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RATE OF GAS EXCHANGE DURING TREATMENT OF COMPRESSED TOBACCO WITH NITROGEN OR CARBON DIOXIDE FOR PEST CONTROL

C. ULRICHS[1], C. REICHMUTH[1], R. TAUSCHER[2] AND K. WESTPHAL[3]
[1]*Federal Biological Research Centre for Agriculture and Forestry, Institute for Stored-Product Protection, Königin-Luise-Straße 19, D-14195 Berlin, Germany*
[2]*Technische Universität München, Institut für Thermodynamik, Arcisstraße 21, D-80290 München, Germany*
[3]*BAT Cigarettenfabriken GmbH, Bahrenfelder Chaussee 139, D-22761 Hamburg, Germany*

ABSTRACT

Tobacco suffers from infestation by the tobacco beetle *Lasioderma serricorne* and the tobacco moth *Ephestia elutella*. Most of the control measures tend to leave chemical residues. Nitrogen and carbon dioxide are proposed for use as non-toxic fumigants. The exposure time for total control depends on how long it takes for the gas to replace the oxygen (O_2) and on bale size; for large compressed bales, especially, there must be sufficient time for the inert gases to diffuse to the centre of the bale where the insects may reside.

The diffusion time necessary to achieve complete exchange of the air inside the tobacco bale was determined in laboratory experiments under controlled climatic and fumigation conditions. At room temperature, high concentrations of both gases, with a corresponding decrease in O_2 content, were reached in the centre within about 6 h. For practical application of both gases for pest control, where exposure periods last many days, this relatively short period can be neglected.

INTRODUCTION

The tobacco moth *Ephestia elutella* and the cigarette beetle *Lasioderma serricorne* cause severe damage in the tobacco processing industry (Ryan *et al.*, 1995). Not all stages of *L. serricorne*, regularly introduced into the factories with raw tobacco, are completely controlled during the processing. Cross infestation between uninfested and infested tobacco is a constant threat in the store rooms. The resulting damage to the manufacturer's reputation and his financial losses may both be enormous. Even a single hole bored by an insect through the wrapper of a cigar makes the product unsmokable and renders it worthless.

Due to growing public concern about the protection of the environment, the use of toxic gases and other insecticides is under critical review. Alternative non-toxic fumigants such as nitrogen (N_2) and carbon dioxide (CO_2) demand a good, hermetically-sealed enclosure around the products as well as requiring lethal exposure periods up to several weeks, depending on temperature, insect stage, and the nature of the commodity (Annis, 1986; Reichmuth, 1986). In these treatments the insects die mainly because of lack of oxygen (O_2) (Adler, 1994a; Friedlander and Navarro, 1979). This procedure does not leave chemical residues.

Raw tobacco is traded in compressed form in bales or in cardboard boxes of about 2 m^3 capacity. Under the most unfavorable conditions, when insects at the centre of the bales have to be controlled, the lethal exposure periods obtained in the laboratory have to be prolonged to allow for the time required for N_2 and CO_2 to diffuse to the centre and replace the O_2.

MATERIALS AND METHODS

Diffusion experiments were carried out in a 2.8-m^3 gastight chamber (Reichmuth, 1979) using compressed tobacco in a European-standard size cardboard box (1,530 × 1,100 × 1,150 mm) weighing 230 kg. A 20-mm diameter stainless steel tubular probe was inserted to the centre of the tobacco. Another concentric tube within the probe sucked gas samples from the centre by continuous purge. The O_2 content was determined and recorded using SERVOMEX and THORAY instruments. The concentric tube was sealed against the outer tube and special holes allowed it to determine synchronically the O_2 content at a depth of 200 mm within the box. The O_2 content in the chamber was also recorded, and the temperatures in the chamber and in the tobacco were monitored. Due to the excellent insulating properties of the compressed tobacco, 15 d of adjustment were necessary to obtain a uniform temperature.

RESULTS AND DISCUSSION

Carbon dioxide purge

Figure 1 shows the slow change and temperature adjustment inside the tobacco. From Fig. 2 it can be seen that after less than 5 h of purging with CO_2, the concentration in the chamber reached 95% after which this level was maintained by means of an automatically switching solenoid valve. A further delay of 8 h was required to obtain this CO_2 level at the centre of the compressed tobacco. Under practical conditions, at 20°C, about 13 h would have to be considered the additional time required for the diffusion process. After 6 h the O_2 concentration was less than 5% (75% CO_2), a lethal atmosphere for stored-product insects (Adler, 1994b; Annis, 1986; Reichmuth, 1986).

In Fig. 3 desorption of CO_2 after treatment can be correlated with the increase in the recorded levels of O_2.

Nitrogen purge

Air contains about 79% N_2. Presumably due to respiration of the tobacco, the initial O_2 content in the tobacco bale was about 12% instead of 21% (the normal value). Purging

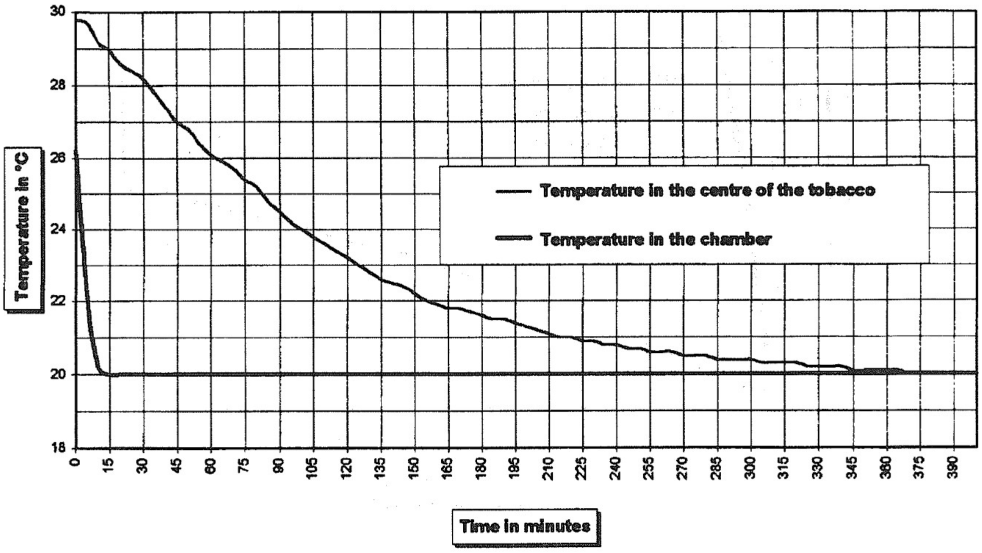

Fig. 1. Time required for temperature adjustment at the centre of a compressed tobacco bale (box dimensions: 1.53 × 1.10 × 1.15 m).

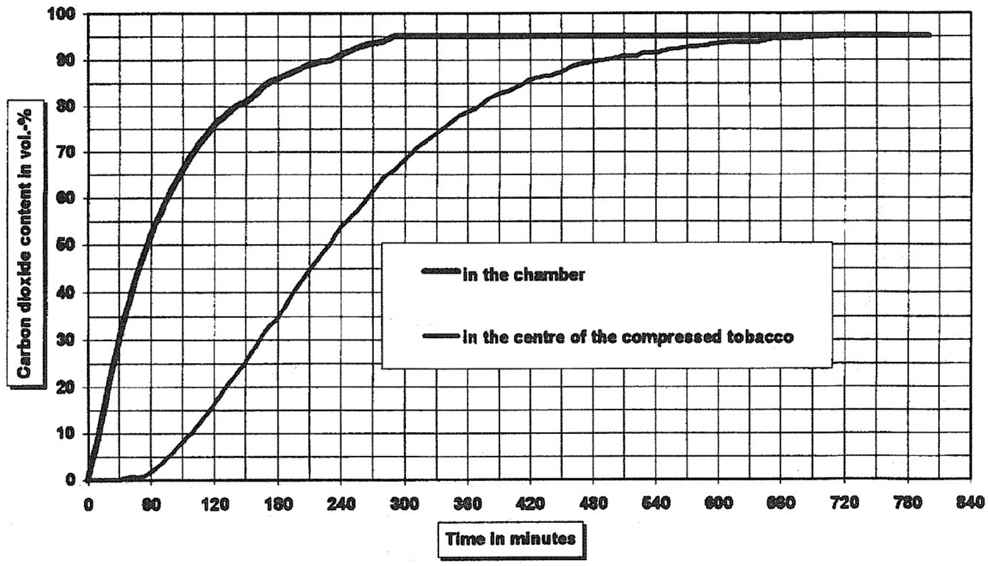

Fig. 2. Build up of CO_2 concentration in the centre of a compressed tobacco bale following the purge with CO_2 to a concentration of 95% with a corresponding final O_2 concentration of 1%.

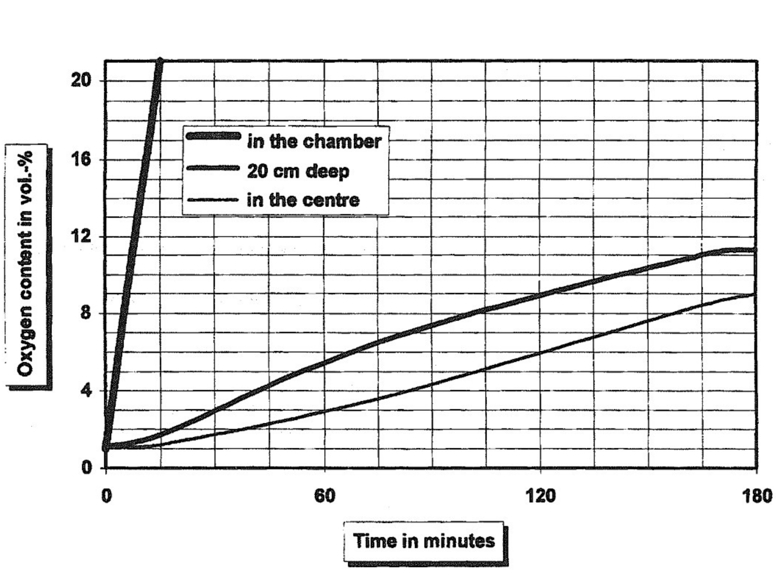

Fig. 3. Increase in O_2 concentration at the centre of a compressed tobacco bale treated with 95% CO_2 following post-treatment aeration of the fumigation chamber.

with pure N_2 produced 99.9% N_2 in the chamber within 2 h, as indicated by the drop in O_2 concentration given in Fig. 4. Although after about 3 h lethal O_2 contents (about 3%) were obtained, the replacement of all the O_2 inside the tobacco bale required about 6 h.

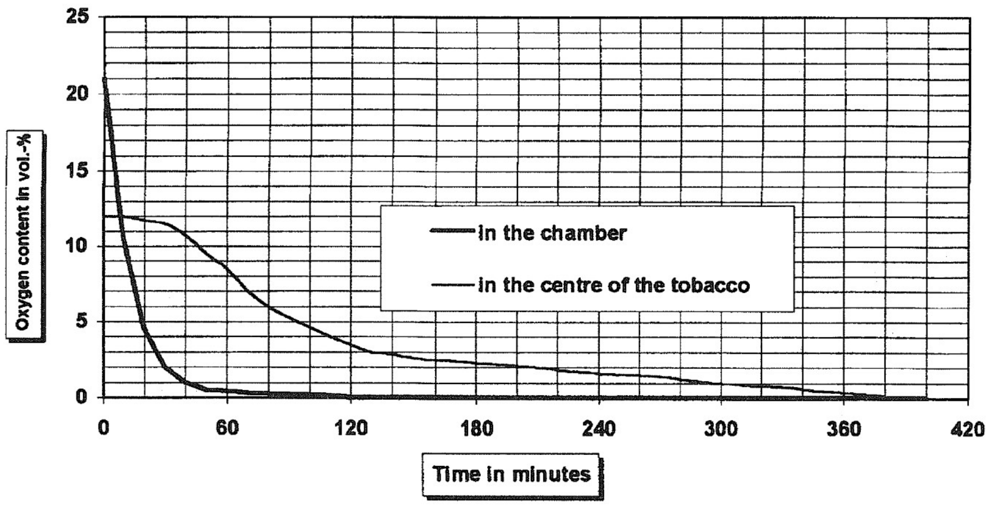

Fig. 4. Decrease in O_2 concentration at the centre of a compressed tobacco bale following a purge of pure N_2.

Direct comparison between the diffusion of the gases is difficult. CO_2 plays an important role by influencing the gas concentration in the chamber by desorption.

CONCLUSIONS

In conclusion, although the diffusion coefficients seem to be quite similar, the type of gas exchange, because air already contains 79% N_2, is quite different. The time needed to obtain lethal conditions for the insects is therefore shorter for N_2 applications. Compared to the necessary lethal exposure periods of many days for both gases (Reichmuth, 1979), neither these small differences nor the few hours required for gas exchange at the centre of this bulky product are significant enough to warrant prolongation of the treatment. This additional time can therefore be neglected when treating tobacco against *E. elutella* or *L. serricorne* with N_2 or CO_2 under atmospheric pressure.

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