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Extending shelf life of organic beans

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AEGILOPS – Greek Network for Biodiversity and Ecology in Agriculture

Addressing **Problem 1.** The bean weevil *Acanthoscelides obtectus*

- ✓ Adult female insects spawn inside the fruit through holes they create
- ✓ Eggs hatch in 5-10 days
- ✓ The larvae nourish in the endosperm, comes out and reproduce
- ✓ A generation lasts 28 days in ideal conditions

- ➢ The first attack of the bean weevil begins on field
- ➢ Been weevil have many generations during storage
- ➢ Total damage has been reported after 16 weeks of storage (Schmale et al., 2002)

The smell and the wholes on the beans make them not tradable even at the beginning of the attack

Addressing **Problem 2**: Qualitative characteristics of beans and changes during conservation

1. Phenolic compounds

Polyphenols in beans are good antioxidants with antimutagenic and anticarcinogenic properties

It was found that phenolic compounds are related with the browning of the white dry beans

In a N_2 environment the total phenolic concentration was preserved during a storage of 12 months (Nasar-Abbas et al., 2008)

2. Cooking time and HTC

Hard to cook (HTC) → texture problem is defined as a failure of the bean to sufficiently soften during cooking / failure of the cotyledon cells to be sufficiently separated.

Increase of cooking time, decrease of nutritional value, energy consumption

- ✓ Modified atmosphere for the conservation of the bean quality
- ✓ Low pressure and cooling conditions (4,5ºC, 125 mm Hg, 50-60% relative humidity) (Berrios et al., 1999)
- ✓ Low temperature (4ºC) (Edmister et al. 1990)
- ✓ Non-permeable packaging PP/PE (Aguilera & Rivera, 1990)

Methods of controlling storage insects in organic agriculture

- ✓ Monitoring
- ✓ Horticultural methods
- ✓ Mechanical methods
- ✓ Plant resistance
- ✓ Biological control

Biological control

In recent years there has been an increase in demand for safe alternatives, low cost, easy to use, insect-resistant, and environmentally friendly methods of dealing with storage insects

Normal atmosphere
20–21% O_2 ,79% N_2 ,0,04% CO_2

MAP
(*Modified atmospheres packaging)*

Modification of the atmosphere in a composition rich in CO_2 and / or N_2 at normal or modified atmospheric pressure

Influence of MAP on storage insects:

- ✓ Control of the development on adult insects
- ✓ Late development of larvae's
- ✓ Reduce of fertility

High level of CO_2

- ❑ Open of breathing pores of the insect and death because of lost if humidity
- ❑ CO_2 >10% → breathing pores stay constantly open
- ❑ Toxic influence on the nervous system

MAP on bean weevil:
"Speed kill" with application of high levels CO_2 and pressure of 20 bar for 60 min
(Riudavet s et al., 2010)

- ✓ It leaves no residue, it is organoleptically neutral and it is not necessary to spend some time between its application and the consumption of the product
- ✓ Possibility to apply MPA at the packaging stage to deal with insect residues and avoid further damage
- ✓ Antifungal activity
- ✓ Maintaining the quality of the food

Restrictions

- High cost, special for application of 100% CO_2 or N_2
- On high levels it is possible to have an acidity on the food (special CO_2)

Combination of MAP with other methods

Essential oils

Essential oils are volatile ingredients produced from plant tissues by various methods, such as distillation, fermentation, extrusion, hydrolysis extraction and aeration, more frequent is water vapor distillation

Insecticidal, repellent properties, delay growth, decrease fertility, inhibit egg laying, inhibit diet

Essential oils against bean weevil:

Essential oils of lavender *(Lavandulla hybrida),* eukalyptus (*Eukalyptus globulus), rosmary* (*Rosmarinus officinalis), wild pistachia (P. terebinthus),* basilicum (*O. bacilicum), cypress (L. sempervirens*)

- ✓ They have been designated as GRAS by the FDA
- ✓ They have already been used in traditional medicine, as pharmaceutical preparations, herbal drinks and natural spices
- ✓ Antifungal, antimicrobial action
- ✓ Low toxicity to mammals
- ✓ Low probability of insect resistance development due to multiple action

Restrictions

- ✓ Wide variation in composition (more effective is the use of monoterpenoid)
- ✓ Small steam pressure for diffusion and penetration inside the food
- ✓ Absorption of oil from the food itself

Potential Use of MAP in combination of essential oils

Application of grapefruit essential oils seemed to be more effective combined with 15% CO_2 + 1% O_2 + 84% N_2 or 12% CO_2 + 5% O_2 + 83% N_2 against *Liposchelis bostrychophila Badonnel* (Wang et al. 2011)

Up to now only few research has been available on the combined effect of essential oils / components with a modified atmosphere and none on bean weevil

AIMS:

- Examine the synergistic effect of modified atmosphere and essential oils on bean weevil

  - A1: 10% CO_2, 2% O_2, 88% N_2
  - A2: 100% N_2

  - Lemon oil
  - Rosemary oil
  - Limonene
  - Cineole
  - Linalool

- Check the effect of the most effective conditions on the quality characteristics of beans

i. Phenolic compounds
ii. Cooking time

Material

- White beans, medium, organic agriculture
- Essential oils and pure components of essential oils
- Bean weevil *Acanthoscelides obtectus*
- Plastic bags PA/PE

Thirty (30) adult insects & 25 g of beans were placed in a special perforated textile which was introduced into the plastic packaging

Essential oil → on filter paper
Appropriate gas atmosphere through the modified atmospheric packaging machine Plus Vac 20 (KOMET, Germany)

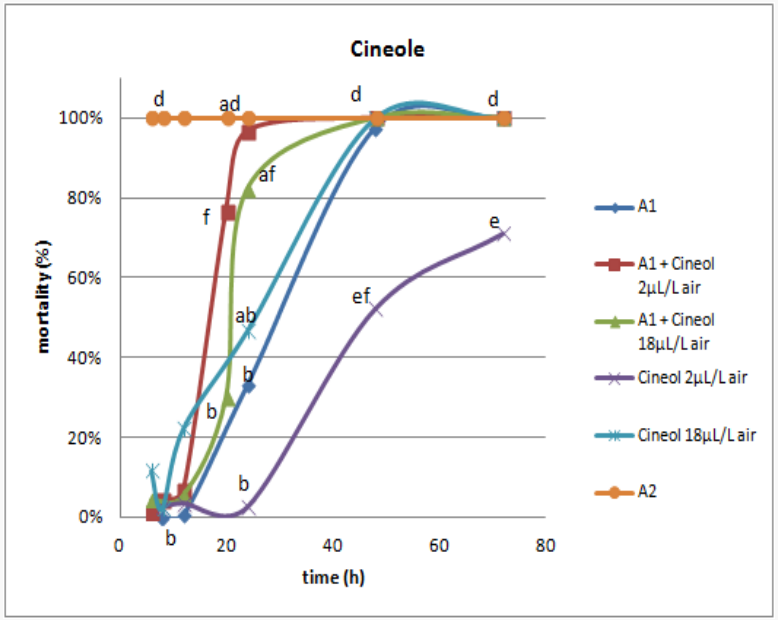
Exposure procedure

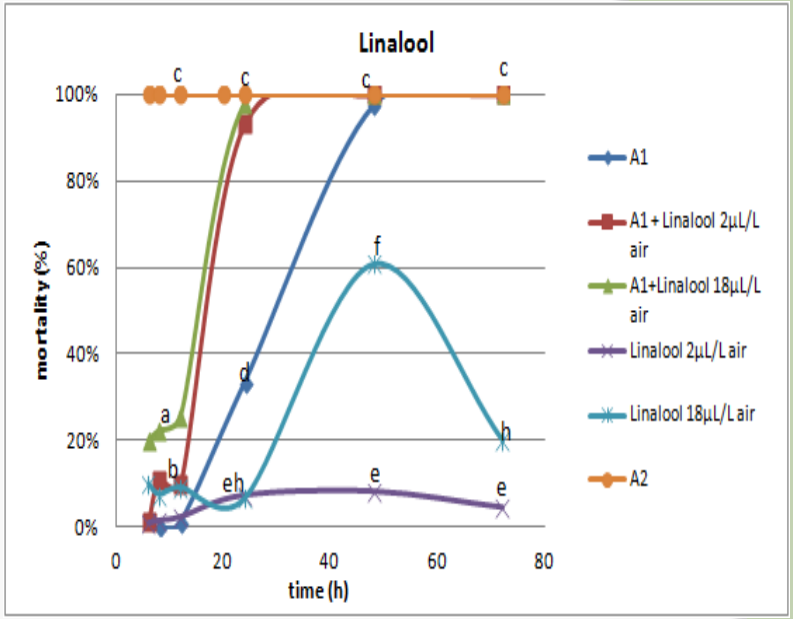
I/N	Modified atmosphere	Essential oil/monoterpenoid	Essential oil/monoterpenoid concentration
1	10% CO_2, 2% O_2, 88% N_2	-	-
2	10% CO_2, 2% O_2, 88% N_2	Cineole	2 μL/L air
3	10% CO_2, 2% O_2, 88% N_2	Cineole	18 μL/L air
4	10% CO_2, 2% O_2, 88% N_2	Linalool	2 μL/L air
5	10% CO_2, 2% O_2, 88% N_2	Linalool	18 μL/L air
6	10% CO_2, 2% O_2, 88% N_2	Limonene	2 μL/L air
7	10% CO_2, 2% O_2, 88% N_2	Limonene	18 μL/L air
8	10% CO_2, 2% O_2, 88% N_2	Lemon oil	2 μL/L air
9	10% CO_2, 2% O_2, 88% N_2	Lemon oil	18 μL/L air
10	10% CO_2, 2% O_2, 88% N_2	Rosemary oil (Rosmarinus officinalis)	2 μL/L air
11	10% CO_2, 2% O_2, 88% N_2	Rosemary oil (Rosmarinus officinalis)	18 μL/L air
12	100 N_2	-	-
13	-	Cineole	2 μL/L air
14	-	Cineole	18 μL/L air
15	-	Linalool	2 μL/L air
16	-	Linalool	18 μL/L air
17	-	Limonene	2 μL/L air
18	-	Limonene	18 μL/L air
19	-	Lemon oil	2 μL/L air
20	-	Lemon oil	18 μL/L air

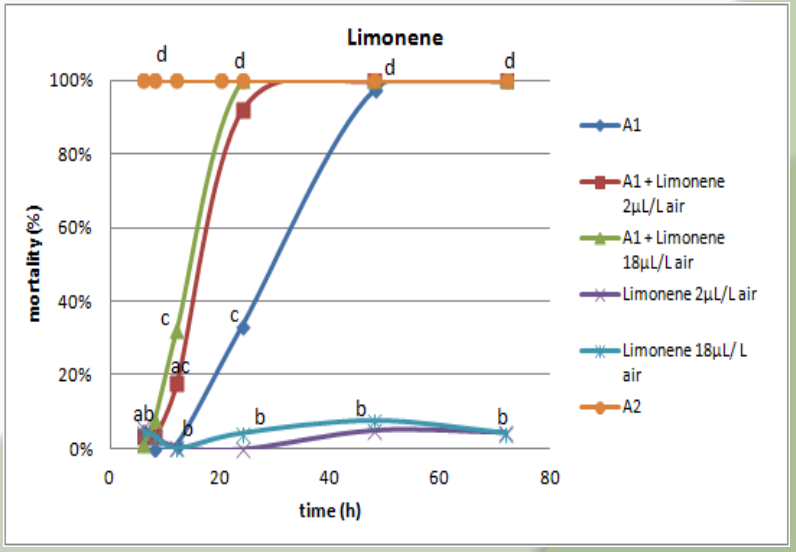
Control of bean weevil appearance : After the above mentioned storage conditions 4 packages were being taken to examine the mortal percentage

Insects were considered dead when no antenna or limb movement was observed

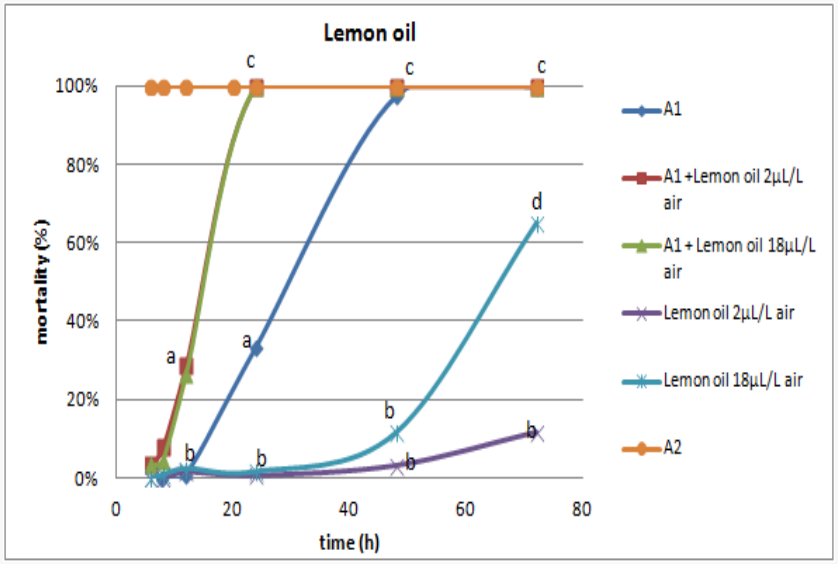
Mortality rate of insects with exposure time for each type of oil / component, at a different concentration, in the presence or absence of MAP.

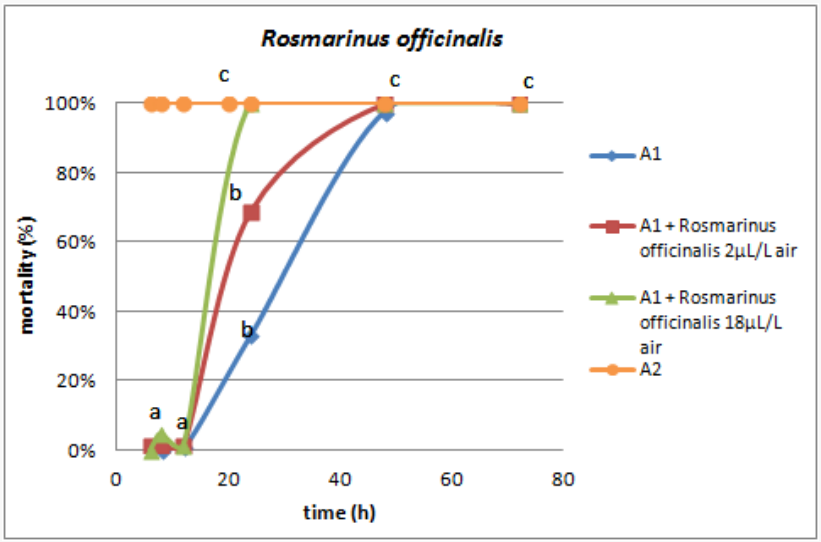






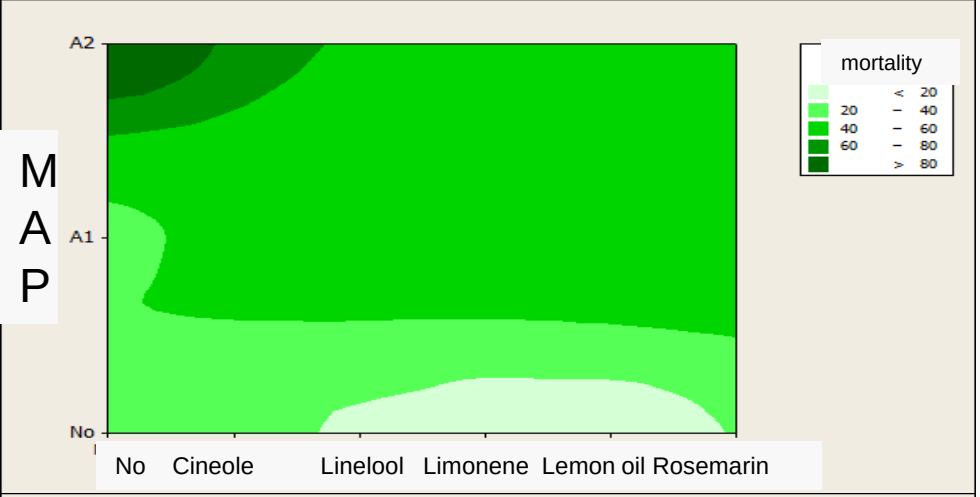
A1: 10% CO_2, 2% O_2, 88% N_2
A2: 100% N_2

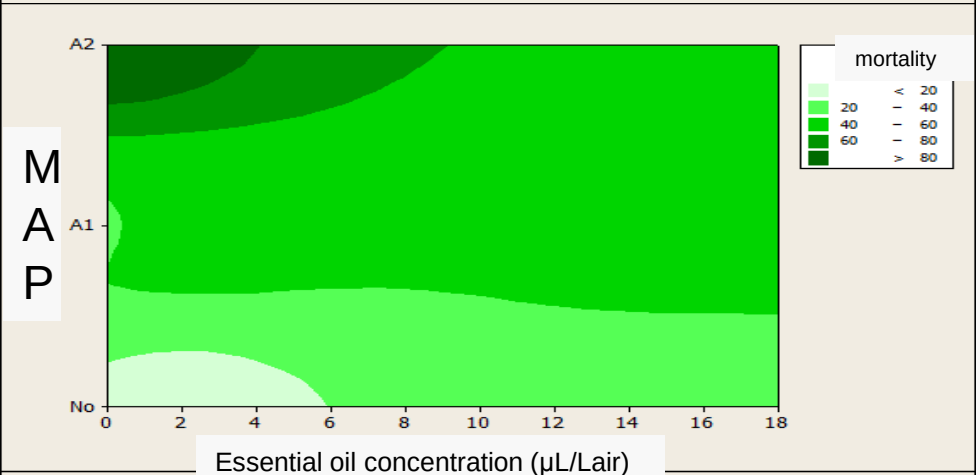


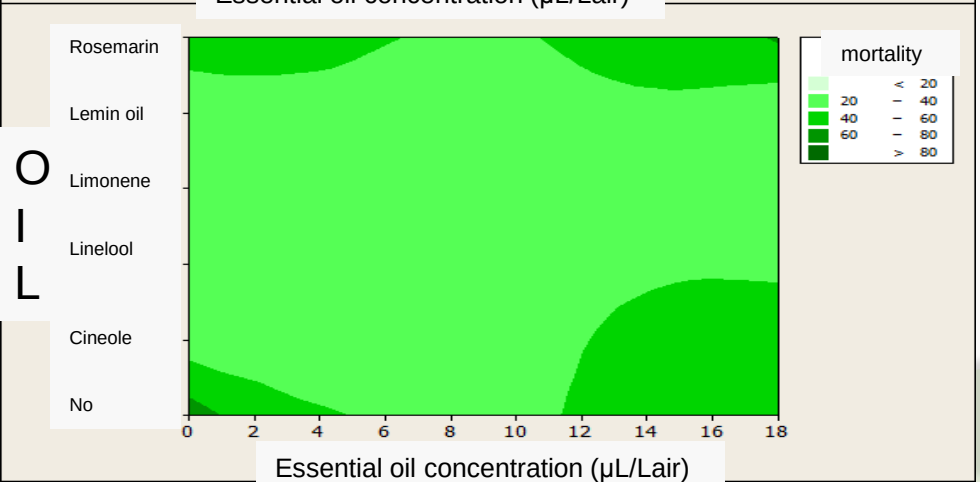


- ✓ A2, effective after 6 hours
- ✓ A1, total control after 48 hours
- ✓ Essential oil & A1 more effective in comparison with A1 without essential oil
- ✓Essential oils without MAP where not so efficient, exception cineole

Contour plots : Influence of the examined parameters on the mortality of the bean weevil and their interactions







Effectiveness on the bean weevil control

- A2
- A1 in combination with the essential oils / monoterpenoid
- A1
- Essential oils / monoterpenoid

✓ In the presence of MAP the same results were observed for the smallest and biggest oil concentration

✓From the oils examined the most active is cineole

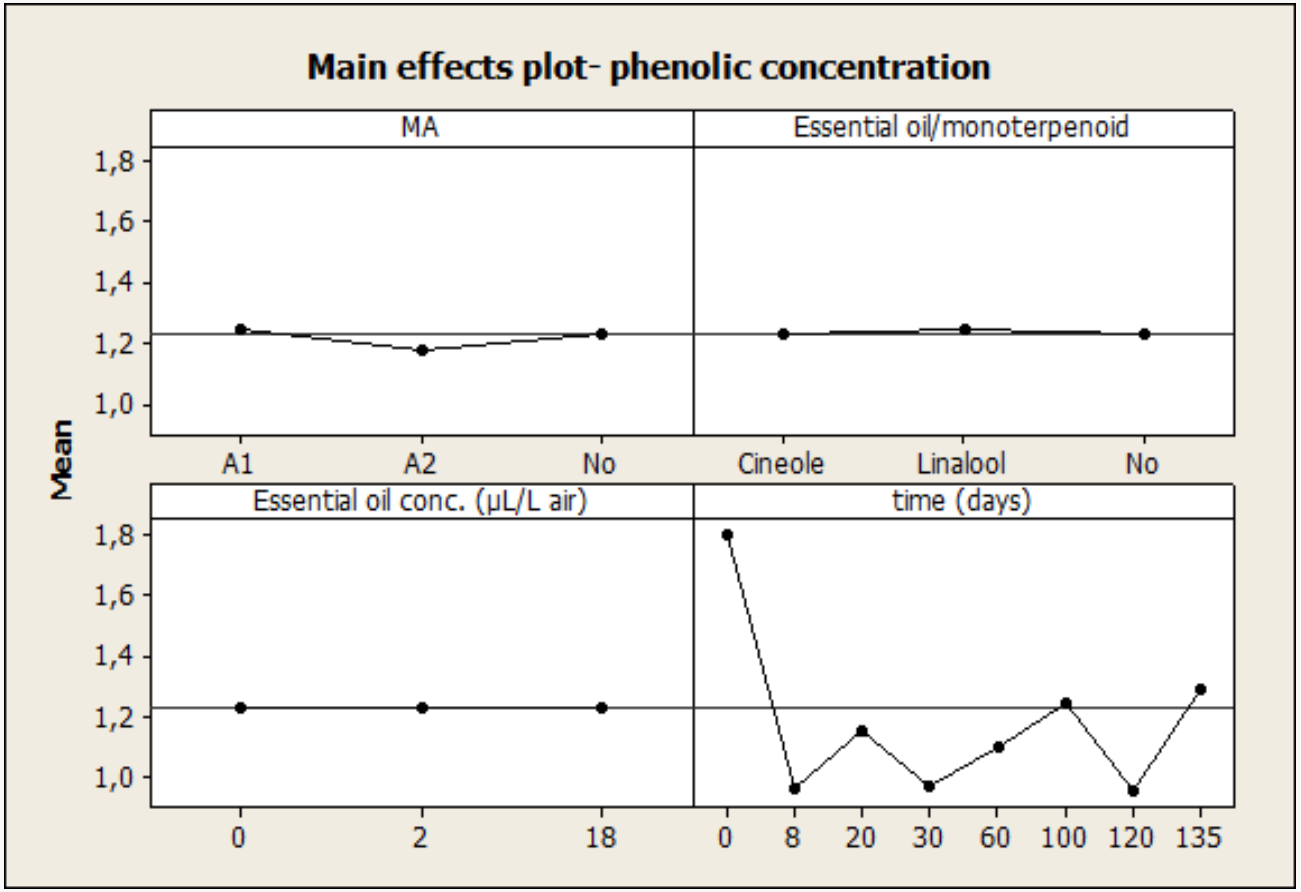
Qualitative characteristics of the stored bean

Influence of the most effective treatment conditions on the qualitative characteristics of beans during their storage

I/N	Modified atmosphere	Essential oil/monoterpenoid	Essential oil/monoterpenoid concentration
1	10% CO_2, 2% O_2, 88% N_2	-	-
2	10% CO_2, 2% O_2, 88% N_2	Cineole	2 µL/L air
3	10% CO_2, 2% O_2, 88% N_2	Linalool	2 µL/L air
4	100 N_2	-	-
5	-	Cineole	18 µL/L air

A1: 10% CO_2, 2% O_2, 88% N_2
A2: 100% N_2

Phenolic compounds



Main influence on the concentration of phenolic compounds → time

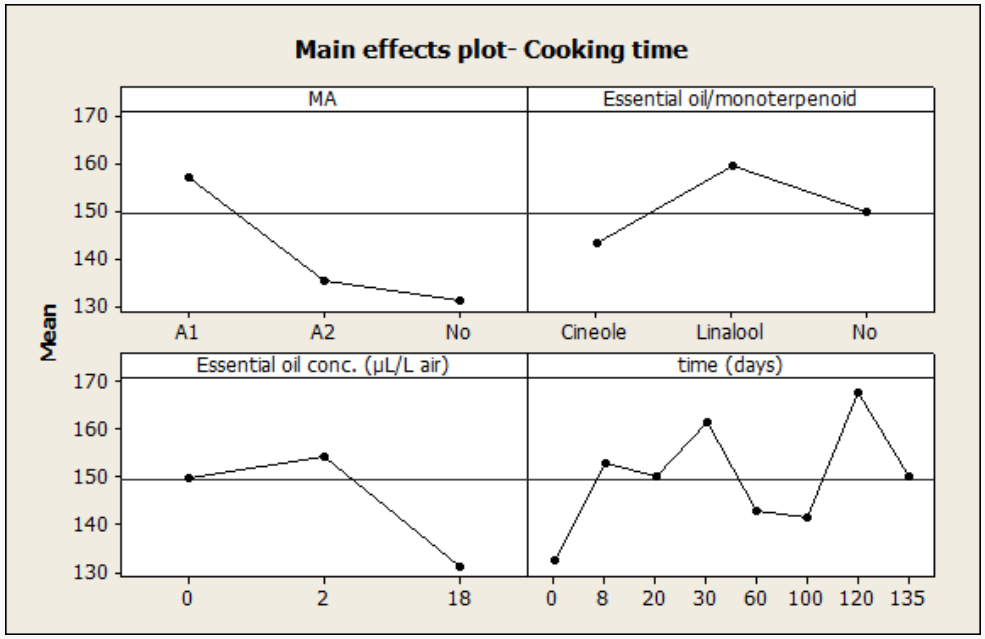
In the present study: in both MAP examined (A1, A2) phenolic compounds maintained their concentration

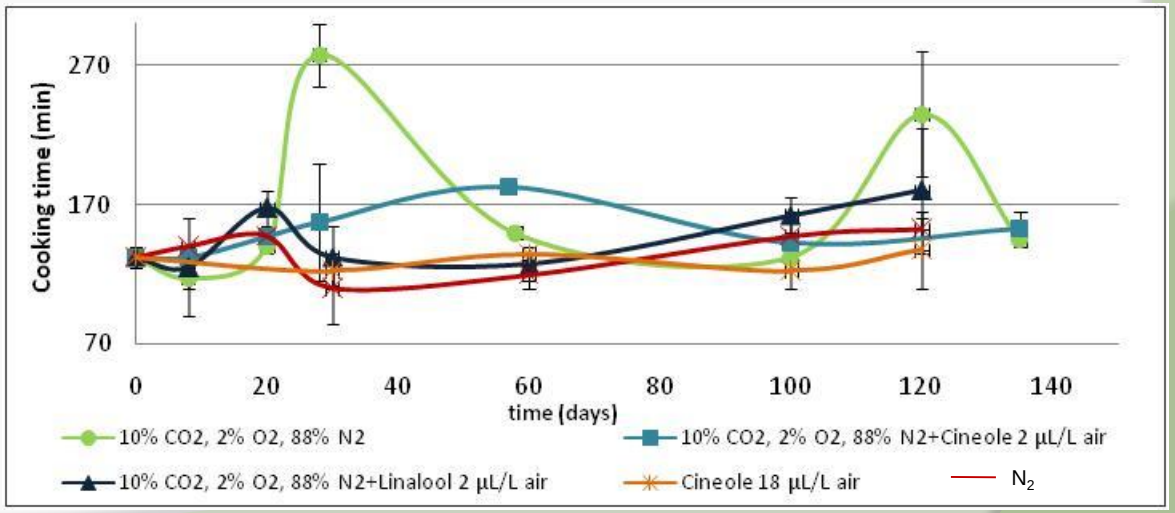
Term	Coefficient	Standard Error(SE)	T	P
Constant	1.0830	0.04578	23.66	0.000
Treatment	-0.0513	0.06640	-0.77	0.442
Time	-0.1732	0.06269	-2.76	0.007
Treatment*Time	-0.1021	0.09100	-1.12	0.266

S = 0.363178 PRESS = 10.0666
R-Sq = 10.75% R-Sq(pred) = 1.28% R-Sq(adj) = 6.87%

A1: 10% CO_2, 2% O_2, 88% N_2
A2: 100% N_2

Cooking time





CONCLUSIONS

✓ Applying a modified atmosphere was particularly effective in dealing with the bean weevil.

✓ Applying a modified atmosphere in combination with essential oils or monoterpenoids resulted in complete control of the bean weevil after 24 hours.

✓ The concentration of the oil in the presence of a modified atmosphere was not statistically significant, so even the smallest oil concentration (2 μL / L of air) can be applied.

✓ Applying a lower concentration of oil-monoterpenoid does not alter the taste and other quality characteristics of the beans.

✓ From the oils tested particularly effective in dealing with the bean weevil is cineole even when applied in ambient air.

✓ Monoterpenoids are pure chemicals and are a safer solution than essential oils.

- ✓ The treatment conditions (type of atmosphere, type of oil and oil concentration) did not appear to influence any of the quality characteristics of the bean.

- ✓ In contrast to the literature, no increase in boiling time of beans over time has been observed, indicating that a good quality characteristics of beans maintained under the treatment conditions.

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