Project Number: 8056 - 08

Title: Optimization of post harvest storage conditions to maintain fruit quality and health maintaining qualities of grapefruit.

Investigators:

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Second Annual Report: 07/31/2010

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Texas Department of Agriculture
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PROJECT INFORMATION	
Project Title	Project Number
Optimization of post harvest storage conditions to maintain fruit quality and health maintaining qualities of grapefruit.	TB- 8056 - 08

I. PROJECT SUMMARY:
In 200 words or less please give a brief non-technical summary of the project's accomplishments.
<p>Antioxidant activity of fruits is gaining wide interest among consumers due to its importance in counteracting oxidative stress, free radicals and preventing DNA damage. Oxygen radical absorbance capacity (ORAC) assay is one of the commonly used assays to measure the antioxidant activity, which is based on hydrogen atom transfer mechanism. Furocoumarins present in grapefruit are reported to have anti-proliferative activity, induce GST activity, inhibit biofilm formation and increase bioavailability of drugs. In the present project ORAC values were measured of Star Ruby grapefruit undergone ethylene degreening treatment, cold storage and temperature conditioning treatment, and modified atmosphere packaging which were stored at different temperatures for prolonged period. In addition, furocoumarins were quantified in Star Ruby grapefruits from cold storage and conditioning experiment conducted in Israel. Conditioning treatment is practiced prior cold storage to reduce chilling injury in grapefruits during cold storage for prolonged period. Levels of 6,7-dihydroxy bergamottin decreased during storage period in all three treatments.</p>
II. EVALUATION OF RESEARCH ACHIEVEMENTS:
a. Utilizing the actual objectives from your proposal document, detail all activities, accomplishments, data, etc. under each objective.
<p>Experiment 1 – Israel Degreening study:</p> <p>ORAC values were measured for Star Ruby grapefruits treated with ethylene (degreened) and without ethylene (non-degreened).</p> <ol style="list-style-type: none">ORAC values were expressed as mM of trolox equivalent per g dry weight (Fig. 1). No significant difference was observed between non-degreened and degreened fruits during 35 days of storage. ORAC values were maintained throughout the storage period from 0 to 35 days of storage. <p>Experiment 2 – Texas Degreening study:</p> <p>ORAC values for Rio Red grapefruits treated with ethylene (degreened) and without ethylene (non-degreened) were measured. Fruits were stored under simulated market conditions at 11°C for 3 weeks and later transferred to 20°C for 2 weeks.</p> <ol style="list-style-type: none">Degreened fruits showed significantly higher ORAC values at 7 and 21 days of storage as compared to non-degreened fruits. However, no significant difference was observed at 14, 28 and 35 days after storage. At the end of the storage period ORAC values were slightly higher in both treatments as compared to initial values (Fig. 2).

Experiment 3 – Israel cold storage and temperature conditioning study:

ORAC and furocoumarin analysis were performed for Star Ruby grapefruits samples from cold storage and conditioning experiment. The experiment consisted of three treatments in which fruits were stored for 16 weeks at 11°C, 2°C and conditioned (CD). Fruits were conditioned by keeping them at 16°C for 7 days and later storing them at 2°C upto 16 weeks.

- **ORAC assay**

1. ORAC values of fruits stored at 2 °C was significantly higher followed by conditioned fruits, while fruits stored at 11 °C had lowest antioxidant activity at 4 weeks of storage (Fig. 3). However, no significant difference was observed among all three treatments at 8 and 16 weeks of storage. Overall ORAC values decreased sharply in fruits stored at 11 °C at 4 weeks of storage. Fruits stored at cold storage (2°C) with or without conditioning showed gradual decrease in ORAC values during 4 and 8 weeks of storage. In all three treatments ORAC values were partially recovered at 16 weeks of storage; however, it was lower than initial level at 0 days (Fig. 3).

- **Furocoumarins –**

Three coumarins 6,7-dihydroxybergamottin (DHB), bergamottin and 5-geranyloxy-7-methoxycoumarin (5G7MC) were quantified using HPLC method (Fig. 4).

1. DHB levels decreased with storage period in all three treatments. Conditioned fruits showed significantly higher DHB levels at 4 and 16 weeks of storage (Fig. 4). DHB was low in fruits stored at 2 °C at 8 weeks of storage, while no difference was seen in other two treatments. No significant difference was observed between fruits stored at 11°C and 2°C at 16 weeks of storage. Overall DHB levels decreased during storage in all treatments.
2. Bergamottin was significantly higher in fruits stored at 2 °C as compared other two treatments at 4 weeks of storage. Where as, fruits stored at 11 °C had lowest levels of bergamottin at 4 weeks of storage. No significant difference was seen at 8 weeks of storage among all three treatments. At 16 weeks of storage fruits stored at 11 °C showed lowest levels, while no significant difference was seen between fruits stored at 2 °C and conditioned fruits (Fig. 4).
3. 5G7MC levels were significantly higher in fruits stored at 2 °C and conditioned fruits at 4 weeks of storage as compared to fruits stored at 11 °C. No significant difference was seen among all treatments at 8 weeks of storage. Where as, at 16 weeks of storage conditioned fruits showed increase in levels of 5G7MC and had significantly higher levels than other two treatments. No significant difference was seen in fruits stored at 11 °C and 2 °C at 16 weeks of storage (Fig. 4).

Experiment 4 - Modified atmosphere packaging experiment :

Modified atmosphere packaging experiment was conducted in Israel where fruits were stored in micro-perforated and macro-perforated bags for 16 weeks. Juice samples were taken for analysis at interval for 4 weeks.

- **ORAC assay**

1. Fruits stored in macro-perforated bags had significantly higher ORAC values at 8 weeks of storage; while, no significant difference was seen between control and fruits stored in micro-perforated bags (Fig. 5).
2. No significant difference was seen among all treatments at 4 and 12 weeks after storage.
3. At the end of 16 weeks, fruits stored in micro-perforated bags showed significantly lower ORAC values as compared other treatments. While no significant difference was seen between control and

<p>fruits stored in macro-perforated bags (Fig. 5).</p> <p>4. Fruits stored in macro-perforated bags and control treatment had higher ORAC values at end of storage period of 16 weeks in comparison with initial storage levels. Fruits which were stored in micro-perforated bags had lower levels at end of 16 weeks in comparison to initial storage levels (Fig. 5).</p>
<p>b. Specifically document the progress made in your project against your original timeline and provide a detailed explanation of any deviations from that timeline.</p>
<ul style="list-style-type: none"> • Quantification of furocoumarins fruits from Israel cold storage and temperature conditioning experiment. • Oxygen radical absorbance activity was measured for all four experiments – <ol style="list-style-type: none"> 1. Degreening experiment (Israel- Star Ruby fruits) 2. Degreening experiment (Texas- Rio Red fruits) 3. Cold storage and temperature conditioning experiment (Israel- Star Ruby fruits) 4. Modified atmosphere packaging experiment (Israel- Star Ruby fruits).
<p>c. Document any changes from the original plan of research (including, but not limited, to changes in species, breed, varieties, experimental method, design or key personnel) and provide a detailed justification for any such change.</p>
<p>Degreening experiment was conducted both in Israel and Texas using local varieties (Star Ruby and Rio Red respectively) for the benefit of growers in both countries.</p>
<p>d. Provide the specific goals and objectives for the next reporting period and the timeline for meeting those objectives.</p>
<ul style="list-style-type: none"> • Final report and manuscripts submission to Journals.
<p>e. Document in specific detail, evidence of integrated and cooperative work between PIs in Texas and Israel for each project objective as required for continued funding of the project.</p>
<ul style="list-style-type: none"> ➤ Degreening experiment, cold storage and conditioning experiment, and modified atmosphere packaging experiment was conducted in Israel, where fruits were stored under different treatments for 16 weeks. Fruit samples were freeze dried and sent to Texas for bioactive compounds analysis and antioxidant activity. ➤ ORAC assay and quantification of furocoumarins were carried out in Texas for degreening experiment, cold storage conditioning experiment and modified atmosphere packaging experiment.
<p>f. Specifically document how your deliverables benefit Texas and any outreach activities relating to your project including:</p>
<p>i. Commercial applications of your research:</p>

Antioxidant rich foods are gaining more consumer preference in grocery stores. Consumers are becoming aware of the health benefits of antioxidants and are ready to pay more for antioxidant rich fruits, best examples being pomegranates and blueberries. Therefore, it becomes necessary to study effect of various commercially practices treatments on ORAC values in grapefruits.

ii. Businesses or vendors that are currently, or potentially, interested in research applications:

The research will benefit citrus industry along with food and pharmaceutical industries. The research can also be applied in crops where similar treatments are followed. Furocoumarins from grapefruit have reported to have drug interaction and affected the grapefruit industry. Optimization of postharvest practices will help to improve marketability and quality of fruits.

iii. Other commodities or components of Texas agriculture that may benefit from this research:

Current research will be useful for other citrus fruits grown in Texas along with citrus juice processing industry. The research can be applied to other crops in which degreening, temperature conditioning and modified atmosphere packaging is used.

iv. Specific areas of the state that can benefit from these applications:

The Rio Grande Valley which accounts for majority of citrus cultivation in Texas will be mainly benefited from the research.

v. Any other information demonstrating the significance of your research to Texas:

The research will help to optimize the postharvest treatments to maintain the health promoting bioactive compounds in grapefruits.

III. LIST OF PUBLICATIONS:

Presentations –

1. Chaudhary, P. R., Jayaprakasha, G.K., Porat, R., Patil B. S. 11th January, 2010. *Grapefruit degreening influence on health promoting limonoids and flavonoids*. Texas A & M Agrilife Conference, College Station, TX.
2. Chaudhary, P. R., Jayaprakasha, G.K., Porat, R., Patil B. S. 2-5th August, 2010. *Ethylene treatment minimally affects Star Ruby grapefruit bioactive compounds and their radical scavenging activity*. 2010 ASHS Annual Conference, Palm Desert, CA.
3. Chaudhary, P. R., Jayaprakasha, G.K., Porat, R., Patil B. S. *Grapefruit degreening influence on health promoting limonoids and flavonoids*. 28th International Horticultural Congress, 2010, Lisbon, Portugal.
4. Chaudhary, P. R., Jayaprakasha, G.K., Porat, R., Patil B. S. *Storage temperatures and conditioning effect on bioactive compounds during prolonged grapefruit storage*. 2011 ASHS Annual Conference, Waikoloa, Hawaii (25 - 28 Sept. 2011)

Manuscripts published-

1. Mayuoni, L.; Tietel, Z.; Patil, B. S.; Porat, R., Does ethylene degreening affect internal quality of citrus fruit? *Postharvest Biology and Technology* 2011, 62 (1), 50-58.

Manuscripts under communication-

1. Chaudhary, P.R., Jayaprakasha, G.K., Porat, R., Patil B. S. *Grapefruit Degreening Influence on Health Promoting Limonoids and Flavonoids*. Submitted –Acta Horticulturae.
2. Chaudhary, P.R., Jayaprakasha, G.K., Porat, R., Patil B. S. *Degreening and postharvest storage influences 'Star Ruby' grapefruit (Citrus paradisi Macf.) bioactives*. (Food Chemistry – In review)

IV. REPORTS ON PATENTS:

***Note:** Researchers may attach additional information, if needed, to include more details, photos, graphs, tables, etc.

Fig. 1. Influence of degreening treatment on ORAC values of Star Ruby grapefruits stored at 11°C for 21 days and transferred to 20 °C.

Fig.2. ORAC values of non-degreened and degreened Rio Red grapefruits stored at 11°C for 21 days and later transferred to 20 °C.

Fig. 3. Variation in ORAC values of Star Ruby grapefruits stored at 0, 4, 8 and 16 weeks at 11°C, 2°C and conditioned fruits in cold storage and temperature conditioning experiment. Fruits were conditioned by keeping them at 16°C for 7 days and later storing them at 2°C upto 16 weeks.

Fig. 4. Levels of furocoumarins and coumarin content in Star Ruby grapefruits stored at 0, 4, 8 and 16 weeks at 11°C, 2°C and conditioned fruits in cold storage and temperature conditioning experiment. Fruits were conditioned by keeping them at 16°C for 7 days and later storing them at 2°C upto 16 weeks.

Fig. 5. ORAC values oxidant activity of Star Ruby grapefruits stored at 0, 4, 8, 12, 16 weeks in micro-perforated, macro-perforated Xtend bags and control treatments.