PRODUCTION OF SPAWN FOR LIGNICOLOUS MUSHROOMS IN A CLEAN ROOM- ENVIRONMENT: RISK ANALYSIS AND RULES OF CONDUCT

MAGDA VERFAILLIE* AND KASPER MOREAUX
Mycelia bvba, 9850 Nevele, Belgium
magda@mycelia.be

ABSTRACT

The aim of spawn producers is to deliver axenic mycelium with a constant quality, which is a prerequisite for a good mushroom yield. Very often, mycelium producers have a poor knowledge as how to estimate the microbiological quality of their working environment or how to implement their knowledge in a real-time situation. This leads to the building and organization of production facilities with an insufficient level of security. A lot of problems in mycelium production can be brought back to an incorrect product flow, as well as to wrong rules of conduct. The aim of this presentation is to analyze a number of problems, while offering a remedy for the latter, so as to prevent financial disasters.

Keywords: spawn production, mycelium, inoculum, axenic, sterilization

INTRODUCTION

The production risks for mushroom spawn are often underestimated. It is a technologically highly advanced process, where scientific background knowledge is of utmost importance. There are many aspects to the production of mycelium, such as substrate components, the pretreatment and heat treatment of the substrate, hygiene before, during and after the time of inoculation, quality of the inoculum, climate and other conditions during incubation and maturation. Whenever problems arise, one must be able to analyze the causes correctly and find solutions within the shortest delay.

Spawn facilities involve considerable investment. As one seeks a proper return on investment, there is not much room for errors once production has started. As a rule, new facilities experience little problems, even if the infrastructure and working rules are not perfect. But after some time, pests and diseases can seek their way into the facilities, infection pressure builds up, resulting in a dangerous vicious circle of reinfection. Eventually, this results in loss of products, low yields or no output at all, the consequences of which are often disastrous. Such situations are encountered at large and small projects alike all over the world. The present discussion is to achieve two goals: (i) assist the spawn producer to find an affordable and efficient problem-solving method (ii) help new projects in preventing these problems.

DISCUSSION

Situation sketch

There are worldwide considerable differences in approach regarding mycelium production. Some of the larger facilities in the EU and the US use a bulk production system, but most spawn facilities handle individual portions, ranging from less than one liter to as much as 10 liters. The used recipients are mainly bottles and bags, which are provided with various closing and breathing systems, the one being more efficient than the other.

Ideally, the spawn production chain should be a strictly controlled activity, operated by highly skilled professionals. In most cases however, production methods are more hands-on, and for that reason more risky. As high competition makes financial margins very tight, mistakes are not affordable. But they do occur, not only with respect to the layout and infrastructure of the facility but also regarding mycelium production technology.

This article indicates that nearly each faulty analysis can be traced back to one single common denominator: lack of implemented scientific knowledge. Mycelium producers are not always scientifically trained and even if they are, that does not necessarily mean that they are familiar with the reality of industrial production, enabling them to make a proper problem analysis.

What kind of knowledge is to be considered essential?

In industrial mycelium production, one shall be aware that problems are not only situated at the macroscopic, but also at the microscopic and submicroscopic level, and that all three levels are equally important. A production unit can only be efficient when the layout and infrastructure of the building, as well as the working method are determined according to the understanding of this full spectrum.

One needs to have a good insight in both fungal and bacterial biology. Many bacteria, as well as so-called weed moulds, have the same specific requirements as the cultivable mushrooms. Competition is fierce, and when undesired microorganisms and mycelium of cultivable mushrooms are both present in the same substrate, the latter will mostly lose the battle. Therefore, mycelium must be protected during all phases of multiplication, where infection pressure comes into play.

Air is never empty, it is loaded with dust particles and propagules, which may float for an extended period of time. Dust is a major source of infections, especially if this dust is coming from an area where spores are produced. Examples are agricultural areas, harvest areas, animal production facilities, open-air fermenting installations and mushroom production areas. Dust is an assemblage of fine particles, and can contain anything fine enough to float, including spores and bacteria. Generally spoken, the infection pressure is proportional to the dust concentration.

But dust is not the only source of contamination. Every person and every object is by nature a producer and carrier of microorganisms, which are invisible to the eye but ever-present. They are stuck to the surface and are easily shed so as to become an airborne particle.

Whatever the source may be, when conditions are favourable, the unwanted microorganisms will start to grow and multiply. When reaching their sporulating phase, weed moulds will generate countless spores in a very short time frame, and these airborne spores will add to the contamination pressure. It is essential to understand that, no matter the location or surroundings, this infection risk is omnipresent in every production facility. For that reason, a number of safeguards are needed to keep the risk as low as possible.

A profitable mycelium production facility has control over the following safeguards at any time. If any one of them is neglected, contamination problems will arise, so as to lead to a vicious circle, in which there is no chance to succeed industrial spawn production.

Sterilization of the raw materials

An efficient sterilization procedure is the first and most important safeguard in the spawn production cycle. In its essence, it eliminates all living organisms, whilst limiting the qualitative degradation of the substrate.

Most spawn producers are fully aware of the risks of a bad sterilization. But what is often underestimated is the need to avoid re-infection of the hygienized substrate after the heat- treatment.

Avoidance of re-infection from various origins

- From airborne microorganisms: aids such as laminar air flows (LAF) and HEPA-filtered air through overpressure units minimize dust levels, and equally airborne microorganisms in the air.
- From various infection sources: a series of precautions shall be taken to isolate potential sources of infection from the hygienized substrates during cooling and inoculation. These include protective clothing for the production staff, manufacturing in clean room areas and product flow management.
- From non- suspended microorganisms: for example microorganisms stuck to machines, shoes, floors, walls, ceilings and people. A number of effective disinfection products are on the market, which can be used for surface disinfection.

But it is not all about preventing infections. To get the best return on investment, one should make his facility optimally profitable through having a full understanding of efficient mycelium production techniques, and this deserves an equal amount of attention.

First of all, the spawn recipes must be standardized, prepared and packed carefully, in the right type of breathable packaging. The sterilization cycle should 100% effective without over- sterilizing. Subsequently, the hygienized substrate shall be inoculated properly, the bag well sealed and placed in the most favourable climatic conditions so as to reach an optimal incubation. The final product shall be kept refrigerated at all times. And all the while, the end product must be traceable and controllable (Royse, 1997; Sanchez, 2004)

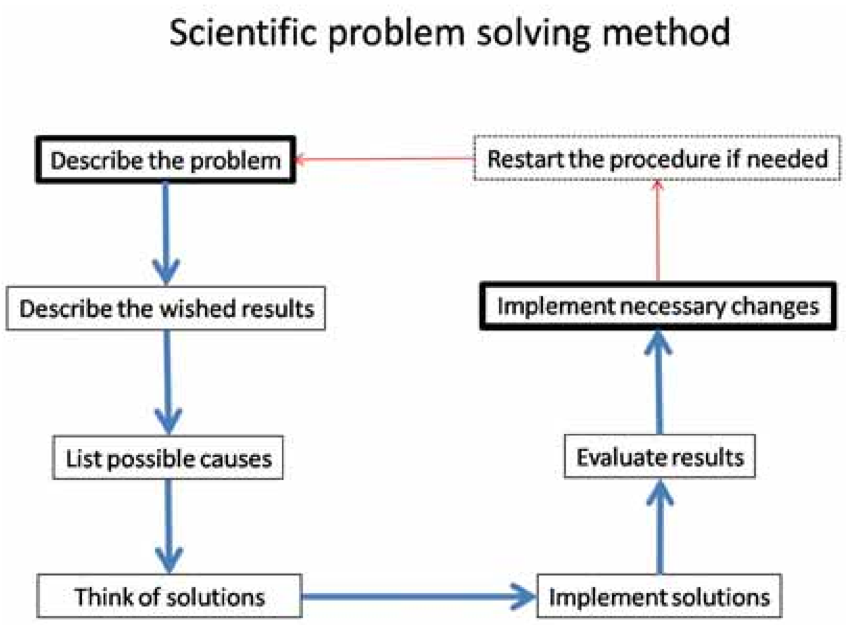
The ensemble of implication of safeguards and production methods make up a set of rules, which, four ease of understanding, we shall henceforth call 'rules of conduct'; (Willig, 2005).

A correct problem analysis is essential in problem prevention

It is not enough to establish that a certain percentage of products has been infected or that mushroom production has dwindled, one should also be able to detect the reasons behind it. We plead for a scientific problem solving method, as it is the most certain way to identifying solutions. Any problem can be related to a large number of causes and it is only through sharpness of analysis that one finds out the true nature of the problem.

The biggest obstacle to proper problem observation is the invisibility of spores and bacteria. Especially when upscaling a production unit, mycelium producers with insufficient understanding of the microscopic and submicroscopic level tend to make wrong conclusions. The susceptibility to infections of freshly sterilized substrates is often underestimated, and therefore ignored. One should realize that only regular maintenance of ultrafilter systems and strict hygiene measures will lead to success.

A true scientific problem solving analysis follows a standardized line of thought, which is depicted below. This method, which is self-evident for anyone with a scientific background, is based on a logic which follows a circular motion. In the case of problem solving, it starts with proper observation, then moves on to postulating a possible cause and their possible solutions, implying those solutions and verifying the outcome. If the outcome is good, those changes should be implemented and if the problem is still present, the procedure repeats itself.



Transfer of know how

The success of the analysis will depend on personal capabilities and on knowledge of Good Manufacturing Practices (GMP). But how does one achieve a good level of theoretical and practical knowledge? There are two solutions to this problem: (i) trial-and-error and (ii) transfer of know-how.

Trial-and-error is a process, which every company at some stage will have to face, and this is even more so for the mushroom sector. As compared to plant cultivation, it is a relatively 'new' type of horticulture, and the sector still faces many unanswered questions. As a result, there are not many databases or practical tutorials on mushroom cultivation, let alone spawn production. Anyone not having access to such a database has only one choice of gaining experience: trial-and-error. Unfortunately, this is a time and money consuming system, and one should avoid it whenever possible.

The second solution is the transfer of know-how. There are a number of ways through which information is distributed, of which the most important are (i) internet, (ii) books, (iii) personal training and (iv) trouble shooting.

Information on the internet is scarce and often inaccurate. High-quality knowledge is mostly expensive, non-transparent or simply non-available. Making this information available represents one of today's largest challenges for the mycelium sector.

Books are a good source of knowledge, if they are written by scientifically trained and experienced professionals. However, for the starting mycelium producer it is difficult to estimate the quality of the provided information.

Personal training is probably the most effective way of learning the proper rules of conduct. Only a few experienced technologists are ready to distribute knowledge and provide training for an affordable price, whether through personal or group courses. The advantage is that for a limited investment, one gains access to a large amount of non-publicly accessible production data. If such training is followed before the production has started, the benefits are countless.

Trouble shooting also provides essential information, but unfortunately only after problems have arisen. In such cases, an external expert with extensive technical and practical knowledge is invited to the trouble site. In cooperation with the production responsible, he will start a proper problem analysis on the spot, and make proposals with respect to the improvement of infrastructure and rules of conduct.

All mentioned information channels have their own benefits, but the most efficient is a combination of all four.

CONCLUSION

Mycelium producers face very specific challenges, as it is a technologically advanced, high-risk business. Financial margins are tight and for this reason, projects often save on important investments such as hygiene and know-how. Wrong assessment will most certainly lead to failures, irrespective the size of the production facility. Although some problems can be traced back to a lack of practical knowledge, most are due to wrong implementation of the safeguards that prevent substrates from being infected by so-called weed fungi and bacteria.

Magda Verfaillie, a biologist and mycologist, is the founding manager of Mycelia, a leading spawn production and technology training company from Belgium, Europe. Throughout the years, the company has been involved in numerous projects involving spawn production. Through professional trouble-shooting, and after having trained a large number of people in the sector, it has become clear that most problems can be traced back to a lack of basic knowledge.

Anyone who already is, or is planning to be involved in mycelium production should be aware of its challenges, and not underestimate the complexity of the process. Before starting, one should seriously consider to acquire the essential scientific and practical knowledge needed for continued success.

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