Mushroom Production Technology

India is the second most populous country of the world with a population of over 100 crores. Increase in population is creating an alarming situation in the food problem in India. Malnutrition in terms of 'protein' deficiency is one of the major factors responsible for high mortality and morbidity in this country and other developing countries of the world. Due to population explosion (100 million yearly) the problem of protein hunger will become more and more acute. Animal protein (meat) is beyond the reach of low income group which forms a large proportion of our population. Exploiting non-traditional food resources can make a substantial breakthrough to meet the serious food deficit. **Mushrooms (often refers to the fruiting body of the gill fungi),** yeasts and algal foods are frequently mentioned as alternative sources of food. Of these, mushrooms are the most preferred. In the present circumstances, popularising mushroom as part and parcel of everyday food is of paramount importance. Modern mushroom culture produces more protein per unit area of land than any other kind of agriculture and technology at present available.

Mushroom farming is becoming successful because of its very low inputs. It is estimated that about 300 million tonnes of fresh mushroom can be produced from just one-fourth of world's annual yield of straw (2,325 million tonnes). It was calculated that approximately 317 million metric tonnes of fresh mushroom could be produced annually that would provide 197 g of fresh mushrooms daily to each person in the world.

What are Mushrooms?

Mushrooms are the fleshy fungi which constitute a major group of lower plant kingdom. The mushroom is a common fungal fruit body that produces basidiospores at the tip of clublike structures, called ***basidia***, which are arranged along the gills of the mushroom. Beneath the mushroom, in the soil, is the mold colony itself, consisting of a mat of intertwined hyphae, sometimes several feet in diameter. The mushrooms first appear as white tiny balls consisting of short stem **(stipe)** and a cap **(pileus)**, which begin to open up like an umbrella (Fig. 23.1). The delicate membrane or veil **(velum)** enveloping the cap tears off, if allowed to develop fully, and

lamellae (**gills**) radiating from the stalk into the cap become visible. These gills become darkened as the **basidiospores** (seeds) develop into millions and fall to the ground for starting their lifecycle once again for second generation of mushrooms. **Since mushrooms grow independently of sunlight so they can be grown in complete darkness** but the darkness is not an essential prerequisite. They are relatively fast growing, do not require fertile soil, since grown on composted or uncomposted agro-wastes and their culture can be concentrated within a relatively small space. In addition to floor, air space is also utilized resulting in higher production. It is a labour intensive indoor activity which can help the landless, small and marginal farmers to raise their income, diversify economic activity and can create gainful employment especially for unemployed/under-employed youths, weaker section of the society and women folk. It produces nutritious food from unused resources, available surplus in India (25 million tonnes of agricultural waste) and also can earn foreign exchange.

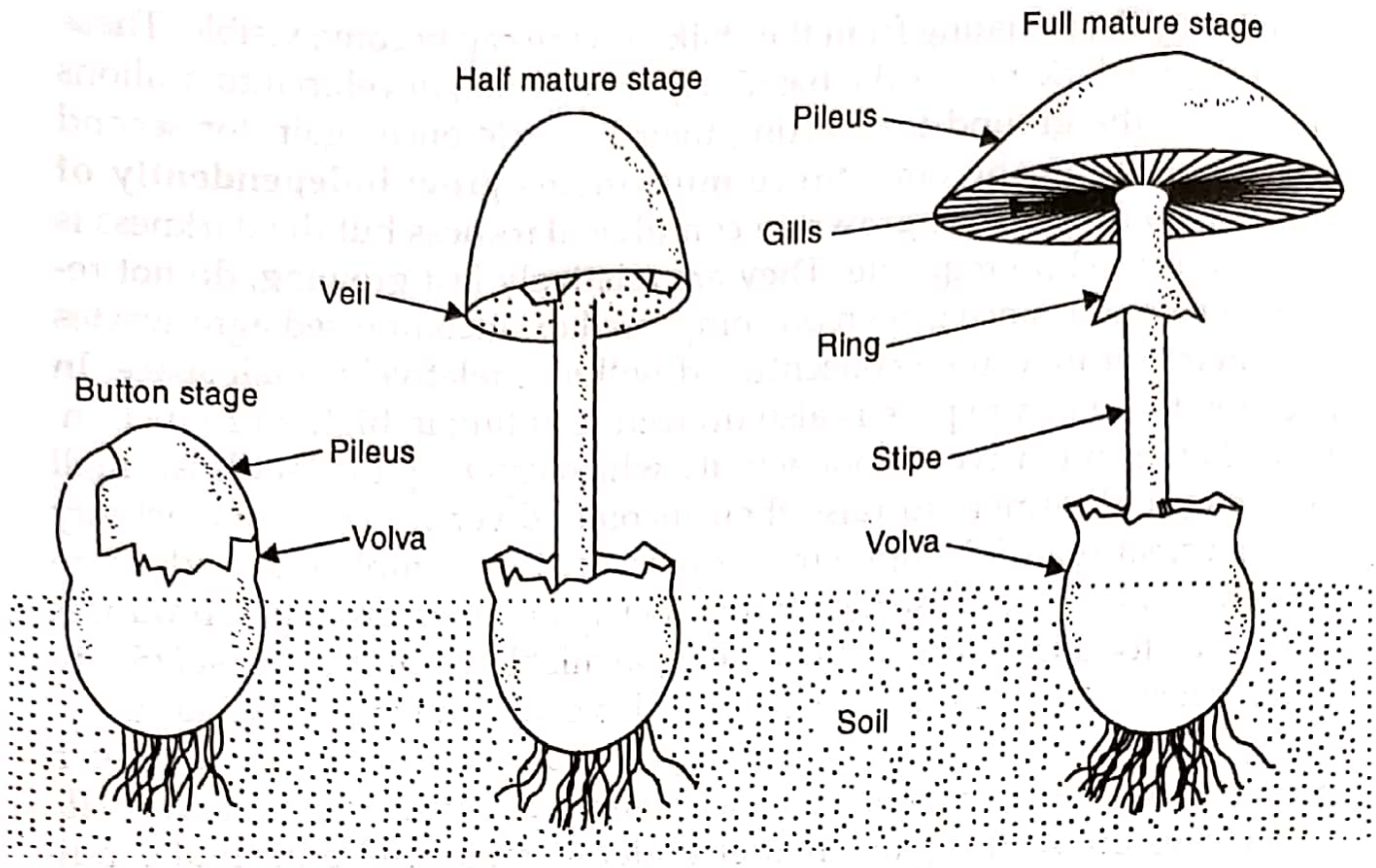
Agaricus campestris is one among several types of mushroom seen growing wild. It is popularly called **temperate mushroom** or ***'Khumb'*** and grows on dead organic matter under suitable environmental conditions. It derives its carbonaceous food by decomposing lignin, cellulose and hemicellulose present in agro-wastes with the help of extracellular enzymes secreted by the mycelium. Microbic protein available in compost is the chief source of organic nitrogen for its assimilation.

Food Value of Edible Mushrooms

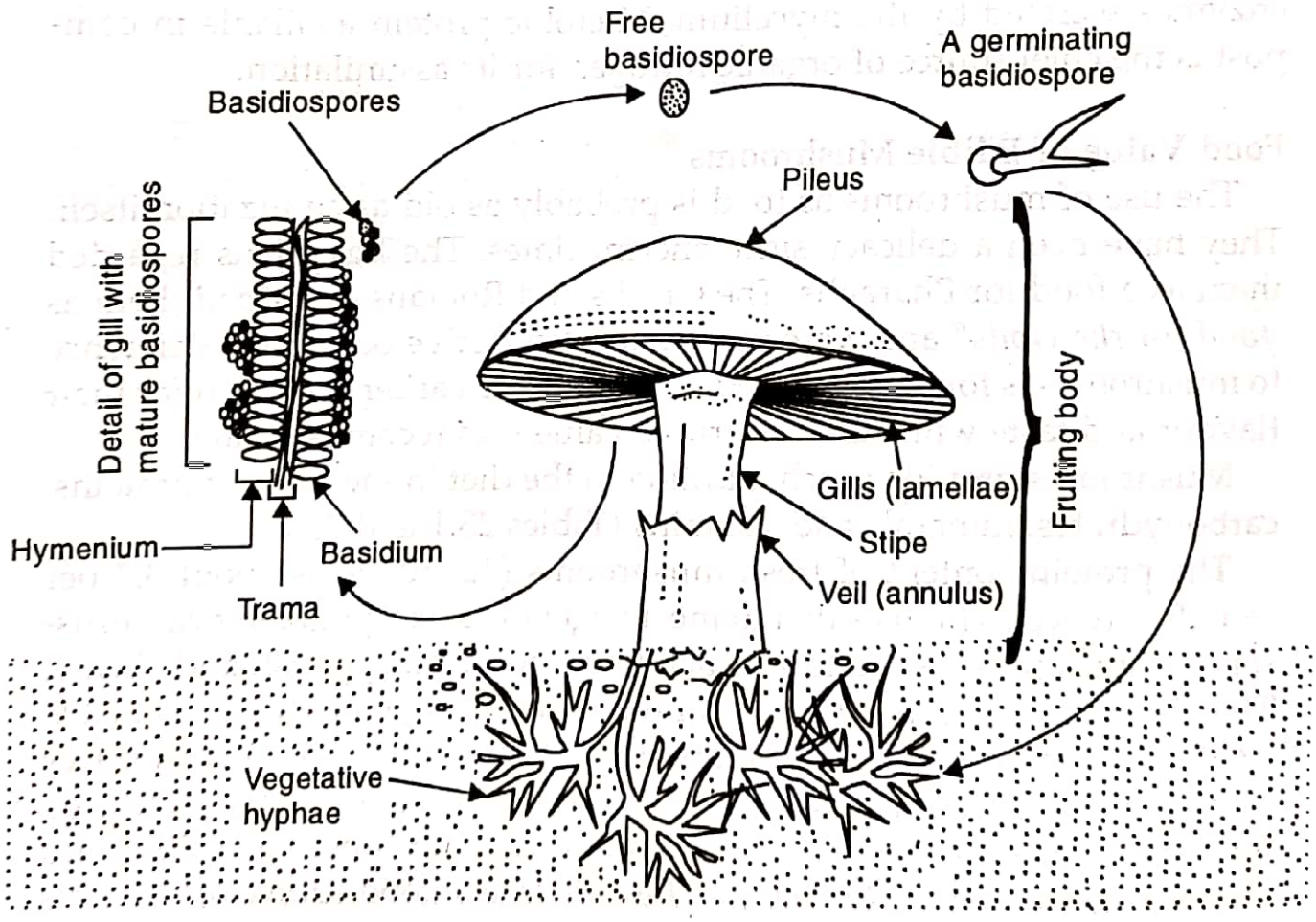
The use of mushrooms as food is probably as old as civilization itself. They have been a delicacy since ancient times. The Egyptians regarded them as a food for Pharaohs. The Greeks and Romans described them as *'food for the Gods"* and were served only on festive occasions. Reference to mushrooms is found in the Vedas. These were earlier preferred for their flavour and taste while their nutritive value was recognised later.

Mushrooms provide a rich addition to the diet in the form of proteins, carbohydrates, minerals and vitamins (Tables 23.1 and 23.2).

The protein content of fresh mushrooms (3g/100 g) is about 3.7 per cent. It is twice as high as that in most vegetables except green peas, brussels sprouts and pulses and is much lower to meat, egg, fish and cheese. They have a high percentage of all the nine essential amino acids (Table 23.2). **They are low in calories (less than 35 K cal per 100 g) with traces of sugar and without cholesterol.** These arc richer in vitamins (B_1, B_2, Niacin, B_{12}, pantothenic acid and vitamin C) than most vegetables and almost free from fat (0.2g/100 g). They are also a good source of minerals P, K, Fe and Copper (Table 23.3). Thus they constitute a valuable source of nutritive and protective food.



A. Different stages of maturity of a basidiocarp



B. Life-cycle and details of a fruit body

Fig. 23.1: A typical mushroom **(A)** Different stages of maturity of a basidocarp. **(B)** Life-cycle and details of a fruit body.

Poisonous Mushrooms

The order Agaricales, commonly called ***gill fungi*** contains over 270 genera. These include the mushrooms, the toadstools and the boletes. The edible species are called 'mushrooms' and the poisonous ones, **toadstools**. These fungi are incapable of causing infectious diseases but produce toxic substances that poison a person who ingests them. These poisonous substances are collectively known as **mycotoxins** (*myco* = fungus + *toxin* = poison) and result in ***mycetismus*** (mushroom poisoning) following ingestion of poisonous mushrooms. These mushrooms contain lethal substances that destroy liver cells and excite the nervous system. The most deadly mushrooms are the **death cap**—*Amanita phalloides*, the closely related **destroying angles**—*Amanita virosa*, the **fool's cap**—*Amanita verna* and

the *fly-agaric-Amanita muscaria.* In the death cap, the toxic principle is a mixture of **α** and **β-amanitin** and **phalloidin**—both complex cyclic polypeptides containing sulfur. Cooking does not destroy the toxin nor it is effected by the human digestive juices. Symptoms of poisoning appear only after 8-24 hours of ingestion and by time the toxin is absorbed by the body, neither vomiting nor a stomach pump can help then. Eating poisonous mushrooms may result in various types of reaction like nervous disorder, gastric disorder, haemolytic disorder and muscular disorder.

It may be remembered that even edible mushrooms can cause indigestion in healthy people and some people may be allergic to a species which is harmless to others. Causes of discomfort and indigestion may be due to eating too much, or eating mushrooms with indigestible food, or having been incorrectly cooked. **Mushrooms may also cause illness if they are taken with alcohol.**

There is no single test of knowing whether a mushroom is edible or poisonous. Alexopoulos, Mims and Blackwell (1996) in their book "Introductory Mycology" state ***"you can commit many mistakes in your life but of consuming a poisonous mushroom only once".***

Agaricus L. is the most common genus of the family with about 200 species which are widespread is occurrence, and are mostly temperate. These are commonly found growing on ground in pastures.

Most of these mushrooms are a well-known table delicacy in many parts of the world, and can be recognized by their spore colour and the lack of sphaerocysts in the cortical layers. The characteristic features of the genus are the presence of deep purplish-brown free gills, and an annulus but no volva, and stalk that readily separates from the pileus. The genus was at one time used for almost all agarics. *A. campestris* is the **common or field mushroom** and *A. brunnescens* (syn. *A bisporus*) is the **cultivated mushroom** and grown commercially in many countries, and the production of sporophores for the food market has become a major industry. All the species of *Agaricus* are edible except a few such as *A. placomyces* and *A. silvaticus* are poisonous which may cause gastrointestinal disturbances in some individuals.

A. campestris (*L. campester* = relating to plain or flat field), the field mushroom, is a common wild edible mushroom which is sought eagerly and is offered for sale. It grows amongst grass in pastures, on old lawns, often growing as **"fairy rings"** marked by grass of a darker green colour. It is now considered to be a different species from the various cultivated mushrooms and is characterized by the gills, which are bright pink at first, 4-spored basidia and the absence of any sterile cells in the gill edge. The skin of the cap is made up of fine radiating fibrils, which become tinged brownish with age, and sometimes may produce a slightly scaly appearance, especially in the centre of the cap.

A. brunnescens (*syn. A. bisporus*) (Fig. 15.10) is the cultivated mushroom of commerce and is characterized by 2-spored basidia. The fruit body is usually more robust and the flesh is thicker and firmer than *A. campestris*. In nature this grows on manure heaps, road-scrapping, and on manured soil in gardens. Cultivation technique for *A. bisporus* has been discussed later in the fungal Biotechnology section.

Man as a mycophagist has been interested in mushrooms since ancient times. Though the mushroom cultivation was started in the early 17th century by French horticulturists, it became as thriving industry only by 1850 in Paris. Until recently it was a gamble growing mushrooms but now by understanding the requirements for fruiting *i.e.* nutrition, temperature, humidity etc. the cultivation of mushrooms has become a sure and profitable industry. Haynes and Nair (1975) discussed the cultivation of *A. brunnescens* and other edible mushrooms. Munjal (1982) discussed the prospects of mushroom cultivation in India. Feeling the impact of mushroom cultivation, the ICAR (Indian Council of Agricultural Research) and the Govt. of Himachal Pradesh started a scheme for the experimental cultivation of this mushrooms at Solan in 1961 and later strengthened it by providing the services of a F.A.O. mushroom expert, Dr. E.F. Mantel. This resulted in successful transfer of technology. However, the yields were poor, because primitive type of technology was adopted. It was presumed that the Indian farmers will not be in a position to afford the pasteurization of composting and casing soil. Therefore, long method for composting and use of synthetic compost became a standard practice with the small growers. This led to the growing of mushrooms in Himachal Pradesh and Kashmir valley. Initially the spawn for both areas was supplied by the Solan Centre but later the Department of Agriculture, Jammu and Kashmir started production of spawn for its supply to mushroom growers in the valley. The conversion of Mushroom Research Project, Solan into an ICAR coordination Mushroom Research Scheme with main centre at Solan and three sub-centres at Ludhiana, New Delhi and Bangalore gave a further fillip to mushroom research in India.

The production of **spawn — a pure culture of the mycelium grown on special medium** is done by specialists under controlled laboratory conditions. Although it can also be produced by culturing a small piece of tissue removed from a fresh basidiocarp on the base medium containing grains (*e.g.* rye, wheat, pearl millet, or sorghum), water and chalk in the milk bottles. The substrate on which spawn grows and mushrooms eventually develop is known as **compost.** In the USA composted horse manure is used almost extensively. A normal compost is made by the addition of 28 lb of gypsum to every ton of fresh manure, either of horse or cow and turning the mixture every now and again till the decomposition is at the right stage; 14 lb of superphosphate/ton is put at the last turning. The manure is allowed to undergo natural fermentation in which many organisms, bacteria and fungi both probably play a part. The manure is either placed on the ground but more often in large wooden trays arranged in tiers for a week or more at a temperature of 55°C in order to eliminate insects. Mushrooms do not require light but for getting the maximum yields they have to be kept at an even temperature of 60-65°F. Indoor beds, where space is limited, such as those in special housed ('sheds') are frequently of the 'flat' type and are made up of a 6-9 inches layer of compost in boxes or trays while those outdoors are generally made as ridges about 2.5 ft. high.

Spawning of the beds is done when the temperature has reached 80°F or less. In the mushroom beds the growth of spawn depends upon environmental conditions. If the conditions are not properly adjusted various other undesirable fungi may grow more rapidly than the desired species thus producing a crop of weed fungi which may reduce the mushroom yield. It is interesting to note that the familiar mushroom sporophores are formed only after the bed (compost) is covered (cased) with a layer (about an inch) of casing material which can be top or subsoil, loam, sand, gravel, ash, litter or peat made alkaline with calcium carbonate. The casing is normally done after 10 days of spawning, when the spawn is 'running'. The investigations of Eger (1961) showed that the microorganisms which naturally colonized the casing layer are implicated in the conversion of the vegetative to reproductive growth of the desired mushroom. Mushrooms are first seen 6-8 weeks after spawning and sporophores production is stimulated by bacteria (Hayes *et al.*, 1969). A bed may go on producing mushrooms for 4 months.

A number of mushroom parasites such as *Mycogone perniciosa* (**white mould,wet bubble**), *Verticillium lamellicola* (**dry bubble, brown spot**), *V. fungicola*, *Cladobotryum dendroides* (**mildew or cobweb disease**), *Fusarium solani* and *Myceliphthora lutea* (**Vert-de-gris disease, 'mat disease'**) are known which are sometimes responsible for causing loss in yields. Mushrooms losses are sometimes also caused by the presence of other fungi which act as invaders of mushroom beds and inhibit the development of the mushrooms.

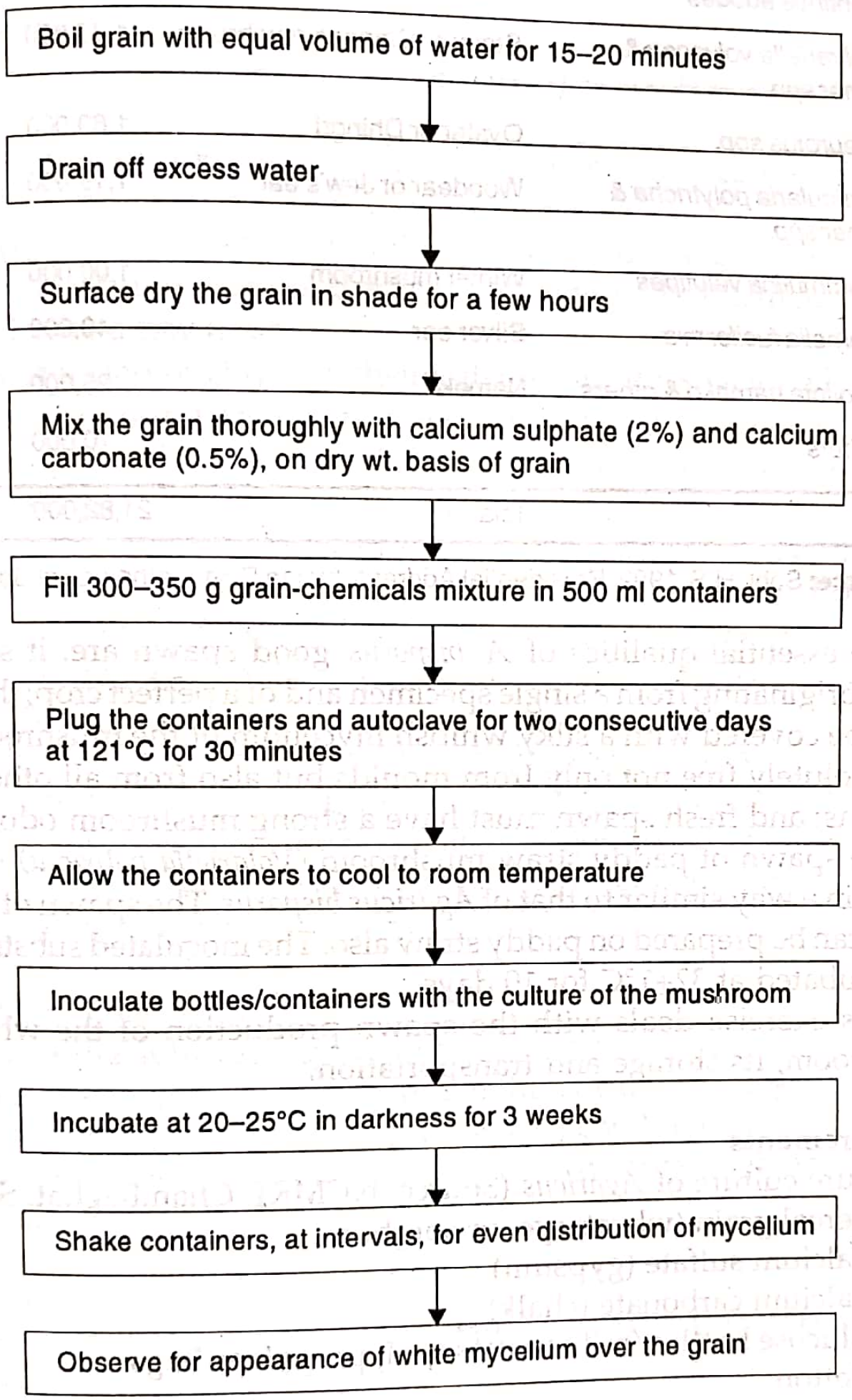


Fig. 23.2: Protocol for the spawn production of *Agaricus bisporus*.