CULTIVATION OF EDIBLE MUSHROOMS ON COTTON WASTE

PAUL F HAMLYN

British Textile Technology Group, Shirley Towers, Didsbury, Manchester M20 8RX.

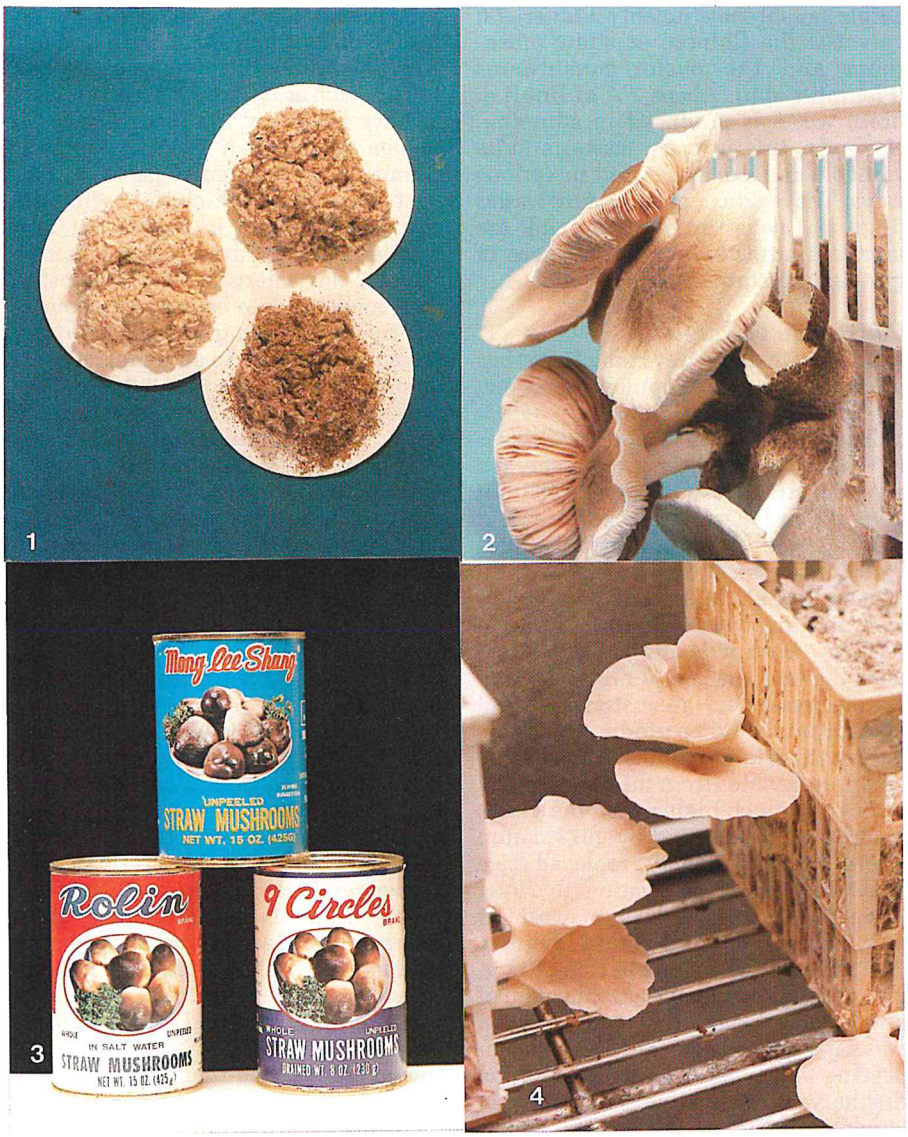

Fig. 1, Examples of cotton waste collected from mills in Manchester area. The different types of waste are normally mixed together for the purpose of growing mushrooms. 2, Mature straw mushrooms grown on cotton waste at BTTG. 3, Canned straw mushrooms purchased from a Chinese supermarket in Manchester. 4, Oyster mushrooms (*Pleurotus pulmonarius*) grown on cotton waste at BTTG.

Cotton is still the worlds leading textile fibre and some 15 million tons of cotton fibre are grown annually by about 80 producing countries. Waste, generated from the mechanical processing of raw cotton prior to spinning provides an ideal substrate for the growth of some edible mushrooms notably *Volvariella volvacea* the Chinese or straw mushroom and the oyster mushrooms (*Pleurotus* spp). About 7% of lint (i.e. fibre) waste is produced in spinning. However, this primary waste is quite valuable and can be re-used in various ways. The residual, or secondary wastes (Fig. 1), have little value and are therefore attractive for the purpose of growing mushrooms.

Volvariella volvacea

Chang (Chinese Univ Hong Kong) has pioneered the development of cotton waste as a substrate for the indoor cultivation of *V. volvacea*. Traditionally *V. volvacea* has been grown outdoors on rice straw (see Sukara, 1985) in several South East Asian countries and the reported mushroom yields have varied between 1.5% to 14.7% B.E.[1] (Chang, 1979). In 1971 cotton wastes were first introduced in Hong Kong to serve as a kind of 'heating material' and raise the temperature of mixed beds of cotton waste and rice straw so that mushrooms could be produced indoors during the winter months. The average mushroom yields from the cotton-straw beds were much higher than the yields of straw-only beds and by 1973 cotton waste had completely replaced rice straw for indoor cultivation in Hong Kong (Chang, 1974). Cotton waste is much cheaper and more readily available than rice straw in Hong Kong, giving a higher and more stable yield of mushrooms (generally 30-40% B.E.), and earlier development (pinheads appearing 5 days after spawning and the first harvest 3-5 days later) than that obtained on straw under the same conditions. Taiwan mushroom growers prefer to use a 2:1 mixture of rice straw and cotton waste as substrate (Ho & Han, 1979) presumably because of the greater availability of rice straw in Taiwan.

Chang (1978, 1979, 1982) outlines the basic procedures for cultivating *V. volvacea* on cotton waste compost. The cotton waste is usually mixed with 4-5% (w/w) rice or wheat bran and about 2-6% (w/w) limestone (or $CaCO_3$). Supplementation with an organic nitrogen source such as chicken manure appears to have fallen out of favour and is no longer employed (J F Peberdy, pers. comm.). It is important to partially compost the mixture which, following the addition of water, is carried out in a wooden frame for about 6 days with mixing at 2 day intervals. The compost is then made up into beds and pasteurized by introducing steam into the mushroom house. An air temperature of 60-62°C is maintained for 2-3 h and the mushroom house is then cooled down to 52° by the introduction of fresh air. This temperature is maintained for up to eight hours with a continued stream of fresh air. The steam valves are then closed and the air temperature allowed to drop gradually to 34-36° for spawning. This latter step takes about 12-16 h depending on the outdoor temperature. The temperature of the room is maintained at 32-34° during the period of spawn running.

The preferred spawn substrate in Hong Kong is a mixture of used tea leaves collected from local restaurants and cotton waste in a 1:1 (w/w) ratio supplemented with 2% (w/w) calcium carbonate and 2% (w/w) rice bran. Spawn produced on this medium is less prone to contamination than grain spawn; the latter encourages the development of competing moulds under the high temperature and humidity conditions employed for the cultivation of *Volvariella*. Small pieces of spawn are inserted into the compost at intervals of 12-15 cm and the beds are then covered with thin plastic sheeting to maintain a high humidity. Under good composting and pasteurization

[1]BE - 'biological efficiency' defined as the ratio of fresh weight of mushrooms to dry weight of compost at spawning expressed as a percentage.

conditions, unidentified species of Actinomycetes and *Humicola* develop in and on the beds together with mycelium of *V. volvacea* during the spawn running period. There is convincing evidence that this microflora can stimulate the growth of *V. volvacea* and at the same time prevent the growth of harmful fungi. Growth of mycelium of *V. volvacea* is complete in about four days after which the plastic sheets are removed and water is sprinkled on the bed surface; this prevents further growth of Actinomycetes and *Humicola*, and stimulates fructification. After watering, the air temperature is kept at 30 $\pm$ 2°. Light is also introduced into the room at this stage by means of fluorescent lamps. It usually takes a further five days for fruitbodies to develop to the stage of harvesting.

Straw mushrooms are not normally left to grow to their maximum size (Fig. 2), but are picked at the stages before the volva enclosing the cap breaks or just after rupture. The former is referred to as the 'button stage' and the latter the 'egg' stage (Chang & Yau, 1971). The first flush lasts for about 4-5 days and is followed by a second flush about a week later. However, the yield of the second flush is only about 10% of that of the first one and most mushroom growers harvest only the first flush. Thus, a mushroom house can have two crops of the mushroom every month, or at least three crops every two months.

Straw mushrooms are highly perishable and must be marketed within 1-2 days. They tend to deliquesce (liquefy) at 4° but have a shelf life of about 3 days when cooled and stored at 10-15°. Mushrooms for export are normally canned. Hong Kong is not self sufficient in straw mushrooms; the major exporting countries are mainland China, Taiwan and Thailand. Canned straw mushrooms can be bought from Chinese supermarkets in the U.K. (Fig. 3).

Pleurotus spp

Oyster mushrooms have become increasingly popular in recent years and are now cultivated in many subtropical and temperate countries. Commercial cultivation is usually carried out on straw but Leong (1982) has reported that non-composted cotton waste supplemented with 5% (w/w) rice bran and 5% (w/w) calcium carbonate is a suitable medium for the cultivation of *Pleurotus*. In Singapore, an average biological efficiency of 63.5% was obtained when *Pleurotus ostreatus* 'Florida' was grown on this substrate. At BTTG biological efficiencies of over 100% have been achieved with *Pleurotus pulmonarius* (Somycel 3014) grown under laboratory conditions on cotton waste supplemented with 5% (w/w) wheatbran (Hamlyn, unpubl. results; see Fig. 4).

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