# Information sheet 1.09

# Controlled atmosphere

This information sheet is a supporting document to Appendix A ('Standardised checklist of risk reduction options') of the Guidance of the EFSA Plant Health Panel on quantitative pest risk assessment

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## A. Description of the RRO

Controlled atmosphere (CA) storage (including modified humidity, $O_2$, $CO_2$, etc.) involves maintaining an atmospheric composition that is different from that in the air. When $O_2$ concentration is ≤ 2% and/or $CO_2$ concentration is ≥ 5 % (usually 5-60 %) the controlled atmosphere becomes insecticidal and can be used for regulatory purposes (Fields and White, 2002; Mitcham et al., 2006). These low $O_2$ and high $CO_2$ concentrations have been used for many years to control stored product pests in grains (De Lima, 1990) and their usefulness can be extended to some additional commodities, such as fresh and dried fruits, cut flowers, vegetables, dried nuts, legumes and oilseed. Control of temperature and pressure may be used to improve the effectiveness of the controlled atmosphere.

## B. Risk factors

Table 1. Points of application of measures

| Points where measures may be effective | On crops at place of production | Pre-harvest treatment | Post-harvest | At import | At place of destination |
|---|---|---|---|---|---|
| Controlled atmosphere | | | x | x | x |

## C. Parameters to consider regarding effectiveness of the RRO

Table 2. Main parameters to take into consideration regarding the modulation of the efficacy of the RRO.

| **Parameters related to controlled atmosphere** |
|---|
| Efficacy of the chosen gas mixture (CA) |
| Duration of the treatment |
| **Parameters related to treatment temperature** |
| Impact of temperature on the efficacy and/or duration of the treatment |
| **Parameters related to treatment pressure** |
| Impact of pressure on the efficacy and/or duration of the treatment |
| **Parameters related to the target pest population** |
| Susceptibility of the target species |
| Relative susceptibility of the different life stages (e.g. quiescent versus mobile) of the target species |
| **Parameters related to the commodity** |
| Relative susceptibility of the commodity (species, cultivar, phenological stage, season…) and possible impact on quality |
| Adaptation to shrink wrapping (fresh fruit) |
| Perishability of the commodity (from a few days to more than one year) |

## D. Applicability / feasibility of the RRO

Approved and certified premises allowing for monitoring of controlled atmosphere conditions (i.e. during transport) are a pre-requisite for the applicability of controlled atmosphere treatments. The main advantages of controlled atmosphere treatments are:

- They can be used with little extra cost compared to traditional quarantine treatments
- For small consignments equipment is usually minimal and easily stored and readily transported.
- They have little environmental impact.
- They can be applied during transport (in specific containers for large consignments).
- If properly designed, they help maintaining quality of the treated commodities.
- They can be applied against many arthropods (e.g. Tortricidae, Curculionidae, Miridae, Tephritidae, and Tetranychidae) on many commodities.

The main limitations of controlled atmosphere treatments are:

- Commodity intolerance to the gas mixture chosen (e.g. for plants for planting).
- Although controlled atmosphere can have an effect on plant pathogens (i.e. fungi and bacteria), these treatments are usually not lethal for these microorganisms. Controlled atmosphere may hide symptoms development and make detection more difficult.
- Commercial scale trials are needed to show that this method is effective and cost-effective; it meets consumer demands for safe food, and can be accepted by regulatory authorities. The USDA Treatment Manual (2015) states that "Controlled atmosphere is being used more and more commonly to preserve the quality of fresh produce during shipment, especially during long voyages. It also has the advantage of reducing the number of many of the pests that may be present. In most cases, however, insufficient research has been done on enough pest species for APHIS to accept CA as a stand-alone quarantine treatment, although this could change in the future.

## E. Other RROs that may lead to similar effects

Any RRO aimed at reducing the pest prevalence in the consignment (i.e. fumigation or irradiation) either (1) at origin, (2) during transport or (3) at destination may have similar effects.

## F. Combinations of RROs that include this RRO

Most treatments applied during transport, either chemical (i.e. pesticides) or physical (i.e. temperature), are compatible with controlled atmosphere and may enhance efficacy of this RRO. The temperature during exposure to controlled atmosphere has a great impact on the insecticidal effectiveness of the treatment. In general, the higher the temperature, the higher is the efficacy of the treatment. However, temperatures beyond the optimal range for the target arthropod may create an additional stress resulting in enhanced efficacy (see for example Alonso et al., 2005). Therefore, controlled atmosphere treatments can be used in combination with heat (either vapour or forced hot air) or cold to increase effectiveness or to decrease the time necessary to achieve 100% mortality (Vincent et al., 2003; Neven and Rehfield-Ray, 2006). Controlled atmosphere conditions can be obtained in an insect-resistant packaging film (i.e. shrink wrapping) (Carpenter and Potter, 1994; Vincent et al., 2003). Low and high pressure treatments can also be considered as controlled atmosphere (Vincent et al, 2003; Neven, 2010). On the one hand, low pressure treatments operate under vacuum and reduce the pressure below atmospheric levels (1 013 hPa), which in turn, reduce $O_2$ concentrations. On the other, pressures ranging from 2 to 5 MPa in an autoclave with a $CO_2$–enriched atmosphere allows a complete disinfestation of raw material packaged in non-airtight enclosures in less than 4 h. These pressure treatments, though, require specialized equipment.

## G. Conclusion

Controlled atmosphere (CA) storage with concentrations of $O_2$ and/or $CO_2$ below 2 and above 5 %, respectively, are insecticidal and can be used for regulatory purposes (Fields and White, 2002; Mitcham et al., 2006). They can be used in commodities such as grains, fresh and dried fruits, flowers, vegetables, dried nuts, legumes and oilseed. This RRO can be used either alone or in combination with additional preharvest or postharvest treatments at origin, during transport and at destination to reduce the prevalence of the pest present in the commodity and therefore to decrease the probability of entry (and of spread if present in the PRA area). The main technical limitation for this RRO is the intolerance of the commodity, as these treatments may negatively impact its quality.

Synoptic table for the RRO.

| Target | Area of application | Expected effect | Main technical limitations of use | RROs with similar effects / most often in combinations |
|---|---|---|---|---|
| Pest | Harvested product prepared for transport | Reduce the probability of entry and spread acting on the association of the pest with the commodity | Tolerance of the commodity to controlled atmosphere conditions (i.e. gas mixture) | Chemical (i.e. pesticides) and physical (i.e. temperature, pressure) treatments are usually compatible with controlled atmosphere and may enhance its efficacy |

## References

Alonso A, MA del Río and JA Jacas, 2005. Carbon dioxide diminishes cold tolerance of third instar larvae of *Ceratitis capitata* Wiedemann (Diptera: Tephritidae) in 'Fortune' mandarins: implications for citrus quarantine treatments. Postharvest Biol. Technol. 36, 103–111.

Carpenter A and M Potter, 1994. Chapter 12: controlled atmospheres. In: Quarantine treatments for pests of food plants. J.L. Sharp & G.J. Hallman (eds.), 171-198.

De Lima CFP, 1990. Airtight storage: principle and practice. In: Calderon, M. and R. Barkai-Golan (eds.), Food preservation by modified atmospheres. Boca Raton, CRC Press, 9–19.

Fields PG and NDG White, 2002. Alternatives to methyl bromide treatments for stored-product and quarantine insects. Annu. Rev. Entomol. 47, 331–59.

Mitcham E T, Martin and S. Zhou. 2006. The mode of action of insecticidal controlled atmospheres. Bull Ent Res 96, 213-222.

Neven L, 2010. Postharvest management of insects in horticultural products by conventional and organic means, primarily for quarantine purposes. Stewart Postharvest Review, 11 pp.

Neven L and Rehfield-Ray L, 2006. Combined heat and controlled atmosphere quarantine treatments for control of western cherry fruitfly in sweet cherries. J. Econ. Entomol. 99, 658-666.

USDA (2015) Treatment Manual
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

Vincent C, Hallman G, Panneton B and Fleurat-Lessard F, 2003. Management of agricultural insects with physical control methods. Annu. Rev. Entomol. 48, 261–81.