



CORESTA GUIDE N° 12

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CONTROLLED ATMOSPHERE PARAMETERS FOR THE CONTROL OF CIGARETTE BEETLE

1. Introduction

Two insects, the cigarette beetle, *Lasioderma serricorne*, and the tobacco moth, *Ephestia elutella*, are major pests of cured tobacco, infesting the commodity during storage, manufacture and distribution. Insect control in stored tobacco has relied on the use of fumigation, deep freezing and contact pesticides applied as space or surface sprays within structures (not directly on the tobacco). Increasing concerns over the use of toxic compounds, linked to health and environmental fears, as well as the ineffectiveness of fumigations below 16°C (61°F) and the development of phosphine resistant populations, have fuelled the need to find alternative control methods.

In controlled atmosphere (CA) treatments, an environment which is lethal to pest insects is created by altering the proportions of CO₂, O₂ and N₂ in the treated airspace. This is commonly achieved by the replacement of the existing air with N₂ so that the O₂ levels are reduced, preferably to below 1%. There are various methods for altering the proportion of gases, but the studies used to generate the data for this guide employed the removal and replacement of O₂ with N₂ using oxygen absorbers/scrubbers or the generation of N₂-rich air.

The efficacy of CA treatments is affected by physical factors such as temperature, relative humidity, gas concentration, pressure and gas tightness of the container; and on biological factors, such as, insect species, strain and developmental stage. The toxic effects of CA treatments on insects are attributed to desiccation. Low O₂ (hypoxia or anoxia) levels force the spiracles of insects to open and remain open, which results in dehydration and in turn impacts on various other metabolic processes. *Lasioderma serricorne* is one of the most anoxia tolerant insect species, with the eggs and last instar larvae likely to be the most tolerant stages.

2. Background

The potential loss of phosphine as a control tool as a consequence of regulation and/or resistance development necessitates finding alternative control methods. In 2008 the CORESTA Sub-group on Pest and Sanitation Management in Stored Tobacco (hereafter referred to as the Sub-group) commissioned the Food and Environment Research Agency (Fera) (formerly the Central Science Laboratory) to conduct a literature review to assess the potential of using CAs for the control of *L. serricornis* and *E. elutella* in stored tobacco. The review concluded that the use of CA treatments may provide a viable option for use in the tobacco industry.

The use of CAs for the disinfestation of stored products is well documented for certain situations and they have been evaluated to disinfest bulk tobacco and finished products. However previous studies on tobacco have generally been on a small laboratory scale or used high CO₂ atmospheres. The laboratory experiments were conducted under controlled conditions and can therefore only approximate the conditions experienced in a practical situation; and the use of large scale CO₂ treatments have environmental and safety concerns relating to the release of a greenhouse-effect gas. There is also no method for on-site generation of CO₂, whereas there are on-site methods for N₂ generation, making these atmospheres more competitive in price and easier to apply. Information was therefore required on the use of low O₂ concentrations under large scale practical conditions.

A CA work-group was formed to investigate the effects of low O₂ atmospheres against *L. serricornis* in stored tobacco, on behalf of the Sub-group. Fifteen large scale trials and a series of laboratory experiments were undertaken by the work-group using low O₂ concentrations (<0.5%) and various temperatures, commodities (leaf and finished product), exposure periods, strains (phosphine resistant and susceptible) and life-stages in order to determine the most effective treatment conditions. A wealth of information was generated which was subsequently collated and summarised by Fera. The information generated was used to determine the minimum conditions required to achieve >99% mortality of *L. serricornis* in tobacco.

It should also be considered that although the insect strains used in the trials were originally collected from the field, they had been in laboratory culture for several years and may therefore differ in their responses compared to naturally 'wild' strains. Also, although relative humidity was monitored in the large scale trials it was not controlled. In practice it is difficult and time consuming to reduce the relative humidity of a tobacco bale due to its density. Therefore although relative humidity is an influencing factor, it was considered impractical for it to be adequately controlled during a CA treatment.

Chemical and organoleptic analyses have shown no difference between treated tobacco samples and untreated control samples.

3. CA Parameters for Cigarette Beetles

The following parameters must be considered for the effective use of CA treatments:

- Oxygen concentration – the lower the oxygen concentration that can be achieved and maintained, the greater the efficacy of the treatment.
- Temperature – increasing the temperature enhances the efficacy of CA treatments by increasing insect respiration and water loss.
- Relative humidity – decreasing the relative humidity enhances the anoxic effect by increasing water transport and loss through the insects' open spiracles, but relative humidity is difficult to control in practice.

- Seal quality – ensuring a good seal quality in the treatment chamber will ensure that low gas concentrations are maintained.
- Total treatment time – this is dependent on the time taken to reach the lethal conditions. For example, the initial temperature of the tobacco, the amount of tobacco to be treated and the position of the tobacco within the chamber will all affect the time required to reach the lethal conditions. Only when the required temperature and O₂ concentrations have been achieved can the exposure periods commence.

It is vital that the temperatures and O₂ concentrations in the commodity are recorded continuously and accurately using calibrated monitors, so that it is known when and for how long the tobacco has been at the lethal conditions.

The Sub-Group recommends the following CA parameters for use in controlling cigarette beetle infestations:

Table 1. Minimum conditions required to achieve >99% control of all stages of cigarette beetle AFTER commodity has reached 0.5% O₂ and the required temperature in the centre of bales at the bottom of a stack.

| Temperature (°C) | Temperature (°F) | Time (days) |
|------------------|------------------|-------------|
| 28 | 82.4 | 9 |
| 38 | 100.4 | 4 |

Limited tests have been done with *E. elutella*. The diapausing larvae are likely to be the most tolerant stage and therefore efficacy may be an issue. Further testing on the moth is being undertaken.

4. Potential Changes and Impact

It is essential that temperature and O₂ concentrations are monitored in the centre of bales at the bottom of a stack, as these are likely to take the longest time to reach the target levels, rather than the reliance on external sensors. Each treatment should be considered separately as variations will occur between treatments e.g. variations in the initial temperature of the tobacco, amount of tobacco to be treated, the CA system used etc. which will all affect the time taken to reach the target levels. Good circulation of temperature and O₂ within the chamber will help ensure that the entire commodity has reached the target levels and will reduce the time required to achieve these levels.

Important aspects to consider:

- Treatment rooms have to be made gastight, to ensure that homogenous levels of the desired gas concentrations are achieved. As reference, the international norm applied for controlled atmosphere storage can be used, which allows a leakage of 0.2 cm²/100 m³. An under/over pressure test can be applied to verify whether this level of gas tightness is indeed achieved.
- Rooms are to be insulated well (flooring, walls, ceiling, doors & possible windows), to avoid condensation.
- Flooring has to be able to resist the maximum loading capacity without cracking, as cracks may cause leakage and humidity problems.
- Internal logistics may need to be adjusted according to the duration, location, timing and capacity of the CA treatment facility.

CAs, when used as part of an integrated pest management strategy, provide a viable alternative to the use of phosphine fumigations and/or freezing. They can be used in situations where resistance to phosphine is an issue and where the use of phosphine is unacceptable.

In many countries, phosphine fumigations are the only acceptable criteria for the issuing of phytosanitary certificates. The Sub-group recommends that proper CA treatments should be added as a viable option.

5. Implementation

The essential components of the CA system are:

- Gas tight chamber.
- Central oxygen absorber / scrubber or nitrogen generator.
- Central measuring, registration & control system (oxygen, temperature and humidity).
- Calibrated sensors to monitor oxygen and temperature inside the commodity.
- Heating and O₂ circulation inside the chamber.

The system should monitor, control and register the conditions inside the room continuously during the treatment. In order to implement an effective CA treatment, it is of utmost importance that the conditions (O₂ concentration and temperature) throughout the treatment chambers are achieved and maintained at the target levels for the prescribed duration. To achieve homogenous conditions inside the room, the gas tightness of the room and air circulation inside the room are important. As a result of ineffective air circulation and/or insufficient heating capacity, some of the commodity inside the treatment room may not reach the required product temperature. It is therefore important that temperatures and O₂ concentrations are monitored in the centre of the commodity using calibrated monitoring devices placed in positions likely to take the longest time to reach the target levels (for example in the centre of a low level bale).

CA treatments may provide a viable alternative option for the tobacco industry. The treatments are environmentally safe, leave no chemical residue, do not affect commodity quality, have a low risk of resistance development and treatment times are comparable to phosphine fumigations. The registration of CAs also varies with country therefore it is important to check with the relevant regulatory authority as to whether CAs are registered for specific uses. The Sub-Group is conducting worldwide joint training sessions to share its knowledge and experience of this alternative control method with the Industry.