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Effect of ozone fumigation on controlling drugstore beetle (*Stegobium paniceum*) and quality of coriander (*Coriandrum sativum*) during storage

S ANANDAKUMAR*, RANJIT SINGH, K ALAGUSUNDARAM, C V KAVITHA ABIRAMI, SUJEETHA R P J ALICE

Indian Institute of Crop Processing Technology, Pudukottai Road, Thanjavur, Tamil Nadu 613 005, India

ABSTRACT

Coriander (*Coriandrum sativum* L.) is a minor aromatic, annual condiment spice crop. Several insect damage fruits of dried coriander during storage. Among the insects, drugstore beetle (*Stegobium paniceum* L.*)* is important one. In the study, three life stages of drugstore beetle such as adult, pupa and larva, were fumigated in lab-scale canisters by ozone at concentrations of 150, 250 and 350 ppm to achieve 100% mortality. It was observed that the adult insect has taken 9.63 h to attain LT_{99} at 250 ppm. Similarly, for pupa and larva the 99% mortality was achieved at 18.05 h and 10.15 h respectively. The ozone treated (250 ppm) coriander samples were kept in airtight plastic containers and storage studies were conducted for 105 days. During the storage, there was significant decrease in the quality parameters of protein (12.25%), colour b value (23.71) and linalool content (37.48%) respectively.

Key words: Coriander, Drugstore beetle, Linalool content, Ozone fumigation, Quality

Spices and condiments have always been considered a legacy of India, and India still continues to be largest producer, consumer and exporter of spices in the world. Coriander (*Coriandrum sativum* L.) the spice comes under minor aromatic annual condiment spice crop. The major varieties cultivated in India are 'Gujarat Coriander 1', 'Gujarat Coriander 2', 'RCr 41', 'UD 20', 'Rajendra Swati', 'CS 287', 'CO 1', 'CO 2', 'CO 3', 'Sadhana', 'Swati' and 'Sindhu' (Spice Board of India, 2012–13).The factors which affect the quality of coriander during storage are poor maintenance and lack of sanitation in storage facilities (Rao et al., 1975).

Stegobium paniceum (L.) commonly known as drugstore beetle (biscuit beetle in the United Kingdom). As name indicates, it is a pest for both herbal medicines and stored biscuits. Adults *S. paniceum* are cylindrical, 2.25 to 3.5 mm long, and are a uniform brown to reddish brown. They have longitudinal rows of fine hairs on the elytra. *S. paniceum* could live on material whose m.c. is between 6 and 15%. The insect has been known to attack grain and grain products, spices and herbs, dried fruit, seeds, dried fish, bread, birdseed, dry dog and cat food, coffee beans, chocolate, powdered milk, and many other organic materials (Hagstrum and Subramanyam, 2009).

Fumigation of godowns with phosphine gas from celphos tablets at a rate of 140 tablets/100 m^3 resulted in mortality of adults and larvae (Kavadia et al., 1978). Now-a-days, ozone finds wide application as a powerful oxidant and it has numerous beneficial applications in the food industry. Ozone is readily generated from atmospheric oxygen and is safe to the environment when used for fumigation. However, it is highly unstable and breaks down to molecular oxygen quickly (Mason et al., 1999; Hollingsworth and Armstrong, 2005). Hence an experiment was conducted to study the effect of ozone in controlling *Stegobium paniceum* and quality of coriander seeds during storage.

MATERIALS AND METHODS

Seeds of variety 'UD 21' coriander variety were procured in bulk quantity from the local market in

*Corresponding author e-mail: *s_anandakumar@iicpt.edu.in*

Thanjavur district of Tamil Nadu, India. The initial m.c. of the coriander was determined using hot air oven method (AOAC, 2000).

Ozone fumigation system

The ozone fumigation system (Fig. 1) consists of oxygen concentrator, ozone generator, fumigation chamber (canister), ozone analyser and ozone destructor. The lab scale canisters were developed using PVC pipe, to carry out the ozone fumigation study. The dimension (height × diameter × thickness) of canister is 390 mm × 60 mm × 2 mm. Both the ends were tightly closed with the help of end cap and the ends were sealed to avoid leakage of ozone gas during fumigation. For uniform distribution of ozone gas inside the canister and for placing of samples in a canister, a perforated sample holder was designed with the help of SS wire mesh, supported by metallic rods.

Test insect

Stegobium paniceum was provided by Department of Primary Processing, Storage and Handling, Indian Institute of Crop Processing Technology. Insects were incubated at 30±2°C, 75±5% r.h. and reared on whole wheat (*Triticum aestivum* L.) flour containing 5% yeast. PROC PROBIT method was used to compute the half lethal time LT_{50} and 99% lethal time LT_{99} at 95% fiducial limits.

Toxicity of ozone at different stages of Stegobium paniceum

Ten adult, pupae and larva of *Stegobium paniceum*, and 100 g coriander seeds were placed into the each canister. The ozone gas was allowed to pass through the canister with different concentration and different exposure time until it attains 100% mortality. The experiment was performed with three replicates for each treatment at 7% m.c. of coriander. The treated adult, pupa, larva were placed in wide opened glass jar with 10 g feed and kept in environmental chamber set at 30±2°C, 75±5% r.h., and the mortality rate of insects were examined. The mortality rate of insects as per Omotoso (2005).

$$\text{Mortality (\%)} = \frac{\text{Number of dead insects}}{\text{Total number of insect}} \times 100 \quad ...(1)$$

Quality analysis

Biochemical analyses are important to assess the quality traits of the coriander and to evaluate their relative loss due to ozone treatment on storage periods. Protein, colours b and linolool content of both control and ozone treated coriander were analysed adopting standard procedures.

Protein: The micro-Kjeldahl nitrogen method was used, which involved the digestion of 0.5 g of sample with sulphuric acid and a catalyst followed by colorimetric determination of nitrogen. The value of nitrogen was multiplied by 6.25 to obtain percentage crude protein (AOAC, 1990).

Colour 'b' value: Hunter lab ColorFlex EZ meter (Hunter Associates Laboratory, Inc., Reston, Virgina, USA) was used for the measurement of colour value of coriander. Chromatic portion of the solids is defined by a (+) redness, a (-) greenness, b (+) yellowness and b (-) blueness. The colour of control and ozone treated coriander was measured at different storage periods at 10° observer at D65 illuminant ASTM E 308. The colour of the sample was measured by filling the coriander seeds in the transparent quartz cup without any void space at the bottom. All the treatments were replicated thrice and the average value was taken for further studies.

Linalool content: Linalool (3,7-dimethyl-1,6-octadien-3-ol) is a monoterpene alcohol, which occurs naturally in several aromatic plants (Shang et al., 2002). Linalool in plant samples was usually

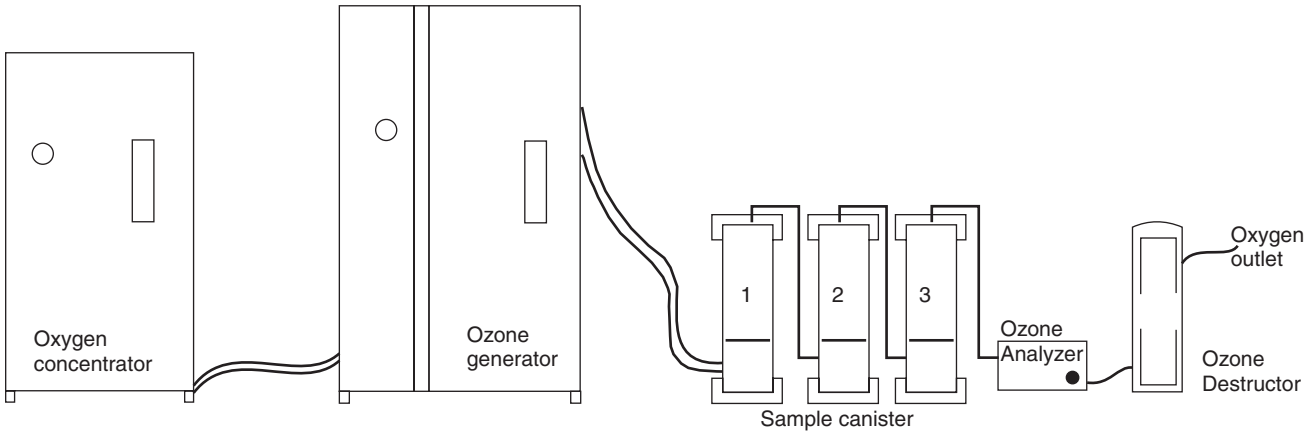

Fig. 1. Schematic presentation of ozone fumigation system

determined by GC-MS (Wang et al., 2008). Twenty five gram of coriander sample was soaked overnight in ethanol. The concentration of 25 g was selected based on availability of target compound peak in GC-MS. The GC-MS analysis of this extract was performed using a Perkin Elmer GC Claurus 500 system which is interfaced to a Mass Spectrometer equipped with a Elite-5 MS fused silica capillary column (30 m × 0.25 mm × 0.25 µm df) composed of 5% Diphenyl and 95% Dimethyl poly siloxane. Mass spectra were taken at 70eV; a scan interval of 0.5 sec and fragments from 45 to 450Da. The relative percentage amount of each component was calculated by comparing its average peak area to the total areas.

RESULTS AND DISCUSSION

The effect of ozone fumigation at different concentrations and exposure times on mortality of *S. paniceum* was determined at 7% m.c. of coriander. The quality of coriander such as protein content, colour b value and linalool content were also evaluated for control and ozone treated coriander during the storage period. The results are discussed here.

Effect of ozone on mortality of Stegobium paniceum

The 100% mortality of adult at 150, 250 and 350 was achieved at 50.8, 24.08 and 18.46 h respectively. The probit analysis of adults was studied (Table 1). The highest fudicial limit for L_{50} and L_{99} recorded for 7% m.c. at 150, 250 and 350 ppm was 8.74, 6.00 and 4.11h; 20.32, 9.62 and 7.37 h respectively. The mortality data of adults tested with ozone fumigation agreed with those of several authors, who observed toxicity of ozone against different stored-products insect pests (Erdman, 1980; Hasan et al., 2012). Similarly, the L_{50} and L_{99} mortality of pupa and larvae at 150, 250 and 350 ppm treated were achieved at 10.95, 7.93 and 6.42 h; 18.54, 18.05 and 13.48 h; 5.60, 4.33 and 3.84; 12.08, 10.15 and 9.34 h respectively. The ANOVA indicated that the mortality of *S. paniceum* has not significant effect at different m.c. for L_{50} and L_{99}. Considering the ozone concentration it showed significant (P<0.05) differences.

Effect on protein

The protein content of coriander seeds decreased with the increase in the storage period (Fig. 2). Among the ozone concentrations, 150 ppm treated sample has retained protein compared with 250 and 350 ppm. The protein content of coriander seeds at initial storage was 12.52%. The protein content of ozone treated coriander seed stored for 105 days was 12.23, 12.25 and 12.22% at 150, 250 and 350 ppm respectively. The lowest protein (11.74%) was recorded at end of

Table 1 Probit analyses on mortality of *Stegobium paniceum* in different stages (adult, pupae and larva) in coriander at 7% m.c. and 30°C

Stages	O_3 concentration (PPM)	LT_{50} (95% Fiducial limits) (h)	LT_{99} (95% Fiducial limits) (min)	Slope ± SE	$\chi 2$ (df)
Adult	150	8.74 (8.38 - 9.09)	20.32 (18.54 – 22.77)	6.35 ± 0.38	15.15 (30)
	250	6.00 (5.71- 6.29)	9.62 (9.03– 10.41)	6.24 ± 0.42	13.88 (22)
	350	4.11 (3.75- 4.47)	7.37 (6.61– 8.55)	5.05 ± 0.38	23.23 (16)
Pupae	150	10.95 (10.57 – 11.32)	18.54 (17.21 – 20.49)	6.96 ± 0.63	5.71(31)
	250	7.93 (7.52- 8.35)	18.05 (16.01– 21.26)	6.51 ± 0.54	8.44 (25)
	350	6.42 (6.08- 6.76)	13.48 (12.11– 15.59)	7.22 ± 0.61	4.608 (22)
Larvae	150	5.60 (5.27 – 5.92)	12.08 (10.74 – 14.22)	6.96 ± 0.63	3.63 (19)
	250	4.33 (4.03- 4.63)	10.15 (8.84– 12.39)	6.29 ± 0.62	4.16 (15)
	350	3.84 (3.49- 4.20)	9.34 (7.69– 12.87)	6.02 ± 0.70	11(16)

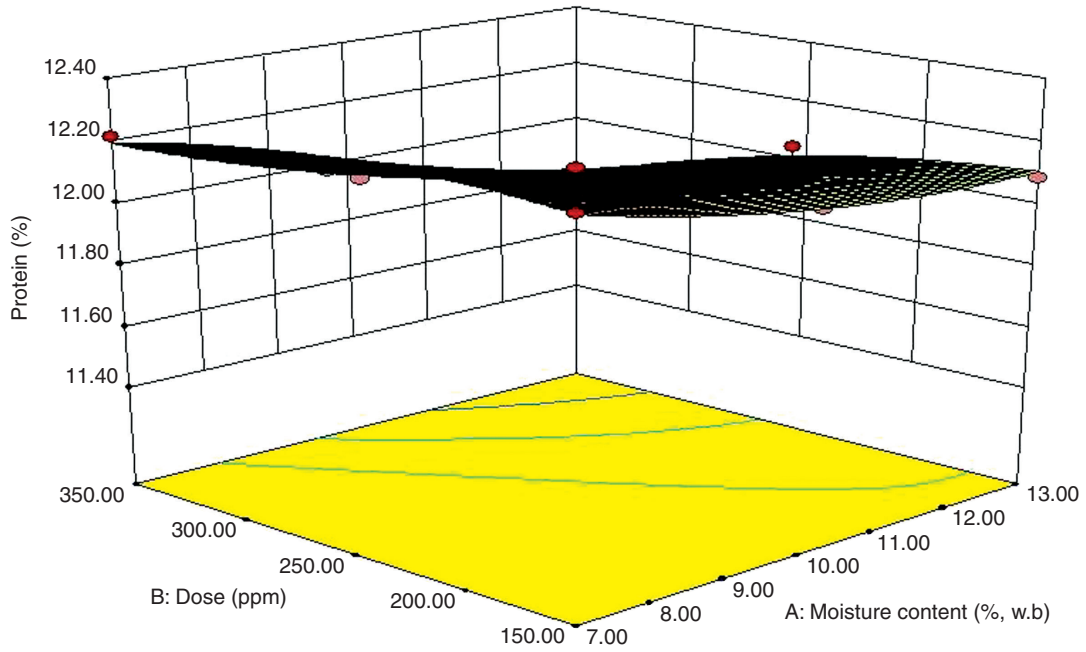

Fig 2. Effect of ozone fumigation on protein content of coriander at 7% moisture content and 30°C

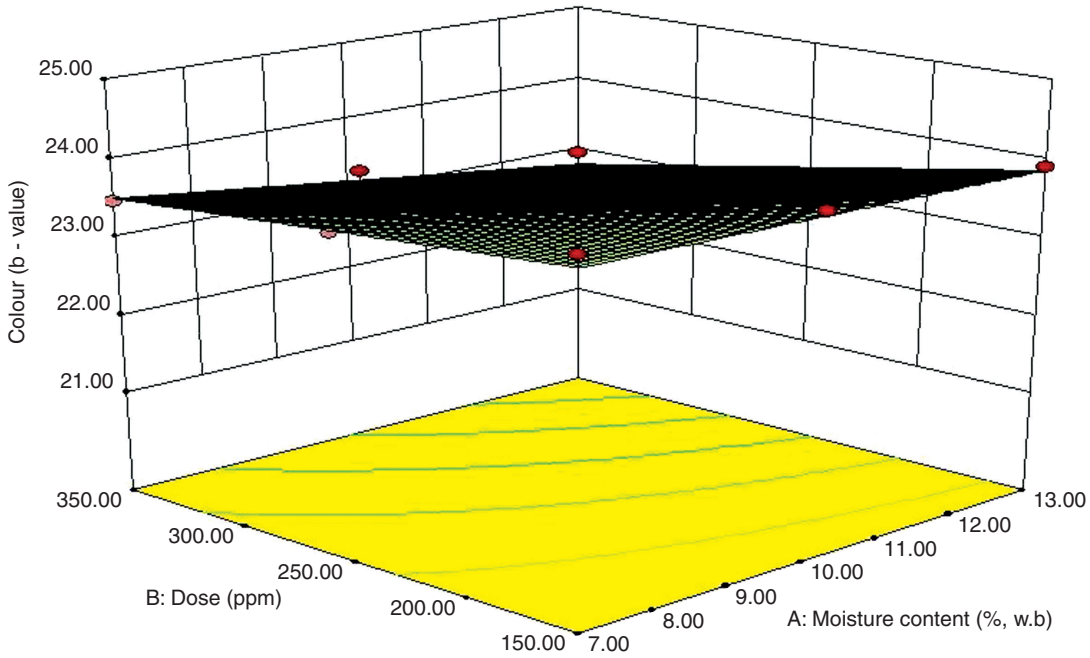

Fig. 3. Effect of ozone fumigation on colour b value of coriander at 7% moisture content and 30°C

105 storage days in open atmosphere. Also, there was significant (P<0.05) effect of all process parameter–m.c. ozone dose and insect stages-on protein content. Ananda kumar et al. (2016) reported similar results for ozone treatment of turmeric rhizome during storage.

Effect on colour b value

The b value of coriander seeds decreased with the increase in the storage period (Fig. 3). The b value of adult treated coriander seeds for 105 days storage period at 150, 250 and 350 ppm was 24.11, 23.71 and 23.49 respectively. The 'b' value after ozone treatment was 25.22. The lowest b value was found as 24.11 at end of 105 storage days in open atmosphere. Similar results were reported by Gunasekaran (2001) during carbon dioxide fumigation of infested coriander powder, sambar powder and turmeric rhizomes storage studies.

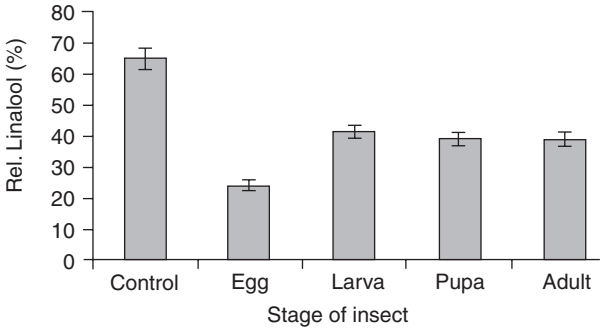

Fig. 4. Effect of ozone fumigation on reduction in linalool content of coriander at different life stages of *Stegobium paniceum* (L.) at 7% moisture content and 30°C

Effect on Linalool content

The effect on ozone fumigation in reduction of linalool component on 105 storage days is shown in Fig. 4. It was observed that the linalool content was decreasing with the increasing ozone concentration and time of exposure. The reduction in linalool content was less in 150 ppm fumigated coriander for 10 h and the relative linalool content was 41.73%.

CONCLUSION

Three life stages of *Stegobium paniceum* were individually fumigated by ozone to achieve 100% mortality. The results showed that when the concentration of ozone increased, exposure time required to attain specific mortality was reduced. Among the treatments and stages, the pupal stage has taken longer time to attain 100% mortality. The quality of coriander like protein, colour 'b' value and linalool decreased significantly ($P<0.05$) with the increase in the ozone concentrations and storage period. The linalool content was found 41.73% in 150 ppm treated sample. These quality losses were found more in control samples than ozone treated samples during storage period.

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