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CONTROLLED ATMOSPHERE: LOW-OXYGEN DISINFESTATION OF POST HARVEST COMMODITIES IN CHAMBERS AND SILOS IN GREECE

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ABSTRACT

With the use of Controlled Atmosphere treatment (CA) based on low-oxygen and increased temperature, we have constructed gastight chambers in 7 locations in Greece and treated various products for commercial purposes since 2008. Additionaly we have used low oxygene atmosphere to control insects in post harvest commodities stored in silos.

Treatments in Greece are carried out by applying the controlled conditions in climate controlled rooms and normal silos using fixed or mobile installations of the EcO_2 technology. CA has shown to be effective under commercial use for controlling eggs, larvae, pupae and adult insects found present in many different commodities.

CA treatments have advantages over traditional fumigants, for commercial applications including worker safety, zero pest resistance and residue-free products. Products treated in Greece with CA are: sesame, nuts, rice, beans, flour, herbs etc.

Key words: Controlled atmosphere, low oxygen, disinfestations, stored product pest control, fumigation, quality preservation, insects.

INTRODUCTION

The use of Controlled Atmosphere (CA) to control insects in final products or raw materials was introduced in Greece in 2008 with the construction of a 6-chambers-complex for a sesame factory. CA was introduced to replace phosphine, to improve worker safety and logistic handling. The treatment of the organic line of products was succesfully accomplished as well. The CA technology and system of the Dutch company EcO_2 has provided the commercial side of the CA principles. These principles have been known for years but were difficult to apply succesfully and economically in a commercial way in the past. Nowadays the system is recognized and used in 17 countries world-wide by different industries.

All oxygen dependent insect species including their pupae, larvae or eggs lose their capability to live and develop vital functions when exposed during a period of time to total deprivation of oxygen as an integrated element of the ambient air mixture. In the ambient air, oxygen (O_2) is present in levels of approx. 21% and the element Nitrogen (N) is present with about approx. 79%.

Each insect species, their pupae, larvae and eggs requires a certain amount of oxygen to secure the capability to live and to use its full vital functions necessary to survive and develop naturally. The amount of oxygen required “both in volume and during a specific time” depends on the actual size, the life stage and the activity of the specie. This required amount of oxygen needs to be freely accessible and available under normal atmospheric pressure and in an ambient atmosphere (^oC, RH) to secure the vitality and full capability to live and develop naturally.

Oxygen deprivation as a tool to eliminate alive species and/or to handicap the vitality and stop irrevocably the capability to live and develop, implies that technically the availability and free access to oxygen for the species is diminished to an as near to zero level as technically possible during a predefined period of time. Whereby the maintenance of an ambient temperature, which is closely related to most viable ambient temperature for the species, is an additional factor to optimize the vitality drive of the species, their larvae and eggs.

The efficacy of oxygen deprivation as a tool to eliminate insects is dependent on physical factors such as temperature, O_2 concentration and duration, and on biological factors such as insect species, strain and development stage.

The maintenance of such low oxygen level and optimum ambient temperatures requires positioning the species in an enclosed environment/area in which continuously the actual presence of oxygen in the atmosphere and the ambient temperature can be fully controlled and maintained during a predefined period of time.

The CA principles that are used by the EcO_2 technology are based on the establishment of a low-oxygen environment able to kill insects of all stages. The principles of CA are established by means of an oxygen burner system or a nitrogen generator and applied to gastight treatment chambers or gastight constructed environments. In the case of gas-tight-chambers the low-oxygen atmosphere is applied in airtight environments with a volume from 40 to 100 m^3. In the case of silos, the conditions are met with the overflown of the silo with on-side produced Nitrogen. Commerical silos treated with CA under the EcO_2 systme had sizes of 100 to 2,000 tones. Some of the treated silos had no sealing at all while others were sealed with the use of special coating. Insects of all stages, present in the products treated, are eliminated (99.9 % lt) due to suffocation by the lack of oxygen and dehydration. This paper will describe the commercial application of CA in gas-tight chambers and silos in Greece as from 2008.

CA APPLIED IN GAS-TIGHT CHAMBERS

The CA system supported by EcO_2 was first chosen as the insect control treatment method by the largest sesame production factory in Greece. Since then more companies changed to CA treatments. See table 1 for an overview of CA applications in chambers.

With an experience of 4,5 years in commercial applications in Greece we can underline the following:

Main advantages of the method:
The duration of the treatments is comparable to phosphine. The precision of the method is much higher than in any commercial phosphine fumigation due to the monitoring and control software equipment that is installed in each terminal. The safety of the workers is guaranteed with the use of CA. Phosphine resistant strains are killed with CA.

Table 1. Overview of CA applications in chambers in Greece

Location	Product	No. of rooms	Yearly capacity
Thessalonica	Sesame seeds	7	35.000 tonnes
Thessalonica	Diverse commodities	1	1.200 tonnes
Thessalonica	Rice	1	2.400 tonnes
Lamia	Rice	4	9.216 tonnes
Athens	Diverse commodities	4	30.000 tonnes
Volos	Flour	2	7.200 tonnes

Main challenge:
Greece is a warm country and insects are very active for 6-8 months. After the CA treatment the treated products shall be stored in a clean room to prevent re-infestation. This is a model not so commonly seen in Greece. 5 out of 7 EcO_2 locations in Greece are equipped with a clean room.

The cost:
Example of using CA:
The rental of 1 average size chamber for 1 year is 20,000 euros. This chamber can take 60 pallets (tones) and will make 2 treatments per week in the 6 warm months and 1 treatment per week in the 6 cold months. This gives a total of 78 treatments per year x60 = 4,680 tones.
So the cost of using CA through the EcO2 system is 4,2 euros per tone for a small and relatively expensive system. The CA installations range from small to big sizes, which can handle more tones of products per year and which will lead to lower cost per ton of product.

Example of using Phosphine:
The fumigation of a 20” container with phosphine costs around 100 euros. Such a container takes around 20 tones.
So the cost of using phosphine is 5 euros per tone. Fumigation of larger volumes with phosphine will lead to lower cost per ton of product.

CA APPLIED IN SILOS

The principle of treating cereals in a silo with the use of CA is simple: overflow the silo with on-site produced nitrogen. The temperature of the grain in large silos cannot be artificially changed in a commercial way so the CA treatment in silos is applied only during the warm months of the year (in Greece April to November). Table 2 gives an overview of the CA systems for the treatment of silos.

Table 2. Overview of CA applications in silos in Greece

Location	**Product**	**No. of silos**	**Yearly capacity**
Thessalonica	Rice	5	12.500 tonnes
Volos	Grains	6	24.000 tonnes

Main advantages of the method:
The precision of the method is again higher than in any commercial phosphine fumigation. The safety of the workers is better supported with the use of CA. Phosphine resistant strains are killed with CA.

Main challenge:
The duration of the treatments is longer than phosphine. With a grain temperature of around 20^oC phosphine needs 4-5 days while CA needs around 12 days depending on the insect.

CONTROL OF INSECTS WITH COMMERCIALLY USED CA CHAMBERS

CA is effective against a wide range of insects and their pre-adult stages: eggs, larvae and pupae. The insects are killed by a combination of temperature, atmospheric composition and exposure time.

During each treatment, the following parameters are controlled and monitored 24/7 to ensure an adequate treatment:

- The <u>temperature</u> within the treatment environment
- The <u>level of oxygen</u> within the treatment environment.
- The <u>duration</u> of the treatment.

Each insect species in the various life stages has its own optimum conditions to live and consequently its own parameters to be successfully eliminated.

During each CA treatment, the relative humidity of the product can be controlled to prevent change in product quality.

It is of basic importance that each industry will identify the insect they want to target in their CA chamber in each single treatment. For example in a freshly produced wheat flour one would expect to find *Tribolium* eggs while in a flour bag that has stayed for a long time in a warehouse more insects can be found including *Sitophilus* species. These two species (*Sitophilus* and *Tribolium*) have a significant difference on CA treatment duration with *Sitophilus* needing 40-50% extra time. This means that an important challenge for a company operating a CA chamber is to identify the target specie.

As previously mentioned another important parameter is to exclude re-infestation of the treated products. This means that a clean room makes a significant difference and still the clean room must remain free of insects. This is another challenge in commercial warehouses.

As part of the precision treatment each CA treatment must receive a close look to guarantee that the set parameters were met. This needs a detailed system, strict procedures and usually a third party overview. The EcO_2 system guarantees a specialist overview of the procedure for each treatment over the Internet. This overview has kept the good name around this company in Greece for more than 4 years.

CONCLUSIONS

The CA treatment makes no use of fumigants, chemicals or any other active ingredients. This guarantees; safety for employees, customers and environment, no residues on treated commodities and no development of insect resistance within treated insect population(s). Note that traditional fumigants can cause deadly accidents (Profume, MB and PH_3), cause ozone layer depletion (MB and Profume), and fumigant resistance issues are spread widely (PH_3).

The use of the toxic fumigant phosphine phase more and more the problem with increasing resistance of the insects and ultimately the increasing need for higher dosage of the gas, leading to higher expenses per treated ton of product. The CA technology requires investment in hardware (gas-tight chambers, CA generator machine) and energy costs when operating. Treating higher volumes of products makes CA competitive with toxic fumigation.

The CA treatment is an effective and safe treatment method suitable for treatment of conventional as well as organic commodities and effectively applied in Greece since 2008. The industries using this technology have all implemented this as part of their integrated pest management in their facilities.

REFERENCES

Bell CH. Modified Atmospheres at raised temperatures, an alternative to methyl bromide as a means of ensuring clean, pest-free, hygienic standards in food commodities. Harral, B.B., Wontner Smith, T.J., Conyers, S.T., Mills, K.A., Cardwell, S.K., Llewellin, B.E.

Rappl Ing F (2004) Report of the Controlled Atmosphere Trial tobacco products. Austria Tabak AG & Co KG, Austria.

Reichmuth C Low O2 Atmospheres for the control of Callosobruchus and Acanthoscelides. Ofuya, T.I., CAF 1992 pgs. 115 -120

Emekci M, Ferizli AG, Tütüncü. Ş, Navarro S (2003). Modified Atmosphere as an alternative to MB in the dried fig sector in Turkey. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, San Diego, California.

Veom N (2004) Methyl Bromide use in the Netherlands. The Hague, The Netherlands.

Vroom N (2008). The use of Low-Oxygen, EcO2 Controlled Atmosphere method, to control insects in sesame seed and dried figs from Greece. Sotiroudas, V., MBAO 2008.

UNEP, Nairobi. Progress Report of the Technology and Assessment Panel, May 2004.

MBTOC, 2010. Assessment report