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)*

![Image of beans with wholes]

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 antimitagenic and anticarcinogenic properties.

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

In a $\text{N}_2$ 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 (4,5°C, 125 mm Hg, 50-60% relative humidity) (Berrios et al., 1999)
- Low temperature (4°C) (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

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.
High level of CO₂

- Open of breathing pores of the insect and death because of lost if humidity
- CO₂ > 10% → breathing pores stay constantly open
- Toxic influence on the nervous system

Influence of MAP on storage insects:

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

Modification of the atmosphere in a composition rich in CO₂ and / or N₂ at normal or modified atmospheric pressure

MAP on bean weevil:
“Speed kill” with application of high levels CO₂ and pressure of 20 bar for 60 min
(Riudavets 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% CO₂ or N₂
- On high levels it is possible to have an acidity on the food (special CO₂)

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% CO₂ + 1% O₂ + 84% N₂ or 12% CO₂ + 5% O₂ + 83% N₂ 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% CO₂, 2% O₂, 88% N₂
- A2: 100% N₂
- 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 \(\rightarrow\) on filter paper

Appropriate gas atmosphere through the modified atmospheric packaging machine Plus Vac 20 (KOMET, Germany)
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.

<table>
<thead>
<tr>
<th>I/N</th>
<th>Modified atmosphere</th>
<th>Essential oil/monoterpenoid</th>
<th>Essential oil/monoterpenoid concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Cineole</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>3</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Cineole</td>
<td>18 μL/L air</td>
</tr>
<tr>
<td>4</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Linalool</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>5</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Linalool</td>
<td>18 μL/L air</td>
</tr>
<tr>
<td>6</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Limonene</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>7</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Limonene</td>
<td>18 μL/L air</td>
</tr>
<tr>
<td>8</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Lemon oil</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>9</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Lemon oil</td>
<td>18 μL/L air</td>
</tr>
<tr>
<td>10</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Rosemary oil (Rosmarinus officinalis)</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>11</td>
<td>10% CO₂, 2% O₂, 88% N₂</td>
<td>Rosemary oil (Rosmarinus officinalis)</td>
<td>18 μL/L air</td>
</tr>
<tr>
<td>12</td>
<td>100 N₂</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>-</td>
<td>Cineole</td>
<td>2 μL/L air</td>
</tr>
<tr>
<td>14</td>
<td>-</td>
<td>Cineole</td>
<td>18 μL/L air</td>
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<tr>
<td>15</td>
<td>-</td>
<td>Linalool</td>
<td>2 μL/L air</td>
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<td>18 μL/L air</td>
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Mortality rate of insects with exposure time for each type of oil / component, at a different concentration, in the presence or absence of MAP.
✓ 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
- 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

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<td>100 N₂</td>
<td>-</td>
<td>-</td>
</tr>
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<td>-</td>
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A1: 10% CO₂, 2% O₂, 88% N₂
A2: 100% N₂
In the present study: in both MAP examined (A1, A2) phenolic compounds maintained their concentration.

Main influence on the concentration of phenolic compounds → time

A1: 10% CO$_2$, 2% O$_2$, 88% N$_2$
A2: 100% N$_2$

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
<th>Standard Error(SE)</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.0830</td>
<td>0.04578</td>
<td>23.66</td>
<td>0.000</td>
</tr>
<tr>
<td>Treatment</td>
<td>-0.0513</td>
<td>0.06640</td>
<td>-0.77</td>
<td>0.442</td>
</tr>
<tr>
<td>Time</td>
<td>-0.1732</td>
<td>0.06269</td>
<td>-2.76</td>
<td>0.007</td>
</tr>
<tr>
<td>Treatment*Time</td>
<td>-0.1021</td>
<td>0.09100</td>
<td>-1.12</td>
<td>0.266</td>
</tr>
</tbody>
</table>

S = 0.363178 \quad \text{PRESS} = 10.0666

R-$\text{Sq}$ = 10.75\% \quad \text{R-$\text{Sq}$(pred)} = 1.28\% \quad \text{R-$\text{Sq}$(adj)} = 6.87\%
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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