

Food from fungi

Fungi have been used as sources of food and for food processing for thousands of years. Mushrooms and other edible fruiting bodies are eaten directly and various other fungi provide supplements and add flavour to foods. Yeasts are used in the fermentation of fruits to produce wines and cereals to make beer, in bread manufacture and for yeast extract flavouring. Filamentous fungi (moulds) are used in traditional processes for the ripening of cheeses and in the production of enzymes used in the food industry. The two examples shown in this leaflet illustrate how fungi are exploited as food products, providing highly nutritious and useful dietary supplements.

Mycoprotein

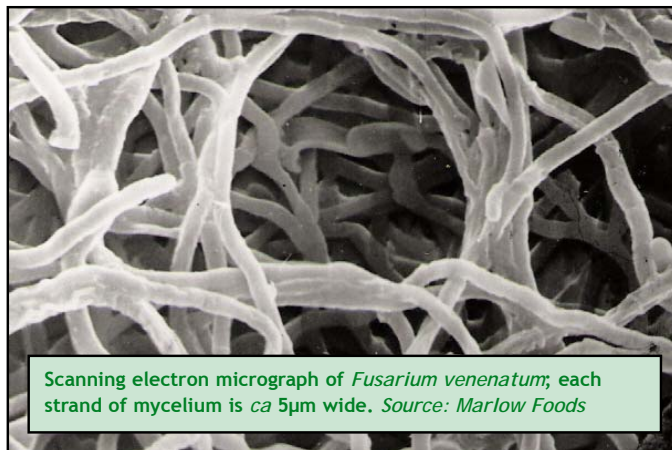
Mycoprotein has been on sale to the public as Quorn™ since 1985 and is a popular meat substitute, particularly with vegetarians. Quorn™ was developed by Marlow Foods. It is the filamentous mycelium of *Fusarium venenatum* which was originally isolated from soil and named *Fusarium graminearum*. It has a stringy consistency which gives a good texture to the final product and compares well with meat. Quorn™ is also adaptable since it readily absorbs flavourings, herbs and spices.

Nutritional value

- Quorn™ is low in calories (80 kcal 100 g⁻¹) and saturated fats. It contains no cholesterol or animal fat.
- It is rich in zinc and is therefore useful in a vegetarian diet where zinc levels can be limited but is required as an enzyme activator. The mineral content compares favourably with meat.
- It is rich in biotin, contains most B vitamins and the protein content is similar to milk.
- Quorn™ is high in dietary fibre.

Production

- The mould is grown in a nutrient medium containing glucose, minerals, biotin and ammonia (as a nitrogen source) in a chemostat. This is a continuous culture system that maintains the mould in continuous exponential growth and gives good productivity.
- Modern technology makes use of an air-lift fermenter (40 m³ volume) which enables the culture to be mixed, fed and harvested continuously. In a chemostat, the growth rate is modified by altering the dilution rate in the culture. The dilution rate - the rate at which the medium is replaced in a



Scanning electron micrograph of *Fusarium venenatum*; each strand of mycelium is ca 5µm wide. Source: Marlow Foods

continuous fermentation - is set to provide a balance between good mycelial growth and high productivity. If the dilution rate is too low, the *Fusarium* grows well but because it remains in the fermenter for a long time, productivity will be low. Conversely if the dilution rate is too high, the *Fusarium* is not in the fermenter long enough to grow well and then medium leaves the vessel unused.

- The air-lift fermenter is a large, closed loop system which uses the addition of compressed air to establish a continuous circulation. This maintains good oxygen levels and culture mixing. CO₂ produced by the mould is continuously removed.
- Fresh nutrient medium is fed in at constant rate and the mycelium is harvested simultaneously.
- The culture is constantly maintained at 30°C and at pH 6.0.

Processing

- The biomass is separated from the culture medium.
- The RNA content of the mycelium is too high for human consumption (it would lead to the production of too much uric acid in the blood) and must be reduced. This is achieved by a heat shock process (64°C for 20-30 minutes).
- The final product is collected by filtration under vacuum. A mechanical process is used to align the mycelial filaments and the resulting pasty-looking material is frozen for storage, flavouring and distribution as Quorn™.

Further information on QUORN™

www.quorn.com

Please turn over

Soy sauce

Soy sauce has its origins in the Orient and it is now popular around the world. It is produced by fermentation involving first a mould and then yeasts and lactic acid bacteria to produce a flavouring liquid with good nutritional qualities from rather unpalatable and indigestible soya beans. Its savoury meat-like flavour and high levels of valuable amino acids make it an important addition to many vegetarian foods.

Pretreatment

- Soya beans or soya-bean meal are first soaked in water and then dehulled.
- The beans are then cooked to kill any bacteria on their surface. These might otherwise spoil the fermentation process.
- Cooked beans are mixed with ground, roasted wheat.
- The flavour, colour, smell and nutritional content of the sauce are influenced by these treatments and also by the proportions in which the soya beans are mixed with the wheat.

Inoculation

- The mould *Aspergillus oryzae* is grown for a few days on cooked rice grains or rice agar until it forms spores. The soya bean/wheat flour mash is then inoculated with the mould by mixing in the sporulated culture.
- The inoculated mixture is known as the *koji*.

Shallow fermentation

- The mixture is incubated in warm conditions on shallow, well aerated trays. It is mixed well at intervals to ensure the even growth of the mould throughout the mixture which is necessary to make a good quality product.
- The *koji* must not become too warm. During incubation *A. oryzae* produces enzymes (amylases, cellulases and proteases) which hydrolyse the carbohydrates and proteins in the soya bean/wheat flour mixture.
- Starch, polysaccharides and proteins are degraded gradually by the mould and the amounts of simple sugars and amino acids in the mixture increase.

Deep vat fermentation and ageing

- Brine (sodium chloride solution) is added to the mixture. This gives the soy sauce its salty taste and tends to preserve the final product. This mixture is called the *moromi*.
- The mixture is inoculated usually with a yeast (*Zygosaccharomyces rouxii*) and a lactic acid bacterium (*Tetragenococcus halophilus*) which grow well in high levels of sodium chloride, i.e. they are "osmophilic", and are also able to grow in low levels of oxygen.
- During deep vat fermentation, the mixture quickly becomes anaerobic, preventing further growth of *A. oryzae*. The sugars in the mixture are fermented by the yeasts and lactic acid bacteria.

- After 4-6 months, a sour (pH 4.7), dark coloured liquid is formed which contains large amounts of amino acids, particularly glutamic acid, simple sugars and a range of vitamins.

Harvesting

- The brown liquid is drained off from the *moromi* and filtered to remove all bean fibre and residue.
- It is heated to inactivate the enzymes and kill the microbes. It is then cooled and filtered again.
- Pasteurised, bottled *shoyu* (soy sauce) is then ready for sale and consumption.
- Taste and smell are both important features and different qualities sell for different prices.

Further information on soy sauce

www.foodprocessing-technology.com/projects/kikkoman

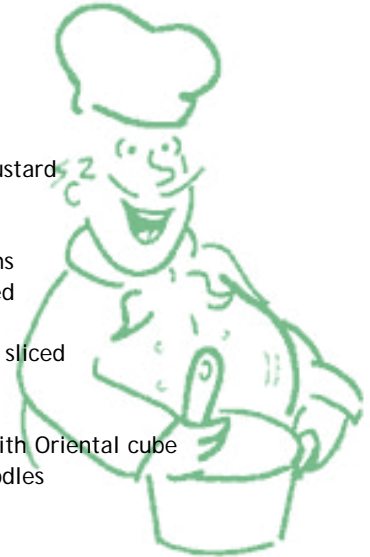
Suggestions for other activities

- Investigate other foodstuffs prepared using fungi.
- Make up recipes containing as many fungal ingredients as possible - see example.

Recipe

Try this tasty stir-fry for two people which incorporates at least five fungal ingredients.

350 g Quorn™
30 cm³ rice vinegar
30 cm³ dark soy sauce
15 cm³ whole grain mustard
100 g mange tout
100 g baby sweetcorn
100 g mixed mushrooms
100 g red pepper, sliced
100 g beansprouts
1 bunch spring onions, sliced
30 cm³ ground nut oil
2 cloves garlic
125 cm³ stock made with Oriental cube
200 g dried thread noodles



- Mix together mustard, rice vinegar and soy sauce.
- Marinate Quorn™ for 30 minutes.
- Cook noodles according to manufacturer's instructions and keep warm.
- Heat oil in wok, quickly fry the chopped vegetables.
- Add stock and Quorn™ until heated through.
- Check seasoning.
- Stir in noodles and serve.