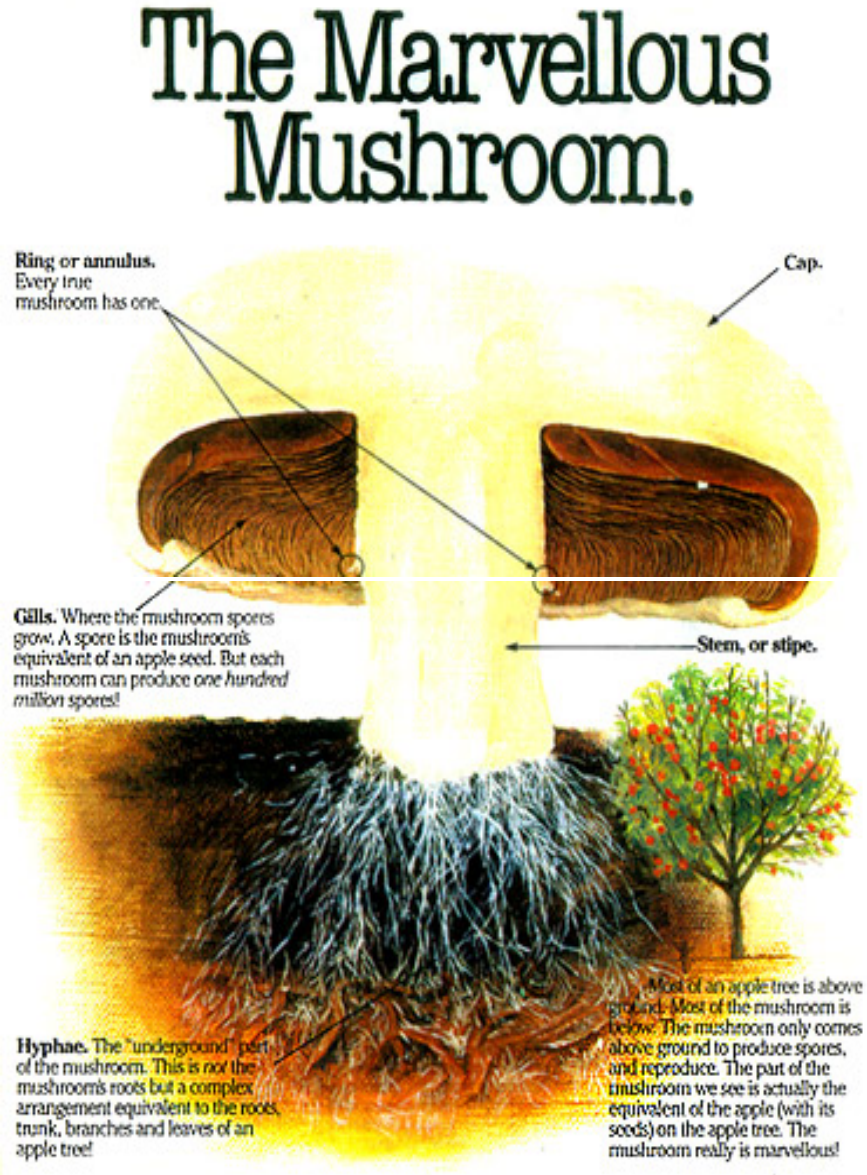
NEW BIOSPHERE AGRICULTURE

TECHNOLOGY
&
PRODUCT INFORMATION



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NEW BIOSPHERE AGRICULTURE – the GOAL:

It is possible to feed 2,000 people all year round from 1 acre of land, that is, 5,000 people can be fed all year round from 1 hectare of land. It is possible to do this almost anywhere on the planet. Okay, the diet may be limited however it will be nutritious, but it is possible without utilising large volumes of water, and it can be all vegetable and fruit based, with products appropriate for the community, thus complementing their existing diets.

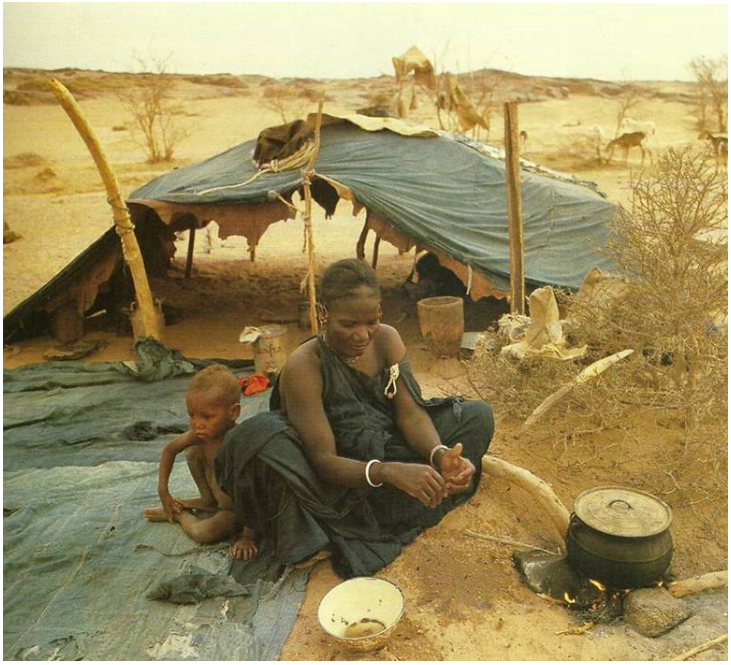
The first objective for New Biosphere Agriculture (NBA) is to establish demonstration units of the production of appropriate vegetables and fruits. These core modules are to be demonstration units at the optimum commercially viable scales as well as demonstration of small cottage units. These demonstration units are to be training units.

A core aspect of these modules is the incorporation of viable, stable, sustainable, renewable energy supply technologies. Without a continuous supply of electricity, then these demonstration units cannot be deployed to remote and emerging communities.

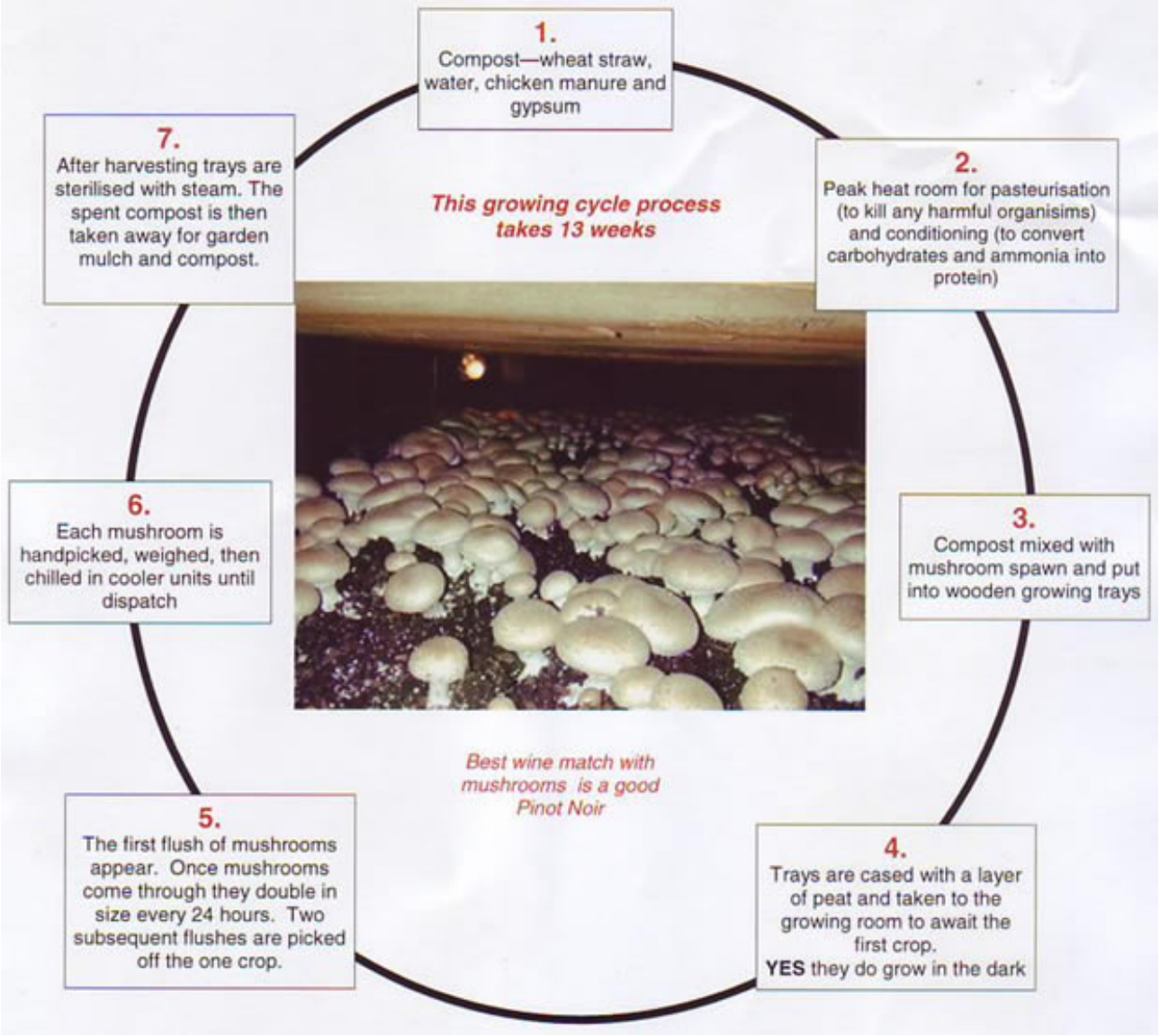
Though the capital cost of establishing these units may be high, once they are in operation, their ongoing operating costs are nominal, thus once the capital equipments are installed into the remote community, they become viable within that impoverished community.

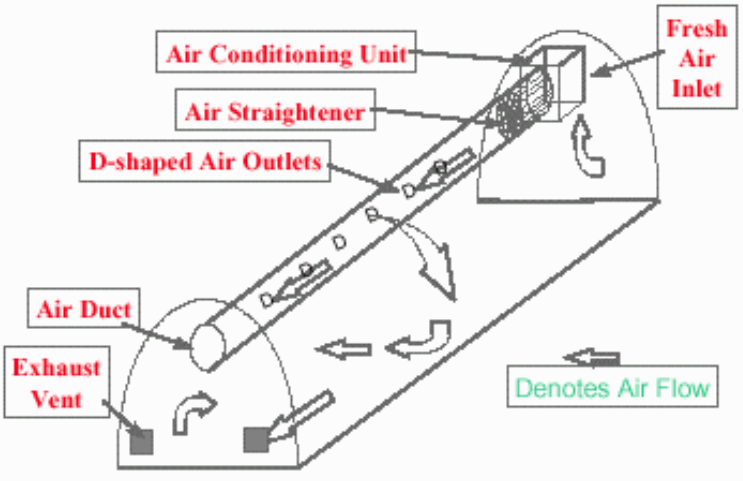
Consider bringing all these technologies together within a refugee camp of any proportions, but more appropriately, to their traditional home regions to enable their return. Train members from that community at the NBA demonstration unit whilst the equipment is being installed. Then leave the ongoing operations for the benefit of the community, whilst providing ongoing technical and administrative support.

We do not have to allow situations like this to continue. We have the solutions!



MUSHROOMS:


1.
Compost—wheat straw, water, chicken manure and gypsum
2.
Peak heat room for pasteurisation (to kill any harmful organisims) and conditioning (to convert carbohydrates and ammonia into protein)
3.
Compost mixed with mushroom spawn and put into wooden growing trays
4.
Trays are cased with a layer of peat and taken to the growing room to await the first crop.
YES they do grow in the dark
5.
The first flush of mushrooms appear. Once mushrooms come through they double in size every 24 hours. Two subsequent flushes are picked off the one crop.
6.
Each mushroom is handpicked, weighed, then chilled in cooler units until dispatch
7.
After harvesting trays are sterilised with steam. The spent compost is then taken away for garden mulch and compost.
This growing cycle process takes 13 weeks
Best wine match with mushrooms is a good Pinot Noir


Air Conditioning Unit
Fresh Air Inlet
Air Straightener
D-shaped Air Outlets
Air Duct
Exhaust Vent
Denotes Air Flow

MUSHROOM CULTIVATION.
IF YOU ARE INTERESTED IN MUSHROOM CULTIVATION, PLEASE CONTACT ME ON
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SREELEKHA KRISHNAKUMAR

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http://www.mushroomadventures.com/graphics/commerial-new-mushroom-shelves1.jpg

INTRODUCTION TO MUSHROOM GROWING

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Although we enjoy mushrooms today as an every-day vegetable, this wasn't always the case.

Mushrooms date back to ancient Egyptian times, when they were considered a rare luxury. In fact, the earliest documented reference to the use of mushrooms as a food is attributed to one of the Pharaohs who decreed them to be "too fine a food to be eaten by the common people". Records from Greece in the period c300 BC refer to mushroom feasts and note that even then the Greeks were exporting them to neighbouring lands. The Romans who enjoyed mushrooms and Julius Caesar passed laws about who was permitted to enjoy the unique flavour of mushrooms.

For centuries, the edible mushroom defied cultivation. It wasn't until the late 15th century that cultivation of mushrooms began in disused quarry tunnels in France.

Mushrooms are a natural product with many nutritional advantages. They are cholesterol free and contain virtually no fat or sodium, all of which dieticians say need to be reduced in Australian diets. Mushrooms supply dietary fibre and are a good source of several important B group vitamins, especially niacin and riboflavin.

The sophistication of today's mushroom farms is in marked contrast to the first commercial attempts to grow this crop in Australia in 1933. At that time, mushrooms were grown in the open field in raised beds covered in straw and Hessian bags, although some were also grown in cellars or other farm sheds. The first growing houses of any size were disused railway tunnels (including the then incomplete Circular Quay – St James line).

Mushroom growers commenced outdoor cultivation in the Hills and Hawkesbury districts outside Sydney in the mid-1930's. There were several reasons for this location, including:

• it was close to a migrant camp at Schofields where many from European backgrounds who had grown mushrooms in their homelands first settled in Australia;
• raw materials for substrate preparation (e.g. straw from the expanding racing industry) could be obtained locally;
• access to a large and willing labour force;
• proximity to the burgeoning markets of Sydney, which was important for a perishable crop in the days before refrigeration.

Two major issues have affected the industry since its inception:

1. Changing Tariff Policy on Imports.

The Australian government's changing policy on tariffs has had a significant impact on the mushroom industry. In the mid-1970's the Australian industry was heavily dependent on sales to canneries.

However, with the lowering of tariffs, the market was threatened by canned products imported from low cost labour countries, mainly in the Asian area.

As the domestic canned market was eroded, growers were forced to concentrate on promotion of fresh mushrooms to develop new market opportunities. This has been a most successful venture; in 1974 less than 25% of local product went to the fresh market; by 1991, this had increased to more than 90%.

2. Changing Growing Methods

In common with much of Australian agriculture in the 1930's, production methods were still substantially the same as they had been in 19th century Europe.

Mushrooms were outdoors in raised beds covered with straw. In Australian climates, this meant they were grown mainly as a seasonal crop in the cooler months, as mushrooms require low temperature ranges to crop properly. Increasingly sophisticated technologies and demands for better quality and supply from consumers have seen a dramatic turn around in production methods. Modern mushroom farming emerged on a world-wide basis in the 1960's.

Scientific breakthroughs in the manufacture of substrate enabled growers to increase production and quality, and extend the growing season.

Today, mushrooms are grown commercially in enclosed atmosphere controlled environments, production is therefore largely independent of the environment. Mushrooms are grown in a series of identical rooms, with the number of rooms determined by the production cycle. Crops of high quality mushrooms are now produced all year round and mushrooms are a regular inclusion on Australian menus.

PRODUCTION TODAY

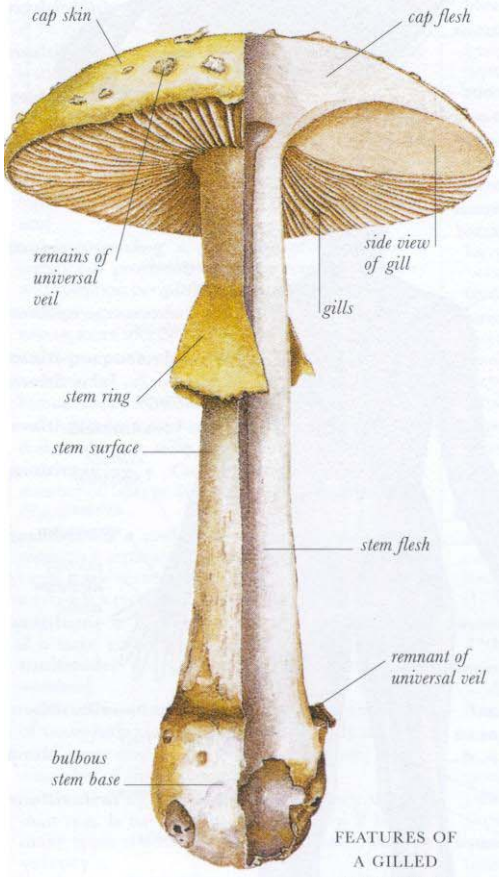
Production Statistics

Mushrooms are the third most valuable vegetable crop in Australia - after potatoes and tomatoes. A recent government study of new horticultural industries identified the mushroom industry as one of the three most successful new industries in Australia.

Most of the mushrooms produced in Australia are common white mushrooms (agaricus bisporus). There is a growing demand for specialty mushrooms (e.g. shiitake, pleurotus, straw, etc) and a niche market will continue to develop for these products over the next few years. Virtually all local production is consumed in the domestic market. Around 90% of domestic production is consumed as fresh mushrooms with only small quantities going to processing.

MUSHROOM

Like all fungi, mushrooms lack the green pigment chlorophyll, which plants use to make food. Instead they absorb nutrients from decaying organic matter or from living plants and animals. The part that is visible above ground is, in fact, the fruiting body of the fungus. The main body consists of hyphal threads, which form a branching web known as the mycelium; this spreads through the substrate that the fungus has colonized, absorbing nutrients. Fruiting bodies vary in shape and colour, but all are designed to spread the spores that enable a fungus to establish new colonies. Spores are produced on the underside of a mushroom and released from flaps (gills) or hollows (pores). Many types of fungi are edible, and some are considered a delicacy.



FEATURES OF A GILLED MUSHROOM

EXAMPLES OF MUSHROOMS

AMANITA
Caesar's mushroom
(*Amanita caesarea*)

MOREL
half-free morel
(*Morchella semilibera*)

BOLETE
penny bun
(*Boletus edulis*)

RUSSULE
crab russule
(*Russula xerampelina*)

AGARIC
field mushroom
(*Agaricus campestris*)

BLEWIT
wood blewit
(*Lepista nuda*)

WAX-CAP
crimson wax-cap
(*Hygrocybe punicea*)

FAIRY-RING CHAMPIGNON
(*Marasmius oreades*)

PARASOL
parasol mushroom
(*Macrolepiota procera*)

SHIELD-CAP
fawn shield-cap
(*Pluteus cervinus*)

VOLVAR
stubble-field volvar
(*Volvariella gloiocephala*)

COPRINUS
lawyer's wig
(*Coprinus comatus*)

GILL TYPES

ADNATE
ADNEXED
NOTCHED
FREE
DECURRENT
SINUATE NOTCHED

This ratio has changed dramatically over the last 20 years: from 75%:25% canned fresh in the mid1970's; to 8%:92% at present. The market share of imported mushrooms has also decreased significantly over recent years to less than 13% of domestic consumption. Imported mushrooms are used mainly in the processing industries.

The industry has been growing at a much faster rate than the national economy as a whole; and certainly faster than most other agricultural industries. Domestic mushroom production has expanded at an average annual rate of about 10% per annum since 1974. In 1995/96, the rate of increase was in excess of 16%. The industry is forecasting further increases in domestic production, with an estimated growth rate of more than 10% during the next two years. This increase will largely result from improved productivity and efficiency on existing farms.

The industry is a significant employer. Industry figures show that in excess of 2,000 people are employed directly by the mushroom industry.

The mushroom industry is very labour intensive, every mushroom being picked by hand. As the industry has grown, so too have the requirements for a reliable local labour market.

Despite the country's poor economic performance, the price paid by consumers for mushrooms has remained relatively constant over the last few years. It has only been possible for growers to maintain this level of return by becoming more efficient and producing better quality mushrooms more consistently.

Production Methods

Organic wastes from other primary industries are used in the production of substrate in which mushrooms are grown. Raw materials used in mushroom substrate production which are by-products of other industries include wheat straw, poultry manure, stable waste. These materials, if not recycled, could pose potential environmental threats. These ingredients are blended together and organically substrated to produce a nutrient-rich medium in which to grow mushrooms. Once the crop has been harvested, the pre-loved substrate provides an organic and nutritionally balanced product, ideal for addition to high quality potting mixes or use as a garden mulch.

Mushroom growing is one of the fastest growing and most technologically sophisticated horticultural industries in the world. However, the raw materials for growing mushrooms owe little to scientific technology. Science has yet to come up with a viable substitute quite as good as old-fashioned substrate.

The mushroom industry is the ultimate recycler.

Mushroom substrate is made from wheat straw; stable bedding; poultry litter; and other organic materials. These by-products of other primary industries are used to produce a selective nutrient-rich medium for production of a high quality food stuff. After these materials are mixed, the substrate is then fermented and pasteurised.

Spore (the seed of the mushroom) is used to produce grain spawn under sterile conditions.

The mushroom spawn is then added to the substrate. Mushrooms are grown in sophisticated rooms in which the environment is precision controlled to provide ideal growing conditions.

Constant checks ensure that temperature, air composition and humidity are kept at the right levels while the spawn grows through the substrate. A surface of peat moss is then added to the substrate to provide a good bed on which the mushrooms will multiply. At every stage of the process, the environment is carefully monitored and hygiene strictly controlled.

The growing process is unusual because mushrooms do not have leaves or a root system like other crops; nor do they need sunshine or chlorophyll. Growers have made big investments in climate-controlled growing environments specifically designed for mushrooms to ensure that quality fresh mushrooms are available for consumers every day of the year. The first mushrooms will appear in about twelve days and be ready for harvest in about three weeks.

Harvesting is done by hand by teams of trained pickers. Each tray or bag of substrate produces three commercially harvestable crops (called 'flushes') over a period of about six weeks. Once the crop has been harvested, the pre-loved substrate provides an organic and nutritionally balanced product ideal for addition to high quality potting mixes or use as a garden mulch. Thus, nothing is wasted.

INDUSTRY STRUCTURE

The industry is highly capital intensive and technically oriented, with most production coming from a relatively small number of large producers. There are approximately 80 farms located throughout Australia.

This number has been decreasing over recent years, as costs of updating to more modern technology have driven less efficient producers out of the market. The only main concentration of operations is in the Hawkesbury district of Sydney, with about half the nation's farms and 40% of production located in this area.

Because climatic or soil conditions are irrelevant to the production of mushrooms, location is not a real issue. Farms need to be near to markets if costs are to be controlled, and must have access to good transport and supplies of labour.

Farms which make their own substrate must also consider the source of raw materials, as these are bulky and difficult to transport over long distances. There are, however, some specialist substrate makers who will supply substrate to farms which do not wish to undertake this process themselves.

The Australian Mushroom Growers' Association (AMGA) represents 95% of Australian mushroom farms. The industry association is very strong and pro-active. There is a very high level of industry participation and co-operation, with members active at both state and national level, as well as on committees across a wide range of areas. The Association has a secretariat in Windsor (Sydney) to service its busy program of activities.

The mushroom industry is one of only two horticultural industries in Australia which collects a voluntary levy to fund promotion and research.

The levy is collected by AMGA on all spawn used in Australia and raises approximately AU$1.5 million per annum. These levy funds are then used to fund a range of activities including: research and development; marketing and promotion; lobbying and representation; education and training.

The Pareto principle applies in mushroom farming - 80% of the production comes from 20% of the farms. Mushroom farms fall into four main categories:

1. Production of < 250 tonnes per annum
These are family farms, with family members doing all the work including picking. They are often operating at the lowest level of technology and capital investment. Turnover on these farms would be less than AU$1 million per annum.

2. Production of 250 - 750 tonnes per annum
These are family farms, but with casual labour hired to assist with picking and other tasks. Capital investment is usually higher with newer facilities and technologies. Turnover on these farms would be between AU$1 - $5 million per annum.

3. Production of 751 - 2,500 tonnes per annum
These are usually family farms but with higher staffing ratios. The family usually maintains management control, but has employees in most other roles. Technology is sophisticated and specialised equipment and personnel, and the level of capital investment is substantial. Turnover on these farms would be between AU$5 - $15 million per annum.

4. Production of >2,500 tonnes per annum.
There are only a few farms in this category, with a mix of family and corporate ownership. The level of technological sophistication varies, as it is usual to update farms such as these over time. High numbers of casual staff are employed for picking, and specialists are employed for other tasks including management, sales, substrate making and growing. Turnover for these farms would exceed AU$15 million per annum.

PRODUCTION
Growing system

Three systems are used for mushroom growing:
• Tray growing is used mainly by medium and large growers. This is the major method used for the growing of mushrooms in Australia. Trays are made of wood, usually lm x 2m x 0.3 m in size fastened using stainless steel fittings.

• Bag growing is becoming increasingly popular with small to medium growers and new entrants into the mushroom industry. This system requires a smaller capital outlay than the tray system. Bag growing offers advantages in pest and disease control by allowing fast and easy removal of infected bags. However, these advantages are offset because bag growing requires a larger labour input per kilo than either of the other two systems.

• Shelf growing is the growing system of choice in Holland, but is used by only a few growers in Australia. It offers large savings in labour costs but this is offset by very large capital setup costs.

Each of these growing systems is economically viable in some circumstances and all are represented in the mushroom industry in Australia.

Of paramount importance is the level of expertise in required in both management and growing methods in mushroom growing. If skills in either area are lacking, production can vary greatly between crops regardless of the growing system used.

TECHNOLOGY AND TERMINOLOGY

Mushroom growing is highly technical and the use of a number of technical terms is unavoidable.

Mushrooms are fungi. Unlike green plants, they cannot convert sunlight into energy (photosynthesis) because they lack chlorophyll.

Like other higher organisms including ourselves, fungi need to have food made for them. For mushrooms, this means complex carbohydrates, microbial proteins, etc. Unfortunately, there is no pure source of these raw materials readily available in nature. Rather, in any organic matter there exists a great variety of simple and complex compounds.

Cultivated mushrooms cannot compete with lower class organisms, e.g. bacteria and some fungi in the class, fungi imperfecti. This is due to a variety of food being available in the raw ingredients and the competitive advantage which simpler organisms have in digesting these ingredients.

It is therefore necessary to find a way to provide the mushroom with a high quality growth medium in which the mushroom can have the competitive advantage.

MUSHROOM GROWING

Modern mushroom growing consists of three sequential phases each of which is dependent on the previous one.

Phase I: Production of substrate (composting).
This is carried out in a specific area of the farm called the compost yard.

Phase II:
Peakheat or pasteurising.

Phase III:
Production of mushrooms.
Phases II and III are carried out in sheds or growing rooms.

PHASE I: PRODUCTION OF SUBSTRATE

Phase I involves the preparation and mixing of raw ingredients to produce a substrate on which mushrooms can be grown. This is commonly called 'phase I compost'. This process usually takes place out of doors and it takes between 14-28 days to produce a compost ready for 'filling'. Ingredients used in the production of mushroom compost can include: wheaten straw; horse manure and/or poultry manure; gypsum and water. Large quantities or water are also used.

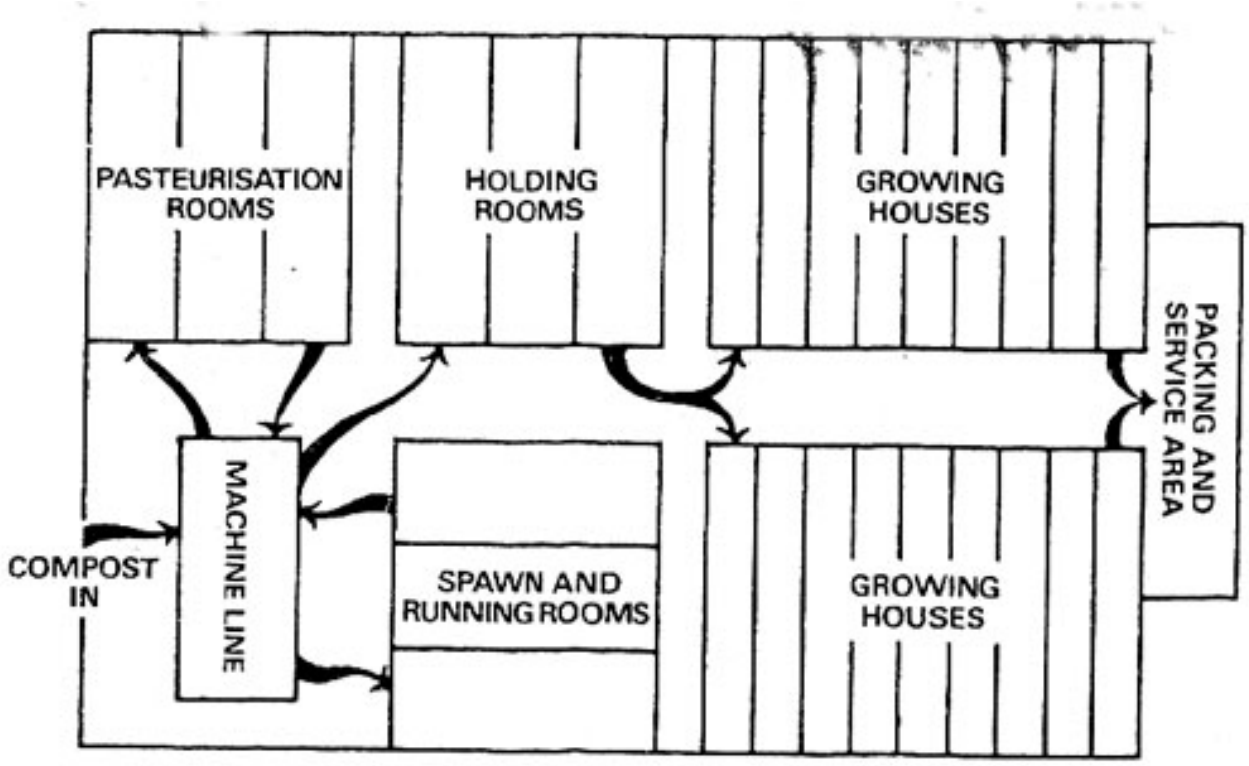
Production of compost requires:
• large areas of concrete surface for stockpiling raw materials, preparation of compost heaps and transferral of materials on site.
• access to large quantities of water and construction of reticulation and water storage systems.
• mechanical compost turning equipment as turning compost by hand is very slow and labour intensive and therefore very costly. It is only possible on a small scale and does not result in a compost sufficiently consistent to produce good yields and commercial quality mushrooms.
• machinery for mixing and moving raw materials and compost in various stages of the process would include front end loaders, forklifts and a compost turning machine.
• in most cases, local government approval is required as odours resulting from the composting process may create a nuisance.

Production of compost is a complex process. It increases the set up costs of a farm and also the effort required by the grower.

Some small farms (less than 3 tonnes per week) opt to purchase bags of compost ready spawned to overcome this problem. These are referred to as satellite growers. In areas where there are concentrations of growers it is sometimes possible to purchase compost from specialised compost makers.

PHASE II: PEAK HEATING OR PASTEURISATION

After the compost is ready, it is filled into the peakheat room. Compost can be filled into conventional trays or pasteurised in bulk in purpose-built tunnels. Phase II has a duration of 7-10 days. Filtration (to 2 μn), of air is very important at this stage to prevent any fungal and insect pathogens from infecting the compost.



It is possible to grow mushrooms without peak heating (pasteurising) the compost by extending the Phase I period. However it is not economically feasible because of the variability introduced. This results in lower yields and poorer quality mushrooms.

Phase II comprises a number of separate stages, during which temperatures are varied according to a precise schedule. The different stages are:

Levelling
After filling the compost, temperatures are levelled.

Heatup
Once levelled the compost temperatures are allowed to climb to 60°C.

Kill

When the temperature reaches 60° C it is maintained for several hours to allow the pasteurisation or kill to take place and remove pathogen loads e.g.. flies and competitor fungi.

Cooldown from Kill
Following the kill the temperature of the compost is brought down to approximately 48°-52° C over the desired time period.

Conditioning
The compost temperature is maintained at between 48°-52° C to allow conversion of gaseous ammonia into microbial biomass to be used as food by the mushroom.

Cooldown
When the ammonia (NH3) is below 10 ppm, temperature of the compost is brought down to below 25° C. The compost is now ready to be inoculated with the mushroom fungus. The industry term at this stage is 'ready for spawning'.

PHASE III: PRODUCTION OF MUSHROOMS

Phase represents the actual growth of the mushroom fungus. It can be broken into the following phases:

Spawning
Once phase II, is complete the compost is spawned. Spawn is mixed with compost and then filled into bags, trays or shelves.

Spawn running
After spawning, the crop is moved to either a specialist spawn-running room or directly to the growing room. The temperature of the compost is allowed to climb to 25° C; the carbon dioxide is allowed to build up.

During the next 10-14 days, the humidity should be maintained between 95-100% to prevent drying out of the top of the beds. This may be achieved by watering the walls and floor or by covering the beds with plastic or paper. If paper is used, it should be kept wet.

Ideally, the room should be humidified. When the surface of the compost is covered with a whitish growth, the beds are ready for casing.

The growing area which can be prepared from 1 tonne of compost will vary with the quality of compost and the depth of fill. Approximately 10-12 tonnes of raw compost at 72% moisture at the end of Phase I is required per 100 m2 of growing area for a 15 cm depth of fill.

Around 20-25% of the weight of the raw compost is usually lost during peak heating and another 7-10% during spawn run (due to loss of moisture and dry matter).

Supplementation

At this stage, some growers add a protein supplement to the compost to enhance yield. This is optional. Various products are available commercially for this purpose. Care should be taken as a temperature surge can result from supplementation.

Casing

Once the spawn has grown fully through the compost, a casing layer is added. A peat / limestone mix is the most widely used casing material. Some growers use soil peat moss combinations but this involves additional handling and steam pasteurisation. Casing mix usually comprises, one large bale of peat moss mixed with 1 bag of superfine agricultural lime and 90-100 litres of water and will cover 8-10 m2 of bed area in a layer 5 cm thick.

The basic functions of the casing layer are to:

- protect the compost from drying out;
- provide humid microclimate for fruit body formation and development;
- provide a moisture reservoir for maturing mushrooms.

Casing material should not be so wet at application that water runs into the compost. Many growers use chemicals (fungicides and/or insecticides and/or nematicides) in their casing as a routine measure to try and prevent severe pest and disease outbreaks. If chemicals are used they are best incorporated at the time of mixing to enable good distribution in the casing layer but should not be considered a substitute for good hygiene.

At this stage, fully grown compost can be added to the casing material.

This is known as CAC-ing (compost added at casing). The added compost acts as inoculum in the casing layer allowing a more even colonisation of the casing layer by the mushroom mycelium and results in more even cropping.

However, those contemplating CAC-ing should follow extreme hygiene practices and seek advice from an experienced grower or consultant as failure to manage and select the correct CAC material can result in total crop loss.

Case run
The crop is then moved to a specialist case run room or directly to the cropping room. The mushroom fungus is allowed to colonise the casing layer and water is added to the casing as required.

Fresh air
When the appropriate casing growth is seen according to the strain, fresh air is introduced into the room and the temperature is reduced to induce mushroom formation.

Pinning
Pins are the first emerging primordial fruit bodies of the mushroom fungus. As the mushroom mycelium starts to form the mushrooms, the climate and pattern of environment management is adjusted to ensure the right number of pins form and begin to grow out.

Cropping
Pins now mature into mushrooms. Mushroom crops grow in what are known as 'flushes'. The first flush is harvested 17-21 days after casing.

Most growers harvest 3-4 flushes per crop.
During cropping temperatures are held between 16°-19° C. Water is applied as required.

Harvesting the Crop
Mushrooms are usually harvested in a 7-10 day cycle. However this may vary depending on a number of factors including: temperature; humidity; strain; and the stage when they are picked.

Mushrooms are harvested by hand, so production is very labour intensive. Picking costs comprise approximately 60% of labour costs or 40% of total costs on a mushroom farm.

The performance of pickers will vary according to the experience and agility of the picker; free space available between the trays, beds or bags; lighting; and the size and distribution of mushrooms standing on the bed. Mushrooms are removed from beds with a twisting motion. The stalk is then trimmed. The mushrooms are usually graded straight into the boxes in which they will be sold.

Picking is a very skilled job. Pickers must be careful not to damage the mushrooms.

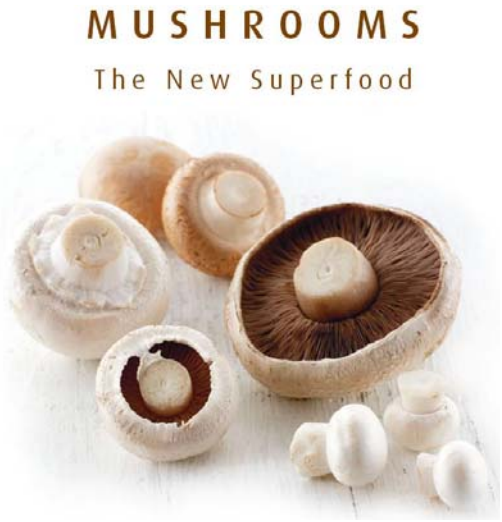
They must also be able to select mushrooms from the bed when they are ready to be picked.

An average picking rate, for hybrids (including grading), is 12-15 kg / hour of good quality button / cup mushrooms.

Mushrooms have the ability to double their size in 24 hours. They can easily grow into an inferior, lower value product if not picked at the correct time.

Grading, Packing and Distribution

Fresh mushrooms are sold in three grades: buttons; cups and flats. Each grade refers to a stage of growth.



• Buttons: these are small unopened mushrooms which usually attract the highest returns in the market place.
• Cups: these are buttons which have been allowed to grow until the cap has begun to open so that some of the gills can be seen.
• Flats: these are cups which have expanded so that all the gills are visible.
• Factory: these are mushrooms of all stages of growth which are not up to fresh market standard.

Within these grades, further grading is desirable.

These sub grades are usually based on size, i.e. large, medium and small.

Mushrooms are picked and packed with the stems upwards directly into the box or crate for distribution. This minimises the handling of the easily bruised mushroom fruit bodies.

Signs of deterioration of mushrooms include: brownish discolouration of surfaces; opening of veils; elongation of stalks; and a general softening of the surfaces due to loss of moisture.

Deterioration of the mushrooms will be minimised if they are cooled immediately to between 2° to 4°C and kept cool throughout the entire distribution chain. Mushrooms are very perishable and their appearance deteriorates each day, so they should not be stored for any length of time.

Most mushrooms are sold through wholesale markets as the demands of small private customers can be unpredictable and time consuming. One of the problems faced by a small commercial mushroom farm away from major mushroom supply centres is to achieve a continuity of supply.

Crop termination
After the final flush the crop is terminated by the injection of wet steam into the growing room and the raising of the temperature to 70° C for 12 hours.

This is referred to as cook out. Once cool again the compost is moved off site and the room cleaned ready for the next crop, the cycle starting again.

SEASONALITY

Mushrooms are unique amongst other vegetable crops in that they are grown in a totally artificially controlled atmosphere. Cropping is not dependent on the climate. Mushrooms are not seasonal and are available all months of the year. Of course, small growers without sophisticated climate control systems can not grow over the hotter summer months.

SPAWN

Spawn is the inoculum used to grow mushrooms.

Spawn is sterilised cereal grain colonised by the desired mushroom strain. The grain provides the food base for the fungus to grow from once the spawn is distributed throughout the compost at the time of spawning.

Several strains of Agaricus mushroom are commercially available.

These include: white; off white; and hybrid types.

Within each of these groups, there are a number of strains. These may differ in characteristics including: yield potential; ease of pinning; suitability of compost types; scaliness of the cap; average mushroom size and cropping pattern. Each spawn manufacturer offers a variety of strains and will provide advice on how they should be grown.

As in other parts of the world, hybrid strains are most commonly grown in Australia. These strains are more demanding in their requirement for the 'correct' compost, environmental conditions and watering.

More losses and second quality mushrooms can be expected if ideal conditions are not provided. However they do offer the possibility of producing good yields and good quality over a shorter cropping period.

Once purchased, mushroom spawn should be mixed with the compost as soon as possible.

Spawn has a limited life. It can be stored at low temperatures (2°C) for several weeks; or at 15-20°C for a few days. Spawn should always be stored in a separate coolroom away from mushrooms or other likely contamination sources.

Care should be taken, especially during transit, as spawn performance can be affected by rapid changes in temperature and temperatures that are too high (over 30°C).

Three to five kilograms of spawn should be used per tonne of compost. When larger quantities of spawn are used, a considerable increase in temperature will occur in the beds generally 6-7 days after spawning. If insufficient spawn is used, the extra time taken for the mycelium to colonise the compost may enable pests and diseases to establish and compete directly with the mushroom mycelium. This will result in reduced yields.

YIELDS

Yields are generally stated in terms of kilograms of mushrooms produced per square metre of compost. This refers to tray and shelf systems; in bag systems growers talk in terms of yield per bag.

Whilst crop management is the most important factor determining yield, many other factors are also influential. These include: the depth of fill; length of cropping; grade of mushrooms picked; quantity of compost per m2 (and whether it was calculated at the time of filling, pawning or casing); compost quality; productive capacity of the spawn, composition and moisture content of the casing soil; climatic conditions in the growing room; and the presence or absence of pests and or diseases.

The average yield for mushrooms in Australia is approximately 22 kg per square mere of growing surface area from 95 - 100 kg of compost (wet weight at spawning) for trays and shelves. For bags, the average yield is 5.5 - 6 kgs per bag from about 20 kg of compost (wet weight at spawning).

Higher yields are of course possible but new growers with limited knowledge would not expect to achieve good yields in the initial stages.

The most economical period for picking is determined mainly by the total yield as well as the growing system used on the farm. The usual cropping period extends over 6 - 7 weeks and four flushes. However, around 80% of the total crop will usually be picked during the first 4 weeks (3 flushes).

Picking over longer periods often creates more problems than it is worth.

Increased pest and disease problems are usually experienced and labour costs are often higher as fewer mushrooms grow on the beds.

Spent mushroom compost is a good soil conditioner. Many growers sell their spent compost to landscape suppliers, etc., for onselling to gardeners. This can be a useful addition to farm income, but must be worked at if it is to be a reliable earner. Returns for spent mushroom compost will vary, depending on availability, local demand, loading facilities and many other factors.

The availability of other organic mulch and compost products has eroded the market which was previously solely filled by mushroom compost. Sewage sludge and similar products are now competing with compost, particularly in the broad scale use areas, e.g. main roads departments; commercial landscape applications and so on.

There have been many instances of ‘bogus’ composts being passed off as mushroom compost. This obviously creates problems for growers trying to sell their compost. However, the outcomes are worse for consumers who buy the imitation stuff. When the results in their gardens are poor, they blame it on real compost and will not buy more in the future. AMGA is working with Standards Australia to develop a standard for marketing product as spent mushroom compost.

STRUCTURES

Mushroom growing sheds
Mushrooms are grown commercially in purpose built rooms. Existing farm buildings such as fruit packing sheds and poultry sheds can sometimes be used but they will require major modifications.

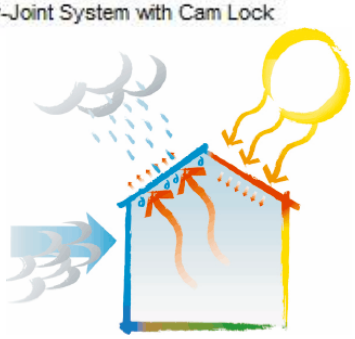
Even after modifications, there can still be limitations because of pest and disease problems and their original construction.

Insulation
Insulation is required to prevent fluctuations in temperature and energy losses from heating and cooling. A common construction material used is polystyrene or polyurethane sandwich panels similar to those used to construct coolrooms.

Panels Dry-Joint System with Cam Lock

Humidity and heat controls
Controls are required to enable temperature and humidity conditions within the shed to be evenly maintained regardless of the prevailing weather conditions.

Ventilation
Mushrooms need a supply of fresh air to ensure growth is not inhibited by a build up of carbon dioxide.



Airfiltering
Air filtering is required to help keep out air-borne spores and insects. Filtering to is highly recommended (2 ~m).

Cement floors
Floors must be of concrete with adequate drainage to enable better hygiene management.

ROOM ENVIRONMENT AT DIFFERENT STAGES OF CROPPING.

Peak heat (Phase II, pasteurization)
During this process, the compost and air temperatures should be maintained between 50°C and 60°C for 7-10 days and humidity should be 90-100%. The air in the growing room should be renewed 25-30 times per hour (or 150-300 per tonne per hour) without allowing the surface of the compost to become too dry.

Spawn Run
During this period, room temperatures of 25°C for 10-11 days are preferred, with a high humidity (95-100%) to prevent drying out of compost. Fresh air is not required, as a build up in carbon dioxide encourages the vegetative growth of the mushroom mycelium.

The temperature in the compost increases due to the metabolic heat produced by the growing mycelium throughout spawn run. Sometimes the rooms may require cooling to maintain the desired compost temperatures.

Picking
An air temperature of 15-18°C is required to keep the temperature of the mushroom beds at 16-20°C. In summer, air temperatures this low cannot be reached without a cooling system. During picking, air in the room needs to be renewed several times per hour. It also needs to circulate evenly throughout the room in order to remove any carbon dioxide and undesirable gases that might be present. Fast air currents (especially of dry air) should be avoided.

During the picking period, relative humidity should be kept at 85-90% to prevent scaling and drying out of the beds.

Cook out
At the end of cropping, it is good practice to cook out the compost using live steam to at least 70°C and maintaining it for up to 10 hours. This prevents the spread of pests and diseases from old to new crops.

Crops at different stages of production should be separated to prevent spread of pests and diseases from old to newer crops. Good Hygiene Is Essential In Mushroom Production.

ESTABLISHMENT COSTS

The price obtained by growers for their product varies, depending on grade, quality, market supply and demand. However, the range of variation is not as great as that experienced in many other crops. Industry averages over recent years have been in the range: Buttons, AU$2.80 - $4.00/kg; Cups, $2.50 $3.50/kg; Flats, $2.00 - $2.80/kg; Factory, $1.60/kg (varies according to grade and contract arrangements). The downside of this is that the margins for growers are very slim and only efficient producers will survive.

Costs of production vary according to the growing system used and the scale of production.

Over recent years, industry averages come out around $2.75 - $ 3.25 per kg. However, these figures can only be a very rough guide, as they make no allowance for borrowing costs, land purchase, market conditions and overhead establishment costs.

In setting up a mushroom farm, costs of the following factors need to be taken into consideration:
• land (minimum size about 1 ha)
• foundations and cement slab and drainage
• structures - for growing, work and storage area, packing room
• power and wiring, steam boiler and pipes, insulation
• air conditioning and duct work
• trays for peak heating and growing
• coolroom
• forklift
• water supply
• spray pump and watering equipment
• casing mixer
• office
• staff amenities
• thermometers - remote for peak heat

• thermometers - for growing rooms
• tools, knives, maintenance
• picking trolleys
• protective clothing and equipment for chemical application.

Farms where compost is made would also require:
• reinforced concrete wharf with adequate drainage and waste water recirculation and disposal system
• compost turning machine; good water supply and reticulation
• special thermometers with a scale of 10-90°C
• storage area for raw materials (some under cover)
• tractor and front end loader, odour control mechanisms.

The most important items of cost to the mushroom grower are:
• structures and equipment
• labour - for filling trays, spawning, casing, watering, emptying, harvesting, picking and packing
• compost
• casing
• spawn
• power and fuel - for air conditioners, boilers, fork lifts, coolroom
• depreciation of plant and equipment
• chemicals, (disinfectants, fungicides, insecticides)
• marketing costs cartons, transport, agents fees
• repairs and maintenance
• miscellaneous including telephone, rates, bank costs

DOING YOUR HOMEWORK

Although Australia's warm climates impose some special difficulties, the principals of mushroom growing are consistent throughout the world.

There is very little technical information written specifically for Australian conditions. The importance of reference material to anyone contemplating setting up a mushroom farm can not be stressed enough. Before making any decisions it is vital to read widely from accepted sources.

Growing mushrooms is not like growing other horticultural crops. The capital investment required to establish a viable operation is significant. Cultural practices are very sophisticated and highly technical. Many people have entered into a venture without sufficient research and have ended up losing a lot of money. Mushroom growing is not for the faint hearted.

MARKETING

The industry has a comprehensive marketing and promotions program, based on five year plans.

Part time co-ordinators are employed in each state to facilitate this program and to involve members in promotional activities. Regular consumer surveys guide the direction of promotion with a wide range of media being included in the program.

Advertisements are placed on TV and radio and in all forms of print media.

The industry has a well developed network of food and cookery writers who support promotional efforts.

As well direct marketing has been used extensively, with cooking demonstrations and in-store activities featuring strongly in the program.

The Association's marketing program has been very successful. This success can be attributed to careful planning and monitoring of activities, as well as a commitment to fund the program at a level which will impact on consumers. Annual per capita consumption has increased from 0.65 kg in 1974 to an estimated 2.82 kg in 1995/96. This compares very favourably with 1.72 kg in the USA.

This increase has resulted from greater consumer awareness of the nutritional value of mushrooms, as well as their great value for money.

The industry is developing a national grade standards scheme, which will also enable better targeting of consumer needs. Whilst some grading now takes place, this varies from state to state and farm to farm. This national scheme will enable product to be described consistently across the country. Consumers have expressed a demand for more choice in size of mushrooms and more grade categories will meet this need.

To date, there has been little activity in the export market: domestic demand exceeds production, so there has been little incentive to venture further a field. The perishable nature of the product makes it costly to transport and to maintain the quality necessary to achieve good returns on overseas markets.

As well, labour costs in Australia are higher than many competitor countries and this makes it difficult to compete. In the near future, this situation is unlikely to change, as there are many other countries better situated than Australia to service overseas markets.

There is increasing interest in specialty mushrooms (ones apart from the common agaricus). This is a relatively new segment of the industry in Australia and as yet there are only a few growers producing these different species. In time, this market will expand to provide consumers with a greater range of choice.

VALUE ADDED COMMODITIES

As yet, growers are not particularly active in this market segment. There are some products well established on the market, including canned mushrooms in sauces or in brine. Some growers are packing into 200gm pre-packs, and these are proving popular with consumers.

There have been some attempts to market a sliced mushroom pack and this may become more common. Overseas trends indicate that it is likely this market segment will expand, with pre-packaged products including salad packs and things like mushrooms with microwaveable sauces common in the US.

Most value adding for mushrooms in Australia is done outside the mushroom industry, by other food producers. Mushrooms are important ingredients in pizzas, pasta sauces and many pre-packaged meals.

CURRENT ISSUES

Most of the mushroom farms in Australia are located in areas on the fringe of major capital cities. These areas have been traditionally rural in nature and have provided much of the fresh produce for the residents of the cities. However, increasing urban development has changed the nature of many of these areas. Existing government policies and community attitudes have meant that urban expansion has been concentrated in the fringe areas of the city. The ever-increasing urban population of these regions has thus placed untenable pressures on many agricultural activities.

The reasons people re-locate to urban fringe areas are varied: lower priced homes are obviously attractive to younger families and many people appreciate the life style benefits of semi-rural areas. However, newer residents in these semi-rural areas often have little experience with agriculture.

This has lead to increasing conflict between agricultural producers and local residents. Whilst many people consider the 'country' nature of the surrounding s to be a real attraction of living in these fringe areas, they seem to have little understanding of or tolerance for the inevitable evidences of agricultural pursuits in the surrounding environment. Local government reacts to these pressures by appeasing the vocal resident groups, often at the expense of traditional land users.

Further pressures are placed on growers by the lack of awareness of the real value of productive agricultural land. As a result of increasing pressure for residential land expansion, agriculture is often viewed as a transitional land use - an interim activity whilst awaiting subdivision for residential purposes. Fringe farming areas are thus often perceived only in terms of the value which could be gained from subdivision.

There is no understanding of the economic value of productive land, nor of the scarcity of land suitable for productive areas. If a true economic value were placed upon these areas, it would be seen that subdivision for short term residential gain was often not the most effective land use and that community benefits are decreased by such activities. This highlights the need for recognition of agriculture as a legitimate land use within the broader urban regional context.

This conflict has impacted on the mushroom industry as a result of the substrating process.

Odour is an unavoidable result of the production of mushroom substrate (indeed substrating in general). Substrate production has become increasingly capital intensive. This has led to a reduction in the number of substrate producers over recent years, as farmers decided not to produce their own substrate but to buy this in from specialist substrate producers. This trend was obviously influenced by an awareness of the possibility of objections to odour produced during the substrating process.

At the present time, four substrate producers make mushroom substrate for most growers in NSW. In other states, it is more usual for each grower to make substrate on-site. Most of these producers are introducing new state of the art technology in an attempt to address the odour issue. However, recent court decisions have threatened the continuation of substrating in its current form. This is a significant and very real threat to the NSW mushroom industry which will also have major impacts on surrounding communities and other rural activities in similar areas.

RESEARCH

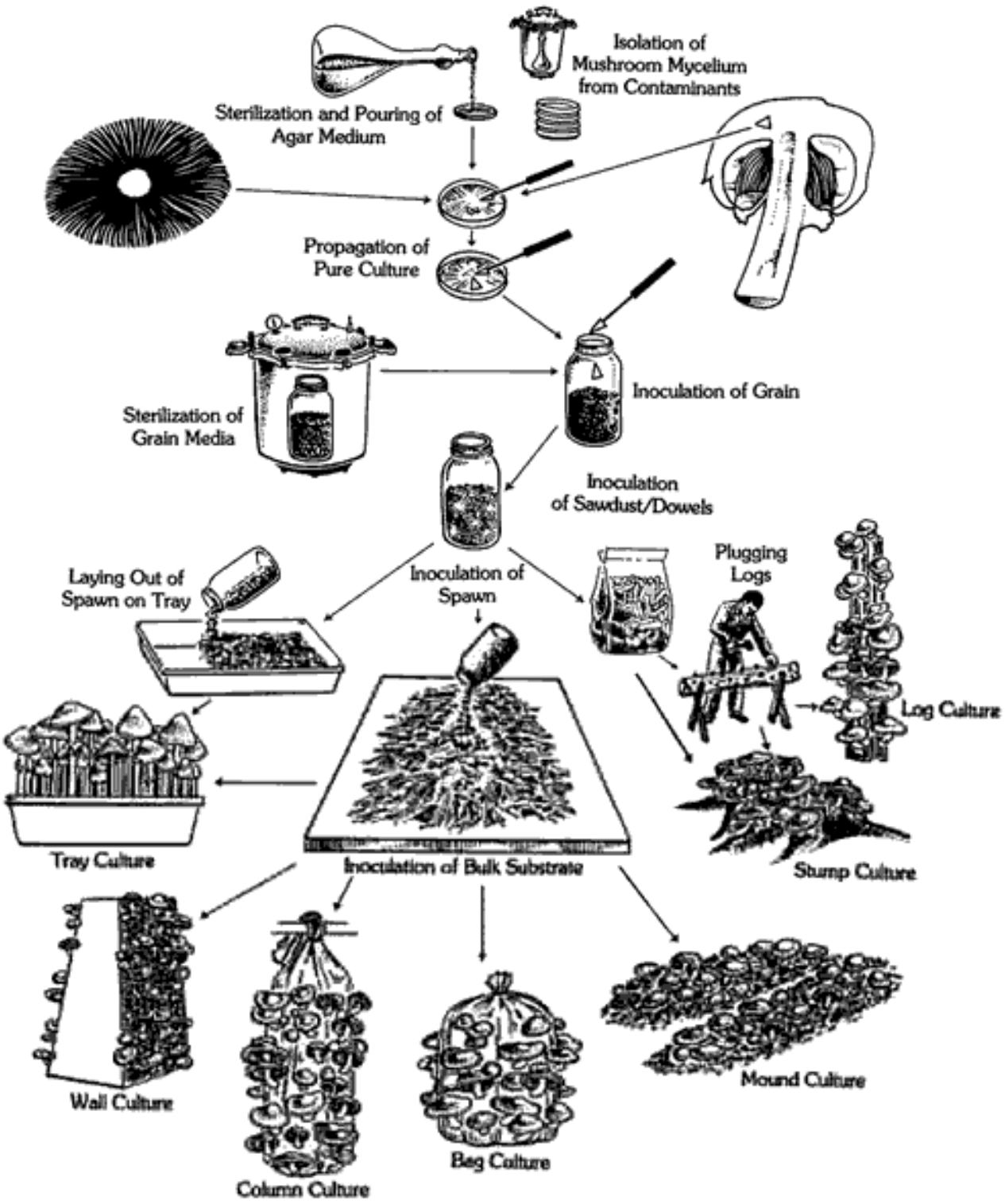
The Australian mushroom industry has a strong commitment to research and funds a significant program of research in conjunction with the Horticultural Research and Development Corporation. A five-year industry R&D plan guides decisions about projects to be undertaken.

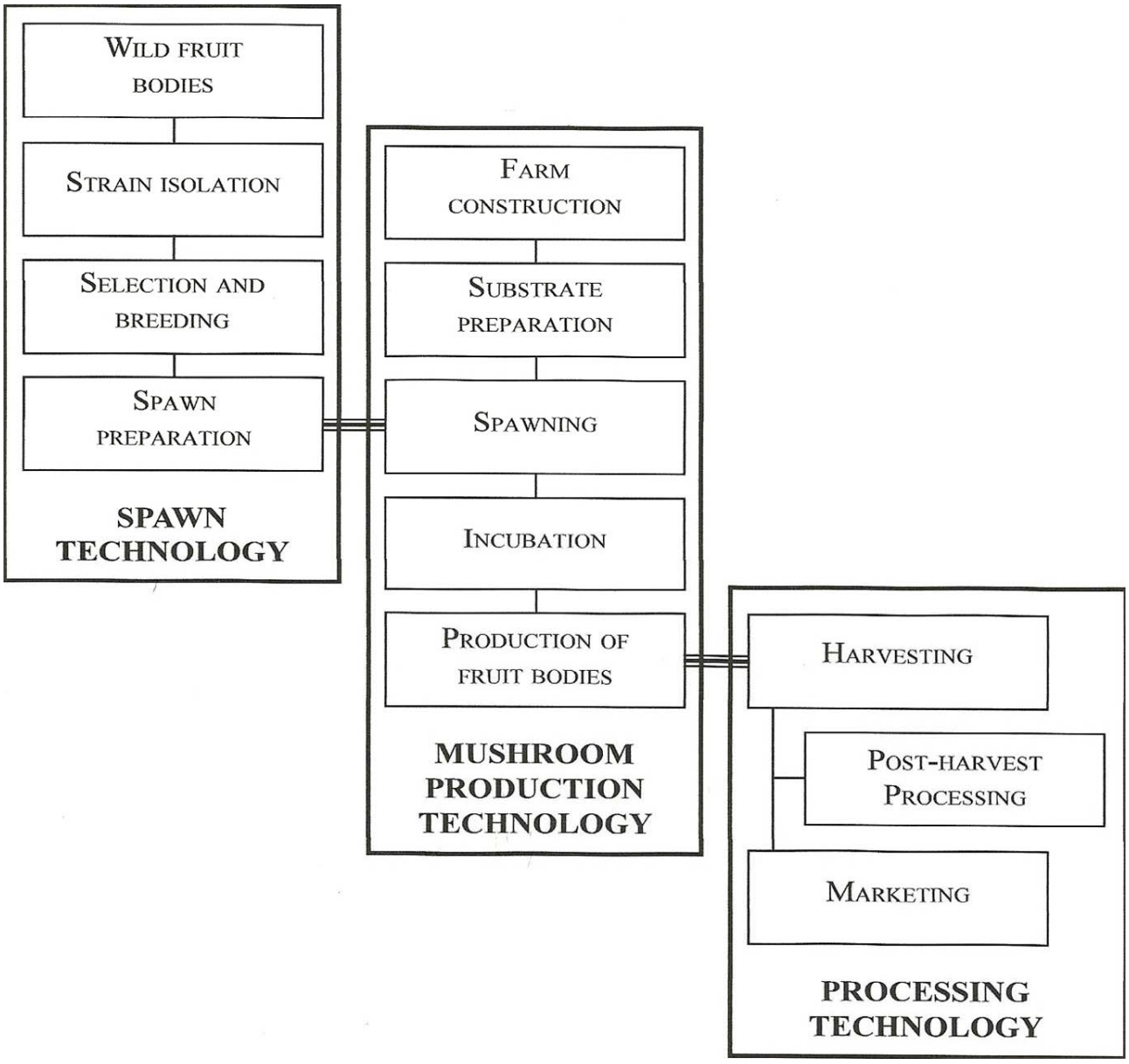
INDUSTRY OUTLOOK

The AMGA regularly develops and reviews five year plans for the industry and for marketing and R&D.

Production will continue to increase and so more effort will need to be put into marketing and promotion. Research projects currently underway will assist with improving presentation of product to consumers.

Niche markets will also expand, as production of specialty mushrooms increases and more value-added products are made available.


Isolation of
Mushroom Mycelium
from Contaminants
Sterilization and Pouring of
Agar Medium
Propagation of
Pure Culture
Inoculation of Grain
Sterilization of
Grain Media
Inoculation
of Sawdust/Dowels
Plugging
Logs
Laying Out of
Spawn on Tray
Inoculation of
Spawn
Log Culture
Tray Culture
Inoculation of Bulk Substrate
Stump Culture
Wall Culture
Column Culture
Bag Culture
Mound Culture


WILD FRUIT BODIES
STRAIN ISOLATION
SELECTION AND BREEDING
SPAWN PREPARATION
SPAWN TECHNOLOGY
FARM CONSTRUCTION
SUBSTRATE PREPARATION
SPAWNING
INCUBATION
PRODUCTION OF FRUIT BODIES
MUSHROOM PRODUCTION TECHNOLOGY
HARVESTING
POST-HARVEST PROCESSING
MARKETING
PROCESSING TECHNOLOGY

Mushroom Exchange, Mernda Mushroom Production Plant - Industrial Refrigeration

http://www.resourcesmart.vic.gov.au/for_businesses/case_studies_3473.html

Background

Mushroom Exchange is the largest producer, packer and marketer of fresh mushrooms in the southern hemisphere, producing around 230 tonnes of mushrooms each week and supplying in excess of 30% of the Australian market.

The cooling system at its Mernda plant, made up of Trane reciprocating refrigeration compressors, serviced six mushroom spawn running rooms. This technology was operating at below optimum levels, with significant opportunities for efficiency and cost improvements. As well as improving the energy efficiency of the plant, Mushroom Exchange wanted to improve the refrigeration capacity of the rooms and productivity of the plant.

Objectives

Review and upgrade the current system.

Actions

The solution involved upgrading the technology and improving the efficiency of the cooling system.

Step 1: After reviewing several options, Mushroom Exchange decided to replace the old compressors with high-efficiency Turbocor compressors from Airmaster Australia. The Turbocor compressor typically uses 40% less power for the same cooling output when compared to other, similar-sized compressors. The units are half the size and one fifth the weight of the same capacity reciprocating compressor, are extremely quiet and use ozone and greenhouse gas friendly refrigerants. The compressors have in-built soft starters and variable-frequency drives, meaning the compressor operates to match the load.

Step 2: Air handling units servicing the spawning rooms were converted from direct expansion units to chilled water type.

Step 3: Cooling capacity for the rooms was increased by 50% to cope with the higher loads imposed on the spawning rooms due to higher throughput. Through improved temperature control throughout the process cycle, yield increased from each room by approximately 10%. The system was designed to maximise efficiency. Two 900 kW PowerPax chillers, utilising a total of six Turbocor type compressors and feeding a common chilled water circuit, were installed to all 12 air handling units.

Results

The cost of purchase and installation of the new system was $365,500 - the Turbocor compressors being over 50% more expensive than a similar capacity reciprocating compressor. However, the total expected annual cost savings compared to the alternative option of purchasing
two 900 kW screw compressor equipped chillers (at an estimated cost of $233,300) was $31,743. Therefore, the payback period on the additional investment was 4.2 years.

The Department of Innovation, Industry and Regional Development provided funding of $66,100 to assist the upgrade. The funding also helped the company accept the potential risk associated with the new application of the technology and to demonstrate its application for future installations.

The new refrigeration system saves about 407 tonnes of carbon per annum and around 48 tonnes per annum from the alternative refrigerant. Total carbon abatement was 455 tonnes per annum.

As well as the energy savings, the compressors operate at less than 70 dBA, reducing noise levels significantly and improving the work environment. The new, oil-free compressor also means Mushroom Exchange no longer has to dispose of 80 litres of oil per annum.

With over 6000 kW of cooling in service throughout their Victorian operations, Mushroom Exchange will consider installing the new technology in its other facilities.

Table 9. Estimated amount of water required for producing 1 kg of fresh oyster mushrooms using rustic technologies, in comparison with that for other food and forage crops (Martínez-Carrera *et al*., 1998).

Product	Litres of water/kg	Protein content[a]	Litres of water per gram of protein
Oyster mushrooms (*Pleurotus*)	28	2.7	1.0
Potatoes	500[b]	2.1	23.8
Wheat	900[b]	14.0	6.4
Alfalfa	900[b]	6.0	15
Sorghum	1,110[b]	11.0	10.0
Corn	1,400[b]	3.5	40.0
Rice	1,912[b]	6.7	28.5
Soybeans	2,000[b]	34.1	5.8
Broiler chicken	3,500[b]	23.8	14.7
Beef	100,000[b]	19.4	515.4

[a]Composition in 100 g, edible portion (fresh weight) [Watt & Merrill, 1975; Duke & Atchley, 1986; Chang & Miles, 1989].
[b]Data according to Pimentel *et al*. (1997).

http://www.hongoscomestibles-latinoamerica.com/Mexico/COLPOS/A/11.pdf

Nutrition http://www.cairnsmushrooms.com.au/nutrition.html

Mushrooms are the perfect food for everyone!

They are low in calories, are fat free, cholesterol free, have very low levels of sugar and salt; they provide a valuable source of dietary fibre, as well as several vitamins and minerals. For more information on specific areas of mushrooms and your nutrition, please see below.

- Fibre
- Vitamins
- Minerals
- Mushrooms & Slimming
- Mushrooms & Antioxidants
- Mushrooms & Cholesterol

Mushrooms & Fibre

Mushrooms are a valuable source of dietary fibre: a 100g serving of mushrooms contains more dietary fibre (2.5g) than 100g of celery (1.8g) or a slice of wholemeal bread (2.0g).

Mushrooms & Vitamins

- **Vitamin D**: Mushrooms are one of the few natural sources of vitamin D, which is essential for healthy bones and teeth.
- **Vitamin B1 - Thiamin**: Thiamin controls the release of energy from carbohydrate, which is needed for the normal functioning of the brain and nervous system. A 100g serving of mushrooms will give you 27% of your recommended daily dietary intake of thiamin.
- **Vitamin B2 - Riboflavin**: Mushrooms are high in Riboflavin, a B-vitamin that helps to maintain healthy red blood cells and promotes good vision and healthy skin.
- **Vitamin B3 - Niacin**: Niacin, another B-vitamin found in mushrooms, helps to control the release of energy from protein, fat and carbohydrate, which keeps the body's digestive and nervous systems in good shape.
- **Vitamin B5 – Pantothenic Acid**: Plays a number of essential metabolic roles in the human body, including providing assistance with the production of hormones; found naturally in mushrooms.
- **Vitamin B9 - Folate**: Mushrooms are a rich source of Folate, which is essential for the formation of red and white blood cells in bone marrow. Folate is an important factor in healthy growth and development: pregnant women are encouraged to increase their Folate to assist with growth.
- **Vitamin H – Biotin**: Is essential in the metabolism of proteins and carbohydrates and is just another B-vitamin found in mushrooms.

Although these vitamins are also found in many vegetables, they are lost when cooked in boiling water: as mushrooms are rarely prepared with boiling water, they retain their valuable vitamin content when eaten.

Did you know: Collectively, the B-vitamins contained in mushrooms may help to relieve stress, depression and fatigue?

Mushrooms & Minerals

- **Sodium**: Mushrooms contain virtually no salt.
- **Potassium**: This important mineral aids in the maintenance of normal fluid and mineral balance, which helps to control blood pressure. Mushrooms contain more potassium than most other fruit and vegetables: one medium Portabello mushroom contains more potassium than a banana.
- **Calcium**: As well as being the most abundant mineral in the human body, calcium provides the structure for our teeth and bones and is needed for muscle contraction. 100g of mushrooms contains 2mg of calcium.
- **Iron**: Mushrooms are a source of iron, which is essential to most life forms and normal human physiology.
- **Zinc**: Found in almost every cell of your body, zinc stimulates the activity of approximately 100 enzymes and amongst other things, supports a healthy immune system. Zinc is found in mushrooms.
- **Magnesium**: Essential to good health, magnesium helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and keeps bones strong; 100g of raw mushrooms contain 9mg of magnesium.
- **Selenium**: This mineral works as an antioxidant, protecting body cells from damage that might lead to heart disease and some cancers. Mushrooms are one of the richest, natural sources of selenium.
- **Ergothioneine**: This is another, naturally occurring, antioxidant which is found in mushrooms.

Mushrooms & Slimming

Mushrooms contain almost no fat, sugar or salt, but they are a valuable source of dietary fibre, creating the perfect snack for those on a diet. In addition to being a healthy 'snack food', mushrooms are a great, low-calorie way to add flavour and texture to a variety of dishes, including pasta and stir-frys. With a high water content (over 90%) mushrooms can be cooked in their own juices, without the need for butter or oil.

Mushrooms & Antioxidants

As highlighted in 'Mushrooms & Minerals' (above) mushrooms contain two antioxidants, Selenium and Ergothioneine. Antioxidants are the scavengers of free radicals and are believed to help the body fight chronic diseases. Researchers in the United States of America have found that White Mushrooms have 12 times more Ergothioneine than wheatgerm, and four times more than chicken livers: previously these were the top rated foods for this antioxidant.

Mushrooms & Cholesterol

Mushrooms [White Buttons and Cups, Brown Portabellos, and the exotic cultivated Shiitakes and Enoki mushrooms] are rich in the non-starch polysaccharides (NSP) chitin and beta-gluten. Recent research demonstrates that these NSP, or dietary fibre, can help to reduce blood cholesterol and protect against heart disease