DETERGENT & FARM SANITATION

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GROWERS' SUMMARY

Effective cleaning removes up to 85% of microorganisms, including mushroom pathogens from the grow room environment, so ensure your cleaning process is optimised.

Failure to remove all the organic material during cleaning will reduce the efficacy of subsequent disinfectant.

Hygiene programmes fail most commonly because of insufficient cleaning. Effective cleaning relies on the application of an appropriate detergent.

Detergents are complex chemical cocktails carefully formulated for specific situations and soil types. Detergents work by wetting and modifying the soil and suspending it in solution so that it can be washed away with potable water.

An alkaline detergent, including an anionic surfactant, is the best fit for mushroom farm cleaning.

Be wary of detergents that contain cleaning boosters such as chlorine compounds. Such additives are corrosive to soft metals and require comprehensive rinsing if used.

Be wary of products that claim to be both a detergent and sanitiser in one.

Use potable water to reduce residues and to optimise both detergent and disinfectant activities.

Mushroom diseases such as MVX mushroom virus complex and *Trichoderma aggressivum* compost green mould cannot be killed by disinfectants when growing in compost. An effective clean is the best way to remove these pathogens from the grow room environment and break the disease cycle.

INTRODUCTION

Starting a new crop in a room free of pests and pathogens is the most potent and cost-effective tool for disease management on the mushroom farm, but it doesn't come easily. Grow room sanitation has two distinct stages – cleaning and disinfection. Too often, we expect our disinfectants to do the heavy lifting and presume they will eradicate the majority of the pathogens. After all, their job is to kill pathogens. But the truth is, it is the *cleaning* process before disinfection that removes the majority of the microbes and pathogens from a heavily soiled environment and not the disinfectant.

A significant contributor to an effective clean is the correct application of an appropriate detergent. Because detergents are complex compounds formulated for specific applications, selecting the detergent most suited to the task at hand will give the best sanitary outcome possible.

This article will look at some properties of detergents and their application and help ensure you are making an informed decision to achieve an effective clean, and ultimately effective grow room sanitation.

WHAT IS MEANT BY 'CLEANING'?

The presence of 'soil' in the grow room is problematic for several reasons: Soil or organic material provides nutrients and habitat for mushroom pathogens and pests if they are present. Under such favourable environmental conditions and with abundant water, pathogens are able to colonise organic material remaining in the grow room following sub-standard cleaning and disinfection and establish a disease reservoir. Organic material provides a physical barrier between pathogens and disinfectants and may insulate them from the effects of the cookout, particularly when compacted into floor cracks and joins.

Organic material neutralises disinfectants of all chemical groups reducing their killing power. This results in poor disinfection and a new crop starting in a contaminated room.

Cleaning is defined as the removal of unwanted material or soil from environmental surfaces which, in the mushroom grow room include floors, walls, ceilings, shelves, light covers, doors or any horizontal surface such as exposed roof trusses that may accumulate soil directly or where condensation can form and trap soil.

Effective cleaning is a multi-step procedure (Table 1). It is the most crucial process in the whole farm's hygiene programme and is the foundation upon which successful disease management is built. Simply put, failure to adequately remove soil is the most common cause of breakdown in grow room hygiene, and the best way of obtaining efficient soil removal is by the correct application of an appropriate detergent.

WHY IS CLEANING IMPORTANT?

Simply by physically removing the organic material, good cleaning eradicates up to 85% of the microbes – including mushroom pathogens that are both living inside and adhering to the outside of soil particles – from the grow room environment. The removal of organic material allows disinfectants to work at full killing power and also to attack pathogens directly rather than through a protective barrier of organic material.

Effective cleaning also removes pathogen reservoirs present as established biofilms, prevents the establishment of new ones and eradicates macromolecules which may serve as a nutrient source for mushroom pathogens.

Table 1: Grow room multi-step cleaning procedure

Cleaning step	Description	Example
1. Gross cleaning	*This is the removal of soil, mushroom debris and other visible organic material using a squeegee and shovel* *Any residual organic material will reduce the efficacy of disinfectants used in later steps and provide a growing niche for contaminating microorganisms including mushroom pathogens* *Failure to remove organic material adequately is the most common cause of breakdown in farm hygiene*	
2. Wet wash	*Wash loose soil from the walls and other surfaces and clean compacted soil from floor cracks and joins. If a high-pressure cleaner is used, allow sufficient time for aerosols to settle before the next step* *Clean out the drains and ensure to remove soil from the wall/floor interface if the floor is not coved* *Wash shelving and other horizontal surfaces inaccessible by shovel and broom*	
3. Pre-rinse	*Pre-rinsing removes any remaining visible organic material using high-volume low-pressure water and squeegee* *Working from high to low, wash remaining organic material to the floor and sluice it into the drain, making sure the drain is free of soiling* *Keep standing water to a minimum to reduce dilution of the detergent*	
4. Detergent	*Apply detergents manually by brush, broom or cloth or mechanically as a spray or foam. Physical effort such as scrubbing is often required to dislodge persistent soil and biofilm* *When applying detergent, dipping the brush, broom or cloth into the detergent will reduce the effectiveness of the detergent by increasing the organic load in the bucket. Make fresh solutions regularly or rinse the brush, broom or cloth before returning to the bucket*	
5. Post-rinse	*Post-rinsing with high-volume low-pressure potable water removes detergent residue which will reduce the efficacy of the following disinfectants* *Finally, standing water must be squeegeed from the floor as much as possible to shorten the drying time and to prevent dilution of the disinfectant*	
6. Drying	*Drying is important to allow the remaining water to evaporate as standing water will dilute the disinfectant and reduce its killing capacity* *Disinfectants will also penetrate cracks and holes better when they are dry as the water surface tension creates a barrier to the disinfectant* *Drying is the step most often neglected, reducing the efficacy of the disinfectant*	

The proven inability of disinfectants to eradicate *Trichoderma aggressivum* when associated with compost (O'Neill *et al.* 2015) demonstrates the importance of physical removal of the pathogen from the grow room environment by effective cleaning.

WHAT IS A DETERGENT?

A detergent is a compound that modifies soil, lifts it from a surface and holds it in suspension so that it can be washed away with potable water. Depending on the type of soil and formulation, detergents alter the physical and chemical properties of the soil in a number of ways (Table 2).

The most significant active ingredient of a detergent is the surfactant (**sur**face **act**ing age**nt**) which provides most of the cleaning activity and is usually a highly foaming compound. Surfactants are responsible for the initial wetting of the soil, are able to emulsify small amounts of fats and oils and are responsible for the suspension of modified soil in solution. They are long-chain molecules that have a hydrophilic (attracted to water, repelled by oil/grease) portion and a hydrophobic (repelled by water, attracted to oil/grease) portion (Fig. 1a).

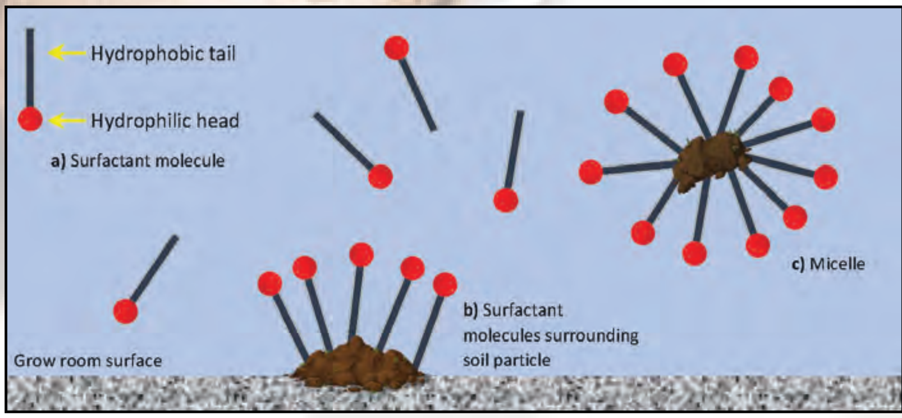


Figure 1: Action of surfactants a) surfactant molecules consist of a hydrophilic head and a hydrophobic tail. b) surfactant molecules orient themselves so the hydrophobic tail interacts with the dirt while the hydrophilic head remains in the water. c) the soil particle becomes encased in surfactant molecules, forming a micelle. The micelle holds the soil in suspension allowing it to be rinsed away. Image: Warwick Gill.

When a surfactant is added to water, the surface tension separating the water from the soil and the surface is broken. The surface and soil become wet, allowing the active ingredients to penetrate and modify the soil. The modified soil is then surrounded by surfactant molecules (Fig. 1b). Because the hydrophobic tails of the surfactant molecules must stay away from water, the molecules arrange themselves in a 3-dimensional sphere called a 'micelle' which has the hydrophobic tails protected from water within the centre. Soil and microbes are also hydrophobic, so they are attracted to the tails of the surfactant. The surfactant lifts them from the surface, and they become encased within the hydrophobic centre of the micelle (Fig. 1c). Once formed into a micelle, the soil cannot settle back onto the surface. Because the outer layer of the micelle consists of hydrophilic surfactant heads, micelles remain suspended in the wash water until they are removed with the potable rinse water, carrying the soil and microbes within them to the drain.

In addition to a surfactant, detergents may also contain chemical groups such as builders, oxidising agents, solvents, inorganic alkalis, sequestrants (chelators), inhibitors, defoamers, stabilisers, fragrances, corrosion inhibitors, oxidising cleaning boosters, organic acids, inorganic acids, preservatives, colouring agents and enzymes. While each of these ingredients has its own specific role to play within a formulation, their collective function is to enhance and optimise the activity of the surfactant.

DETERGENT SELECTION

Modern synthetic detergents are complex chemical cocktails formulated to remove a specific soil type from a particular environment or surface. The careful selection of the correct formulation for the soil type present is very important. The failure of a detergent to perform is not necessarily due to a poor quality product. It is much more likely that the product has been applied incorrectly or the wrong product has been applied.

The range of detergents available to the grower is wide. Detergents neither kill nor control the growth of

Table 2: Examples of the reactions between detergent and soil

Reaction type	Reaction	Description
PHYSICAL	**Wetting**	*decreases surface tension and allows detergent components access to the soil*
	Penetration	*detergent accesses the soil to modify its chemical and physical properties*
	Dispersion	*splits up dirt particles*
	Emulsification	*splits and suspends oils and fats*
	Solubilization	*dissolves soluble soils such as sugars and some salts in water*
	Suspension	*floats and carries away soil particles*
CHEMICAL	**Hydrolysis**	*splits large proteins and carbohydrates into smaller water-soluble units*
	Saponification	*splits oil, fat and grease molecules resulting in water-soluble glycerol and soap*
	Chelation	*sequestrants form water-soluble complexes with insoluble ions found in hard water*
	Oxidation	*bleaches coloured deposits, breaks down some proteins and fats*

Compiled from Safefood 360 (2012) and Voysey (2020) pathogens, and they are not regulated by the APVMA (Fig. 2). The selection of an appropriate detergent is not therefore restricted to a finite number of registered products.

To select an appropriate detergent formulation, there are three major factors to consider. Ideally, the detergent must:

- Remove the type of soiling present.
- Be compatible with the surface being cleaned.
- Be compatible with the water supply.

It must also be:

- Safe for farm personnel to use.
- Compatible with the disinfectants being used in the facility.
- Environmentally friendly.

The type of soiling present is the biggest consideration when selecting a detergent. Soiling can be generally classified as being either inorganic or organic. Inorganic soiling leaves mineral deposits on surfaces such as rust, limescale, milk stone and beer stone. Inorganic soiling is unsightly and may affect the efficacy of disinfectants, but in terms of mushroom disease management, inorganic soiling is insignificant. Organic soiling is the major issue.

There are two levels of organic soiling in the mushroom grow room environment – visible and non-visible. Visible soil is the gross material such as dust and dirt, compost, casing and mushroom debris. The non-visible element can include invertebrate carcasses, mushroom spores, fungal pathogen spores, bacterial cells, mushroom mycelium and fungal pathogen mycelium.
On an even finer level, non-visible soil also comprises large organic molecules such as fatty acids, polysaccharides and other carbohydrates originating from the breakdown of straw and poultry manure during the composting process. These molecules are deposited on the floor, shelving and walls through routine cultivation practices. Some of these large molecules are also major structural components of biofilms which can form significant pathogen reservoirs in the grow room. For detergents to be effective in the mushroom grow room, the formulation must be capable of modifying all mineral soil/dirt and organic material so that it can be suspended by the surfactant.

The majority of soil in the mushroom grow room is organic, which is best managed with an alkaline detergent. Although proteins and carbohydrates are more susceptible to acid detergents, they are only a small component of the grow room soil compared to, for example, a meat processing facility. Similarly, fats are a minor contributor to the overall soil, but their presence is significant with regard to biofilm development and pathogen nutrition. Given the character of grow room soil, an alkaline detergent such as one based on sodium hydroxide is most appropriate.

Alkaline detergents are generally non-reactive with their environment. However, some formulations may include boosters such as chlorine compounds to enhance cleaning ability. Such formulations are corrosive to surfaces made of aluminium, brass, copper, galvanised coatings, nylon and some painted finishes. One grower recently commented anecdotally that using detergent with a booster in it aged his facility by 20 years! Extra care will need to be taken with a careful and thorough rinsing to ensure no detergent residues remain on these susceptible finishes if they exist in the grow room.

Investigate the inclusion of corrosion inhibitors within the detergent formulation, such as silicates, which reduce the corrosion of soft metals.

There are three major surfactant types to consider:

Anionic surfactants, which:

- Are good detergents;
- Have good wetting properties;
- Are high foaming;
- Are negatively charged in solution; and
- Have some emulsifying ability.

Non-ionic surfactants, which:

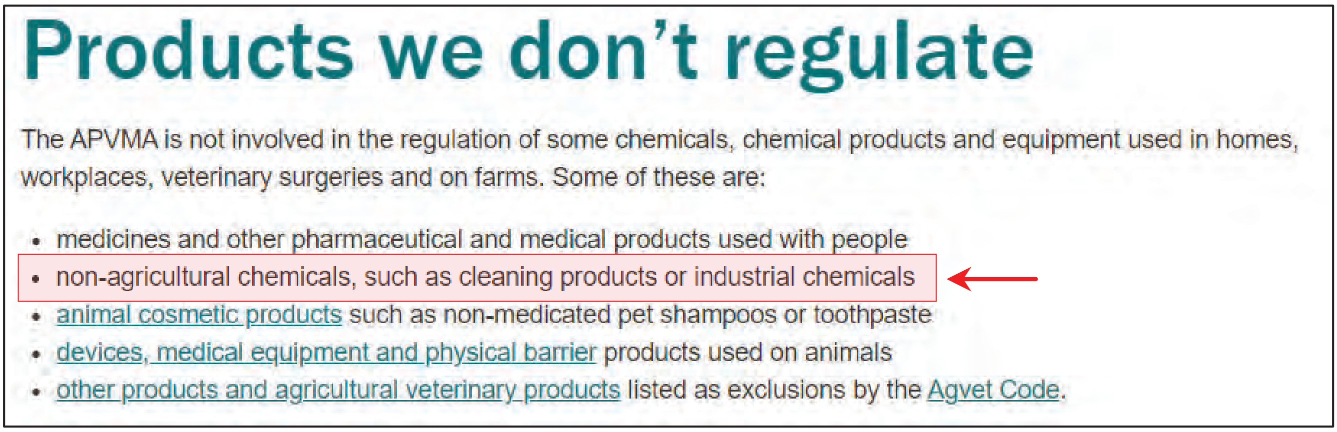
- Do not ionise in solution;
- Have good wetting properties;
- Are low foaming; and
- Are compatible with both anionic and cationic surfactants.

Cationic surfactants, which:

- Are positively charged in solution;
- Have poor wetting characteristics;
- Are high foaming;
- Are commonly quaternary ammonium compounds, so have antimicrobial properties; and
- Are commonly used as sanitisers when mixed with non-ionic surfactants.

An anionic surfactant is the better fit for the mushroom farm as it has multiple activities and can be rinsed without leaving a residue. They are also compatible with non-ionic surfactants, so detergents can benefit by having both anionic and non-ionic surfactants in the formulation.

Examples of common anionic surfactants which you will find around the home include sodium lauryl sulfate, sodium laureth sulfate, ammonium lauryl sulfate, ammonium laureth sulfate, sodium stearate and potassium cocoate.



Products we don't regulate

The APVMA is not involved in the regulation of some chemicals, chemical products and equipment used in homes, workplaces, veterinary surgeries and on farms. Some of these are:

- medicines and other pharmaceutical and medical products used with people
- non-agricultural chemicals, such as cleaning products or industrial chemicals
- animal cosmetic products such as non-medicated pet shampoos or toothpaste
- devices, medical equipment and physical barrier products used on animals
- other products and agricultural veterinary products listed as exclusions by the Agvet Code.

Figure 2: Screen shot from the APVMA website stating their position on the regulation of non-agricultural chemicals including cleaning products

Table 3: Appropriate detergent bases for soil types present in the mushroom grow room

Soil type	Soil	Detergent base	Description
ORGANIC	**Organic soils**	Alkaline	*alkaline detergents soften organic and particulate soils making them easier to suspend*
	Carbohydrates and starches	Alkaline or acid	*variable group of compounds ranging from soft and powdery to hard and they are more insoluble if exposed to heat. Acid detergents hydrolyse starches, but they lose their 'power' and must be monitored*
	Polysaccharides (sugars)	Water or alkaline	*simple sugars such as glucose are soluble in water. Complexed polysaccharides are more difficult to remove and require an alkaline detergent*
	Fats, oils and greases	Alkaline	*insoluble in water, may oxidise and polymerise making them very difficult to shift. Alkaline detergents will saponify and emulsify fats, making them easy to remove*
	Protein	Alkaline or acid	*removal is difficult if denatured by heat which makes them harder and more insoluble. Acid detergents hydrolyse proteins, but they lose 'power', and their effectiveness must be monitored*

Compiled from Safefood 360 (2012) and Voysey (2020)

Because these chemicals are not hazardous, they may not be listed on a product's SDS and are often not included on the label ingredients for commercial reasons. You may need to consult with your chemical supplier to check which type of surfactant(s) your detergent has.

Some detergents are formulated with antimicrobial cationic surfactants such as quaternary ammonium compounds. These detergents are sometimes marketed as 'sanitisers' or as detergents with microbiocidal ability but be aware that if you decide to use a cationic detergent, it must be applied *either* as a detergent or as a disinfectant. Cationic surfactants often leave a residue which may reduce the impact of disinfectants. Also, be aware that only APVMA-registered sanitisers are allowed to be used on-farm.

While it may be tempting to try and perform two procedures with one product, the result will be a compromised clean and/or ineffective disinfection. This is well-illustrated in the assessment of disinfectants carried out during the European MushTV project.

For those farms with a significant issue of inorganic soiling severe enough to lead to a reduction in disinfectant efficacy, targeted cleaning with an acidic detergent is appropriate.

DETERGENT APPLICATION

When making up detergent solutions, the correct amount of detergent concentrate must be added to the correct amount of potable water according to manufacturers' label instructions. Water used for cleaning must be potable; water containing mineral ions (hard water) will prevent detergent from performing to expectations and will result in unsightly inorganic residues remaining, such as scale, which will also affect the performance of subsequent disinfection.

Some alkaline detergents will be formulated with a sequestrant such as EDTA, which will negate the effects of hard water but using potable water to both make up the detergent solution and for terminal rinsing will give better results.

The 'energy' input to detergent cleaning is a significant consideration. The required energy for effective cleaning is the sum of four inputs (Table 4), and a reduction in one input can be offset by an increase in another.

In the practical farm situation, time is often a limiting factor, despite its importance in cleaning. But the reduced input can be made up by, for example, increasing the mechanical input. If little effort is put into applying the detergent solution and time is reduced while the other inputs remain static, then the effectiveness of cleaning will be reduced. By increasing the physicality of the application method, a much better clean will result over a shorter time. Application methods in order of increasing physical agitation include wiping, mopping, scrubbing, spray/jet washing and foaming.

Foaming is a good way of applying a detergent. Foam on walls should be applied from low to high to build a support base of foam, preventing the higher foam layers from collapsing to the floor. Foam persists without drying out, and it is easy to see where the detergent has been applied. This ensures that detergent isn't wasted by applying it to a surface already treated while also ensuring no areas are missed.

As the foam breaks down, the popping bubbles provide kinetic energy and increase the agitation within the foam, making the detergent more effective. And, by working around the room foaming the walls, by the time the room has been foamed, the detergent will have had a good contact time to work before being rinsed off with potable water. Biofilms need special attention. They are often impervious to detergents, so they require scraping and scrubbing with a stiff brush and warm detergent solution (<50°C) to ensure they are removed.

Table 4: Inputs determining the effectiveness of detergent

Input	Description	On the farm
Chemical energy	*the action of the detergent formulation determined by the concentration of the final working solution*	*this is fixed – do not deviate from the detergent manufacturer's label rates*
Mechanical energy	*the physical input which is determined by the application method and includes wiping with a cloth, mopping, scrubbing, jet washing and foaming*	*this is where the most improvement can be made on the mushroom farm. The application method can mean the difference between effective cleaning and insufficient soil removal*
Thermal energy	*increased water temperature improves detergent performance by speeding reactions and by softening fats and oils*	*this is restricted as it is impractical to wash an entire grow room with warm water. However, it is recommended that problem areas such as biofilms or excessive build-up of hard to remove soil can be treated with detergent in warm water up to 50°C*
Time	*the contact time or time for the detergent to work*	*this is a critical factor, but it is often reduced to fit farm production schedules. Detergent must be left on the surface for as long as possible to allow the chemicals to react with and lift the soil and it must not be allowed to dry out in that time*

Compiled from Safefood 360 (2012)

CONCLUSION

Cleaning is the most important component of a mushroom farm's sanitation programme and is perhaps the most potent and cost-effective tool available to the grower for successful mushroom disease management.

Yet the failure to clean adequately is the most common cause of breakdown in hygiene and the perpetual on-farm cycle of re-infection and cross-contamination.

Effective cleaning removes up to 85% of the microbes in a soiled environment. It leaves no chemical residues and ensures that subsequent disinfectants are able to work at their maximum killing power unimpeded by organic material.

Detergents are a critical component of effective cleaning, but we give them little thought. The selection of an appropriate detergent and its correct application will greatly assist in achieving the high level of sanitation required to break disease cycles on the farm.

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