



The University of Georgia

Center for Agribusiness and Economic Development

College of Agricultural and Environmental Sciences

A Technical and Economic Evaluation of Alternative Methods for Extending the Shelf life of Fresh Pecans

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Executive Summary

Demand for pecans has been stagnant over the last seven years, leading pecan producers to look for new ways of increasing demand. With new preservation techniques it may be possible to produce snack products of pecans similar to that of peanuts. In order to determine potential consumer demand for pecan snacks and other potential products requiring an extended shelf-life, a national survey of 913 people was performed in order to obtain data on the demographics and buying habits of pecans consumers. A Tobit model was used to analyze the survey data to determine the mean Willingness to Pay for a pecan snack product. The mean willingness to pay was estimated to be \$0.89 for a snack size bag of pecans. In addition, the average pecan consumer does not purchase pecans very often, fewer than three times a year, with most purchasing one pound bags of halves. Almost eight percent of pecan consumers surveyed indicated that they had a problem with rancidity in pecans.

The consumer study indicated a potential for pecan products requiring an economical method to preserve quality and flavor. Four potential methods to treat pecans to extend storage and reduce rancidity were evaluated. Chemical analysis of treated pecans at 3 and 6 months indicated that rancidity levels (as measured by peroxide value) were only slightly higher for pecans exposed to supercritical carbon dioxide and supercritical carbon dioxide plus an antioxidant treatment, stored at room temperature, as compared to the frozen control pecans. Pecans treated with the antioxidant but not exposed to supercritical carbon dioxide had lower rancidity levels than untreated pecans stored at room temperature but were significantly higher than the supercritical carbon dioxide treatments and the frozen pecans. Preliminary taste test results were contrary to the chemical analysis and indicated that there may be unfavorable attribute changes (flavor, texture etc.) associated with the supercritical carbon dioxide treatment methods even though the methods seem effective in controlling rancidity.

Problem Definition and Project Goals

Pecans account for 25 percent of total nut tree-nut consumption on a per pound basis. This places them directly after almonds and walnuts in terms of consumption. Since the 1980's, pecan consumption has been stagnant and has actually trended downward since 1998. The average annual pecan consumption in the U.S. over the past five years was approximately 0.42 pounds. This is a slight decrease from previous year's averages. Walnut consumption is closer to that of pecans with 0.47 pounds per capita consumed annually (USDA, 2004). Prior to 2002, more pecans were consumed than walnuts. However, since 2002 walnuts have outpaced pecans. The consumption of almonds has also increased rapidly the past fifteen years compared to pecans and walnuts. The reasons behind this phenomenon may include crop size, consumer attitudes and preferences towards certain nuts, and the industries' marketing strategies. In recent years, the consumption trend for "heart-healthy fats" has increased. Pecans contain nearly 65 percent monounsaturated and 28 percent polyunsaturated fats; these are considered good fats. One problem is perishability of pecans. Pecans are semi-perishable, and unless stored properly may become inedible due to rancidity, mold, and insects. It has been shown that adequate drying, packaging, and refrigeration are the most important facts in preserving the quality of a shelled pecan. Proper storage is one of the solutions to the problem of carryover of pecans from heavy crops to lighter crops the next year (Woodruff, 1979).

Experiments conducted by the Georgia Experiment Station have shown that controlled refrigerated storage can retard rancidity while preserving the natural color, flavor, and texture. High moisture in nuts is the most significant cause of deterioration during pecan storage and it can cause a nut to become inedible within two weeks.

Pecan farmers are interested in adding-value to pecan products by allowing producers to hold inventory until market conditions are favorable, access distant export markets that were previously unavailable due to time and distance, create new pecan based snack products, or even turn low price byproducts such as broken pieces into an ingredient that is attractive to customers in the candy or other manufacturing segments that use pecans as an ingredient. However, the inability to create a shelf stable pecan product has hindered the creation of new value-added pecan products. To further develop the pecan industry, a shelf stable product needs to be developed to address the shelf life issue.

One goal of this project was to evaluate a new technique using supercritical CO₂ to infuse pecans with antioxidants in order to extend storage life and retard rancidity development. Supercritical systems were first used in the food industry in the 1980's as a substitute for chemical extraction of caffeine from coffee beans. Supercritical systems are considered "clean" processes because they use a gas such as carbon dioxide that is heated and compressed to above its critical point where it behaves like a liquid and is capable of dissolving lipid soluble components and removing them from a food matrix. Since the first commercial application for the decaffeination of coffee beans, supercritical systems have found many uses in food processing. In most cases the supercritical systems are used to take something out of a mixture, however, in this study we investigated a novel use where the supercritical solvent was used to infuse a preservative *into* the

pecans. It was thought that with the antioxidant distributed evenly throughout the nut's meat, it would be more effective than being just applied to the outside. Shelled pecan meats (both halves and broken pieces) were soaked in a solution of antioxidant then loaded into a pressure vessel and supercritical CO₂ introduced and held for a predetermined period of time to allow the antioxidant to be carried into the nuts. The treated nuts were then stored in bags at room temperature and tested chemically at three and six months for the level of oxidation that had occurred. At six months, the nuts were also evaluated using an untrained taste panel to determine if there was a noticeable difference between the treatments. The specific controls and treatments that were evaluated during the study are listed here;

SYMBOL

DESCRIPTION

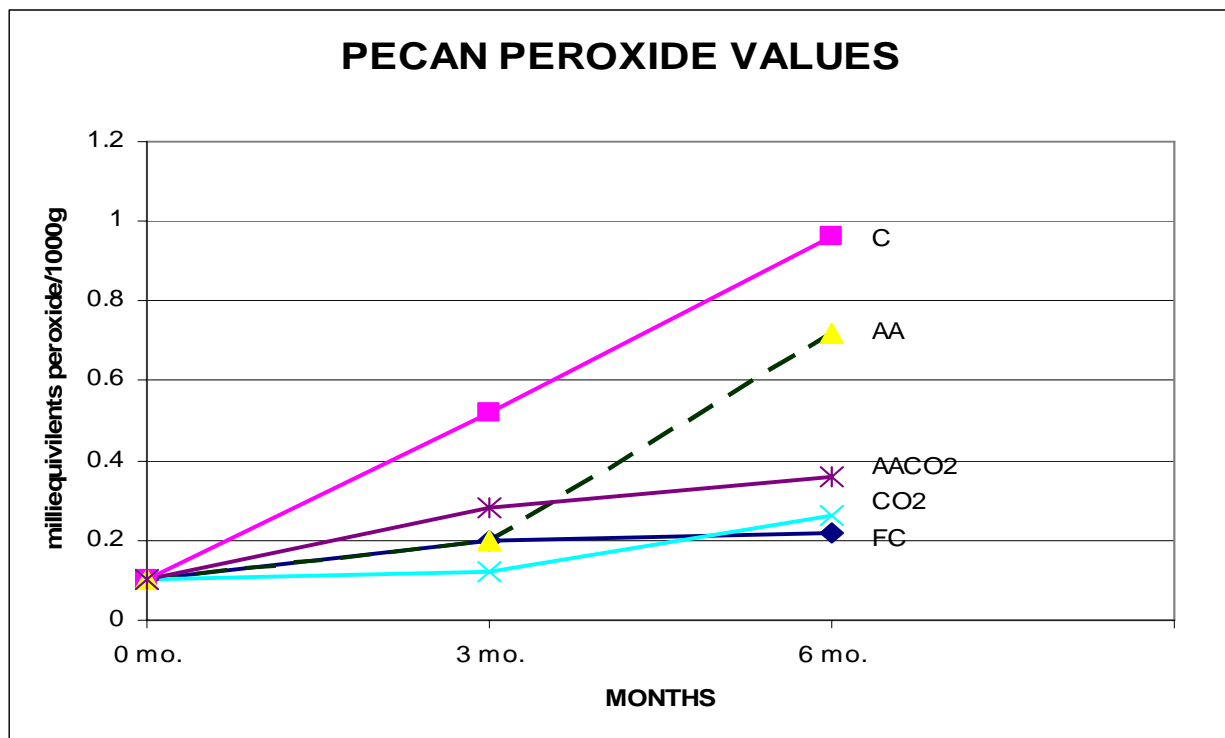
(FC)	Frozen Control	- held in plastic bags at 10 - 20°F for the duration of the study to simulate the current commercial method of holding pecans.
(C)	Control	- untreated nuts held in plastic bags at ambient temperatures of approximately 60-70°F.
(AA)	Antioxidant Alone	- nuts were soaked in a solution of pecan oil and propyl gallate (a currently approved oil soluble antioxidant), allowed to drain for 24 hours, then held in plastic bags at ambient temperatures of approximately 60-70°F.
(CO ₂)	CO ₂ Alone	- nuts that were <i>not</i> soaked in the antioxidant but were placed in the supercritical system and exposed to supercritical CO ₂ , then stored in plastic bags at ambient temperatures of approximately 60-70°F.
(AACO ₂)	Antioxidant and CO ₂	- nuts that were soaked in the antioxidant solution, then treated with the supercritical CO ₂ that were then stored in plastic bags at ambient temperatures of approximately 60-70°F.

A second goal was to evaluate the market for value-added pecan products, both as a snack food and as an ingredient, data was collected to help understand the factors impacting consumers' willingness to purchase pecans. In addition, a profile of the frequent pecan consumer will be constructed to provide information on consumption habits and the likely acceptance of a new pecan snack product.

Project Summary and Findings

Fresh shelled pecans from the Fall 2004 harvest were obtained in late November and held in refrigerated storage (approximately 34°F) until being treated and packed for the study as described above. The treatments were carried out over approximately a two week period between January 15th and 30th of 2005.

After both 3 and 6 months of storage, the peroxide value was determined as a chemical test to determine the amount of rancidity that had developed in each treatment. The results of those tests are shown in Table 1 below.



The results presented in Table 1 indicate that the frozen control (FC) had the lowest level of rancidity as measured by the peroxide value, but that the pecans exposed to supercritical carbon dioxide alone (CO₂) were only slightly higher after 6 months of storage at room temperature. The pecans treated with the antioxidant and then exposed to the supercritical carbon dioxide (AACO₂) were the next highest with 0.36 milliequivalents of peroxide per 1000g after 6 months indicating a slightly higher level of rancidity than the frozen control or carbon dioxide treatment groups. Finally, the pecans treated with the antioxidant but not exposed to supercritical carbon dioxide (AA), and the untreated nuts that were left at room temperature (C) were both significantly higher with peroxide values of 0.72 and 0.96 respectively.

After six months storage a consumer taste panel was conducted to determine if there was a noticeable difference between the various treatments and the frozen control sample. The taste panel employed a triangle test methodology where untrained participants were presented with three unidentified samples with two being the same and one different and asked if they were able to identify the different (i.e. “odd”) sample. The results of the taste panel evaluation are presented in Table 2 below which shows for each comparison the number of participants who were able to correctly identify the single sample (CORRECT), the number who identified one of the duplicate samples as the “different” one (INCORRECT), and the number who chose the no difference selection.

Table 2: PECAN TASTE PANEL RESULTS					
SINGLE SAMPLE	DOUBLE SAMPLE		NUMBER CORRECT	NUMBER INCORRECT	NO DIFFERENCE
AACO2	FC		8	9	3
AACO2	AA		7	7	6
AACO2	CO2		3	12	5
CO2	FC		10	3	7
AA	CO2		9	4	7
FC	AA		10	5	5

While the results of the taste panel data are still being analyzed at the time of this writing, the most significant outcome seems to be in the last three comparisons where the participants were able to correctly identify the “odd” sample twice as often, or even three times as often in the case of CO2 vs. FC comparison. In addition to asking the participants to identify the different sample they were then asked to comment on what they felt the difference was. Unfortunately, when the CO2 sample was correctly identified as the different sample, the comments usually indicated that the reason it was selected was that the flavor, texture, or some other attribute was *worse* than that of the other two samples presented. This result seems contrary to the chemical data presented in Table 1 and may indicate that while the CO2 treatment is effective in preventing the development of rancidity, it may have other effects that are not perceived as positive by the consumer. This possibility will be addressed further in the discussion section below.

The other finding of note that bears reporting here is that as the pictures in Table 3 show, none of the experimental treatments had an adverse effect on the color or appearance of the pecans. In preparation for this study a sampling of commercially available pecans in one pound bags were purchased during the Fall of 2004 from local retail stores and it was observed that those pecans were frequently dry, shriveled, and very dark in appearance. The only treatment that appeared to have changed over the course of the 6 month study was the frozen control (FC) which lost some of the red or bronze color of a “fresh” pecan, and appeared more yellow in color. One of the taste panelists described the color of the FC sample as “washed out” or “faded” as compared to

the other samples. It was also interesting that even the untreated control sample (C) that was held at room temperature did not change significantly in appearance with only a slight overall darkening and the development of some subtle darker “stripes” in certain areas which are difficult to see in Table 3. There are samples of each treatment still being held in the Department of Food Science at the University of Georgia, and the appearance changes will be monitored again at 9 and 12 months of storage later this year.

Table 3: COLOR AND APPEARANCE OF THE TREATED PECANS AFTER 6 MONTHS OF STORAGE



The survey data reveals needed information pertaining to the pecan consumers. For instance, only 16 percent of the respondents reported that they have had a bad experience with pecans. Almost half of those who did have problems, indicated rancidity was the cause of their bad experience (45.9 percent). Other reasons included a flavor different than expected (20.3 percent); piece of shell in pecans (14.9 percent), color was different than expected (1.4 percent), and smaller than expected (4.1 percent).

Eighty-nine percent of the survey participants indicated they would be likely to purchase some form of pecan snack product. During the survey interview, participants were asked if they have purchased pecans for a gift, for a snack, or for cooking or baking. A follow up question was then asked as to which form of pecans they purchase for each purpose. Only 8.4 percent indicated they have purchased pecans as a gift. Less than 11 percent reported purchasing pecans as a snack and 22.5 percent for cooking and baking purposes. The majority of respondents indicated they purchase pecan halves for each use.

Survey respondents were asked several questions about how much they pay, where they purchase their pecans, and how they store them. The average price per pound of pecan halves reported was \$4.50. This reported price was much lower than the average retail price of \$9.00 per pound in 2005. The following statistics include all forms of pecans. Eighteen percent prefer to purchase pecan halves opposed to in-shell, pieces, or granules. Seventy-six percent prefer to purchase their pecans from the grocery store, and 41.6 percent reported only purchasing pecans during the holidays (Thanksgiving, Christmas, and New Years) and special occasions. Thirty-three percent responded to purchasing pecans on a regular basis throughout the year. These statistics include all forms of pecans. Survey participants were also queried on their purchase decision on snacks and snack nuts. When asked if the respondent has ever purchased a single serving snack size bag of nuts, 31.4 percent have said they have purchased almonds. Cashews were second with 22.5 percent, peanuts follow with 15.7 percent, pecans and macadamia nuts were close with 2.3 percent and 2.1 percent respectively. Other nuts mentioned were purchased at one percent or less.

Respondents were also asked how they perceived the price of snack nuts compared to other snack foods such as chips, cookies, etc. Forty-six percent felt that snack nuts were somewhat more expensive compared to other snack products. Twenty-nine percent believe that snack nuts are expensive or very expensive compared to other snack products. Survey respondents were also asked what they believed the price of pecans was compared to other snack nuts. Nearly half, 46.2 percent, of respondents felt that pecans were priced about the same as other snack nuts, with 40 percent and 6.5 percent believing they are more expensive or less expensive respectively. During the survey interview the respondents were asked where they most often purchased snack nuts. The response was a majority purchase them at the grocery store, 58.5 percent. Other responses included convenience stores, gas stations, and vending machines with the following respective percentages 22.4, 9.0, and 4.9.

When asked how often the respondents eat pecans as a snack, 35.3 percent replied they eat pecans as a snack about once a year. Only 16.8 percent said they eat pecans once a week as a snack. Fifty-seven percent reported eating roughly one handful of pecans in one sitting. An

average handful was determined to be about two ounces of pecans or about ten pecan halves. One of the objectives of the survey was to determine the demographic profile of pecan consumers. The frequent pecan consumer is older than the average American being somewhere between 35-54 years old, with the median being 52 years old which is significantly older than the U.S. population median age of 35 years. Female pecan snack consumers comprise 72 percent of the respondents. This is not surprising given that females are more likely to purchase groceries than are males. However, it is important when marketing products to take into account female perceptions of the new snack product as they appear to be the gate keeper to the family. The midpoint of the household income categories of the frequent pecan snack consumer is \$49,999 which is noticeably higher than the median for the U.S., \$41,994. The income data suggests that consumers whose household income is less than \$15,000 annually are not as likely to purchase pecans as a snack as are more affluent consumers. The income data also suggest that affluent consumers, those whose annual household income exceeds \$105,000 are more likely to purchase pecans for a snack.

From the detailed consumer survey, a model was constructed to test consumer's willingness to pay for certain pecan products. The results indicated a mean willingness to pay for a snack size pecan product was \$0.89 a bag. The mean willingness to pay indicated that the average consumer was willing to pay only about the price paid for other snack nut products.

Conclusions and Impact on the Food Industry

The technical portions of this study, while very preliminary in nature, would seem to indicate that it would be possible to increase the shelf life of pecans through chemical interventions and/or processing methods. Over the course of this 6 month study the chemical treatments showed that it may be possible to make the pecans shelf stable with further study to refine the process conditions as well as the chemicals and the concentrations employed. Of particular interest was the apparent contradiction that treating the pecans with supercritical carbon dioxide alone seemed to significantly retard the development of rancidity as measured chemically, yet taste panel results showed those pecans to be unacceptable. It seems feasible that the supercritical carbon dioxide may have extracted some of the oils from the fresh pecans which would have left less fat as a substrate for the development of rancidity, but that it may have also reduced the flavor components, or possibly even resulted in the formation of new compounds that the panelists perceived as off flavors. Treatment of the pecans with subcritical carbon dioxide may reduce the extraction of the natural flavor components, but still provide the protective effects observed in this study. As is often the case with preliminary studies of this nature, there are many new avenues of investigation indicated which appear to have potential for achieving the desired shelf stability and potential for new market opportunities.

The results of the market study portion of this project suggest that pecan consumption can be increased by introducing new pecan snack products. The market study also found that the frequent pecan consumer is an affluent older person. There is untapped potential among younger consumers. However, to tap this market, it will be necessary to produce snack products that meet these consumers' tastes and preferences. Currently, other nut products are packaged in snack

packs and sold in grocery and convenience stores across the county. Given the problem with shelf-life, pecans have not taken advantage of this market. By producing a series of value-added products focused on the convenience pack nut snack consumer and developing products that appeal to younger consumers, the pecan industry can increase its per capita consumption of pecans and capture a larger share of the marketing margin.

The Center for Agribusiness and Economic Development



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J. Scott Angle, Director