

A SENSORY ANALYSIS OF NATIVE, KANZA, AND  
PAWNEE PECANS

By

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A SENSORY ANALYSIS OF NATIVE, KANZA, AND  
PAWNEE PECANS

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Abstract:

The purpose of this study is to evaluate the appearance, texture, color, and taste of two popular Oklahoma cultivars (Kanza and Pawnee) as compared to native pecans, in a blind sensory analysis. The overall objective is to establish a set of facts regarding consumer preferences for common Oklahoma pecan varieties given the notion of native pecan flavor superiority. Through the use of hedonics, consumer ratings are given for four pecan attributes – appearances, texture, flavor, and overall satisfaction – based on sensory analysis. Crossmodal sensory effects of pecan color and size on the evaluation of flavor and the overall eating experience of pecans are determined. The study was conducted over a three-year period and asked participants to complete a survey based on a blind taste-test of three pecan samples. The data was analyzed using the ordered logit model in SAS to evaluate consumer preferences and determine hedonic scores. The results show that it is not the variety of a pecan that influences consumer preferences, but rather the appearance of the pecan and most specifically the size of the pecan. The common notion within the Oklahoma pecan industry of native pecan varieties being the preferred variety due to taste is shown to be unfounded.

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## CHAPTER I

### INTRODUCTION

Pecan production using cultivars rather than natives has a number of advantages. Cultivars produce a more consistent harvest, produce more and larger nuts that have thinner shells, and their disease resistance properties are known. For this reason, per pound of nut harvested, they are often less expensive to produce and even provide higher prices (Florkowskie and Hubbard, 1994; Warren, 2018). Cultivars are pecans whose stump and roots are grown from a seed with unknown genetics, but with a top that is grafted onto the stump that is a clone of other pecan trees and thus have known genetics. Because these clones are chosen from the best performing trees' cultivars, they also provide superior harvests. Within Oklahoma, native pecan production far surpasses the production of cultivars with 80 percent to 90 percent of total production belonging to native pecan varieties (Carrol, 2017). Native pecans are grown entirely from seed with no grafting, and thus every 'native' pecan tree is essentially a different variety with different genetics. While occasionally a single native tree may outproduce a cultivar in terms of nut size or consistency, usually natives produce inferior harvests.

However, a common belief expressed in the pecan industry is that native pecans taste better. It is common to hear sentiments akin to Worley (1994, p. 12) when he writes, "Native or seedling nuts usually have excellent flavor due in part to a high oil content, and are frequently preferred by many users." This could be the case if cultivars are chosen mostly for their yield, and if the nuts are larger then perhaps it comes at the expense of oil content within the pecans, leading

to an inferior taste. If this is true, pecan producers might consider segmenting their market, selling natives to consumers who emphasize taste and cultivars to those who prefer larger nuts with softer shells.

There is evidence that pecans with different genetics have different oil contents, and that natives can display high amounts of certain oils relative to other cultivars (but lower amounts of other oils). For example, in a study of pecans grown in Chihuahua, Mexico, native pecans had a higher oil content than the Western Schley cultivar but a lower content than the Wichita cultivar. Not only did the oil content differ across pecan types, but the composition of the oil did as well; the oil from native pecans had higher amounts of linoleic acid but lower amounts of oleic acid (Rivera-Rangel, *et. al.*, 2018).

If native pecans indeed taste better than cultivars, the higher expense and difficulties of production might be justifiable, especially if this better taste was manifested in consumer demand. There is evidence that consumers prefer native pecans. Palma, Collart, and Chammoun (2015), demonstrate that in surveys consumers prefer native pecans over ‘improved’ pecans, where ‘improved’ refers to cultivars. However, this evidence comes from a hypothetical survey where subjects were presented only with written descriptions of the pecans—no tasting, no actual pecans to visualize. Subjects were asked to choose between pecans described as ‘Native’ or ‘Improved’, where ‘Improved’ referred to cultivars. Moreover, they were asked to choose between natives or cultivars holding all other pecan attributes constant, including size. In reality, though, native pecans are considerably smaller, and while the study is certainly useful for understanding how consumers respond to the labels ‘Native’ and ‘Improved’, research using blind taste-tests is needed to see if consumers actually prefer native pecans.

Little sensory research involving taste-tests has focused on pecans, and the research that does tends to exclude native pecans. Sensory research has demonstrated that the flavor of pecans can indeed depend on the pecan genetics. Two studies (Magnuson, Kelly, and Reid, 2016; Silva



*et. al.*, 1995) showed that different cultivars do have different flavor profiles, but they also remark that environmental conditions probably played a larger role than genetics. Their study did not include native pecans and used a trained sensory panel of 6-12 individuals. Trained sensory analysts have a much keener sense of taste than the ordinary consumer, and it is not clear if ordinary consumers can even discern among different pecan types. Their decision to exclude natives is understandable. Given that all native pecan trees are different, it is difficult to gauge what the results would mean if they were included. The Kanza cultivar in Georgia has identical genetics as a Kanza in Oklahoma, but two native pecan trees on the same farm may have a vastly different genetic profile, even if those two trees shared the same mother. However, one trait shared by almost all native trees is that the nuts are smaller. If there is a relationship between nut size and taste, then sensory analysis might detect differences among natives and cultivars.

This is important, for if consumers do not actually prefer the taste of native pecans, and if they were made aware of this, then producers would be able to increase production of cultivars and decrease the production of native pecans to the benefit of consumers and the pecan industry. Thus we ask: do raw native pecans taste better than popular, raw cultivars like Kanza and Pawnee? Moreover, given the other possible differences in raw pecan attributes such as size and texture, how do natives and cultivars differ? The purpose of this study is to evaluate the appearance, texture, color, and taste of two popular Oklahoma cultivars (Kanza and Pawnee) as compared to native pecans, in a blind sensory analysis.

### Terminology

To be precise about the nature of the tests conducted in this study, the following short glossary might be helpful to some readers.

- Native pecans—pecans acquired from trees that were the result of natural reproduction and not cloning, such that the exact genetics of the trees are unknown.
- Cultivar—pecans acquired by cloning a donor tree. Because the clones contain identical genetics its genetic profile is known.
- Kanza cultivar—a cultivar developed by crossing the Major and Shoshoni cultivars in 1996. (<https://pecanbreeding.uga.edu/cultivars/alphabetical-list/kanza.html>)
- Pawnee cultivar—a cultivar created in 1963 by crossing the Mohawk and Starking Hardy Giant cultivar.
- Crossmodal effects—when one sensory variable like appearance affects other sensory variables like taste/flavor.
- Taste-test—a sensory experiment where subjects are asked to evaluate a food product and report its sensory characteristics. Unless otherwise noted, ‘taste-test’ in this paper is assumed to be a blind taste-test where the subject does not know the variety of the pecan being tasted, and there are no labels or information associated with the pecan other than a generic identifier. Although ‘taste’ is defined by scientists to be the result of taste-bud sensations only, absent of olfactory sensations, in this study ‘taste’ is actually the equivalent of ‘flavor’, meaning the psychological appraisal of a food resulting from all sensory inputs.

## Objectives

The overall objective is to establish a set of facts regarding consumer preferences for different pecan varieties, as a complement to the anecdotes circulated informally within the pecan industry. Given the common notion that native pecans are superior in taste to cultivars, one objective is to determine whether consumers do prefer natives over cultivars in blind taste tests.

Given that various pecan genetics may be superior in some attributes and inferior in others, pecans are evaluated in terms of their appearance, texture, flavor, and overall satisfaction. The first taste-test experiments suggested a major role in the appearance of pecans, so the objectives in subsequent tests were refined to concentrate on the various ways by which appearance impacts consumer appeal. After all tests were complete the two specific questions answered are as follows.

1. How do consumers rate the appearance, texture, flavor, and overall satisfaction of native pecan varieties and the Kanza and Pawnee cultivars?
2. What are the crossmodal sensory effects of pecan color and size on the evaluation of flavor and the overall eating experience of pecans?

## CHAPTER II

### MATERIALS AND METHODS

This study was conducted over a three-year period, each year using raw pecans from the previous year's harvest that had been in cold storage, with all the pecans coming from the same Oklahoma farm. Subjects were asked to participate in a blind taste-test of raw Kanza, Pawnee, and native pecans. They were given three containers labeled only with a shape (see background picture in Figure 1). Each container contained two pecans, chosen mostly randomly. The pecans were placed in a container and shaken, after which pecans were randomly chosen. So long as the pecan was not obviously inferior in some way, it was used. If it had a distinctly different color from the other pecans of the same variety, or was broken, it was not used. Thus, the pecans used to represent each pecan type were generally representative of the pecans from that farm in that year.

The exact materials and methods used to achieve the aforementioned objectives evolved throughout the study, with the results of one taste-test informing the design of subsequent tests over the three years the study was conducted. The initial taste-test suggested consumer disapproval with the native pecans compared to the Kanza and Pawnee cultivars. This was surprising, as it countered the common notion in the pecan industry that natives taste better. Suspecting that the smaller size of natives may be a reason, subsequent taste-tests were then designed to focus on how appearance altered sensory perceptions. Although there were five different taste-test experiments conducted over the three-year period, four of these closely

resemble one another, so the five experiments are described here as two different studies.

### Study 1 Design

The first taste test (test 1.a in Figure 1) was conducted at an elementary school during a teacher workday. A free lunch was provided to 49 teachers in return for participating in the taste-test prior to the lunch. The test was administered by providing each subject with a tray containing an unsalted cracker, water, pen, questionnaire, napkins, and a plate containing three containers. Each container contained one of the three pecan types: natives, Kanza, or Pawnee. Each container was identified only by a shape; the container with a square contained two Kanza pecans, the triangle two Pawnee pecans, and the circle two native pecans, though the subject did not know the relationship between the shapes and pecan varieties. These containers are shown in the background picture of Figure 1. The instructions required the subject to taste each pecan in the following order: triangle, circle, then square. Before tasting each pecan, though, they were asked to take a bite from the unsalted cracker and take a sip of water to cleanse their palate.

<b>Overview of Taste-Test Experiments</b>		
Study 1	Randomization of pecan order?	Preparation of cultivars?
1.a) 49 taste-tests at an elementary school in fall of 2016	No	All whole
1.b) 47 tests in various focus groups in fall of 2016	No	All whole
1.c) 99 tests in 1907 Meat Co. in December 2016	No	All cut in half
1.d) 112 tests in 1907 Meat Co. restaurant in June 2017	Yes	Some whole, some cut in half
<b>Study 2</b>		
2) 99 tests in 1907 Meat Co. in spring of 2018.	Yes	All whole

*Hedonic scales for appearance, texture, flavor, and overall satisfaction*

*Measures of pecans' color, length, and width. Hedonic scales for color, size, flavor, and overall satisfaction*

Figure 1. Overview of Taste-Test Experiments

Before tasting each sample, the subject was asked to rate the appearance of the pecans using the hedonic scale (Stone, 2012) shown below, where 1 = dislike extremely, and 9 = like extremely. They then proceeded to taste the pecan and rate its texture, flavor, and overall eating equality using the same hedonic scales, shown below. All pecan samples were whole pecans screened to be free of abnormal blemishes or marks. A series of focus groups regarding pecans was also being conducted at the time, where the subjects completed the same taste test at the beginning of the session, producing 47 additional observations in study 1.b.

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a TRIANGLE shape and rate the extent to which you like its appearance. After that, taste the pecan and rate its texture, flavor, and your overall satisfaction with it.										
<b>Pecan TRIANGLE</b>	<b>Appearance</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
	<b>Texture</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Flavor</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Satisfaction with overall eating quality</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 2. Example of Study 1 Survey Design

As will be discussed shortly, the subjects give higher hedonic scores to the cultivars relative to the native pecans for all four categories, even in regards to flavor, which was unexpected. Although it could be that the native pecans actually do have an inferior flavor, it was also observed that the native pecans were considerably smaller in size, leading us to wonder whether the smaller size had a crossmodal effect whereby a less visually appealing pecan was also perceived to have a less appealing flavor. Such crossmodal effects are so prevalent in sensory studies (Spence, 2017) that one generally assumes they are present unless evidence suggests otherwise.

A third test (1.c) was performed to determine whether the natives' flavor scores would be improved if the Kanza and Pawnee cultivars were of a smaller size. The idea was that perhaps the natives looked less appealing than the cultivars, causing an inferior perceived flavor. If there is such a relationship between appearance and reported flavor then making the cultivars less visually appealing would increase the flavor scores for natives. This test was identical to 1.a and 1.b except that it was conducted in the 1907 Meat Co. restaurant, and the two cultivars were cut

in half, making them smaller and irregularly shaped, which is presumably less visually appealing. As will be shown, this improved the perceived attractiveness, flavor, and overall eating satisfaction of the natives considerably, even though nothing about the natives had changed. It thus appeared that making the cultivars look less appealing improved the reported flavor of native pecans.

To further test the crossmodal relationship between the appearance and flavor scores, a fourth test (1.d) was conducted. The assignment of shapes to pecan types, and thus the order in which the varieties were tasted, were not randomized in the previous three tests because different groups of students assisted in the experiments and the methods had to be kept simple to prevent confusion. This might present a bias, if the order in which pecans are evaluated impacts their scores. For the fourth test only one trained assistant was used, allowing us to randomize the order in which the pecans were evaluated. Subjects were randomly allocated to one of six ordering treatments, with the treatments representing all the possible orders in which the three pecans can be evaluated. Also, the subjects were randomly assigned to one of two treatments: in one treatment the cultivars were left whole and in the other the cultivars were cut in half. Once again, the data suggest that natives receive higher flavor scores when the cultivars are cut in half relative when they are left whole, suggesting that the appearance of pecans is a major driver of pecan flavor and overall likeability. As evidence increasingly pointed to a crossmodal effect between appearance and flavor, a second study was conducted that not only measured the likeability of a pecan's appearance, but measures of its color and size.

## Study 2 Design

To further explore the relationship between the appearance and reported flavor of pecans a second study was conducted. Much about the taste tests were the same. It was conducted at a



similar location, using similar materials. Cultivars were never cut in half, and the pecan’s color, length, and width were measured. Length and width were objectively measured using grid paper where one unit is equivalent to 1/8 of an inch. Color was measured using the subjective scale shown below, where subjects indicated the brownness of the color on a scale of 1 = very light brown to 7 = very dark brown.

The questionnaire used, shown below, first asks the subject to describe the color of the pecan in terms of very light to very dark brown. Then they were asked to provide hedonic scores indicating how much they like the pecans’ color, size, flavor, and overall eating quality. Whereas Study 1 elicited hedonic scores for appearance, texture, flavor, and overall eating quality, Study 2 acquired scores for the color of the pecan and the size of the pecan, in addition to flavor and overall satisfaction.

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a TRIANGLE shape and indicate its color and the degree to which you like its color and size. After that, taste the pecan and rate its flavor and your overall satisfaction with it.

<b>Pecan TRIANGLE</b>	<b>The pecan's color appears to be</b>		Very light brown	Light brown	Somewhat light brown	Between light and dark brown	Somewhat dark brown	Dark brown	Very dark brown		
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<b>Do you like the COLOR?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>SIZE?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>FLAVOR?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Satisfaction with overall eating quality</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Figure 3. Example of Study 2 Survey Design

Descriptive statistics of these length and width measurements, as well as subjective evaluations of color, are shown in Figure 4 below. Measurements from a sample of 99 pecans of each variety showed that natives are indeed smaller than the cultivars. The Pawnee cultivar is the largest in terms of both length and width. Kanza is slightly longer than native pecans but 32% wider. All pecans were evaluated to be in the light brown range, with Pawnee being the darkest and Kanza being the lightest.

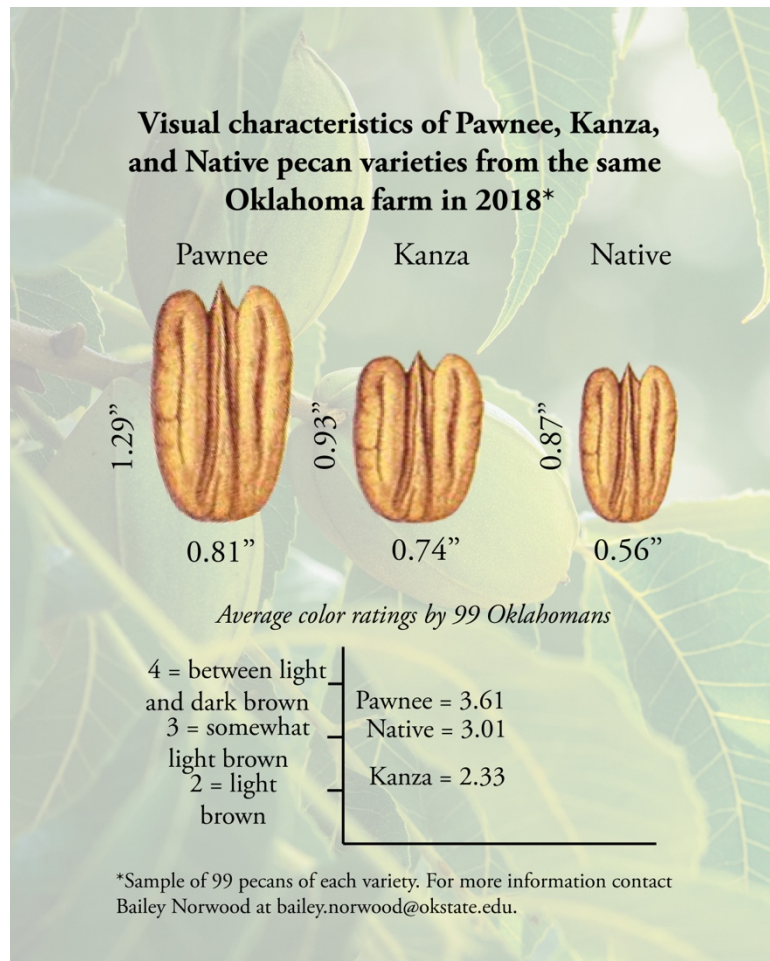


Figure 4. Visual Characteristics of Pecan Varieties

## CHAPTER III

### EMPIRICAL MODELS

#### Study 1 Empirical Model

To analyze how consumer preferences and eating habits influenced the hedonic scores of the pecans, data analyzed using the ordered logit model in SAS. The hedonic scores are reported in discrete integers from 1 to 9, but the actual likeability of the pecan for person  $i$  and pecan type  $j$  (e.g., native, Kanza, Pawnee) in terms of attribute  $k$  (e.g., appearance, flavor) is assumed to be represented by a latent (meaning unobserved) and continuous variable  $U_{ijk}$ .

Referred to generically as utility,  $U_{ijk}$  is assumed to behave according to (1), where  $V_{ijk}$  is the deterministic portion of utility and  $\varepsilon_{ijk}$  is a stochastic error distributed according to the standardized logistic distribution.

$$(1) U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_{1k}(KANZA_{ijk}) + \beta_{2k}(PAWNEE_{ijk}) + \beta_{3k}(TREATMENT_{ijk}) + \beta_{4k}(KANZA_{ijk})(TREATMENT_{ijk}) + \beta_{5k}(PAWNEE_{ijk})(TREATMENT_{ijk}) + \beta_{6k}(NORANDOM_{ijk}) + \varepsilon_{ijk}$$

The variables are as follows.  $KANZA$  ( $PAWNEE$ ) are indicator variables that equal one if pecan  $j$  is a Kanza (Pawnee) cultivar and zero otherwise. If pecan  $j$  is sampled in a context where the Kanza and Pawnee pecans are cut in half then the  $TREATMENT$  indicator variable equals one. Recall that in experiment 1.d (see Figure 1) the order in which the pecans are sampled is randomized, so that there is no ordering bias present for these 112 observations. To account for any ordering bias in tests 1.a – 1.c the indicator variable  $NORANDOM$  equals one if the

observation was from 1.a, 1.b, or 1.c, and zero otherwise. Some normalization is required for the parameters to be estimated, so the deterministic portion of utility for native pecans, when  $TREATMENT = NORANDOM = 0$ , is normalized to equal zero.

Preferences for cultivars relative to native pecans are then evaluated by predicting the average utility for each pecan type. Consider the predicted utility for Kanza, and recall that the utilities for natives are normalized to zero for the cases where all cultivars are whole. The coefficient  $\beta_{1k}$  indicates how hedonic scores for Kanza cultivars differ relative to natives for the  $k^{\text{th}}$  attribute. If positive and statistically significant, and if  $k = 1$  refers to appearance, then the subjects on average report a higher likeability for the appearance of Kanza relative to natives, as the utility of natives is zero. If  $k = 3$  refers to flavor then Kanza has a more likeable flavor relative to natives.

This is for the case where  $TREATMENT = 0$ , meaning the cultivars are whole. If the cultivars are cut in half, meaning  $TREATMENT = 1$ , then the predicted utility for natives now becomes  $\beta_{3k}$ . If  $\beta_{3k}$  is positive and statistically significant then cutting the cultivars in half increases the predicted score for natives. Whether Kanza is preferred to natives when Kanzas are cut in half can then be tested by testing the null hypothesis  $\beta_{1k} + \beta_{4k} = 0$  relative to the alternative hypothesis that it is positive.

$$(2) \text{ Predicted utility for Kanza} = \beta_{1k} + \beta_{4k}(TREATMENT_{ijk}) + \beta_{3k}(TREATMENT_{ijk})$$

$$(2) \text{ Predicted utility for Pawnee} = \beta_{2k} + \beta_{5k}(TREATMENT_{ijk}) + \beta_{3k}(TREATMENT_{ijk})$$

$$(2) \text{ Predicted utility for Natives} = \beta_{3k}(TREATMENT_{ijk})$$

## Study 2 Empirical Models

The second study uses measurements of the pecans' color, length, and width to investigate the role of appearance in taste perceptions. The first study suggests that pecan appearance is the major driver of pecan preferences. If appearance is the only driver, then

information on the size and color of the nut might contain all the information needed to predict hedonic scores. This is tested by first specifying a model where the width, height, and color of the pecan are the only attributes explaining hedonic scores, as shown in (1) below. In (1), the variables *WIDTHPECAN* and *HEIGHTPECAN* is the actual width and height of the pecans where a value of eight equals one inch. The variable *COLORPECAN* is the subjective evaluation of the brownness of the pecan by the subject on a scale of 1 = very light brown to 7 = very dark brown.

Model 1

$$(1) U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_{1k}(WIDTHPECAN_{ijk}) + \beta_{2k}(HEIGHTPECAN_{ijk}) + \beta_{3k}(COLORPECAN_{ijk}) + \varepsilon_{ijk}$$

Model 1 has the potential problem of multicollinearity between the width and height of the nuts. Longer nuts also tend to be wider, so pecan width and height are correlated (correlation = 0.68). This means that information on the width also contains information on the height, and so estimations might not be able to separate the effects of width versus height. Model 2 thus creates one size variable *AREAPECAN* which equals *WIDTHPECAN \* HEIGHTPECAN*.

Model 2

$$(1) U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_{1k}(AREAPECAN_{ijk}) + \beta_{2k}(COLORPECAN_{ijk}) + \varepsilon_{ijk}$$

As suggested in Figure 4 there are distinct differences in the size of the three pecan varieties. While the actual size of each variety varies across individual nuts, any one Pawnee is usually larger than any one Kanza, and any one Kanza is usually larger than any one native. For example, three standard deviations below the mean of the area of the Pawnee variety is larger than three standard deviations above the mean of the area of the native variety, testifying that the

Pawnee is virtually always larger than a native. Thus, information on the pecan variety already contains information on the pecan size, and so Model 3 is specified to capture this.

Model 3

$$(1) U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_{1k}(KANZA_{ijk}) + \beta_{2k}(PAWNEE_{ijk}) + \varepsilon_{ijk}$$

If indicator variables for pecan variety already contain information on pecan size, the adding information on the size of the pecan to Model 3 should provide no additional information, and thus we specify Model 4 as well.

Model 4

$$(1) U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_{1k}(AREAPECAN_{ijk}) + \beta_{2k}(COLORPECAN_{ijk}) + \beta_{3k}(KANZA_{ijk}) + \beta_{4k}(PAWNEE_{ijk}) + \varepsilon_{ijk}$$

Estimates of the four models are used to describe how preferences for pecans vary with size measurements, color measurements, and information on pecan variety. The main hypothesis test concerns Model 4 applied to overall satisfaction. If the size of the pecan is the only determinant of pecan preferences, then for overall satisfaction (1)  $\beta_{1k}$  will be statistically significant and  $\beta_{3k}$  and  $\beta_{4k}$  will not (2)  $\beta_{1k}$  will be insignificant and  $\beta_{3k}$  and  $\beta_{4k}$  will be statistically significant, or (3) all three variables will be statistically insignificant due to multicollinearity. However, if  $\beta_{1k}$ ,  $\beta_{3k}$ , and  $\beta_{4k}$  are all statistically significant, then both the size of the pecan and the pecan variety provide information on the eating experience provided, and there are differences in the pecans' variety other than size and color.

## CHAPTER IV

### RESULTS

#### Study 1 Results

There was a total of 307 subjects in Study 1 and 99 subjects in Study 2. If a participant was under the age of 18, their observations were omitted from the data. Any observations that were incomplete were also omitted from the data. This resulted in 294 subjects in Study 1 and 99 subjects in Study 2. The data was analyzed in SAS and results were produced for the predicted utilities of native pecan varieties and Kanza and Pawnee cultivars in regards to each attribute – appearance, texture, flavor, and overall satisfaction.

The model estimates for Study 1 are shown below. While the coefficients measure the unobserved latent utility and are thus difficult to interpret, a positive coefficient indicates a higher hedonic score, meaning a more likeable evaluation of the attribute. A negative coefficient indicates the opposite, meaning a less likeable pecan. Here, only coefficients with p-values less than 0.05 are considered statistically different from zero; all other coefficients are interpreted to be, zero. All coefficients are statistically significant except the *NORANDOM* variables, suggesting that there is no ordering bias for tests 1.a, 1.b, and 1.c. The significance of the other coefficients suggests differences between the pecan varieties across all four attributes, and that sensory perceptions change even for natives when the Kanza and Pawnee varieties are cut in half.

For all four attributes—appearance, texture, flavor, and overall satisfaction—the coefficients for Kanza and Pawnee are statistically significant and positive, indicating that the

subjects preferred the two pecan cultivars over native pecans on all four dimensions. The coefficient for *PAWNEE* was larger than *KANZA* for appearance, suggesting that the Pawnee was favored in terms of appearance. The coefficient for *KANZA* was greater than *PAWNEE* for the remaining three attributes, suggesting Kanza has a superior flavor. However, likelihood ratio tests (see Table 2) for the null hypothesis that  $\beta_{1k} - \beta_{2k} = 0$  cannot be rejected at the 5% level across all attributes. Thus, Kanza and Pawnee cultivars are superior to natives, but subjects are indifferent between the two cultivars.

The coefficient for *TREATMENT* is statistically significant and positive for all attributes, indicating that natives receive higher likeability ratings when they are being compared to the halved cultivars. The fact that native pecans are given a higher likeability rating for their appearance when compared to the cultivars suggests that the hedonic scores being measured are not absolute appraisals but are easily influenced by contrasting them with nuts of varying appearances. Also, the fact that native pecans have a higher rating for texture and flavor when the cultivars are halved suggests a crossmodal effect whereby an improved appearance produces a more likeable eating experience.

**Table 1. Ordered Logit Model Estimates for Study 1**

Variable	Attribute			
	<i>Appearance</i>	<i>Texture</i>	<i>Flavor</i>	<i>Overall Satisfaction</i>
	Parameter Estimates (p-values)			
$\beta_{1k}(\text{KANZA}_{ijk})$	1.795 (0.00)	0.826 (0.00)	0.897 (0.00)	1.192 (0.00)
$\beta_{2k}(\text{PAWNEE}_{ijk})$	2.145 (0.00)	0.526 (0.01)	0.623 (0.00)	0.944 (0.00)
$\beta_{3k}(\text{TREATMENT}_{ijk})$	0.768 (0.00)	0.394 (0.06)	0.797 (0.00)	0.812 (0.00)
$\beta_{4k}(\text{KANZA}_{ijk})(\text{TREATMENT}_{ijk})$	-1.119 (0.00)	-0.811 (0.01)	-1.262 (0.00)	-1.163 (0.00)
$\beta_{5k}(\text{PAWNEE}_{ijk})(\text{TREATMENT}_{ijk})$	-1.050 (0.00)	-0.619 (0.04)	-1.067 (0.00)	-1.013 (0.00)
$\beta_{6k}(\text{NORANDOM}_{ijk})$	-0.088	0.036	-0.223	-0.167



	(0.49)	(0.78)	(0.08)	(0.19)
<b>Threshold Parameters</b>				
$\eta_1$	-4.1915	-6.3782	-5.7667	-6.2158
$\eta_2$	-3.3861	-5.2763	-4.5055	-4.8234
$\eta_3$	-2.2017	-3.5225	-3.1655	-3.4158
$\eta_4$	-0.9087	-2.3410	-2.1934	-2.1810
$\eta_5$	-0.2356	-1.5051	-1.5110	-1.4123
$\eta_6$	0.5084	-0.6996	-0.5681	-0.4146
$\eta_7$	1.5515	0.5107	0.6338	0.8629
$\eta_8$	3.4347	2.5996	2.1287	2.7007

---

The coefficients for  $(KANZA)(TREATMENT)$  and  $(PAWNEE)(TREATMENT)$  are statistically significant and negative for all attributes, meaning that the cultivars receive less favorable ratings when they are halved. This is not surprising for appearance, but why would they have a worse flavor when halved? As before, this might be a crossmodal effect, but another reason might be that subjects are consuming less total pecans and thus experience less flavor. When comparing whole pecans the subjects preferred the cultivars to the natives, but what about when the cultivars are halved? The likeability of the Kanza cultivar relative to the native pecans when the Kanza is halved can be assessed by the value of  $\beta_{1k} + \beta_{4k}$ ; if positive, Kanzas are preferred to natives. Table 2 shows that the null hypothesis  $\beta_{1k} + \beta_{4k} = 0$  is rejected at the 5% level for appearance, and since the value of the estimates  $\hat{\beta}_{1k} + \hat{\beta}_{4k}$  is  $1.795 - 1.119 = 0.676$ , the appearance of Kanza pecans is superior to that of natives even when the Kanzas are halved. The same can be said for Pawnee pecans relative to natives. This is surprising, and it is not clear why this would be the case. Even though the cultivars are smaller they are still wider, so perhaps wideness is still preferred by subjects even if they have an unusual shape. In regard to texture and overall satisfaction, when the cultivars are halved statistical tests show that the subjects are

indifferent between the three pecan types in terms of overall satisfaction. However, when the Pawnee is halved and the natives are not, the natives are deemed to display a superior flavor.

**Table 2. Hypothesis Tests for Study 1**

Null Hypothesis	Attribute			<i>Overall Satisfaction</i>
	<i>Appearance</i>	<i>Texture</i>	<i>Flavor</i>	
$\beta_{1k} - \beta_{2k} = 0$	Fail to reject	Fail to reject	Fail to reject	Fail to reject
$\beta_{1k} + \beta_{4k} = 0$	Reject	Fail to reject	Fail to reject	Fail to reject
$\beta_{2k} + \beta_{5k} = 0$	Reject	Fail to reject	Reject	Fail to reject
$\beta_{1k} + \beta_{4k} - \beta_{2k} - \beta_{5k} = 0$	Reject	Fail to reject	Fail to reject	Fail to reject

Notes: Tests are conducted using likelihood ratio tests to compare ordered logit estimates with and without the parameter restrictions. The null is rejected if the p-value is less than 0.05, making the probability of a Type I Error less than 5%.

Next consider how Kanza and Pawnee varieties compare to one another when they are both halved. For example, if the value of  $\beta_{1k} + \beta_{4k} - \beta_{2k} - \beta_{5k}$  is positive then they prefer the Kanza, and if negative they prefer the Pawnee. As Table 2 shows the null hypothesis that this expression is zero is only rejected in terms of appearance, and for appearance the value is negative, indicating the appearance of Pawnee is preferred, presumably due to its larger size.

Figure 5 below provides a more aesthetically pleasing illustration of the results. These are the average hedonic scores for each of the three pecan types in the two treatments. They are the simple averages, and not a prediction from the ordered logit model. Notice first that all of the scores are in the ‘like’ side of the hedonic scale, meaning on average the subjects like all three pecan types. Second, notice how the appearance of natives improves considerably when they are

compared to halved cultivars, whereas the average score for Pawnee’s appearance is virtually unchanged and the Kanza’s appearance falls somewhat. Third, observe how the texture, flavor, and overall likeability improves for natives when the cultivars are halved. When the cultivars are whole the native has the lowest flavor rating, but attains the highest flavor rating when the cultivars are halved. Finally, consider how the subjects overall prefer Kanza to Pawnee and Pawnee to natives when the cultivars are whole, but when the cultivars are halved the scores are virtually indistinguishable. These results further illustrate the finding that the appearance of a pecan is not only important to the consumer, but also impacts their evaluation of other attributes of the pecans as well.

**Average Hedonic Scores for Cultivar (Kanza and Pawnee) and Native Pecans in Study 1**

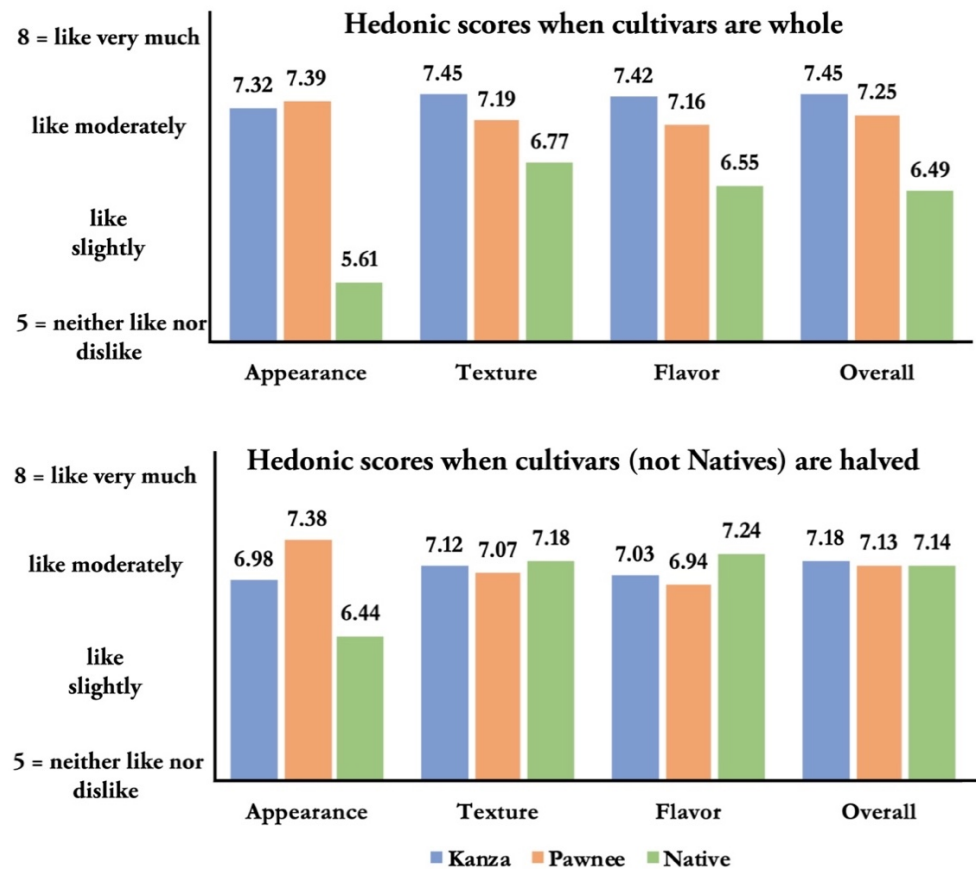


Figure 5. Average Hedonic Scores in Study 1

In summary, considering both the ordered logit results and the average scores, Study 1 shows that when native pecans are evaluated alongside whole Pawnee and Kanza cultivars, subjects prefer the two cultivars in terms of appearance, texture, flavor, and overall satisfaction, and are largely indifferent between the two cultivars. When the cultivars are halved they are still preferred in terms of appearance, but not necessarily flavor. In all instances the texture and overall satisfaction are not statistically different between the three pecan types, when the cultivars are halved. Finally, the native pecans' scores improved on all attributes when the cultivars it was compared to were halved.

## Study 2 Results

There was a total of 99 participants in Study 2, resulting in 297 individual observations. There were no participants under the age of 18 and there were no incomplete observations within the data. The data was analyzed in SAS and results used to acquire the predicted utilities of native pecan varieties and Kanza and Pawnee cultivars in regards to each attribute – color, size, flavor, and overall satisfaction.

The model estimates for Study 2 are shown below. Four different models are estimated, and each model considered different explanatory variables associated with the three pecan varieties and four different attributes – color, size, flavor, and overall satisfaction.

## Model 1

The first model contained three variables – *WIDTHPECAN*, *HEIGHTPECAN*, and *COLORPECAN*. The height and width of each pecan sample was measured before administering the survey to the participants, and the color of each pecan sample was determined by the survey participant. For all four attributes, the coefficients for *COLORPECAN* were insignificant, indicating that the color of a pecan does not influence the sensory evaluations of attributes. The coefficients for *HEIGHTPECAN* were insignificant for all attributes except size, suggesting that the height of a pecan only influences subjects' pecan size preference. For all four attributes, the coefficients for *WIDTHPECAN* were significant, indicating that the width of a pecan influences subjects' preferences of color, size, flavor, and overall satisfaction.

The regression shows pecan width matters but not height. However, a wider pecan may also tend to be a taller pecan, such that width is a proxy for height. If this is the case then the regression may not be able to tease apart the impact of width versus height, implying that one matters but the other one does not, even though in reality both may matter.

## Model 2

If width and height are both reasonable proxies for size, it may be best to combine them into one size variable. With this in mind, the second model contained two variables – *AREAPECAN*, and *COLORPECAN*. The area of each pecan sample was calculated by multiplying the measured height and width of the pecan, and the color of each pecan sample was determined by the survey participant. For all four attributes, the coefficients for *COLORPECAN* were insignificant, while the coefficients for *AREAPECAN* were significant. Similarly to the first model, the second model indicates that the color of a pecan does not influence subjects' sensory evaluations.

In the first model, the coefficients for *WIDTHPECAN* were significant across all attributes and the coefficients for *HEIGHTPECAN* were only significant for the size attribute. When those two variables are multiplied together to create a new variable – *AREAPECAN* – the dimensions of a pecan become significant for all four attributes.

### Model 3

The three different varieties all have distinct size and color characteristics. It might be that information on the variety explains the important details about the pecan size and color, such that once the variety is known the length and width measurements do not provide any additional useful information. Thus, the third model contains two variables – *KANZA* and *PAWNEE* – allowing the regression to estimate preferences based on distinct pecan variety characteristics. The two variables represent the Kanza and Pawnee pecan cultivars, and if the pecan being evaluated is a native then both of the variables were zero. Both the *KANZA* and *PAWNEE* variables have positive and significant coefficients for size and overall satisfaction. Since the native pecans are reflected in the intercept of the model, the coefficients for *KANZA* and *PAWNEE* represent how much more subjects preferred those cultivars over the natives. This shows that when compared to native varieties, Kanza and Pawnee cultivars were preferred in their size and considered superior overall to natives.

### Model 4

The fourth model contained four variables – *AREAPECAN*, *COLORPECAN*, *KANZA*, and *PAWNEE* – ultimately considering individual pecan characteristics along with distinct variety characteristics. If the pecan being evaluated was a native then both the *KANZA* and *PAWNEE*

variables were zero. Throughout the entire model, the coefficients for *COLORPECAN* are insignificant and the entire attribute of color preference is insignificant. Whether or not the pecan being evaluated was a Kanza or Pawnee cultivar or a native did not influence the model. The most significant variable observed in the model was *AREAPECAN*, indicating that the larger the pecan, the more it is preferred by subjects when considering the size, flavor, and overall satisfaction attributes. This model shows that the size of a pecan is the only thing that really matters, not the variety – apart from the impact of variety on size – meaning if a native happened to be the same size as a Pawnee the two pecans would be equally preferred.

**Table 3. Ordered Logit Model Estimates for Study 2**

Variable	<i>Color</i>	Attribute		
		<i>Size</i>	<i>Flavor</i>	<i>Overall Satisfaction</i>
Parameter Estimates (p-values)				
<b>Model 1</b>				
$\beta_{1k}(WIDTHPECAN_{ijk})^a$	0.3585 (0.0195)	0.9333 (0.00)	0.3922 (0.0107)	0.4730 (0.0023)
$\beta_{2k}(HEIGHTPECAN_{ijk})$	-0.0586 (0.5163)	0.4509 (0.00)	0.0119 (0.8952)	0.1501 (0.1001)
$\beta_{3k}(COLORPECAN_{ijk})^b$	-0.1183 (0.1680)	0.00845 (0.9219)	-0.0699 (0.4146)	-0.1272 (0.1410)
<b>Model 2</b>				
$\beta_{1k}(AREAPECAN_{ijk})$	0.0139 (0.0368)	0.0927 (0.00)	0.0228 (0.0007)	0.0398 (0.00)
$\beta_{2k}(COLORPECAN_{ijk})$	-0.1485 (0.0733)	-0.0339 (0.6832)	-0.1080 (0.1921)	-0.1546 (0.0641)
<b>Model 3</b>				
$\beta_{1k}(KANZA_{ijk})^c$	0.6546 (0.0102)	1.6609 (0.00)	0.4691 (0.0642)	0.7610 (0.0030)
$\beta_{2k}(PAWNEE_{ijk})^c$	0.4819 (0.0574)	3.4098 (0.00)	0.6300 (0.0134)	1.2414 (0.00)
<b>Model 4</b>				
$\beta_{1k}(AREAPECAN_{ijk})$	0.0124 (0.4350)	0.0718 (0.00)	0.0463 (0.0042)	0.0584 (0.0004)
$\beta_{2k}(COLORPECAN_{ijk})$	-0.1095 (0.2138)	0.00723 (0.9348)	-0.0752 (0.3934)	-0.1199 (0.1764)
$\beta_{3k}(KANZA_{ijk})$	0.4426 (0.1884)	0.7424 (0.0319)	-0.2032 (0.5459)	-0.0838 (0.8045)
$\beta_{4k}(PAWNEE_{ijk})$	0.1087 (0.8605)	0.9514 (0.1304)	-0.9937 (0.1106)	-0.7805 (0.2125)

<sup>a</sup> All area measurements are in units of 1/8 of an inch.

<sup>b</sup> Color is determined by the subject according to a 1-7 scale where 1 = very light brown and 7 = very dark brown.

<sup>c</sup> Kanza and Pawnee are indicator variables designating the pecan variety. If both Kanza and Pawnee are zero the pecan is a native.

### Average Hedonic Scores from Cultivar (Kanza and Pawnee) and Native Pecans in Study 2

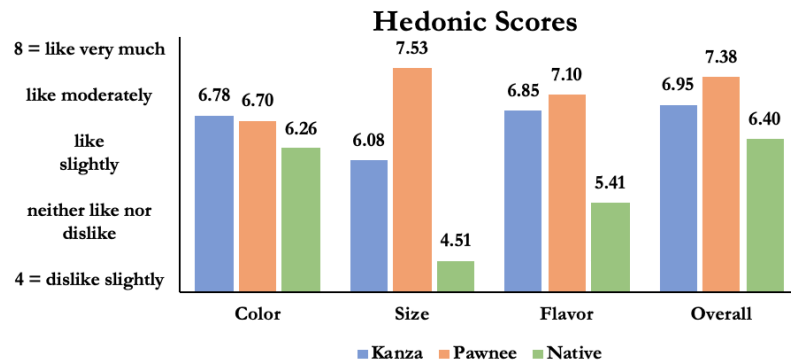


Figure 6. Average Hedonic Scores in Study 2

The average hedonic scores for each of the three pecan types and all four attributes are shown in Figure 6. The values are simple averages and not predicted values from the ordered logit models. Notice first there is only one instance where a pecan type was not on the ‘like’ side of the hedonic scale; the size of native pecans were, on average, neither liked nor disliked. This shows an indifference of preference by the subjects when considering the typically smaller size of a native pecan. Second, the attribute that had the least difference in ratings for the three pecans was color. This shows, similarly to the ordered logit results, the preference of a pecan variety in terms of color does not differ much across the three varieties. Third, Pawnee ratings for size were dramatically higher than Kanza, and Kanza ratings were also dramatically higher than native ratings. Recall that on average, Pawnee pecans are much larger than Kanza pecans, and Kanza pecans are larger than native pecans. These hedonic ratings of size indicate that the larger the



pecan variety, the more it is preferred. This observation is present in the flavor and overall satisfaction ratings with Pawnee being the most preferred, followed by Kanza and then native. As with the results from Study 1, these results illustrate that the appearance of a pecan is highly influential in a consumer's evaluation of other attributes. However, these results indicate that more specifically it is the size of a pecan and not the color that most strongly influences a consumer's evaluation of appearance and rating of other attributes.

In summary, considering both the ordered logit results and the average scores, Study 2 shows that when the appearance of the pecans is evaluated based on two attributes – color and size – both the Pawnee and Kanza cultivars are preferred over the native varieties in all categories. For color, there is little difference in preference across the three pecan types, suggesting that the color of a pecan is not very important to a consumer. There are large differences seen in the ratings of size, with Pawnee being the most preferred and native being the least. This is also the case for flavor and overall satisfaction. This suggests that while appearance is a deciding factor in consumer preferences, it is more specifically the size of a pecan that matters the most.

## CHAPTER V

### CONCLUSION

Native varieties are not the preferred pecan in blind taste-tests when compared to Kanza and Pawnee cultivars. Furthermore, while both Kanza and Pawnee are preferred over natives, both cultivars are liked about the same. The data suggests that appearance is the most influential attribute when considering consumer preferences, with Kanza and Pawnee being more visually appealing. When considering different characteristics of pecan appearance, it is the size of the pecan, not the color, that matters the most to the consumer. Specifically, the larger a pecan is, the more satisfied the consumer is overall.

Through these studies, the common notion within the Oklahoma pecan industry of native pecan varieties being the preferred variety due to taste is shown to be unfounded—in blind taste-tests of raw pecans, at least. This may not be the case with actual pecan purchases if the pecans are labeled by variety. It was mentioned earlier that Palma, Collart, and Chammoun (2015) found that in hypothetical settings consumers say they prefer pecans labeled ‘Native’ over cultivars labeled ‘Improved’. Just as appearance seems to influence flavor via a cross-modal effect, so could the pecan name. Knowing a pecan is labeled native could induce the consumer to rate its flavor higher even though in blind taste-tests that is not the case. What this study suggests is that, if consumers do prefer raw native pecans, it probably has more to do with the pecan’s name than any real differences in the pecan itself.

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## APPENDICES

### Appendix A – Instrument Used for Study 1:

#### **PARTICIPANT INFORMATION OKLAHOMA STATE UNIVERSITY**

- **Please accept this free lunch from the Department of Agricultural Economics in recognition of your valuable contribution to the community.**
- **We invite you to help us by participating in a free pecan taste-test.**
- **But your participation is purely voluntary. Please accept the free lunch regardless of whether you participate.**
- **Only volunteer to participate if you are sure you are not allergic to pecans.**
- **These are regular pecans purchased from a local supplier and were not modified in any way. There is no more risk from eating these pecans than pecans purchased in a store.**
- **At no point do we ask for your name or any contact information, so your information is completely anonymous.**
- **If you begin the taste-test you are welcome to stop at any time.**
- **If you decide to help us by performing the activity, just follow the directions on this questionnaire, and let us know if you have any questions.**
- **Once you have completed the activity please hand this questionnaire to the researcher.**
- **Thank you!**

If you have questions about this [research](#) please contact Bailey Norwood at [bailey.norwood@okstate.edu](mailto:bailey.norwood@okstate.edu) or 405-744-9820.

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or [irb@okstate.edu](mailto:irb@okstate.edu)

→→→→ Proceed to next page to begin taste-test→→→→

**If you choose to participate in this activity**, we would first like you to evaluate the three pecans in front of you, one at a time.

## Step 1

Please take a sip of water and a bite from the unsalted cracker, to cleanse your palate. Then observe the pecan labeled with a SQUARE shape and rate the extent to which you like its appearance. After that, taste the pecan and rate its texture, flavor, and your overall satisfaction with it.

<b>Pecan SQUARE</b>	<b>Appearance</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Texture</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Flavor</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Satisfaction with overall eating quality</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

## Step 2

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a CIRCLE shape and rate the extent to which you like its appearance. After that, taste the pecan and rate its texture, flavor, and your overall satisfaction with it.

<b>Pecan CIRCLE</b>	<b>Appearance</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
	<b>Texture</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Flavor</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Satisfaction with overall eating quality</b>										



### Step 3

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a TRIANGLE shape and rate the extent to which you like its appearance. After that, taste the pecan and rate its texture, flavor, and your overall satisfaction with it.

<b>Pecan TRIANGLE</b>	<b>Appearance</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Texture</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Flavor</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<b>Satisfaction with overall eating quality</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

## Step 4

Please answer the following questions to the best of your ability.

Gender: \_\_\_\_\_

Age: \_\_\_\_\_

How often do you consume pecans?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

How often do you eat whole pecans, not as part of a food recipe?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

How often do you eat pecans as part of a food recipe, like pie, cereal, granola, or muffins?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

Please provide examples of foods you consume that contain pecans.

**PARTICIPANT INFORMATION**  
**OKLAHOMA STATE UNIVERSITY**

- **Please accept this free lunch from the Department of Agricultural Economics in recognition of your valuable contribution to the community.**
- **We invite you to help us by participating in a free pecan taste-test.**
- **But your participation is purely voluntary. Please accept the free lunch regardless of whether you participate.**
- **Only volunteer to participate if you are sure you are not allergic to pecans.**
- **These are regular pecans purchased from a local supplier and were not modified in any way. There is no more risk from eating these pecans than pecans purchased in a store.**
- **At no point do we ask for your name or any contact information, so your information is completely anonymous.**
- **If you begin the taste-test you are welcome to stop at any time.**
- **If you decide to help us by performing the activity, just follow the directions on this questionnaire, and let us know if you have any questions.**
- **Once you have completed the activity please hand this questionnaire to the researcher.**
- **Thank you!**

If you have questions about this [research](#) please contact Bailey Norwood at [bailey.norwood@okstate.edu](mailto:bailey.norwood@okstate.edu) or 405-744-9820.

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or [irb@okstate.edu](mailto:irb@okstate.edu)

→→→ Proceed to next page to begin taste-test→→→

**If you choose to participate in this activity,** we would first like you to evaluate the three pecans in front of you, one at a time.

## Step 1

Please take a sip of water and a bite from the unsalted cracker, to cleanse your palate. Then observe the pecan labeled with a SQUARE shape and indicate its color and the degree to which you like its color and size. After that, taste the pecan and rate its flavor and your overall satisfaction with it.

<b>Pecan SQUARE</b>	<b>The pecan's color appears to be</b>		Very light brown	Light brown	Somewhat light brown	Between light and dark brown	Somewhat dark brown	Dark brown	Very dark brown		
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<b><u>Do you like the COLOR?</u></b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>SIZE?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>FLAVOR?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Satisfaction with overall eating quality</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

## Step 2

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a CIRCLE shape and indicate its color and the degree to which you like its color and size. After that, taste the pecan and rate its flavor and your overall satisfaction with it.

<b>Pecan CIRCLE</b>	<b>The pecan's color appears to be</b>		Very light brown	Light brown	Somewhat light brown	Between light and dark brown	Somewhat dark brown	Dark brown	Very dark brown		
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<b><u>Do you like the COLOR?</u></b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>SIZE?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>FLAVOR?</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Satisfaction with overall eating quality</b>		Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

### Step 3

Please take a sip of water and a bite from the unsalted cracker. Then observe the pecan labeled with a TRIANGLE shape and indicate its color and the degree to which you like its color and size. After that, taste the pecan and rate its flavor and your overall satisfaction with it.

<b>Pecan TRIANGLE</b>	<b>The pecan's color appears to be</b>	Very light brown	Light brown	Somewhat light brown	Between light and dark brown	Somewhat dark brown	Dark brown	Very dark brown		
	<b>Do you like the COLOR?</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
	<b>SIZE?</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
	<b>FLAVOR?</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
	<b>Satisfaction with overall eating quality</b>	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely



## Step 4

Please answer the following questions to the best of your ability.

Gender: \_\_\_\_\_

Age: \_\_\_\_\_

How often do you consume pecans?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

How often do you eat whole pecans, not as part of a food recipe?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

How often do you eat pecans as part of a food recipe, like pie, cereal, granola, or muffins?

- Almost every day
- At least once a week
- At least once every two weeks
- At least once a month
- At least once a year
- Rarely
- Never

Please provide examples of foods you consume that contain pecans.

Appendix C – Institutional Review Board Research Approval:

**Oklahoma State University Institutional Review Board**

Date: Friday, September 23, 2016  
IRB Application No AG1632  
Proposal Title: Sensory evaluation of pecan varieties

Reviewed and Exempt  
Processed as:

**Status Recommended by Reviewer(s): Approved Protocol Expires: 9/22/2019**

Principal Investigator(s):  
F. Bailey Norwood  
426 Ag Hall  
Stillwater, OK 74078

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The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,



Hugh Crethar, Chair  
Institutional Review Board

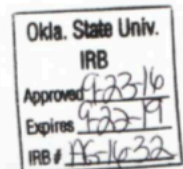
**PARTICIPANT INFORMATION  
OKLAHOMA STATE UNIVERSITY**

- Please accept this free lunch from the Department of Agricultural Economics in recognition of your valuable contribution to the community.
- We invite you to help us by participating in a free pecan taste-test.
- But your participation is purely voluntary. Please accept the free lunch regardless of whether you participate.
- Only volunteer to participate if you are sure you are not allergic to pecans.
- These are regular pecans purchased from a local supplier and were not modified in any way. There is no more risk from eating these pecans than pecans purchased in a store.
- At no point do we ask for your name or any contact information, so your information is completely anonymous.
- If you begin the taste-test you are welcome to stop at any time.
- If you decide to help us by performing the activity, just follow the directions on this questionnaire, and let us know if you have any questions.
- Once you have completed the activity please hand this questionnaire to the researcher.
- Thank you!

If you have questions about this research please contact Bailey Norwood at [bailey.norwood@okstate.edu](mailto:bailey.norwood@okstate.edu) or 405-744-9820.

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or [irb@okstate.edu](mailto:irb@okstate.edu)

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VITA

Gianna Ricci

Candidate for the Degree of

Master of Science

Thesis: A SENSORY ANALYSIS OF NATIVE, KANZA, AND PAWNEE PECANS

Major Field: Agricultural Economics

Biographical:

Education:

Completed the requirements for the Master of Science in Agricultural Economics at Oklahoma State University, Stillwater, Oklahoma in May, 2020.

Completed the requirements for the Bachelor of Science in Agribusiness at Oklahoma State University, Stillwater, Oklahoma in 2018.

Experience:

Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, 2018-2020

Teaching Assistant, Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, 2016-2018