FACULTY OF ENVIRONMENTAL AND DEVELOPMENT STUDIES

MUSHROOM PRODUCTION CENTRE

A DESIGN THESIS REPORT PRESENTED TO THE DEPARTMENT OF ARCHITECTURE, UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE POST-GRADUATE DIPLOMA IN ARCHITECTURE

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JUNE 1996.

DEDICATION

This Design Thesis is dedicated to My Parents and my Sisters.

ACKNOWLEDGMENT

My sincere gratitude and thanks goes to Nana Abora for helping me choose this topic. Also my gratitude goes to Prof. H.N. Wellington who as my supervisor guided me to the successful completion of my Design Thesis.

My gratitude also goes to Mr. Sawyer of the Food Research Institute, the Ghana Export Promotion Council for letting me use their Library.

Mr. W. Enninful-Eghan, my year master for encouraging me.

Ms Eunice Amuzu - for having the patience to type this report.

All my course mates (1993 - 1996) and numerous friends, S.M., Shato, Oliver.

I also thank my parents and sisters for supporting me through the course and above all the Lord Almighty for making everything possible.

CHAPTER ONE

1.0 INTRODUCTION

A major advance in agriculture today is the development of cultivation techniques for edible tropical mushrooms which, since earliest times, have been valued as a special delicacy in soups and stews. This development has been necessitated by the seasonal appearance of this crop as well as the fast increasing demand for meat substitute here and abroad.

Successful cultivation of crops, such as mushroom is the kind of crop which requires knowledge of basic sciences. But one remarkable characteristic of these mushrooms is that they only require many kinds of either agricultural, industrial or other waste as substrates for the production. the substrates must have quite a reasonable degree of warmth and humidity and the nutrient content must be higher to support the growth of a particular mushroom. If these basic requirements could be met by this organisms the mushrooms could convert these waste material into human food.

Notwithstanding the simplicity of its growth process,mushroom cultivation is a complicated business. It involves a number of different operations including the selection of an acceptable fruiting culture of the mushroom, preparation of spawn and compost, inoculation of the compost, crop care, harvesting, preservation of the mushroom and marketing. Each of these operations consists of many other sequential steps to be pursued which are equally necessary for a successful operation of the mushroom business.

While there is available, a solid background of scientific information for these various operations with a number of cultivated species. In many aspects mushroom cultivations is an art and a science. Consequently, in order to maintain a reasonably high and stable yield of mushrooms both fundamental knowledge of mushroom science and the

accumulative information of practical experience in mushroom cultivation are required.

The cultivation of mushroom deals with living organisms, not only the mushroom itself but also other microorganisms including both harmful and beneficial ones. Therefore the methods employed in mushroom cultivation require some modification from one region to another, as different environmental conditions and different species of micro organisms may be encountered.

Mushroom farming provides one of the most economical way to make use of agricultural by-products which otherwise would have been left to rot in the field. These include eg. 1. Rice Straw 2.Maize Storer, cobs and chuff.

In summary, science and practice in mushroom cultivation have led to some useful general concepts about various stages in the process but the biological complexity involved in the interaction of various micro organisms, different natural substrates and a diversity of environmental conditions requires a multitude of methods for cultivating mushrooms.

1.1 HISTORICAL BACKGROUND

Mushroom farming has been well developed in the U.S.A. and most of the European countries. The Southeast Asian countries which fall within the sub tropical Region have also seriously in the past two decades occupied most of the research activities on edible mushrooms.

In Ghana, the main dishes are almost always prepared from a carbohydrates rich source. Therefore if mushrooms could be introduced into the diets of Ghanaians great step would have been made to improve the food quality.

The Ghanaian taste for mushroom is generally high especially among the rural folks. Mushrooms are usually collected wild from the bush during the rainy season and especially after a heavy rainfall they are either eaten by the family or sold on the markets.

Since these edible mushrooms do not grow in isolation but do also sprout with many other fungi species, either poisonous or non-poisonous, the wild collection of these edible mushrooms present special problems.

It is most common to hear that people especially children have been poisoned by eating the poisonous mushrooms. The edible mushroom and other non-edible ones are very much similar in colour, scent and the environment in which they are mostly found are almost the same, therefore, many mushroom hunters confuse the edible with the poisonous one. Experience may be counted as the most reliable tool to select the edible from the poisonous fungi in Ghana. But experimentations with pilot schemes have shown that a systematic, scientific commercialisation of mushroom farming may be an ideal solution to mushroom poisoning and creation of a large market for mushroom domestic consumption and exports.

1.2 MUSHROOM PRODUCTION IN GHANA

In Ghana mushroom production has always relied on the rains. After a heavy rain the mushrooms spring up on dead wood etc, and after the rains mushrooms are no longer readily available.

This thus makes it difficult for those who love mushroom to have it all year round, until recently when the Food Research Institute introduced the scientific approach to the cultivation of mushroom. This method made it possible for people to grow their own mushrooms in their back yards.

This process of cultivating mushroom was introduced into the country by the Food

Research Institute. It has thus made it possible for so many backyard growers to regularly mushrooms on the market always. The demand is always higher than the supply can meet. As at now there is a pilot project in Accra where mushrooms are cultivated for sale to the general public.

1.3 OBJECTIVES OF STUDY

To research into sawmill waste management in Akim Oda including operations and to find an architectural solution for the use of sawdust in the production of mushroom.

Also to develop in consonance with ecological requirements a model layout for the cultures and growth of mushroom for local and international consumption.

To generate sustainable employment for the redundant rural youth in order to discourage them from migrating to the already choked cities.

Then also to utilise saw waste ie. saw dust in the timber industry more productively and to keep the environment clean.

The basic scope of the project will be to design a mushroom production centre with the following:-

1. Production Halls

   a. composing b. inoculation room c. incubation room d. cropping room

   e. finished product area f. waste handling

2. Research laboratory for spawning

3. Storage facility for Raw Materials

4. Storage facility for finished product

5. Central administration to house the administrative sector of the unit

6. Parking facilities for staff, visitors, vehicles for raw materials and finished products

7. Sanitary and changing rooms for staff, visitors and workers

8. Welfare area for both staff and visitors

CHAPTER TWO

2.0 SAWMILL WASTE

The main raw materials of sawmills is timber. The by-product of these sawmills which is sawdust is not put to maximum economic utilization.

With the exception of slabs and edgings which are used to some extents as firewoods and for manufacture of charcoal, the rest of the by-products including sawdust are declared waste. There are no proper system of treatments and disposal of these waste. They are either disposed of on site or off-site untreated in areas not planned for waste disposal. Consequently, much land is wasted on waste disposal.

Most of the time the saw waste is burnt causing pollution to the atmosphere. Also because it is left untreated when the wind blows it carries some of this saw waste which is not too good for breathing thus causing illness. The burning of sawdust can sometimes lead to the burning down of houses when care is not taken. Also farm lands are burnt down sometimes causing deforestation.

Generally, sawdust is not put to any economic use. It is disposed off as waste without pre-treatment. This disposal involves higher volumes of land. The loose particles of the untreated sawdust also pollute the air causing poor visibility, bronchialial and eye disease. Disposal into valleys and water bodies in the long run causes water pollution. Burning is the principal source of common air pollutants.

The harmful gases emitted in the form of fumes and smoke adversely affect vegetation and man. Disposal on site is a threat to fire safety. Sawdust can easily catch fire and the probability to burn down the mill cannot be overlooked.

2.1 WASTE GENERATION

Sawmills turn out large volume of wood residuals. Solid wood waste and sawdust composing the wood residual have been estimated at fifty (50) to fifty-five (55) percent of the log input. Virtually all wood solids are consumed locally as domestic fuel. Sawdust have been estimated at 15 to 20% of the total log input. The bulk of sawdust generated by the sawmills is not utilised. A small proportion is used in charcoal burning to effect incomplete combustion. The rest is disposed of as waste, leading to serious environmental problems.

There are about 120 registered sawmills currently operating in the country. These sawmills together generated 400,000 cubic meters (118,200 tons) of sawdust in 1993. As at now the sawdust generated is under utilised.

Sawmills in Akim Oda account for about 30% of the total sawdust produced in the Country. Disposal of sawdust produced here in Oda is a problem to both sawmillers and the people in the town hence a proper utilisation of saw dust by means of its employment as a major component in the process of cultivating mushrooms will be much appreciated.

It has been realised that over the years a lot of sawdust has been generated.

Table showing sawdust generated in cubic Meters since 1990:-

Year	1990	1991	1992	1993	1994
Sawdust					
M	297,000	315,000	350,000	397,000	407,000

Source I.R.N.R.

Out of this total only about 10% of this is utilised as landfills and as a cover material for charcoal burning.

2.2 AGRICULTURAL WASTE UTILIZATION

Mushroom farming provides one of the most efficient ways to make use of agricultural land. Mushrooms grow well on many agricultural by products which otherwise would have been burned or left to rot in the field. These include:

- Rice Straw
- Maize Storer, cob and chaff
- Banana or plantain leaves
- Oil palm pericarp fibre, empty bunches
- Sawdust and logs of timber and fruit trees
- Waste paper, tea leaves etc

Mushroom growing is the best way to make use of the land. Many mushroom farms produce between 60,000 and 70,000 pounds dry protein per acre annually using really unsophisticated methods comparatively. Fish farming in contrast yields about 600kg dry protein per acre per year.

Mushrooms grow successfully on a wide variety of inexpensive, easily obtainable agricultural wastes.

Another important advantage of growing mushrooms is the use to which the spend material can be put after the mushroom has been harvested. The spent compost can be used s manure or organic fertiliser.

Spent straw can also be used for feeding sheep and cattle since it has little fibre and therefore its' digestibility is improved.

The protein content of the straw is also drastically increased by the presence of

mushroom spawn.

Thus it can be seen that agricultural waste can be utilised profitably, by means of mushroom cultivation. It has been realised that with mushroom cultivation there is always the utilisation of almost all agricultural by products as high lighted above.

2.3 OBSERVATION

The sawmilling industry in Ghana generates a lot of saw dust which is generally underlisted. The sawdust is disposed of as waste, leading to serious environmental problems.

These environmental problems go a long way to affect the life of man and the ecology. Thus if a method can be found to make maximum use of the waste product which is sawdust, then an optimal solution to the problem of the environment would have been solved.

2.4 SUMMARY

In appropriate planning of the sawmilling industry has led to great environmental losses. The problem is gathering pace due to rapid increase in population and demand for timber. The more timber produced the more the generation of saw dust thus increasing the problem of the environment.

One area of obvious potential is he development of a process to utilise the sawdust generated to produce or cultivate mushroom for human consumption.

CHAPTER THREE

3.0 MUSHROOM CULTIVATION

A major advance in agriculture today is the development of cultivation techniques for edible tropical mushrooms which since earliest times, have been valued as a special delicacy in soups and stews.

This development has been necessitated by he seasonal appearance of this crop as well as the fast increasing demand for meat substitute here and abroad. simple methods are now available by which individuals can quickly grow their own mushrooms all year round without much horticultural knowledge.

In cultivating ones own mushrooms one avoids the danger of picking poisonous wild mushrooms which when eaten may result in death or violent illness. There is no ready test to assist one to establish if gathered mushrooms are poisonous or edible. the safe way is to identify the species correctly or to grow ones own from purchased pure spawn of a known species.

A very attractive characteristics of mushroom cultivation is that the cultivations is not confined to one season as it is with most other garden (crops) vegetable mushroom can be grown all year round, furthermore the grower has the choice of growing mushroom of different species and of high yielding ones. By also providing better growing conditions and preventing insects damage and other pest attack, one can continuously control the yields continuously.

Mushrooms are without doubt the fastest growing vegetables. The oilpalm mushroom for example requires 10-14 days after planting to reach maturity and as many as five (5) crops may be harvested on the same bed within a period of 1.5 - 2 months.

One notable advantage in mushroom growing is the fact that almost any place can be adapted to accommodate its growth eg. lawns, pastures, old sheds, garages, green houses etc.

3.1 THE NEED FOR MUSHROOM CULTIVATION

Apart from the utter deliciousness of this tempting food, it has a number of food values. The notion that mushroom contains little or nothing of real food value has been entirely disproved.

A mushroom contain more protein per 100 pounds by weight than any other vegetable with the exception of green peas, soya beans and a few legumes. Whereas the fresh mushroom contains only 3-4% protein. The dried species has between 21-40% soya bean is rated over 40% dry protein. However, the mushroom is unequalled as a farm crop for producing the highest yield of protein per acre per year.

Mushroom protein is also of a high quality containing all the nine (9)basic protein units (amino acids) essential to man. This is contrast to legumes and cereals which lack some of these protein units.

Mushrooms are richer than most vegetable in some vitamins such as vitamins B1, B2 and B6. They also contain vitamin C and D. They have a rich supply of folic acid (the vitamin which cures pernicious anaemia) in larger amounts than practically any other vegetable or meat with the exception of liver.

Mushrooms have a richer supply of minerals than many meats and have double the amounts appearing in most vegetable. They contain calcium, sodium potassium, phosphorous, zinc, iron and a fair amount of sulphur and manganese.

Mushrooms are however low in calories and have very little sugar and no starch, the worst fattening agents. It is known that the sugar content and cholesterol level in

blood are both lowered by eating some species of mushrooms.

Mushrooms, thus serve a useful purpose in providing amongst others sustaining food for diabetics in place of other vegetables and are one of the most suitable diet for heart patients and over weight cases.

The following indicate the corresponding uses of many species of mushrooms in treating some health problems: -

1. Common Button Mushroom - lowers blood pressure and increases lactation in breast-feeding mothers.
2. Oyster Mushroom - prevents occurrence of liver cirrhosis and vascular sclerosis, inhibits the growth of tumour and cancer cells.
3. Oil Palm Mushroom - promotes body resistance against infectious diseases, accelerates healing of wounds and reduces blood serum, cholesterol.
4. Jew's Ear Mushroom - used for the treatment of hypertension, weakness, after child birth, rheumatic pains cures sores and boils not healing due to old age.

This shows how important mushrooms are to us as a society. It is evident therefore that mushrooms will not only serve the farmer and his family as a tasty meat substitute but also as a vegetable with a high protein content vitamins and universal salts. Apart from being an source of income.

3.2 SUMMARY

As already mentioned mushrooms are very good for consumption and thus are necessary for good health.

Their medicinal properties makes it a very useful vegetable. a promising new addition to backyard gardening in Ghana is the production of tropical mushroom on

domestic and agricultural waste which can be practised all year round.

The cultivation methods are not difficult but to avoid contamination, competitive micro organisms aid to ensure optimal mushroom production, cultural practices must be carried out correctly.

CHAPTER FOUR

4.0 FEASIBILITY STUDIES

There is the need for the country to make economic use of resources that have been hither to regarded as waste. This has been solved in the development in recent years of a whole new modern technology for sawdust processing and utilization.

Research into the utilisation of Sawdust for the production or cultivation of mushroom has been developed extensively. It has been realised that throughout the year the demand for mushrooms are high but they are only available seasonally not to mention the fact that some are very dangerous for human consumption.

The demand for mushroom is not limited to Ghana only but all over the world especially in North America and Europe there is always a constant demand for it. Ghana is endowed with a lot of trees and therefore the greater number of sawmills generating a lot of the sawdust for use in the production of mushroom.

Also the increase in population demand a lot of wood for various purposes.

4.1 ESTABLISHING THE NEED FOR THE PROJECT

In Ghana, the main dishes are almost always prepared from a carbohydrates rich source. Therefore if mushrooms could be introduced into the diets, a great step would have been make to improve the food quality.

The Ghanaian taste to mushroom is very high. It is most common to hear that people especially children being poisoned by eating the poisonous mushrooms.

The edible and non-edible mushrooms look alike in colour, scent and the environment in which they are mostly found are almost the same therefore, many "mushroom hunters" confuse the edible with the poisonous ones. Experience may be

counted as the most reliable tool to select the edible from the poisonous fungi in Ghana. But a systematic scientific commercialisation of mushroom farming may be an ideal solution to mushroom poisoning.

It has been estimated that about 35,000 tons of sawdust is produced in Akim Oda annually. When this amount of raw material can be utilised in the cultivation of mushrooms the amount of vitamins, iron, protein etc - which will be gained when consumed by people will be very enormous. Also the ailments and diseases which will be cured will be beneficial to the society.

Sawdust which is disposed of in heaps indiscriminately in the industrial area of Akim Oda could be recycled into raw material for the cultivation of mushrooms.

Mushrooms can be sued as substitute for meat. Comparing the cost of 1kg of meat to 1kg of mushrooms, one will realise that it is cheaper to buy mushrooms than meat. Moreover, mushrooms have a better protein content than most meats.

Sawmills spend a lot of money to dispose of sawdust. This money spend will be reduced if the sawdust is used profitably in the production of mushrooms which is edible. Amount gained thereby could then be used wisely somewhere else for the good of the community.

Furthermore, conversion of sawdust into a raw material for the production of edible mushrooms means, a reduction in pollution. This process of converting sawdust to edible mushrooms would create employment for the youth in the town.

4.2 SUITABILITY AND SUPPLY OF RAW MATERIAL

It is quite certain that mushrooms grow on wood waste. If one goes or happens to go round the local timber sawmills during the wet season, it can be observed how mushrooms are often collected by the local people, from the heaps of woodwaste.

Agricultural wastes such as used tea leaves rice straw, cotton waste, and tobacco mud ribs (which are used by the South East Asians)are not easily available in Ghana. The most common industrial waste is the sawdust which is one of the major raw materials for the cultivation of mushrooms.

Traditionally the oyster mushroom has been cultivated on hardwood logs in natural environments. The technique usually requires more than one year from the time of inoculation of the mushroom spawn to the harvesting of the first crop and it is also inevitably influenced by weather conditions.

Recently new methods have been developed that allow production on a regular and stable basis in a relatively short time.

By using lignocellulosic material supplemented with other ingredients and growing under controlled environmental conditions a "sawdust cultivation method" has been devised which requires only 2 to 4 months for fruiting to occur. Here the sawdust is mixed with other raw materials and incubated for cropping.

Biological efficiency (fresh weight of mushroom/ dry weight of sawdust substrate) on supplemented sawdust is up to 145% in 6 months as compared to 35% over a 6 year period with the natural log cultivation.

Generally sawdust is the main substrate for the cultivation of mushroom and is readily available from the sawmills.

Water, which is needed in large quantities for mixing the compost ie water and sawdust are the main raw materials needed for the process. This therefore makes the project very economically and environmentally feasible.

4.3 MARKET CONDITIONS

Traditionally, marketing of mushrooms is not be too difficult a task. This is due to its seasonal nature as it is only obtainable during the rainy season during which its demand very is high. By means of systematic cultivation, it can be got through the year and this keeps the market active on continuous basis.

As mentioned earlier mushroom have medicinal properties and we also better substitute for meat. Considering that 1kg of meat is about ¢4000 - ¢4,500, which is almost beyond the 'average mans pocket' a kilogram of mushroom cost less than the price of 1kg of meat. Moreover, it is relatively healthier from the point of view, ailments associated with meat consumption. It gives more protein and has almost all the vitamins.

Currently there are not enough mushroom growers to satisfy the demand for mushrooms all year round. Because of this, people buy the fresh ones and store for such a long time that it loses its flavour.

The present producers are not able to satisfy the local consumption, left alone exports.

4.4 EXTENT OF MARKET

Quite recently specialised international tradefairs on food products taking place in the European community throughout the year,has shown the demand for mushrooms.

The steady growth of the quantity and dried mushrooms imported into the European Community during the last five years (see table) has shown there are increasing. European Community imports are constantly looking for new sources of supply of dried mushrooms. Moreover national legislation on picking an selling of wild species are becoming more strict, thus favouring imports.

The European Community market for dried mushrooms is expected to increase very much in the coming years and sales prospects are good for exports in developing countries able to compete with traditional suppliers in meeting quality requirements and delivering terms.

The extent of market for mushrooms produced here is very wide and show how lucrative it is becoming everyday.

4.5 PROCESS SELECTION

The choice of technology this offered in mushrooming is materially narrowed down by limitations imposed by the availability of materials for production. When a choice is made, it is necessary to know about the process available in order to access the possible application of each process to the end product, the raw material available and the size and area under consideration shall also be considered.

There are three major types of edible mushrooms and these are: -

1. Oil Palm Mushroom, 2. Oyster Mushroom and 3. Woodear Mushroom and they are cultivated differently. The raw materials are different, but the general process is almost similar.

4.5.1 THE OIL PALM MUSHROOM

The best materials for indoor cultivation of the oil palm mushroom, which occurs naturally on decaying oil palm trunks are cotton waste and kapok. The cotton waste is a waste product from the textile industry.

This process consist of mixing the compost substrate in cotton waste with water and limestone (Calcium Carbonate) and then left to stand for 2 days for the compost to ferment, then turn it inside out till the fifth day before bagging takes place.

Then it is sterilized and spawn are added. Not water is used in sterilization. The substrate is soaked in boiling water for 10 - 15 minutes or in hot water (65 - 75 degrees C) for one hour. After this it is left to cool to room temperature.

After spawning, full growth of the mycelium is achieved within 5 - 6 days depending on the quality of the cotton waste, and the temperature. This phase of growth is best at 33 degrees celsius in the dark and no watering is required.

The Mushroom House can be closed tightly for the first five days. An insecticide is used to control flies eg. acatellic or agrothon.

After this fruiting takes place. This process takes a longer time to reach fruity stage and its prone to contamination.

4.5.2 THE OYSTER MUSHROOM

The Oyster Mushroom is generally easier to grow than the oil palm and should be the choice of every grower because of the following reasons:-

a. yields obtained from this process are higher than any other process ie Oil Palm. Whereas the latter can produce between 20-45 kgs of fresh mushrooms on 100kgs (dry weight) of cotton waste, the Oyster mushroom gives between 70 - 100lbs or more on the same amount of material.

b. the raw material (sawdust) is readily available.

c. only a small amount of light is needed for the fruit bodies to grow.

d. the oyster mushroom requires a high concentration of Carbon Dioxide for the rapid growth of the spawn and therefore grows well in closed containers such as polythene bags. The polythene bag technique is inexperience and gives best yields and the earliest appearance of

fruitbodies.

4.5.3 THE WOODEAR MUSHROOM

The Woodear Mushroom grows on maize cobs, sugarcane bagasse. It is cultivated on logs of eg coconut, cocoa and mango etc. Bottles are used for the compost material. Plug the bottles with cotton wool and cover with water resistant paper or aluminium foil held in place with rubber band. Sterilize the bottle in a pressure cooker for one and a half hours or steam at 100 degrees celsius for 10 hours.

Here incubation of the bottles takes a month for the mycelium to grow. The mature fruit bodies can be harvested 12 -14 days after in the growing house. The expected yield is 25 -75lbs of fresh mushroom per 100lbs of dry substrate after three flushes in a production cycle of about 65 days.

Of all the three processes, the Oyster Mushroom cultivation technique is the most appropriate. This is because the materials are readily available and also it is easier to grow and the yield is more within a short period.

This system was selected because of simplicity of the process, cost of production and the quality of mushroom.

4.6 STORAGE

The quality of mushroom depends on efficient storage. To get good quality mushrooms the sawdust should be well kept preferably under a shed or covered with polythene bags.

This is to increase the calorific value of the sawdust. If the sawdust is exposed to too much moisture the calorific value is reduced. Some heat is necessary to evaporate

water out of material.

Sawdust for mushrooming, require protection from ambient condition especially water since water will eventually be added to make the compost otherwise it will become very soggy and will cause a lot of contamination. Therefore the sawdust will have to be kept very well.

4.7 SITE SELECTION

In selecting a site for the production of mushroom, proximity of plant to the source of raw material is essential to cut down unnecessary cost of transporting over long distances.

An efficient transportation system must exist in the area to be able to transport finished product economically to the various outlets for sale. The cost of sawdust is an element of transport cost from sawmill to plant.

Large quantity of water is necessary to run the plant. Water is consumed directly by staff and indirectly by the process ie. for composting and during cropping. A total of about six hundred gallons can be consumed during composting and cropping within one cycle of production. The water need not come from the water and sewerage network. Water from the stream (River Birim) near the site can be used. Power is also very essential, for the environmental control deserves the use of air-conditioners.

Site for the plant must therefore be serviced or close to the main power supply lines.

4.8 MANPOWER

The nature of the plant process requires highly skilled and semi-skilled labour. Training the plant staff by experts with particular emphasis on management and maintenance skills is necessary.

4.9 WASTE MANAGEMENT

Volume of waste generated by the plant is low. Plant's waste include new harts of compost, carbon dioxide and water.

The Carbon dioxide is disposed off into the atmosphere. collection is aided by extractor or absorbers, fitted into ventilation woods connected to the roof and walls.

The waste water drains off into the main drains which runs off to the stream. Waste water is generated from the cropping stage.

Compost remnants are generated when the compost has been harvested. the remains are gathered and bagged. This is sold as fertilizer to farmers. It is very good to use as fertilisers. It is collected only after the mushroom has been harvested.

CHAPTER FIVE

5.0 CASE STUDIES

The objective of these case studies is to study the way the construction of plants was done. Also to see how the environmental conditions were handled and the choice of materials used.

5.1 MUSHROOM FARM, MEXICO

The farm was built in a diary and coffee ranch in the neighbourhood of Coateec State of Veracruz. On the ranch grounds besides "beneficio" (a place for the wet coffee processing) for easy management and transportation of the raw material (coffee pulp). The area covered by the farm is about 145 square metres (Fig). This area was divided into four (4) sections

Outdoor - a. area of the coffee pulp fermentation
(+/- 31sq.m)

b. pasteurization area (+/- 9sq.m)

Indoor - c. spawning (+/- 36 sq.m)

d. mushroom production and growing area
(+/- 69 sq.m)

The installations for indoor cultivation were built in plastics, wood and with a design in order to reduce capital cost. the walls were made of black plastic mostly supported by a wood frame. This plastic is a good material to keep the farm warm during the cold months (October to February) in this region. Likewise in the warmer months, (March to September), the humidity and temperature can be relatively well controlled by spraying water on the floor. The farm roofing was made of dark and transparent plastic

sheets.

5.1.1 PRODUCTION PROCESS

The fresh coffee pulp was prepared to a store of about 5 X 3.85 X 2m raised to 3.40m where the pulp was then transferred to the fermentation area. The fermentation was carried out by piling up the pulp in pyramidal heaps. The period of fermentation was between 4 - 7 days. For pasteurization the coffee pulp was immersed in hot water at about 70 degrees celsius for thirty minutes. The substrate was then allowed to drain for about one hour in order to reach 70 - 80% of humidity and subsequently cooled and spawned.

The spawned coffee was introduced into plastic bags of 50 X 70 cm with randomly distributed holes. These containers were filled with about 9kg of fresh substrate. The number of replicates depended on the strain used.

It was then moved into the Mushroom growing area for harvesting.

5.2 OBSERVATION

The layout is very simple and convenient to use. The general conditions for the cultivation of mushroom has been satisfied. The farm did not express any architectural forms. Also it was realised there were no changing rooms.

5.3 CONCLUSION

The choice of material is very good, especially for the interior of the cropping area. Generally the construction is very simple and that should help in achieving a good and efficient running of the facility.

5.4 NATIONAL MUSHROOM PROJECT, ACCRA

The facility occupies a total area of about 800 sqm and its production capacity is about 5 tons of fresh mushrooms a year. It is an experimental project. Generally the farm was constructed with block work with asbestos as the roofing material.

The cropping house is the only place with a different type of construction. It is constructed with thatch as the roofing material and the walls as mat supported by timber frames.

5.4.1 OBSERVATION

Production process is easily identified. The spaces have been well defined for the various processes. There are changing rooms for the workers. The cropping house which is supposed to be close to the incubation room is rather located quite a distance. It is near the composting area, thus creating the environment for contamination. There is no character about the facility.

5.4.2 GENERAL COMMENTS

The facility lacks any form of cleanliness. The hygienic conditions are very low. Also the general condition for the growth of mushrooms has not really been achieved. The facility did not have any real character in terms of architecture. Also a clean environment will have to be well conceived to enhance the new project.

CHAPTER SIX

6.0 GENERAL ASPECTS OF GROWING MUSHROOM ON SAWDUST

The Oyster Mushroom is a non-pathogenic fungus growing on the wood of dead deciduous trees in nature. Normally mushrooms are produced from dikaryotic mycelia that are composed of binucleate cells with clamp connections. To germinate and produce their original hyphae, they have to be under suitable environmental conditions.

In order to achieve success with the sawdust cultivation method, as many of the natural growing conditions as possible, must be reproduced. Some of the factors that require attention are the inoculum (spawn), substrate nutrients, temperature, pH value, moisture, relative humidity, aeration and light.

6.1 INOCULUM (SPAWN)

Many of the oyster mushroom straws used as inocula or spawn for the Wood Log cultivation are not suitable for sawdust cultivation. All cultures selected for making spawn must always be tested for actual mushroom production. This cultures are preserved as "stock" cultures. They must be carefully managed to maintain all genetic potentials such as adaptability to various nutrients in the substrate, a high yield of mushrooms with desirable quality flavour, good post harvest shelf life, ability to grow and fruit at a wide range of environmental conditions and resistance to pests and diseases.

The production of the inoculum (spawn) involves a series of operations that must be carried out under supervision of technically trained microbiologist and requires specialised equipment in a properly designed laboratory.

6.2 TEMPERATURE

Temperature is considered to be one of the most important environmental factors for mushroom growing. There are distinct differences of growth-and-fruiting temperature range in difference strains. In general, mycelia grow within the range of temperature of 5 degrees celsius to 32 degrees celsius, with optimum at 25 degrees celsius. A constant temperature is better than a fluctuating temperature for mycelial growth. However, the optimum temperature for the development of fruit bodies is lower than that for the growth of mycelia and fluctuating temperature is required for the fruiting. For the thermo-type strains, preferred for sawdust cultivation, the temperature should be between 15 degrees to 30 degrees celsius during fruiting.

6.3 MOISTURE AND RELATIVE HUMIDITY

Maximum mycelial growth or spawn run for mushroom in supplemented sawdust is at a moisture level between 55-60%. The mycelial grow slower, if the water content is much more or less than this level. After inoculation on substrate with a water content of 60%, the water content increases to 63% during the spawn run, to 70% during browning and 78% after the hardening period. Water content must be more than 70% for normal development of fruit bodies. If the water content is too low, abnormal fruit bodies will be formed despite a favourable relative humidity. In general a range of 60-75% relative humidity and adequate aeration are preferable for mycelial growth. However, at the beginning of fruiting, a relative humidity of around 90% is necessary to increase development of umbrella cells and to decrease the formation of abnormal fruit bodies. After 24 hours, the relative humidity is reduced to 80% to prevent over development of the stipe.

6.4 LIGHT

Light is essential for fruiting, though it may inhibit mycelial growth. Light intensities of 50 Lux and 500 Lux slow mycelial growth about 3% and 16% respectively, after 30 days incubation. Initiation of fruiting depends on light during mycelial growth and the effect is not translocated to the unexposed mycelia. Light is required to obtain normal morphology and pigmentation of the fruit body. The optimum light intensity for fruiting is between 100-150 Lux, depending on the strain used, but usually any strain can produce fruit bodies with a light intensity below 500 Lux.

6.5 HYDROGEN ION CONCENTRATION (PH)

Mycelia of mushroom can grow in the pH range of 3-6, but usually grow more quickly at about 3-5. The pH of the substrate falls rapidly to about 3.0 following the consumption of the substrate and a production of organic acids, such as acetic, succinic and oxalic.

The most suitable pH range for mycelial formation and fruit body development is around 3.5 - 4.5. Therefore aeration in the incubating room should be precise to prevent the abnormal development and death of fruit bodies.

6.6 AERATION

Mushroom is an aerobic fungus needing enough oxygen during the growing period to develop well. Usually, rough liquocellulosic particles are better for mycelial growth than fine particles, loosely packed particles are more advantageous than heavily compacted particles and a suitable water content is more conducive to growth than saturated substrate.

Inadequate aeration inhibits fruiting much more strongly than it does mycelial

growth. Aeration removes Carbon Dioxide which inhibits the expansion of the mycelial.

6.7 SUBSTRATE NUTRIENTS

From studies made on the nutrients requirements of mushroom,it has been found that organic nitrogen, magnesium, sulphur and potassium are required in addition to Carbon, Hydrogen and oxygen.

Many materials suitable for the growth of mushroom hyphae such as sawdust, rice hulls, cotton seed hulls and corn cobs and other such materials have been used as the basic nitrite component of the substrate. They can be used singly or together. It has been found that, in nature, growth is best on hardwoods. Therefore these varieties of sawdust are most commonly used. The sawdust texture should be about 50% fine ground (1-2mm) and 50% coarser material, such as wood chips for better aeration.

Supplements added to the sawdust include a carbon source, a nitrogen source and calcium carbonate (chalk). The sawdust is usually 75 to 85% by weight of the total ingredients.

There is need to sum up the growth and requirements and relate them to the built-eminent - to be developed for the cultivation of the mushrooms. ie. the architectural design implication should be made clear here.

CHAPTER SEVEN

PRODUCTION PROCESS

The production of oyster mushroom on sawdust follows the general principles of producing mushrooms, ie. the various stages which include composting, bagging, sterilisation, inoculation, incubation and cropping and harvesting. It takes about 35 days for the first fruit to be harvested after inoculation.

7.1 COMPOSTING

The raw materials needed for this process are sawdust, rice bran, calcium carbonate, NPR fertilizer and water. The materials are mixed at various percentages viz:-

Sawdust - 75%

Rice Bran - 10%

Calcium Carbonate - 3%

NPR Fertilizer - 2%

Water - 70%

All ingredients are mixed thoroughly and water added. The water content of sawdust varies according to the type of wood used and the time of storage before use. Therefore the amount of water to be added can vary from 1 to 1.5 parts of water to 1 part of dry mixture to achieve about 60% moisture. Sawdust can be stored for several months and partially decomposed or only pasteurised before use. About 3 - 5 days after adding water to a high quality hardwood sawdust medium, or after 2 weeks for mixtures of variable or not so desirable materials, the water content can be tested by grasping a handful firmly. If a few drops of moisture leaks out between the fingers the material is ready to be packed. This process takes place outdoors.

7.2 BAGGING

The mixed materials are packed into polypropylene autoclavable bags with cotton stoppers or micro porous filter patches for gas exchange during spawn growth. Some bags used are 17.8 x 35.6 x 45.7cm producing stamp shapes, when filled and grown through with mycelium that can stand alone. The mushroom will grow from the top surface when the bag is open.

The materials are packed firmly into the bags to make a desired farm and a 1.5cm wide 10cm deep hole is made into the sawdust with a dowel or rod for convenient inoculation and for aeration. Packaging can be done by hand or in large production, the filling and compacting can be done automatically as is the case for this project. The loose end of the bag is gathered around and fastened to a polyprophene with a microsporous filter or a bottle neck or tube with a cotton plug inserted.

7.3 STERILIZATION

The filled bags are sterilized under high pressure in an autoclave at 121 - 125 degrees celsius for two (2) hours. For low pressure sterilization, a temperature of 95-100 degrees celsius must be maintained for 4 hrs. After sterilization the bags are allowed to cool down to below 60 degrees celsius. This process is done outside under a shed because of the heat exerted.

7.4 INOCULATION

After the bags have been cooled down they are then moved into the inoculation room, where the bags are washed in alcohol mixed with water and then arranged on the floor in rows. Great care must be taken before and during the inoculation process since months of work and the entire harvest may be lost due to contamination. The original cultures or spawn should be checked or inspected for any signs of contamination or

abnormality.

The inoculation area should be cleaned with soap solution and 75% of alcohol, and the workers scrub and wear sterilised gloves and working clothes. The bottle of spawn should be cleaned with alcohol and the opening flamed before beginning. With two people working together one can hold the inoculum bottle and remove and replace the cap. This process takes a day.

7.5 INCUBATION

The sawdust filled plastic bags are placed on trays and taken to an incubation room for mycelial growth. The room should be air-conditioned or the temperature controlled by fans, vents and heaters. The bags may be stacked into piles 1.5 - 1.8m high and wide with aisles about 0.6m wide.

The mycelium grows more rapidly in the dark, but some light is necessary during mycelial growth for the development of mushrooms later as mentioned earlier. 10 to 50 Lux seems to be the intensity of light necessary for the future development of fruiting, and usually 8 - 12 hours a day depending on the strain used. This process takes between 28 - 30 days.

7.6 CROPPING AND HARVESTING

After the mycelium has colonised the substrate, the surfaces of the bags must continue to be exposed to the light to produce the mushrooms. Therefore the bags are transferred to the cropping house after the incubation period. Care must be taken to avoid drastic temperature changes or fluctuations,which could cause condensation in the bags, inducing contamination.

Great efforts will be required to regulate temperature and humidity.

A thermometer and hygrometer are necessary to check high and low temperatures and humidity. The temperature should not be over 25 degrees celsius or below 20 degrees celsius and should remain constant, if possible.

A method of aeration - fans and vents or roof ventilators - or a fresh air supply to prevent high temperatures or humidity over 60% is necessary. Some ventilation is always necessary to prevent high humidity which should be kept below 60% to prevent contaminants from growing on the cotton plugs.

Usually, the first harvest of mushroom will last about 7 days with the highest yield on the third or fourth day. The mushrooms must be harvested daily as they reach the preferred state,just before the cap extends to the fullest or about 70 - 80% open.

The mushrooms are carefully placed top down in shallow trays or basket for transfer into drying rooms. Careless handling can damage the mushroom, reducing their commercial value. After the mushroom are harvested, they are sorted and classified according to size and quality. Mushrooms with thicker pileus and cleavage lies over the surface of the cap and are called the donkey type and bring a premium price.

They must be dried within 4 hours of harvest to preserve their colour and brightness.

The trays of washed mushrooms are placed into a preheated 45 degrees celsius oven. The temperature will drop to 35 degrees celsius through the introduction of the trays with the mushroom and then gradually rise to 40 degrees celsius. This temperature should not be exceeded in the first two (2) hours. The exhaust should be at the maximum to remove the moisture quickly. After two (2) hours, the temperature can be allowed to increase gradually. After the mushrooms are dried partially (6 - 8 hours), the trays can be rearranged in the oven for more uniform drying and the stem of the

mushroom can be bent down into the cap to produce a more uniform shape.

In a commercial establishment, drying of mushrooms on racks in heated forced air chambers beginning at 30 degrees celsius and ending at 60 degrees celsius for 1 hour enhances the flavour and lustre of the mushroom to make a more desirable product.

When the drying is complete, the water content should be about 13%. The mushroom will absorb a little moisture if left standing a while before packing, thus preventing breakage due to brittleness.

7.7 EQUIPMENT AND THEIR FUNCTIONS

i. Compost Mixer: - this equipment is used to mix the compost that is the sawdust, rice bran, NPR fertilisers, Quicklime and Water (Fig)

ii. Composting Machine: - This is used to compress the bagged compost. It compresses the compost so that all pores will be filled so as to enhance uniform growth of the mushroom.

iii. Weighing Scales: - This is used to get uniform weight of the bags. This is used because a certain amount of spawns is needed to inoculate a certain amount of compost otherwise contamination may occur.

iv. Autoclaves: - This is a pasteurisation chamber which is used to sterilise the bagged compost at 121 - 125 degrees celsius to kill all organisms which otherwise would have caused contamination.

v. Ovens: - These are used for pre-heating and drying of the mushrooms.

7.8 CONCLUSION

If all the processes involved are strictly adhered to, contamination will be non-existent and a good harvest is very much assured. All conditions will have to be established and well kept, for an efficient production to take place.

7.9 STATISTICAL STUDIES

7.9.1 MARKET CHARACTERISTICS

Generally, the world market for cultivated mushrooms is very high. The bulk of the exported dried mushroom goes to the EC countries. It has also been realised that the total imports always exceed the export, thus giving rise to the need to have a factory to actually produce to supplement the world demand.

YEAR	1991	1992	1993	1994
IMPORTS	4008	4160	4687	4934
EXPORTS	3900	4000	4450	4500

TABLE SHOWING IMPORTS AS AGAINST EXPORTS OF DRIED MUSHROOM.

It has been realised that demand for mushroom is on the increase whereas exporters are not able to meet these demands.

The bulk of imported dried mushroom goes to the retail market of the EC Countries such as Germany, Spain, France and the United Kingdom really demand the dried mushroom.

YEAR	1991	1992	1993	1994
ITALY	1175	1351	1430	1670
GERMANY	1141	1218	1529	1615
FRANCE	819	855	872	967

U.K.	300	342	350	355
SPAIN	60	72	91	187

TABLE SHOWING IMPORTS OF MUSHROOMS

As the years go by demand for mushroom keeps increasing:-

TABLE SHOWING THE GRAPH OF WORLD IMPORTS OF MUSHROOM

The demand for mushrooms worldwide is on the increase therefore we will be on the right path if such a factory to produce mushroom is put in place to at least be part of the world producers.

7.9.2 MARKET OPPORTUNITIES

EC Countries are constantly looking for competitive products and consequently new sources of supply. Moreover, national legislation on picking and selling of wild species are becoming more stringent, thus favouring imports.

The EC market for dried mushroom is expected to increase in the coming years and sales prospects are good for exporters in developing countries, meeting quality requirements and delivery terms.

Cultivated mushrooms in dried forms are mostly marketed to the food processing

industry as raw materials for soups and prepared meals.

7.9.3 COMPOSTING

For a floor area of 12m x 12m, 4 trips of sawdust will fit in here. For each trip of sawdust 2000 compost bags will be filled.

1 trip of sawdust = 2000 bags.

7.9.4 HARVESTING

Harvesting can last for about a month. Each bag when completely harvested will give 1kg of fresh mushroom. So that for the 2000 bags, we get at the end of harvesting 2000 kgs of fresh mushroom which is equivalent to 2 tons of fresh mushroom.

About 10kg of fresh mushroom when dried will give us 200kg of dried mushrooms.

1 compost bag = 1kg of fresh mushroom

2000 bags = 2000kg = 2 tons fresh mushroom

10kg fresh mushroom = 1kg dried

2000kg fresh mushroom = 200kg dried.

7.9.5 SUMMARY

It can be realised that with an increase in the area for sawdust, more heaps can be stored and if the conditions are right a lot of compost bags can be filled for the process to start. Mechanisation of the compost mixing will enhance productivity.

The more the number of compost bags under very satisfying condition the higher the yield of fresh mushroom.

This factory will therefore be producing up to about 15 - 20 tons of dried mushrooms for both local and foreign consumption.

CHAPTER EIGHT

PROJECT LOCATION AND SELECTION

8.0 PROJECT LOCATION

The project will be located at Akim Oda in the Eastern Region of Ghana. It is one of the leading industrial towns in the Eastern Region due to the siting of timber and mining industries consequently, this town is of national significance.

8.1 CLIMATE

The climate is equatorial continental

8.1.1 Temperature

Maximum mean monthly temperature occurs in March (27.9 degrees celsius). The minimum mean monthly temperature occurs in August (21.7 degrees celsius).

8.1.2 Sunshine

On ordinary non-rainy days sunshine is between 4 (four) and 6 (six) hours.

8.1.3 Humidity

High often exceeding (90%) ninety percent throughout the year during the morning period and seventy percent (70%) in the afternoons.

8.1.4 Wind Velocity

This is in the range of between 6.0 to 15km/hr. Wind direction is more or less constant between February - November, is South-West to North-East direction. Between December and January the wind is the opposite direction, that is north-east to South-West. Maximum period of calm is twenty five to thirty percent occurs late in the evenings till early morning.

9.1.5 Rainfall

There is double equinovial maxima. The first peak is in May/June and the send around October. Average rainfall varies between 1800mm to 2100mm. Fluctuations are considerable with frequent deviation from average. Average rainstorm lasts between 1 - 3 hours. Rainstorm seldom persist beyond eight hours.

8.2 PHYSICAL FEATURES

Generally, the land gently undulates towards River Birim towards the north eastern portion of the town.

8.3 INFRASTRUCTURE

The Ghana Water and Sewerage Corporation supplies water to Akim Oda.

Electricity is supplied from Akosombo through the Volta River Authority Grid.

9.4 PLANT LOCATION

The establishment of the factory to produce mushroom depends on the following: -

a. access to home market;

b. availability of raw material and flexibility of supply;

c. proximity to raw materials;

d. good road and rail connection;

e. supply of power and water;

f. possibility to waste disposal;

g. good drainage and services;

h. possibility of acquiring required size of land;

i. easy accessibility; and

j. industrial interdependency.

In the studies made of Akim Oda, the potential area which best fulfilled most of the acquired requirements is the industrial zone for the development.

The advantages this zone has is that it is nearer to where the raw material will be available. There are other industries with related activities . Also almost all the sawmills are located in this area.

There is availability of essential services and moreover they are not too far from the city centre.

CHAPTER NINE

SITE ANALYSIS

9.0 LOCATION

The site is located in the industrial area of Akim Oda. It is near the Oda Kade Road. An untarred road turns off from the bridge road and leads towards Kade. The road in front of the site is untarred but hopefully it will be tarred soon.

Existing on the western section of the site is an undeveloped industrial site. On the northern site is the River Birim. Towards the north-east is the bridge over the River which leads to Kade.

On the Southern side of the site is another virgin industrial site.

9.1 CHARACTERISTICS

The site covers an area of about ..... The site is well drained. It slopes gently towards the North-West with a gradient of about 1:20. There are no existing properties on site, the site is a virgin land with secondary forest and patches of grass. Water table is not too high but level changes with seasonal slope.

9.2 INFLUENCE OF SURROUNDING SITES AND OTHER FACTORS

The site is a heavy industrial area, consisting mostly of timber industries. This will result in industrial interpendency. Timber industries would rely on the plant as their waste dumping ground and plant as its source as one of the major raw materials.

The entry point is the proposed road towards the south-west.

The Birim River is a source of water for production and a possible channel for waste water disposal.

This also helps in the aeration of cool micro climate.

CHAPTER TEN

THE BRIEF

10.0 The brief is to develop a factory to produce mushrooms for the home and external markets. The planned intake capacity of sawdust is about 100,000 cubic meter yearly. And it is hoped that the plant will be able to produce about 15 to 20 tons of dried mushrooms yearly.

10.1 GENERAL CONSIDERATION

The physical environment of the plant which is suppose to be of high standard and should be very clean was considered. Extraction Equipment for the removal of gas generated during the production process should be provided.

For efficient operations of a factory, there is the need to centralise the entire organisation on the same site. As mush as possible, compact planning shall be aimed at reducing cost and facilitating inter-communication.

Working methods that were considered are: -

i. **Linear Movement -** this does not allow for future development;

ii. **L-Shaped Movement -** depending on the process circulation can be increased and this does augur well for the man/hour lost;

iii. **U-Shaped Movement -** this reduces the amount of circulation and thus reduces man\hour lost during production process;

Fire protection is very necessary since some of the raw materials are prone to fire.

10.2 BRIEF DEVELOPMENT

The clients for this project is the Birim North district assembly. A total number of about 40 people will be working at the factory and this broken down as follows: -

Administration - 6

Kitchen Staff - 6

Production Staff - 30

10.2.1 ADMINISTRATION

This area requires a generally cool, quiet and clean atmosphere to house all administrative departments namely, accounts, commercial, personnel, technical and managerial. Its location shall be near the entrance and shall be of high architectural quality in terms of design and finish. It shall be located on the windward side of the processing plant to avoid possible sawdust particles in the air and also to block off the view of the process of composting. The administration should be provided with a car park for 10 cars.

10.2.2 PRODUCTION BLOCK

This area shall accommodate all the necessary activities and machinery equipment for the process of cultivating and products of mushrooms.

The production hall ensure smooth production alignment, consistent with earlier studies on production process described in chapter seven.

Adequate working areas around the shelves and machines as well as circulation for both pedestrians and trolleys should be provided.

Quality control and supervision should be provided with spaces.

A laboratory for the preparation of spawns which are the seeds for the production process should be provided in the production hall ie. inoculation area.

Mushrooming is a process that involves clean and dirty procedures. Composting which is the dirtiest because it is dusty therefore the design shall be such that

i. composting shall be semi-enclosed for maximum ventilation.

ii. plant shall be constructed with block work and reinforced ferrocement parts of the production areas and the administration shall have translucent fibre glass sheeting incorporated in sections of the roofs for the provision of natural lighting and possibly ventilation.

The roof shall be of ferrocement with reinforced beams. The choice of the floor finish must be non-slip, hard-wearing, easy to clean material.

The cropping section where harvesting takes place, will have the wall lined with plastic and ceiling will be of a material which is resistant to humidity ie. organosol.

Lighting levels in the incubation will be well checked since only a minimal amount of light is needed.

The final painting and furnishing of the building shall be carefully considered to give an attractive and durable finish.

Also air-conditioning will be used in the incubation and cropping rooms. The system to be sued is the aqua stream system. It is based on a simple operating principle. It allows for the air-conditioning of adjoining rooms. It consists of one outdoor unit and 1 to 9 distribution modules each of which can supply 4 terminal units. This design allows complete freedom when setting up the components and an installation adapted to all requirements; ie number of rooms.

The waste compost substrate is bagged in a jute sack as fertilizer. The space demarcated will have screed as its floor finish and a normal room condition for effective work to be done.

10.2.3 WELFARE FACILITIES

There will be two welfare areas. The first will be for changing and first aid. the second will be for eating.

The first one will be located nearer the production area since the workers are suppose to be very clean and very hygienic. This will house the changing room and sanitary facilities for both male and female staff. This is where the production staff will generally meet to interact most especially during break.

It also houses a first aid post for treatment of all minor ailments. This block is directly linked to the production halls.

The Second welfare house, the eating area for staff and also a restaurant to prepare mushroom based dishes for the public to eat. Also the kitchen is located right there. This will be located near the entrance of the main project. This is so because of the high level of hygiene associated with the production process.

VENTILATION

It is necessary to mention ventilation in this chapter due to the conflicting needs of the worker and pollution control.

It will be recalled that certain conditions for the various process will have to be satisfied.

Workers will most of the time be in the inoculation or the finished products area.

The incubation and cropping areas are to be air-conditioned so as to prevent contamination from the outside ie. sawdust particles.

Almost all the enclosed spaces are air-conditioned. Those not air-conditioned have extractors to extract whatever pollution poured out into the environment.

The choice of material for the factory was due to the following reasons:-

a. the high level of hygiene required;

b. the clear and healthy nature of the workers;

c. economical in cost;

d. availability of the material;

e. durability of material; and

f. inexpensive in maintenance.

Considering the factors discussed and the nature of the raw material the following materials were selected:-

a. blocks for partition walls;

b. shell or dome Ferrocement roof;

c. reinforced Ferrocement for structural members; and

d. windows are of glazed glass.

10.2.3 ANCILLARY FACILITIES

For efficient functioning of the plant, the following ancillary facilities are required:

i. A security gate to check entry and exit of persons and vehicles;

ii. disinfecting pit;

iii. parking lot for about 20 cars for both the administration and restaurant;

iv. good road network;

v. good drainage works to be laid without hinderance to vehicular movement;

vi. generator and transformer area;

vii. water reservoir; and

viii. air-condition plant.

Provision has been made for future expansion.

CHAPTER ELEVEN

DESIGN

11.0 DESIGN PHILOSOPHY

As a departure from the traditional common and off times drab factory architectural styles and also as a major contribution to the aesthetics of the streetscape (site location being along a major road), there was a basic intention to come out with a visually captivating architectural piece.

11.1 EVOLUTION OF CONCEPT

The design concept was evolved from the various stages of the mushrooms growth. Its organic nature, ie. from the hyphae stage to the mature fruit body. The high level of cleanliness and hygiene required by such a facility in its operations was also a major influence in the evolution of the design concept.

11.2 CONCEPT

Architectural translation/interpretation of the mushroom in an employee oriented environment.

11.3 EVOLUTION OF FORM

In the light of the above concept, the stages of growth of the mushrooms from the hyphae to bottom stages to mature fruitbody suggested circular plan shapes.

The domical cap shape of the mushroom was the source of the roof shape (shell form). Mushrooms as we know do not grow uniformly, their heights vary and they spring up just anywhere. This suggested the general configuration of the plans to symbolise growth of mushrooms. the way mushrooms do not uniformly grow in heights suggested

the varying heights of the buildings.

11.4 VIBRATION AND NOISE

Vibration and noise to surrounding buildings is a problem that needs considerable attention. The fact that during composting,ie mixing of the sawdust with other raw materials, the sound pressure ranges between 50 and 65 db justifies the need for proper noise control. Apart from this process, noise generated will be from the trucks bringing in the raw materials and those taking the finished products away. The following measures are therefore necessary:-

a. carefully chosen and deployed planting of different heights to provide a sound buffer;

b. separation of the noisy areas, that is the composting area, from the quite areas ie. administration by the greatest possible distance.

11.5 POLLUTION

In this operation there are two main pollution agents. These are carbon dioxide generated during the incubation period and the suspended sawdust particle. The following measures shall be taken:-

a. **Arranged Landscaping -** will be introduced to absorb the carbon dioxide generated, which has a concentration of 0.3%. This is not harmful to the atmosphere.

b. **Extractors -** will be provided in the incubation room to extract the carbon dioxide to the outside.

c. **Sawdust reception bay -** shall be partially enclosed, to give maximum ventilation and at the same time check wind from blowing off sawdust.

d. **Specially designed trucks -** for collecting sawdust from source to the plant.

e. **Facial masks, Wellington boots, goggles, hand gloves and overalls -** shall be supplied to workers.

11.6 CONCEPTUAL STUDIES

Zoning in terms of dirty and clean areas was really considered to cut down an possible contamination.

A well landscaped factory will give viewers the chance to appreciate the plant not only as a factory but as an architectural show piece.

A common entry/exit point for both vehicles and pedestrians was considered so as to allow a good security check and efficient running of the facility.

Siting of the administrative and welfare was made bearing in mind the possible conflict in any future expansion.

The aeration of ample green areas is for environmental and anaesthetic reasons.

Manoeuvring of vehicles within the factory especially at the off and loading bays was a crucial issue, since vehicles turning radii, lay-byes and parking lot require enormous space.

The moving and quite zoning was necessary to enhance better working conditions within the various working sector.

11.7 PLANNING PRINCIPLES AND STRATEGIES

An important requirement for the effective planning of the site was in the location

of the production sector and the administration and welfare areas. Because of the high level of hygiene the production areas were separated from the administration so as to limit the public from getting to the production area.

Separate parking was made for loading and off-loading ie. finished product and raw materials respectively.

Although the various process require different conditions for production close links were provided for activity zones to each other for effective operations.

The wind direction was really considered, this was due to the nature of the raw material ie. sawdust. This was put at the north-east part of the site so that the wind will blow any dust particles away from the working areas.

The administration and welfare block were located to screen off the composting nature from the viewing public.

Ample car parking space has been provided for both staff and visitors.

There is a clear segregation of the production areas and public areas.

11.8 DESIGN HIGHLIGHTS

The design highlights mainly the plan and roof forms and the varying heights of the buildings. This, as already written already, portrays the growth of mushrooms irregularly. circular plans are self supporting and the utilisation of space within it is the mose efficient in terms of circulation. Also solar penetration is very minimal, and it is due to its circular form.

While trying to achieve a good appearance a conscious effort has been made to make the treatment of the administrative and welfare sector unique. But then also it is important to portray the production sector in boldness and dynamism because of its

function and the organic nature of the concept. The sizes of the various production areas were varied and linked together. This is to show how mushroom grow together and in different sizes. The building heights were varied, so that when one looks at it, one gets the whole concept of the irregular growth of mushroom with different heights.

Access to the site is from the southern part. On entering the site one follows a winding drive and walk way line with trees. On the left portion are located the welfare and administrative block.

The road network takes the form of the hyphae of mushroom opening up to become a mature fruitbody.

On the norther part of the site is located the production halls and the view in entering the site shows the varying heights of the roofs which has been mentioned already to portray the irregular growth of mushroom.

Generally, the design highlights the building forms and the road network.

11.9 LANDSCAPING

The area is an industrial concern. Plants for the site, ecologically must do well in this area of semi-deciduous forest. As the factory is sited away from low land area, the landscape plants should not be water loving plants.

Good topsoil is essential for good plant performance and so it must be provided from outside. Before planting starts, planting holes of 1.2m diameter and 0.9m diameter and 0.9m deep for shrubs are adequate for vigorous and sustained growth.

Shorter planting spaces will be used and a thinning programme launched after plant establishment. The whole landscaping is to conform with the organic nature of the factory. The whole landscape idea wants to make use of plants for colour, shade, wind breaking, dust and smoke absorbing, screening sound, mottling and creation of clean

environment.

Trees to be introduced will be of the type that produced little waste in the form of leaf and flower fall and does not have vigorous roots. The following schedule illustrate the building and design intensively:-

TREES

A. DUST, SMOKE AND WINDBREAKERS

Pinus Hondauransis

B. SOUND ABSORBERS

Lagerstroemia Speciosa (Queen Flower)

Tectonagrandis (Teak)

C. SCREENING

Polyscias (Panax) Brundelsin Calcycina

D. SHADE

Khleinhoria Hospita (Guest Tree)

Adenanthera Pavanina (Bead Tree)

CAR PARK

Milletia Thorningii

Mimusops Elengi

E. AESTHETICS

Peltophorum Pterocarpon (Rust Tree)

Lagestroemia Speciosa (Queen Flower)

F. AVENUE

Ruystumea Regia (Royal Palm)

7.5 - 8m planing distance

G. GRASS OPEN AREAS

Chrysopogen Aciculatus

Cynodon Dactylone

11.10 ACCOMMODATION SCHEDULE

ADMINISTRATION	NO	AREA(sqm)
General Manager	1	40
Marketing	1	30
Accounts Office	1	30
General Office	1	50
Reception	1	25
Sanitary Area	1	
LABORATORY		
Working Area	1	70
Store Room	1	30
Office	1	20
Ancillary Area		
COMPOSTING		
Working Area	3	113
Store Room	1	28
Sawdust Area	1	36
INOCULATION		
Large Room	1	150
Washing Area	1	40
Store Room	1	40
Working Area	1	50
Circulation		
INCUBATION		
Large Room	1	254
CROPPING		
Quality control	1	296
Large Room	1	18
FINISHED PRODUCT		
Washing Area	1	40
Drying Area	1	40
Packaging Area	1	72
Office	1	72
Store Room	1	24
Delivering Bay	1	60
WELFARE		

Changing Room	2	80
Sanitary Area	2	30
RESTAURANT		
Kitchen	1	60
Store	1	20
Sanitary Area	2	30
Changing Rooms	2	30
Staff Eating	1	80
Public Eating	1	120
PARKING	**NO**	**AREA(sqm)**
Staff	1	200
Visitors	2	200
Loading Bay	2	250
Off-Loading Bay	1	250
ANCILLARY		
Circulation		--
Generators		20
Transformer		5
Gate House		11

CHAPTER TWELVE

FINISHES

Choice of materials is based on the following considerations:-

1. fire resistance properties;
2. resistance to humidity and water;
3. ease of cleaning;
4. resistance to wear and chemicals;
5. low maintenance.

EXTERNAL

Building Type	Columns	End Walls	Roof Covering
Gate House	-	smooth plaster and masonry water repellent paint	solar gard hy-build paint over concrete
Restaurant	smooth plaster and snow cem paint	"	"
Administration	"	"	"
Composting	smooth plaster, masonry water and repellent paint	-	mansory water, repellent paint over concrete
Welfare	smooth plaster and oil paint	smooth plaster and solar gard hy-build paint	rubber flex paint over concrete
Incubation	"	"	"
Cropping	"	"	"
Finished Product	"	"	"
Waste Handling	"	"	"

INTERNAL

Building Type	Floors	Ceilings	Walls
Gate House	screed	smooth plaster and emulsion paint	smooth plaster and emulsion paint
Restaurant and Kitchen	polished terrazzo	soft board panels and chip board	"
Administration	"	timber panels (t&g)	"
Composting	screed	smooth plaster	
Inoculation	terrazzo	chip board	smooth plaster and emulsion paint
Incubation	terrazzo	organosol	solar gard by-build paint
Cropping	tiles	organosol	"
Finished Product	tiles	"	"
Waste Handling	screed	chip board	smooth plaster and emulsion paint
Toilets	ceramic tiles		tiles

CHAPTER 13

SERVICES

Water Supply

Water supply to the centre is tapped from a running mains, 100mm in diameter to over head water tanks by 50mm diameter pipes and distributed by gravity feed. A ring main runs round the whole centre.

Sewerage Disposal

Sewerage disposal systems follow the slope of the land with the septic tank located at the lowest end. 150mm diameter P.V.C. soil pipes run behind toilets into manholes.

Drainage

Drains follow the slope of the land and drain towards the lowest part of the site.

Electricity

Power intake is by 415kv, 3 phase armoured underground cable to an intake panel at the gate house where it is than distributed to the other sectors of the centre.

Telephone and Telecommunication

Telephone linkages have been provided for use by the administration and the other sectors.

Air-Conditioning System

The aqua stream system has been used for the production blocks.

Lightning Protection

Lightning protection system provided in accordance with local standards installed on the highest part of each building and linked to a single conductor cable to a copper ground rod.

Fire Protection and Escape Planning

Building has been configured for ease of circulation and access are adequate for emergency vehicle accessibility.

Fire Hydrants

Fire hydrants of B.S.S. 750 with 62mm diameter outlets have been provided. One is located between the Restaurant and administration. Another in front of the production area and the other at the back.

CHAPTER FOURTEEN

Phasing

Phasing of the project would have to be carried out due to high building costs.

Phase One

The production blocks will be the first to be constructed and also the gate house.

Phase Two

The Administration Block

Phase Three

The Restaurant

Costing

Floor areas of phasing

Phase 1 = 1492

Phase 2 = 254

Phase 3 = 374

Estimated cost per sq meter =¢150,000

Cost per phase:

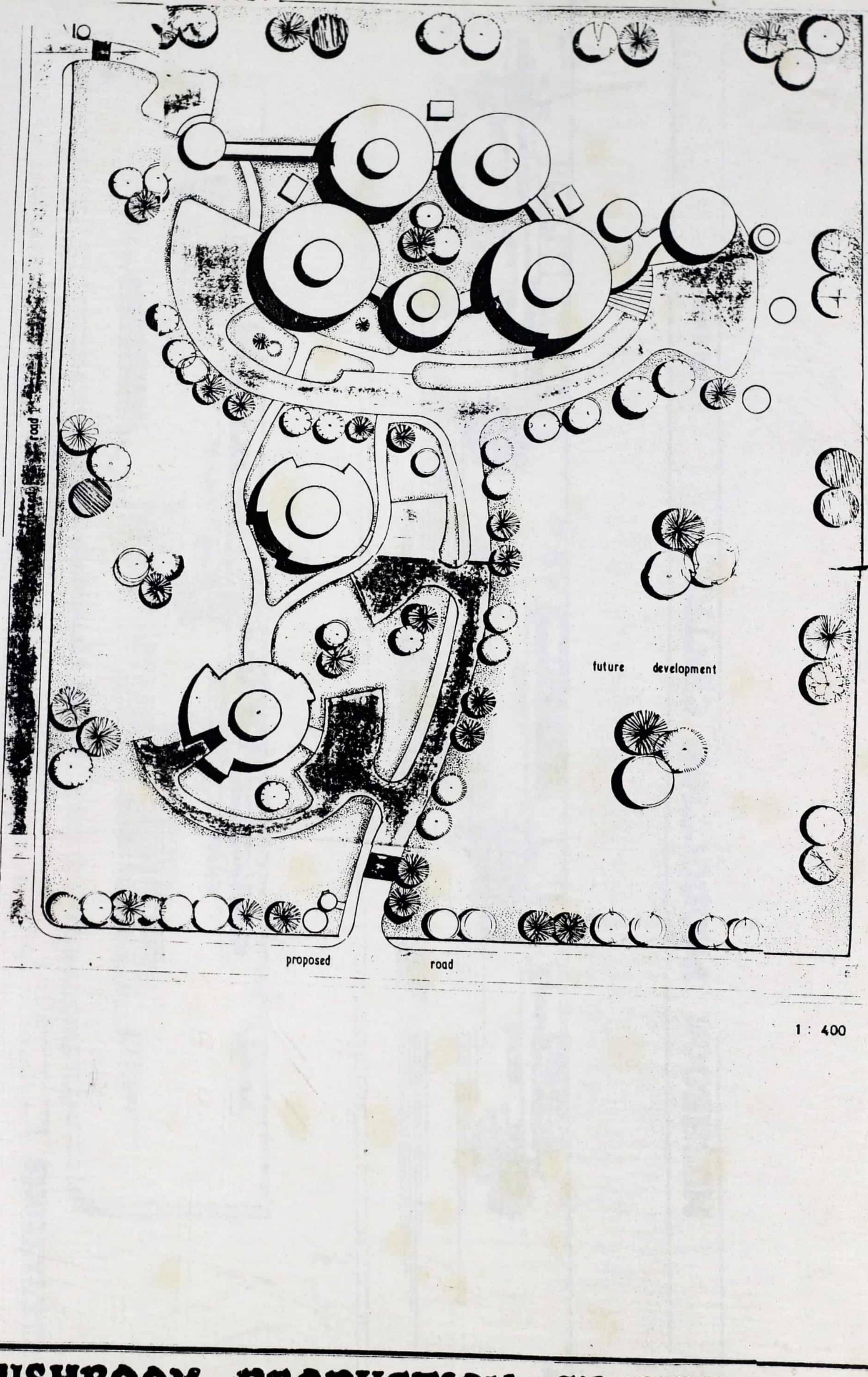
Phase 1 ... .¢223,800,000

Phase 2 ... .¢38,100,000

Phase 3 ... .¢56,100,000

Total Cost = ¢318,000,000

BLOCK PLAN



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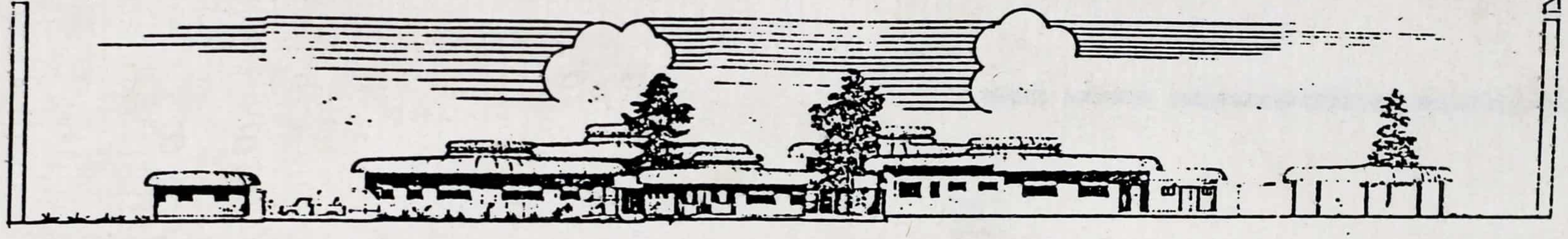
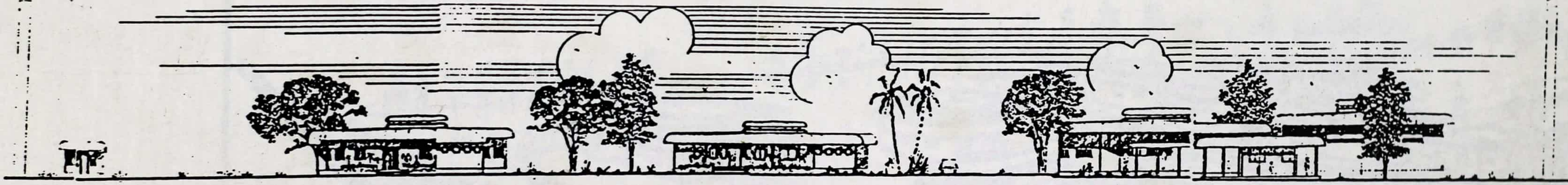
MUSHROOM PRODUCTION CENTRE, AKIM ODA.

ELEVATIONS

south (production area)



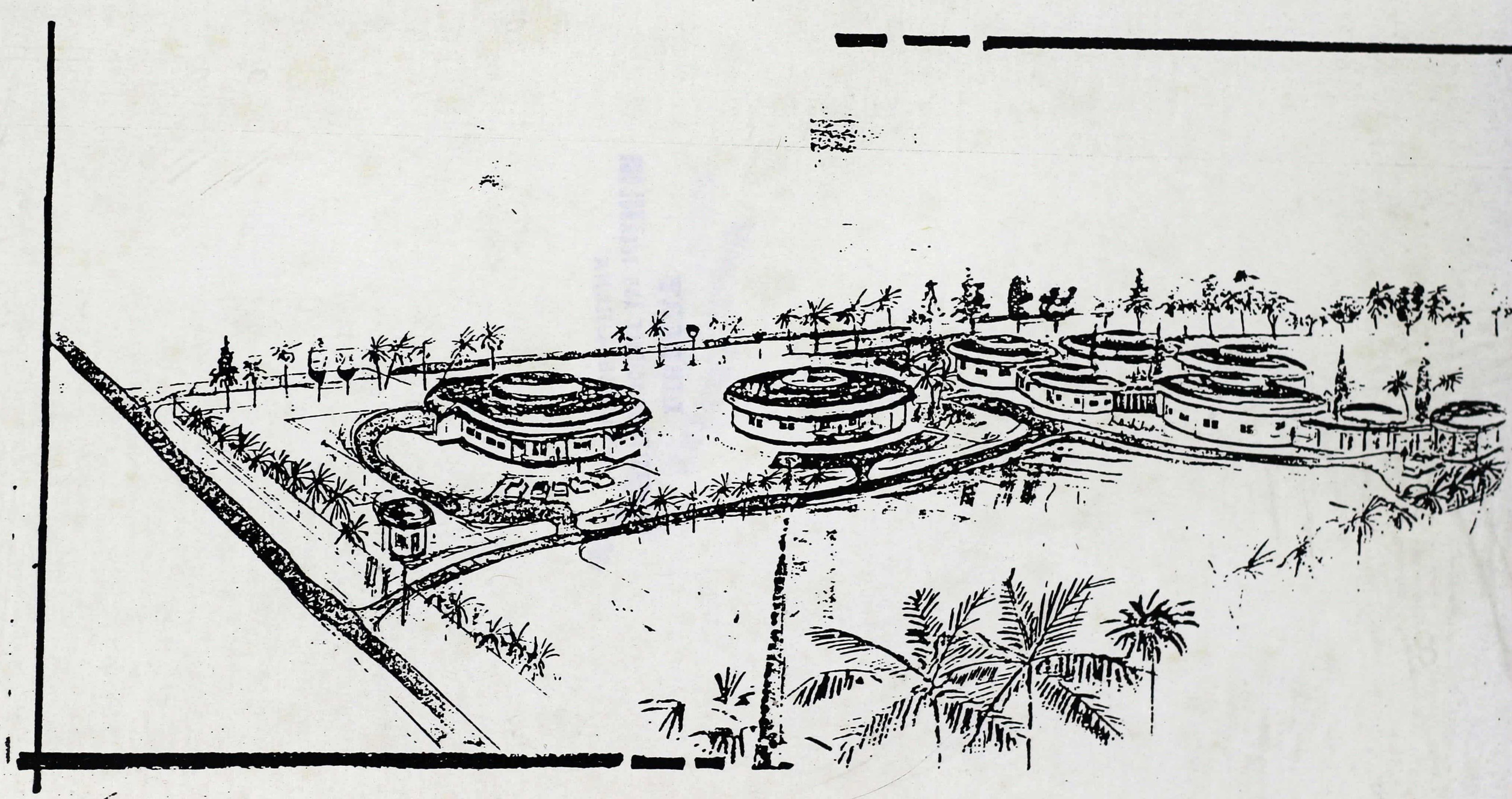
east



MUSHROOM PRODUCTION CENTRE.

ARIM ODA

PERSPECTIVE



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