tank (2,500 litres), electricity generator, steam generator with burners, incubators, shelves or fruiting boxes. These facilities may vary slightly depending on the options under consideration. Shelves are to be constructed with durable wooden frames and wire mesh tiers. The steam generator is to be fired with cooking gas. For the project producing only spawns, the incubation room is thermostatically controlled, windowless with shelves and washable walls. Allowance is made for incidental costs at 5% of the cumulative cost on each list of facilities and civil structures. The allowance of 5% of the cumulative cost of facilities and civil structures for incidental costs is usual in the local equipment fabrication industry to take care of minor flunctuations in the cost of construction materials.

Each option, when operated at full capacity is expected to produce 100 kilograms of fresh mushroom per week, and it will run for 50 weeks in a year. This amounts to 5,000 kilograms of fresh mushroom generating revenue of about 1.25 million naira per annum for the 6 year project life. A typical cash flow for the project on cultivation of *Volvariella volvacea* using option A is shown in Table 2, while Table 3 shows the summary of the profitability analysis (NPV) for the two mushroom varieties using the three different technology options. An adopted price of₦ 250 per kilogram which is about 37.5% lower than the current market price is used in the calculation. This is strategically done to increase the competitiveadvantage of the new business and also to make cultivated mushroom affordable to the less affluent Nigerians.

Table 2: **Cash Flow (₦*) for Project Cultivating *Volvariella volvacea* using Option A.**

	Capacity I	Capacity II	Capacity III	Capacity IV
Investment				
Capacity Investment	724,080	724,080	724,080	724,080
Pre-production expenses	72,408	72,408	72,408	72,408
Sub-total	796,488	796,488	796,488	796,488
Annual Disbursement				
Compost materials	25,200	50,400	75,600	100,800
Operating supplies Polythene Chemicals	8,500 20,000	17,000 20,000	25,500 30,000	34,000 30,000
Fuel and Energy	60,000	90,000	120,000	120,000
Maintenance	41,112	41,112	41,112	41,112
Labour	168,000	168,000	252,000	252,000
Distribution cost	75,000	75,000	75,000	75,000
Sales promotion	15,625	31,250	46,875	62,500
Sub-total	413,437	492,762	666,087	715,412
Revenue				
Sales of Mushroom	312,500	625,000	937,500	1,250,000
Salvage value	181,020	181,020	181,020	181,020
N P V	. 1,133,913	-118,366	487,783	1,633,989

* 1 US $ ₦ 80.00 (Nigerian currency)

The capital investment which is made up of pre-production activities, fabrication, construction and installation expenses vary with the mushroom varieties and technology options (Table 2). The annual operating cost including raw materials, operating supplies, energy, maintenance, labour, sales and distribution expenses are estimated using the prevailing market prices. The business will require 4 and 6 workers for cultivating *Pleurotus species* and *Volvariella species* respectively at full capacity utilization. Their wages will amount to₦ 168,000 and₦ 252,000 per annum respectively. The lower number of staff requirements for cultivating *Pleurotus ostreatus* results from the less volume of substrate to be handled due to higher yields per given quantity of substrate.

The NPV analysis made for the different mushroom varieties and technology options show positive NPVs at 100% capacity utilization indicating that the business is profitable at this capacity (Table 3). All the three options give negative NPVs before tax when the installation is operated at 25% capacity utilization. This implies that production at 25% capacity is not profitable. Both options A and B give positive NPVs before tax at 75 and 100% capacity utilization for the two varieties of mushroom showing that the business will make profits at above 75% capacity utilization. For instance, using option A at 75% capacity for cultivating *Volvariella volvacea* and *Pleurotus ostreatus*, NPV before tax of ₦ 487,783 and ₦ 1,429,819 are generated respectively (Tables 3). Furthermore, option B at 75% capacity utilization for cultivating *Volvariella volvacea* and *Pleurotus ostreatus* generates NPV before tax of₦ 636,133 and₦ 1,843,028 respectively (Table 3).

Table 3: Profitability (NPV) and Sensitivity to Capacity Utilisation for Projects Cultivating *Volvariella volvacea* and *Pleurotus ostreatus*

	NPV (₦)*			
	25% Capacity	50% Capacity	75% Capacity	100% Capacity
Volvariella volvacea				
Options :A	-1,133,913	-118,366	487,783	1,633,989
B	734,697	155,417	636,133	1,656,907
Pleurotus ostreatus				
Options: A	-943,462	243,178	1,429,819	2,616,460
B	-455,961	693,534	1,843,028	2,992,522
C	-438,787	336,674	1,112,135	1,887,596

* 1 US $ ₦ 80.00 (Nigerian currency)

Option C which is applicable to only *Pleurotus ostreatus*, gave a negative NPV before tax at 25% capacity utilization. However,if the plant is operated at above 50% capacity it will generate positive NPV an indication that the business will make profits using option C at above 50% capacity utilization.

The summary of the profitability analysis for projects producing spawns and inoculated bags is in Tables 4. Profitability indices show positive NPVs before tax₦ 608,160 and₦ 2,942,509 respectively for the two projects at 100% capacity utilization. The project producing inoculated substrate bags is relatively marginally profitable at 100% capacity and therefore it is not strongly recommended to investors.

Sensitivity Analyses

The sensitivity of the project was tested in relation to capacity, selling price and useful life of the project.

Sensitivity to capacity was tested for the project using the NPV before tax method. The results show that cultivation of the mushroom varieties using options A,B and C are rather sensitive to capacities. For instance, using option B, a 25% reduction in capacity utilization generated 62% and 38% reduction in NPV for the projects cultivating *Volvariella volvacea* and *Pleurotus ostreatus* respectively (Table 3). This also indicates that the project cultivating *Volvariella volvacea* is more sensitive to capacity utilization.

Table 4: **Summary of Profitability Analysis for Projects Producing Spawns and Innoculated Substrate Bags**

	NPV (₦)*		
	Capacity I	Capacity II	Capacity III
Spawns	-556,883	21,283	608,160
Innoculated Substrate Bags	414,258	1,613,054	2,942,509

* 1 US $ ₦ 80.00 (Nigerian currency)

Capacities per Annum
Spawns

I = 10,000 bottles**
II = 15,000 bottles
III = 20,000 bottles

** Each bottle contains 250g of spawn and sells for ₦30.00

Innoculated Substrate Bags

I = 10,000 bags***

II = 15,000 bags

III = 20,000 bags

*** 1 bag = 1.0kg compost =₦ 75.00

The sensitivity of the project to selling price was also tested using the annual worth (AW) method at 50, 75 and 100% capacity utilization (Table 5). When the operation was considered at 75% capacity utilization, a 12% decrease in price (from₦ 250 to₦ 220 per/kilogram) generates about 99% decrease in AW when working with *V. volvacea* using option A, while the option B's AW decreased by 77%. This shows that the project is quite sensitive to price using either options A or B.

When a similar comparison was made with *Pleurotus ostreatus*, a 12% decrease in price (from₦ 250 to₦ 220 per kilogram) gives a 34% decrease in AW while using option A. The option B gives a decrease of 27% in AW. The results show *V. volvacea* to be more sensitive to price than *P. ostreatus*. This implies that the low priced strategy is better applicable to *Pleurotus ostreatus* cultivation. Option C for *P. ostreatus* showed a 44% reduction in AW when the price is reduced by 12% (from₦ 250 to₦ 220 per kilogram) while working at 75% capacity utilization. From the above analyses, option B is most recommended for its ability to make profit at lower capacity utilization and selling prices.

For a general consideration involving all the technology options, rented premises would relieve the investor of the capital investment cost on land and buildings thereby improving the cash flow and increasing operational profit. It is also likely that the project will operate profitably while selling at a lower price than₦ 140 per kilogram.

The sensitivity to useful life of the project is shown in Table 6. The only variable for each consideration is the useful life. When considering option B at 75% capacity utilization a reduction of the project useful life by 33% from the usual 6 years while working with *Volvariella volvacea* gives a 22% reduction in AW. The same considerations with *Pleurotus ostreatus* gives a 5% reduction in AW. When an increase in useful life was considered, *Volvariella volvacea* gives a 11% increase in AW while *Pleurotus ostreatus* gives a 2% increase in AW. The results show that the project is rather insensitive to the assumed useful life with *Pleurotus ostreatus* being the most stable.

Technology Management And Policy Implications

Some research stations in Nigeria have carried out researches on mushroom cultivation. Their results however remain mostly uncommercialised probably because of lack of research linkages between the researchers and the entrepreneurs (Ilori 1992, Oyebisi *et al* 1996). Ogbimi, (1990) revealed that such lack of proper linkages among the researchers, government, consumers and entrepreneurs hinders the commercialisation of scientific and technological information. Interaction between different sectors of any society is the only means of accelerating its development process. In the above perspective and with reference to researches on mushroom cultivation in Nigeria, the linkage factor which would induce the interaction should be provided through government involvement. The government could encourage such interaction by establishing an agency for coordinating researches and development activities in mushroom cultivation. Workshops and Seminars should also be organised by the agency to disseminate information among researchers and train prospective investors in mushroom technology and management techniques. In such a way the current available mushroom biotechnologies would be harnessed for the physical development of the industry. Some existing organisations, e.g Federal Institute of Industrial Research, Oshodi (FIIRO) Lagos are well suited in performing the above mentioned function because of the existing infrastructural facilities and available specialized skills. Just of recent FIIRO organised a training workshop on mushroom cultivation for existing and potential mushroom growers. The workshop was well attended. Other governmental bodies like the National Directorate of Employment (NDE), Industrial Development Centres (IDC), Ministries of Agriculture, Industry, Science and Technology, and Technology Business Incubation Centres (TBIC) should be engaged in skill training programs for mushroom cultivation.

Table 5: Sensitivity of Mushroom Cultivation Project to Selling Price

		AW (X 100)											
		Selling Price (₦/kg)											
		140	150	160	170	180	190	200	210	220	230	240	250
50 % Capacity													
V. volvacea	A	-302	-277	-252	-227	-202	-177	-152	-127	-102	-77	-52	-27
	B	-239	-214	-189	-164	-139	-114	-89	-64	-39	-14	11	36
	C												
P. ostreatus	A	-219	-194	-169	-144	-119	-94	-69	-44	-19	6	31	56
	B	-116	-91	-66	-41	-16	9	34	59	84	109	134	159
	C	-198	-173	-148	-123	-98	-73	-48	-23	2	27	52	77
75 % Capacity													
V. volvacea	A	-301	-263	-226	-188	-151	113	-76	-38	1	37	74	112
	B	-266	-229	-191	-154	-116	79	-41	-4	34	71	109	146
	C												
P. ostreatus	A	-84	-47	-9	28	66	103	141	178	216	253	291	328
	B	11	48	86	123	161	198	236	273	311	348	386	423
	C	-157	-120	-82	-45	-7	30	68	105	143	180	218	255
100 % Capacity													
*V. volvacea*A		-175	-125	-75	-25	25	75	125	175	225	275	325	375
	B	-170	-120	-70	-20	30	80	130	180	230	280	330	380
	C												
P. ostreatus	A	51	101	151	201	251	301	351	401	451	501	551	601
	B	137	187	237	287	337	387	437	487	537	587	637	687
	C	-117	-67	-17	33	83	133	183	233	283	333	383	433

* 1 US $ ₦ 80.00 (Nigerian currency)

Table 6: Sensitivity to Useful Life of Project.

	AW (₦) (X 1000)		
	Useful Life		
	4 Years	6 Years	8 Years
50% Capacity			
V. volvacea			
Option A	-80	-27	-1
B	4	36	51
C	—	—	—
P. ostreatus			
Option A	14	56	76
B	139	159	169
C	63	77	84
75% Capacity			
V. volvacea			
Option A	59	112	137
B	114	146	162
C	—	—	—
P. ostreatus			
Option A	287	328	349
B	403	423	433
C	241	255	262
100% Capacity			
V. volvacea			
Option A	322	375	401
B	349	380	396
C	—	—	—
P. ostreatus			
Option A	559	601	621
B	667	687	697
C	419	433	441

A "culture bank" should be established by the Federal Government at the FIIRO and some other research centres so as to preserve and propagate the various mushroom varieties in order to prevent their extinction, and make them available to growers at commercial rate. FIIRO presently has adequate facilities like back-up power supply, other infrastructures and technical skills needed to accomplish this function. These facilities could be expanded further as the demand increases. The coordinating agency should also be given the task of unpackaging and imitating the imported mushroom cultivation technology.

Furthermore, privately and/or government owned spawn companies should be established to produce spawns and ready-to-fruit inoculated bags for sale to farmers. The government should also make the facilities of the family economic advancement programmes (FEAP) readily accessible to mushroom investors.

Biosafety regulation should be enacted and enforced to prevent poisonous mushroom from getting into the market. The enforcement authorities should be well equipped with personnel and vehicles to ensure effectiveness.

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References

Adeniyi, A.; Ilori, M. O. and Akarakiri, J. B. (1997) *An evaluation of market potential and impact of cultivated mushroom in South-Western Nigeria.* Submitted for publication in Ife Quarterly Journal of Administration.

Agricon, (1988) "Mushroom Cultivation in the People's Republic of China". *Speizepilze Entwicklung + Landlicher Raum*, 2:11

Alofe, F.V. (1985) *The General Characteristics and Cultivation of some Nigerian Mushrooms.* Ph.D. Thesis, Obafemi Awolowo University, Ile-Ife, Nigeria.

Chang, S. T. (1987) "World Production of Cultivated Edible Mushroom in 1986". *Mushroom Journal for Tropics*, 7, 117 - 120.

Chang, S. T. (1988) "Biotechnology for Mushroom Cultivation in Developing

Countries." *Proceedings of the International Symposium on Application of Biotechnology for Small Industries Development in Developing Countries*, Bangkok, Thailand, 21-24 Sept. 1988 pp. 92-97.

De Garmo, E.P.; Canada, J.R. and Sullivan, W.G. (1979) *Engineering Economy.* 6th Edition. Macmillan Publishing Co., Inc. New York. 111-156.

De la Mare, R.F. (1991) *Manufacturing Systems Economics* pp.57-90. Technological Management Consultants Ltd. Bradford.

De Leon, R. and Rolz, C. (1988) "Mushroom Cultivation in Guatemala". *Speisepilze, Entwicklung + landlicher Raum*, Germany 2:88.

Fasidi, I.O. and Kadiri, M (1990) "Effect of Maturity on the Nutritive Value of two Nigerian Mushrooms, *Tricholoma lobayensis and Cortinarius melliolens. Fries*", *Nigeria Journal of Botany* 3:41 - 47.

Fasidi, I.O. and Kadiri, M (1993) "Use of Agricultural Wastes for the Cultivation of *Lentinus subnudus* (Polyporales Polyporaceae) in Nigeria". *Rev. Biol. Trop* 41:411 - 415.

Fasidi, I.O. and Kadiri, M (1995) "Toxicological Screening of Seven Nigerian Mushrooms". *Food Chemistry* 52:419 - 422. Elservier Science Ltd. Great Britain.

Hill, B.J., Overholts, L.O., Popp, H.W., and Grove, A.R. (Jr.) (1960) "Fungi". In: *Botany - A textbook for Colleges*, 3rd Edition, pp. 376 - 422. Mc Graw-Hill Book Company, Inc. New York

Ilori, M.O. (1992) "A Bibliographic and Policy Review of Technological Development in Food Processing Industries of Nigeria". *Science, Technology and Development.* 10:67-79.

Ilori, M.O. and Isikhuemhen, O. S. (1995) "Mass Production of Edible Mushroom." *Project Report Group in the 9th International Training Programme on Introduction of Industrial Biotechnology.* Braunschweig, Germany. 28 Aug. - 13 Oct. 1995, pp.1-25.

Ilori, M.O. Layokun, S.K. Idowu, A.O. and Solomon, O.B. (1996) "Economics of Small Scale Ethanol Production from Breadfruit and Cassava via Plant Enzyme and Acid Hydrolysis". *Technical Quarterly, Master Brewers Association of the Americas.* 33 (1):39-43.

Kadiri, M. and Fasidi, I. O.(1990) "Studies on enzyme activities of *Pleurotus tuber-regium* (Fr) Sing and *Tricholoma lobayensis* (Heim) at various fruiting stages". *Die Nahrung* 34:695- 699.

Kadiri, M. and Fasidi, I. O.(1994) "Growth requirements of *Lentinus subnudus* Berk, a Nigerian edible mushroom". *Chemie Mikrobiologie Technologie der Lebensmittel* 16:80-84.

Kamra, D.N. and Zadrazil, F., (1988) Microbial Improvement of Lignocellulosics in Animal Feed Production. Commission of the European Communities Treatment of Lignocellulosics. Elsevier Applied Science Publishers, London, 55-63.

Madunagu, B. E. (1988) "Collection and studies on the cultivation of *Pleurotus sqarrosulus* (Monto) Singer". *Nigerian Journal of Science* 22:51-55.

Maziero, R. (1988) "Mushroom Cultivation in Brazil. *Speisepilze". Entwicklung+ Landlicher Raum*, Germany 2:10.

Ogbimi, F.E.(1990) "Preparing for Commercialization of Scientific Research results in Nigeria". *Science and Public Policy* 17:373-379.

Okhuoya, J. A. and Okogbo, F. O. (1991) "Cultivation of *Pleurotus tuber-regium* (Fr) Sing. on various farm wastes". *Proceedings of Oklahoma Academy of Science* 71:11-121.

Oyebisi, T. O; Ilori, M. O. and Nassar M. L. (1996) "Industry-academic relation: An assessment of the linkages between a university and some enterprises in Nigeria". *Technovation* 16:203-209.

Park, J.S. and Zadrazil, F. (1988) "Der Pleurotusanbau in Korea". *Speisepilzer, Entwicklung + Landlicher Raum* 2:12-13.

Zadrazil, F. (1988) "Production of Inoculum (spawn) for cultivation of ediblemushroom in tropical Countries". *Proceedings of the International Symposium on Application of Biotechnology for Small Industries Development in Developing Countries.* Bangkok, Thailand, 21-24 Sept. 1988 pp. 84 - 91.