FINAL PROJECT REPORT

Project Title: Assessment of organoleptic traits in sliced pears

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Cooperators: Blue Bird Growers – Ron Gonzales; Blue Star Growers – Smart fresh treated fruit; Crunch Pak: Ozgur Koc, WSU: Seanna Hewitt and Scott Mattinson

Other funding sources

Agency Name: WSDA
Amt. requested/awarded: $249,926 **(requested)**
Notes: Production of high quality fresh sliced pears

Agency Name: Crunch Pak
Amt. requested/awarded: $30,000 **(Requested – matching funds for the WSDA proposal)**
Notes: Support for pear slicing, packaging, purchase of fruit, labor and fruit quality analysis

Agency Name: NIH Protein Biotech Training Program
Amt. requested/awarded: $52,234 **(awarded)**
Notes: Support for Seanna Hewitt, Ph.D. student includes stipend, travel, medical, tuition and fees

Total Project Funding: $67,808

Budget History:

Item	2017	2018
Salaries[1]	16,800	17,472
Benefits	8,106	8,430
Supplies[2]	7500	7500
Travel[3]	1000	1000
Total	33,406	34,402

Footnotes:
1. Technical support for evaluation and analysis of fruit
2. Support for purchasing fruit, chemical compounds, and modified atmosphere bags
3. Travel to warehouses for fruit procurement

OBJECTIVES

The objectives of this project aimed to quantify the profile and content of volatile compounds critical for a positive consumer experience. In order to produce market ready fresh sliced pears, quantitative information regarding the volatile profile in modified atmosphere bags with different OTRs is needed to complement the promising results obtained from the consumer trials and willingness to pay study that was published recently.

The two objectives of this study were:

1. Assess commercially valuable traits of sliced pears
2. Evaluate flavor profile of the sliced fruit using HPLC and GCMS in a time course experiment

SIGNIFICANT FINDINGS

- Under regular atmosphere, the respiration rate of 1-MCP pears after slicing is lower than non 1-MCP pears (Figure 1).
- The respiration rate as measured by percentage carbon dioxide generated from 1-MCP sliced pears treated with the ripening compound increases steadily as a function of number of days in modified atmosphere bag with an OTR of 140. OTR 140 represents the thinner MA bag used for production of fresh sliced apples. However, the average rate of respiration in 1-MCP treated sliced pears is lower than non-1-MCP treated pear controls (Figure 2), which is somewhat expected.
- In the thicker MA bag with a lower OTR of 100, carbon dioxide percentage was nearly 1.5x – 2x more than the MA bag with OTR of 140 (Figure 3).
- The Ripening compound results in an increased accumulation of esters, which are critical component of pear aroma.
- The thicker MA bag with a lower OTR of 100 produced more ethyl acetate, which may not be desirable for consumers.
- Shelf life of 21 days was easily achieved with 1-MCP treated pears sliced and ripened with the Ripening Compound.
- Overall, a need to test a MA bags with OTRs ranging from 110 to 130 for pears has been identified.

METHODS

Objective 1: Assess commercially valuable traits of sliced pears

Smart fresh (1-MCP)-treated and untreated Anjou pears were sliced. The ripening compound treatment was applied in conjunction with anti-browning solution provided by Crunch Pak. Typically, 1 gallon of the solution was prepared with varying concentrations of the ripening compound. The sliced fruit was dipped in the solution for 1 minute prior to being packaged in two different types of modified atmosphere bags along with a regular atmosphere control.

> Shelf life and brix of the sliced product with smart fresh treated fruit packed in November and March and packed in 3 different types of modified atmosphere bags was assessed. Five, 2 oz. bags of sliced fruit were sampled every 3 days till day 21 for these analyses.

At each sampling time point duration, all samples were frozen at 0 deg C. Within 1 month the samples were removed and by using frozen tissue from 2 MA bag replicates an extract was prepared. The sample was thawed and blended with a Waring blender by adding an additional 20% of ddH2O.

Samples were filtered using cheese cloth and once again frozen at 0 deg C in 3 x 20 ml aliquots. Samples were stored in plastic cone capped scintillation vials.

Objective 2: Evaluate flavor profile of the sliced fruit using HPLC and GCMS in a time course experiment

Volatile compounds from dynamic headspace were collected and analyzed by GC/MS. The volatile profiles included esters, alcohols, hydrocarbons, aldehydes, and ketones. Five, 2 oz. bags of sliced fruit were used for HPLC analysis. Fruit were sampled every 3 days till day 21 for these analyses.

Respiration rates for regular atmosphere were analyzed on treated cut slices by randomly assigning up to 500 g of slices into individual jars. Two jars per treatment were used. Lids on the jars were left open until the day of sampling. Lids were shut for 1 hour, then a 0.5 ml gas sample was removed and injected into a HP-5890 GC, containing a 10 m X 1.0 cm CRC column. The injector was packed while it was held at a temperature of 100 deg C and the TCD detector was also held at 100 deg C. The GC oven was held at 30 deg C during sampling. The quantification of oxygen and carbon dioxide was performed by injecting a gas standard, 10% oxygen in helium, and a 10% carbon dioxide standard in nitrogen. Both standards were purchased from Alltech Scientific.

Volatile Analysis:
The headspace solid phase microextration technique was performed using 2.0 ml of pear extract in a 4.0 ml vial (Supelco, Bellefonte, PA). The pear sample was mixed with 30% NaCl and was stirred at room temperature for one hour. An SPME device with a fused silica fiber coated with 65 µm polydimethylsiloxane/ divinylbenzene was exposed to the sample headspace. The samples were injected using splitless injection for 2 min. at 200 deg C into an Agilent 6890/5973 GC/MSD(Agilent,Wilmington, Del.) equipped with Chemstation C1024 A02. The column consisted of a DB-1MS 60 m column (Phenomenex,Torrance,CA.) with a bore of 0.32 mm i.d. and 1.0 µm film thickness. Chromatographic conditions used were as per Mattheis et al. (1991) with the exception that the transfer line and ion source temperature were held at 250 deg C and 150 deg C respectively. The GC inlet contained a 0.75 mm SPME injection sleeve, which assured peak sharpness especially for early eluting peaks (Yang and Peppard, 1994). Initial compound identification was made by matching the results with the Wiley/NIST library (Wiley 125K) and later confirming the match with commercial standards. Volatile quantification followed by analyzing mixtures of compounds per functional group. Thereafter, the standard curves were used for final quantification.

RESULTS AND DISCUSSION

Objective 1: Assess commercially valuable traits of sliced pears

The commercially valuable traits included – shelf life, sugars and brix.

The 1-MCP treated ‘D’Anjou’ sliced and treated with three concentrations of ripening compound consistently achieved a shelf life of 21 days. As the head space was sampled from the bags of different OTRs, the fruit tissue was juiced and stored. The analysis of %Brix and sugars is currently underway.

Objective 2: Evaluate flavor profile of the sliced fruit using HPLC and GCMS in a time course experiment. All fruit packaged in different OTR bags was stored at 39 deg F.

1. Baseline respiration: First step was to understand the difference in the basal respiration rates. As is evident in Figure 1, fruit stored at regular atmosphere does not show substantial difference in respiration rates between the type of fruit (control or 1-MCP treated). Overall the rate is lower in case of 1-MCP treated fruit.

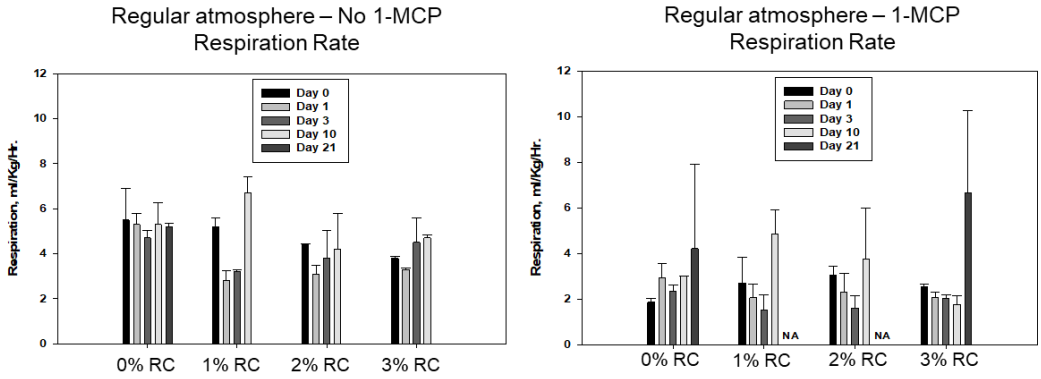

Figure 1: Respiration rate of non 1-MCP and 1-MCP treated sliced pears under regular atmosphere. The fruit was stored at 4 deg C or 39 deg F.

2. Respiration rates under modified atmosphere – non 1-MCP and1- MCP fruit packaged in two different OTR bags. The MA bag used for producing fresh sliced apples has an OTR of 140. In addition, a MA bag with an OTR of 100 was also used.

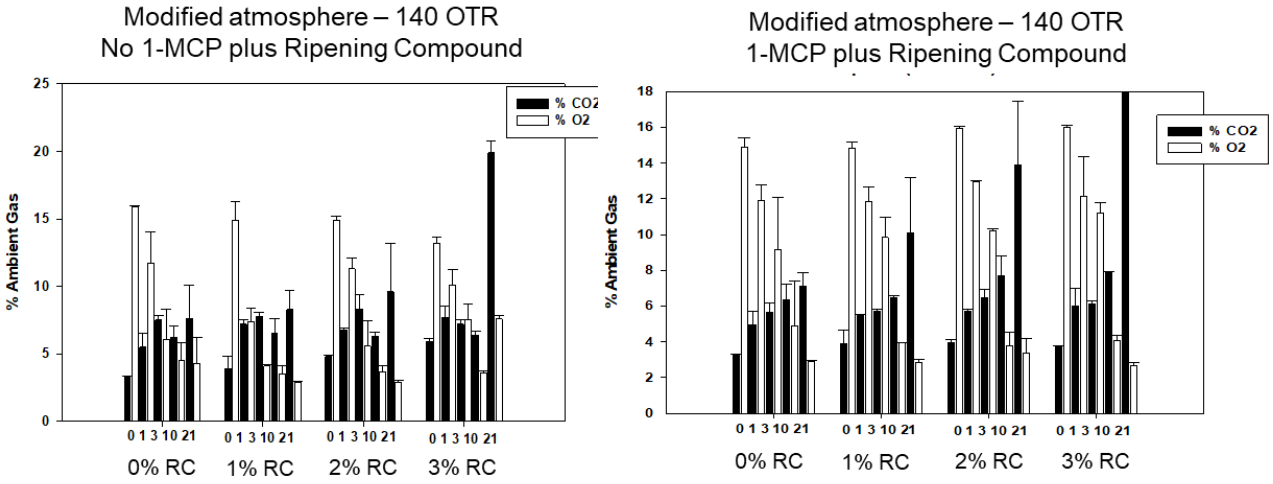

Figure 2: Percentage ambient gas generated by non 1-MCP and 1-MCP treated sliced pears under modified atmosphere bag OTR = 140. The fruit was treated with 0, 1, 2, or 3% of Ripening Compound (RC) and bags were stored at 4 deg C or 39 deg F after slicing. X-axis is number of days and Y-axis represents percentage ambient gas. Open bars – oxygen and dark bars – carbon dioxide.

Figure 2 shows percentage ambient gas in the MA with an OTR of 140. As is clear, addition of the Ripening Compound results in a consistent increase of carbon dioxide. The increase is consistent with an increase in the percentage of the Ripening Compound.

When the fruit was packaged in MA bags with a lower OTR of 100, the rates of respiration were much higher (Figure 3). This data is very important in determining the correct OTR for pears. The data on 'D'Anjou' can also help guide production of fresh sliced pears from other varietals as well.

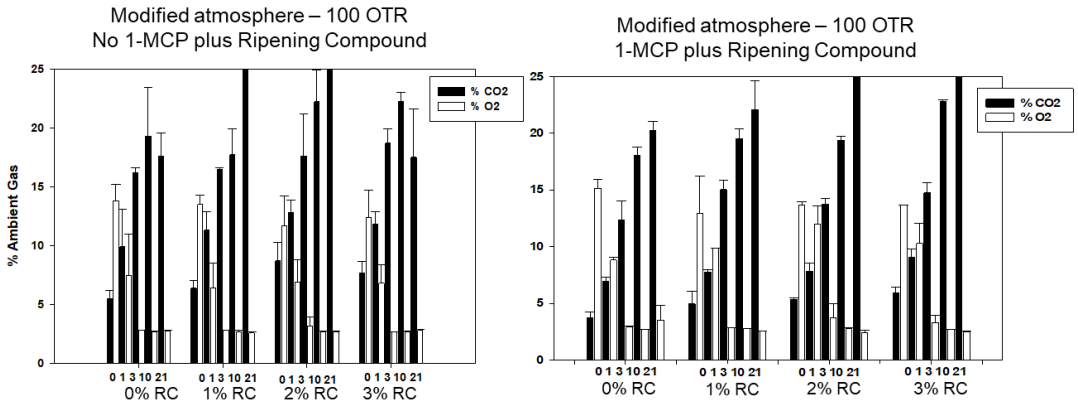

Figure 3: Percentage ambient gas generated by non 1-MCP and 1-MCP treated sliced pears under modified atmosphere bag OTR = 100 – low permeability – thicker bag. The fruit was treated with 0, 1, 2, or 3% of Ripening Compound (RC) and bags were stored at 4 deg C or 39 deg F after slicing. X- axis is number of days and Y-axis represents percentage ambient gas. Open bars – oxygen and dark bars – carbon dioxide.

3. Estimation of aldehydes and esters, and alcohols

The 1-MCP treated fruit when sliced and treated with ripening compound resulted in increased production of esters. The concentration of aldehydes remained low in both types of MA bags. Esters are essential for pear aroma. While the MA bag with an OTR of 100 produced far more esters (Figure 4), it is important to consider this result in light of amount of alcohols produced. There has to be a good balance between all these components.

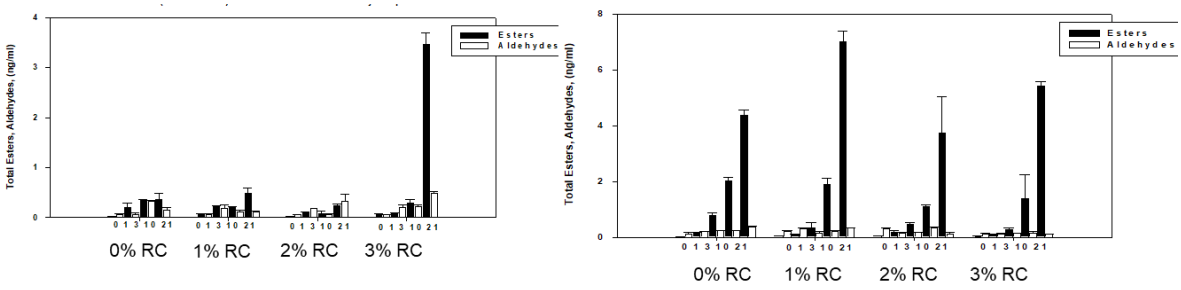

Figure 4: Total esters and aldehydes. Open bars – aldehydes and dark bars – esters. Represented as a factor of number of days on the shelf. This data is for 1-MCP treated sliced pears under modified atmosphere bag OTR = 140 (left panel) and OTR – 100 (right panel). The fruit was treated with 0, 1, 2, or 3% of Ripening Compound (RC) and bags were stored at 4 deg C or 39 deg F after slicing. X- axis is number of days. A.

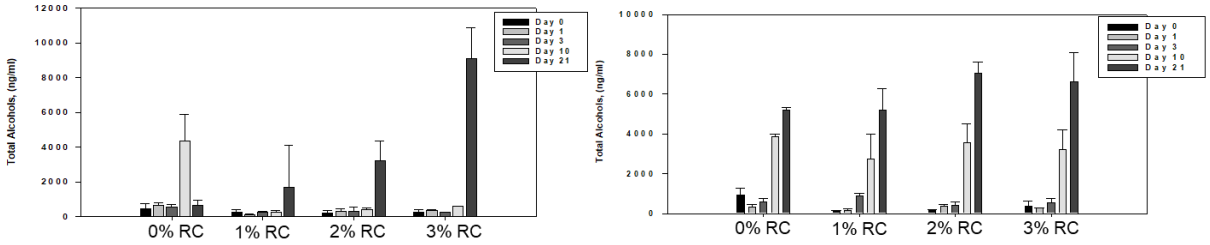

Figure 5: Total alcohols as a function of number of days on the shelf. This data is for 1-MCP treated sliced pears under modified atmosphere bag OTR = 140 (left panel) and OTR – 100 (right panel). The fruit was treated with 0, 1, 2, or 3% of Ripening Compound (RC) and bags were stored at 4 deg C or 39 deg F after slicing. X- axis is number of days.

A similar pattern was also observed for total alcohols. The thicker (OT – 100) MA bag resulted in production of higher amounts of total alcohols. While these alcohols did not produce offensive smell or flavor, a proper consumer trial is essential to quantify the impact on consumer decision.

In summary, the data presented here shows that a MA bag with an OTR around 120 might be best for production of fresh sliced pears. However, the pears need to be treated with 1-MCP and subsequently treated with the Ripening Compound to obtain desirable shelf life and flavor profile. As the data regarding sugars is finalized, the results from this work will be compiled into a manuscript for publication.

As the decision to utilize a MA bag of different OTR is being considered, the fact that the modified atmosphere bags have a range of oxygen transmission rates (OTRs) and carbon transmission rates (CO2TR) is important to keep in mind. It is known that the transmission of gases across packaging structures is governed by factors described by the Fick's law:

Jgas = *A x ACgas/R*

Jgas is the total flux of gas (cm3/s)
A is the surface area of the film (cm2)
Cgas is the concentration gradient across the film
R is the resistance of the film to gas diffusion (s/cm)

For any given fresh – cut produce, the choice of optimal OTR and CO2TR is dependent upon its respiration rate, weight, the internal package dimensions, the targeted atmosphere composition, and product handling temperature. Therefore, it is necessary to select a modified atmosphere bag where oxygen and carbon dioxide transmission rates match the needs of the product. Carbon dioxide diffusion rates are two to five times faster than oxygen and the ratio of carbon dioxide transmission rate to oxygen transmission rate of a polymer in the bag. It seems that the OTR of 140 is somewhat optimal and OTR of 100 can be detrimental to quality.

NOTE: I plan to provide an update to the final report once the data on %Brix and total sugars is collected and analyzed.

Outreach

Peer-reviewed publication - Ikiz D, Gallardo RK, Dhingra A, Hewitt S (2017) Assessing consumers' preferences and willingness to pay for novel sliced packed fresh pears: A latent class approach. Agribusiness

Good Fruit Grower article - Dhingra A, Gallardo K (2017) Customers are willing to pay a premium only on high quality, fresh sliced pears. In: Good Fruit Grower. Washington State Fruit Commission, Wenatchee, WA, pp 36-39

Presentation - Sliced Pears—How to add $1 million to the pear market's bottom line in the PNW. Seanna Hewitt and Amit Dhingra. Annual Washington State Tree Fruit Association Meeting, December 2017.

Presentation to WA and OR packing houses regarding the possibility of producing fresh sliced pears.

Manuscript under preparation – Impact of different OTRs on production of fresh sliced pears.

EXECUTIVE SUMMARY

Executive summaries are required for ending projects. This one-page report should include significant progress or outcomes and summary of finding and future directions (if applicable). Formatting requirements are the same as other project reports. The executive summary should be attached to the end of the final report and sent as one file. This page does not count towards the 10-page final report maximum.

Increasing the per capita consumption of pears has been the most urgent and important priority of the pear industry since the publication of a seminal paper by George Ing (late commissioner, WTFRC) in 1994. Consumers continue to be dissatisfied due to inconsistent quality of pear fruit available on the grocery store shelf.

Respiration (CO_2 production) is one of the primary physiological processes involved in fruit maturation and ripening. The rate of respiration of sliced fruit is greater than that of whole fruit. Since no prior data on respiration rates of sliced pears grown in the PNW exists, there is a critical need to determine the respiration rate for sliced pears. This knowledge will be necessary in order to test and develop modified atmosphere (MA) bags with optimal oxygen/carbon dioxide transmission rates, which will maintain high quality of the slices while reducing overall oxidation (browning), retain pear aroma, and extend the shelf life of the sliced fruit for up to 3 weeks.

The aim of our research is to develop a market ready fresh sliced pear product by identifying the optimal modified atmosphere (MA) packaging that will produce highest quality sliced fruit with reduced browning, retention of pear aroma, and extend the shelf life to 21 days. This study has demonstrated that MA bag with an OTR of 140 is somewhat optimal but not ideal and MA bag with an OTR of 100, while producing higher concentration of esters that are critical for pear aroma, may produce less than ideal product due to higher accumulation of alcohols and acetates.

Future research should evaluate MA bags of OTR 110, 120 and 130 combined with consumer trials. There are new types of packages with specialized vials that can regulate OTR tightly and such incorporate of innovations in packaging along with the Ripening Compound can enable the production of market ready fresh sliced pears.