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Shape Influence on Consumers' Willingness to Purchase Jujube Fruit

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Abstract
Agricultural producers diversify their operations to reduce vulnerabilities to market and weather fluctuations. Agriculture producers in New Mexico often search for profitable, water efficient alternative crops and have shown interest in jujube fruit. A sensory evaluation determined consumer preferences of dried jujube based solely on the shape of the sample. An ordered probit regression model analyzed the data to determine the willingness to purchase. The analysis showed more than half of the participants were overall likely to purchase and had a clear preference for the circular shaped sample jujube fruit. This evidence supports jujube as a successful alternative crop.

Key Words: Value-added, agriculture, consumer behavior, alternative crop, New Mexico, marketing, ordered probit model.

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Introduction and Background

In 2018, the majority (58.2%) of farms in New Mexico were less than 100 acres in size and 78.3% of all New Mexico farms had annual sales of less than $9,999 (Agriculture, Economic Research Service, 2020). The small scale of production in New Mexico contributes to the diverse range of commodities grown in the state. New Mexico's top five commodities by cash receipts are dairy products, cattle and calves, miscellaneous crops, pecans, and hay (Agriculture, Economic Research Service, 2020). The miscellaneous crops category includes grains and a variety of fruits, vegetables, nuts, and nursery products.

New Mexico's climate is semi-arid due to low humidity, low precipitation, abundant sunshine, and large annual and diurnal temperature ranges. Water availability is also important for the state's agriculture sector. Current drought conditions, water distribution to urban, industrial, and recreation usage, and obligations to provide water to Texas are all growing issues

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of public concerns. Water concerns provide producers greater incentives to use irrigation allocations efficiently while maintaining profitability (Ward, Michelsen and DeMouche, 2003). Jujube trees grow well under existing conditions and could provide both producers and consumers in New Mexico new opportunities.

The jujube is a cold-hardy ornamental tree, native to China, where it has been cultivated for over 4,000 years, produces a drupe fruit, shown in Figure 1, which has a pit. After 1908, jujube cultivars were distributed to USDA experiment stations in Texas, New Mexico, Oklahoma, Georgia, and Florida. Upon further study, it was found to produce well in the southwest due to the climate, plentiful sunshine, and the ability to develop fruit after a late bloom, reducing late frost hazards. Unlike some fruit trees, jujubes are very precocious, and certain cultivars can bear fruit the same year as planting or grafting. Jujube trees come to full maturity after four to five years and can produce anywhere from 40 to 100 pounds of fruit (Yao, 2012).

Figure 1. Jujube Fruit – Shuman cultivar

Jujubes have successfully produced fruit in New Mexico State University experiment orchards in the past eight years. Jujube trees are extremely drought resistant and cultivation is simple (Mishra and Krska, 2017). This crop could be a good alternative to increase New Mexico's orchards' yields and profitability without expending large amounts of resources. In 2017, there were only about 1,796 acres of fruit orchards in New Mexico. The state's orchard fruit industry has declined since 2002, from 1,991 bearing acres for indicated crops as shown in Figure 2, to 982 bearing acres (Agriculture, Quick Stats 2020). Jujube trees provide a viable crop option for New Mexico agriculture producers looking to diversify their operations.

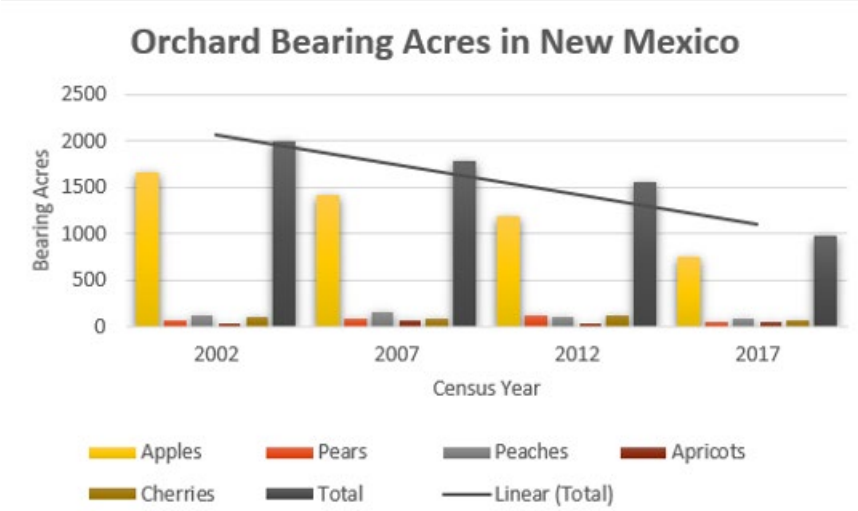

Figure 2. Decline of Orchard Bearing Acres in New Mexico from 2002 to 2017

Even though jujubes were introduced from Europe to the United States in 1837, they are a relatively new-to-market fruit and consumer preferences have not yet been fully assessed. Jujube producers will need to extend their marketing window to allow consumers time for exploration and incorporation of the fruit into their diets. Marketability of jujube is somewhat limited as it can only be stored refrigerated for approximately 14 days (Yao, 2012). Recognizing this limitation, it is necessary to explore alternative preserving methods to extend marketability of this new-to-market fruit. Worldwide, jujube's uses include as a candied or smoked fruit; as an ingredient in juice, jam, wine, mixed beverages, powders, and teas; and, after drying, as a substitute for raisins and dates (Mishra and Krska, 2017). Drying extends the shelf life of the fruit for at least a year, depending on the drying type, and does not have a significant negative effect (loss) of nutrients (Mishra and Krska, 2017). Since this fruit does have a pit, there are a limited number of ways to cut the fruit before drying. Determining consumer preference for the shape of dried jujube will provide jujube producers information about consumer preferences as well as give them direction for investment decisions about processing equipment.

Consumers have specific preferences, and these preferences are important to know when marketing a product. Previous marketing research has shown product shape directly influences consumer purchases of both food and non-food products. *Different Roles of Product Appearance in Consumer Choice* showed aesthetics influenced 65% of their subjects to select a product based on attractive appearance (Creusen and Schoormans, 2004). Additionally, *Completeness Heuristic: Product Shape Completeness Influences Size Perceptions, Preference, and Consumption* showed people prefer completely shaped items because they are perceived to have more quantity (Sevilla and Kahn, 2014). Shape can even affect how a consumer perceives flavor of a product. More recently in the article, *Hedonic Mediation of the Crossmodal Correspondence Between Taste and Shape* (Velasco, et al., 2015), a correlation was shown between circular shape and sweetness, offering essential information when marketing a new dried fruit.

Sensory evaluations are commonly used to gather information on preferences for food products. Sensory evaluation is science that measures, analyzes, and interprets reactions of people to products as perceived by the senses (Stone, 2018). This approach uses a representative

sample of consumers in order to gain information to be applied to a larger population. The primary objective of this study is to evaluate significant factors determining consumer decision to purchase dried jujube fruits using sensory evaluation data.

Methodology

Mature jujubes, Sherwood cultivar, were obtained from NMSU's Agricultural Science Center at Los Lunas, NM. Fruits had seeds removed, and then were cut into one of three different shapes: circular, diced and crosscut, Figure 3. Samples were oven-dried in a preheated convection oven at 60° C for 12 hours and stored in quart bags at room temperature. Later, the sample shapes were sorted and placed into color coded small sample cups: red for circular; blue for diced; and green for crosscut.

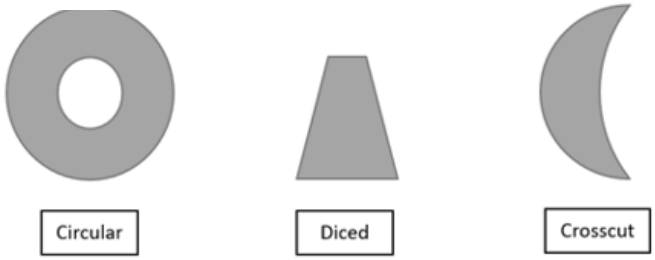

Figure 3. Three Shapes for Jujube Sensory Test

The sensory evaluation was conducted in the Tejada Food Lab at New Mexico State University in a sensory room with 4 seats. The room was climate controlled (around 70 °F) and neutral lights were used to prevent bias on perception of the sample. There were 121 samples in this evaluation; most signed up via SignUpGenius.com and selected a time slot for a particular day during the experiment. A consent form and latex allergy notice was provided to participants electronically. Each participant responded to online survey prompts and received randomized samples. Unsalted crackers and water were distributed to participants to cleanse their palates between sample tastings.

Survey Instrument

The Internal Review Board of NMSU approved this research and survey. The survey consisted of 40 questions and an attention check question. Respondents took between 8-15 minutes to answer questions about corresponding samples. Each participant responded to a randomized sample of jujube and ranked the following attributes: sweetness, flavor, texture, after-taste, chewiness and overall liking based on a five-point Likert Scale identified as: 1- dislike a great deal; 2- dislike somewhat; 3- neither like nor dislike; 4- like somewhat; 5 - like a great deal. Each respondent also ranked their overall willingness to purchase each sample using a Likert Scale of 1-extremely unlikely to 5-extremely likely.

Following completion of the taste test, respondents were asked to answer questions about their shopping habits and demographics. Participants were asked how often they consumed fresh fruit and vegetables on a scale of infrequently, once a week, twice a week, three times or more a week, once a day, or three times a day. Demographic questions included gender, age, race, income, education, and marital status. Table 1 shows participant demographics in percentages.

Survey demographics show the majority of the participants in this sensory evaluation were white (61%), unmarried (83%), female (68%), students (51%), in the age range of 18-24 years old (75%) and had a household income of less than $19,999 (40%).

Table 1. Survey Demographics

	Total Sample	Percentage
Race	n=121	
White	74	61.29%
Black or African American	2	1.61%
American Indian or Alaska Native	6	4.84%
Asian	4	3.23%
Native Hawaiian or Pacific Islander	1	0.81%
Other	34	28.23%
Age		
18-24	92	75.81%
25-34	20	16.94%
35-44	5	4.03%
45-54	4	3.23%
55 or older	0	0.00%
Gender		
Male	38	31.45%
Female	83	68.55%
Annual Household Income		
Less than $19,999	48	40.32%
$20,000 - $39,999	33	27.42%
$40,000 - $59,999	15	12.10%
$60,000 - $79,999	14	11.29%
$80,000 - $99,999	1	0.81%
$100,000 or greater- $119,999	10	8.06%
Education		
Less than high school	2	1.61%
High school graduate	12	9.68%
Some college	62	51.61%
2-year degree	17	13.71%
4-year degree	19	16.13%
Professional degree	8	6.45%
Doctorate	1	0.81%
Marital Status		
Married, Widowed, Divorced, Separated	20	16.13%
Never married	101	83.87%

Model

An ordered probit model was chosen as the methodology for empirical analysis since the choice alternatives do not have an exact value but instead represented an underlying interval scale. After tasting the dried jujube samples, the study participants expressed their intent to buy using a five-point ordinal Likert Scale ranging from extremely unlikely (1) to extremely likely (5). Following Green and Hensher (2009), we specify an ordered probit model which accounts for the natural ordering of the dependent variable to estimate the consumer's jujube purchase decision function (Daykin and Moffatt, 2002; Green and Hensher, 2009).

$$y_i^* = \beta' X_i + \varepsilon_i \quad (1)$$

Where y_i^* is the underlying latent variable reflecting respondent *i*'s intent to purchase and consume the fruit; β' is a vector of unknown parameters to be estimated; *X* is the vector of explanatory variables including survey participant's sensory evaluations of dried jujube attributes (chewiness, aftertaste, flavor, texture, and sweetness), fruit purchase and consumption behavior (fresh and dry fruits purchase), the shape of dried fruits (circular, crosscut, and diced), and demographic variables (gender, race, education, income, marital status); and ε_i is a normally distributed random error term.

Since y_i^* is an unobserved latent variable, the model is estimated using its observed counterpart y_i. The relationship between y_i^* and y_i is:

$$\begin{aligned} &y=1 \quad \text{if} \quad y* < \mu_1 \\ &y=2 \quad \text{if } \mu_1 < y* < \mu_2 \\ &y=3 \quad \text{if } \mu_2 < y* < \mu_3 \\ &y=4 \quad \text{if } \mu_3 < y* < \mu_4 \\ &y=5 \quad \text{if } \mu_4 < y* \end{aligned} \quad (2)$$

Where y = 1, 2, 3, 4, or 5 to identify the likelihood to purchase as being extremely unlikely, somewhat unlikely, neither likely nor unlikely, somewhat likely, or extremely likely. The μ_i's are threshold parameters (or cut points). Assuming that the error term in equation (1) is normally distributed, the probabilities of consumer purchase intentions can be expressed as:

$$Prob[y = j] = \Phi(\mu_j - \beta' x) - \Phi(\mu_{j-1} - \beta' x). \quad j=1, 2, \ldots, 5. \quad (3)$$

The threshold parameters μ_j are estimated along with other unknown parameters (β') by maximum likelihood estimation (Greene and Hensher, 2009). Some of the recent studies use ordered probit models to examine consumer food choices (Jiang, et al. 2017; Keogh, Li and Gao, 2019; Nguyen and Solgaard 2017), country of origin labeling (Ehmke, Lusk and Wallace, 2008; DeLong and Grebitus, 2016), food security (Maitra and Rao, 2015) (Nkegbe, Abu and Issahaku, 2017), and poverty (Kingdon and Knight, 2006; Maitra and Rao, 2015)

Results

The summary statistics of the variables used in the regression analysis are presented in Table 2. The table also includes the proportion of respondents who are 'extremely unlikely' (0.13) to 'extremely likely' (0.15) to purchase the fruit. The results show that about 55% of the respondents are likely or extremely likely to buy dried jujube. Among the five attributes

evaluated, the most liked quality of jujube is the sweetness (3.81) followed by flavor (3.67), after taste (3.36), texture (3.28), and chewiness (3.04). The sample also includes 2% of respondents who do not currently purchase fresh fruits and vegetables and 29% who consume dried fruits at least weekly.

Table 2. Summary of Statistics of Variables

Variable	N	Mean	Std Dev.	Min	Max
Likelihood of buying dried jujube	363	3.25	1.29	1	5
Extremely unlikely (%)		0.13			
Somewhat unlikely (%)		0.20			
Neither unlikely nor likely (%)		0.12			
Somewhat likely (%)		0.40			
Extremely likely (%)		0.15			
Flavor	363	3.67	1.22	1	5
Chewiness	363	3.04	1.24	1	5
After Taste	363	3.36	1.19	1	5
Texture	363	3.28	1.25	1	5
Sweetness	363	3.81	1.08	1	5
Gender (female)	363	.69	.46	0	1
Race (white)	363	.61	.49	0	1
Education (>12 years)	363	.88	.32	0	1
Income (>$40,000)	363	.31	.46	0	1
Marital status (married)	363	.13	.34	0	1
Do not buy fresh produce	363	.02	.13	0	1
Consume dry fruits weekly	363	.29	.45	0	1
Crossed Cut	363	.33	.47	0	1
Circular	363	.33	.47	0	1

The ordered response model (equation 1) was estimated using ordinary least squares (OLS), ordered logit, and ordered probit models for comparison, and the results are presented in Table 3. The R^2 (OLS) and Pseudo R^2 (ordered logit and probit models) are relatively high, indicating a good model fit. As expected, the magnitude of parameters from the three models is very different. However, the sign and level of significance of the coefficients are similar except for a few variables – sweetness, race, education, income, and marital status. Most variables of interest are significant in the probit model. Therefore, discussion going forward will focus on results from the ordered probit model.

The empirical results show that all five coefficients associated with the jujube attributes are positive, and four of them are statistically significant. Although the study participants liked the sweetness of the dried jujube the most, as indicated by its highest average score of 3.81, it is not one of the significant factors affecting consumer purchase decisions. Based on their statistical significance and the magnitude of parameter estimates, the most crucial jujube attribute that motivates consumers to purchase is its flavor followed by chewiness, after taste, and texture.

Only four of the five demographic variables included in the model are statistically significant. In particular, gender has no impact on purchase decisions, and the coefficients of the race and education variables are significant only at the 10% level. Results show whites are less

likely to purchase dried jujube than the non-white population. Similarly, a significantly negative sign of education variable indicates that people with more than two years of college-level education are less likely to purchase jujube.

Table 3. Ordered Response Model Results

	(1) OLS	(2) Logit	(3) Probit
Flavor	0.304***	0.696***	0.392***
	(0.071)	(0.164)	(0.090)
Chewiness	0.236***	0.679***	0.368***
	(0.050)	(0.134)	(0.072)
After Taste	0.221***	0.656***	0.349***
	(0.054)	(0.136)	(0.075)
Texture	0.179***	0.401***	0.253***
	(0.051)	(0.130)	(0.071)
Sweetness	0.082	0.311*	0.136
	(0.071)	(0.165)	(0.093)
Gender (female)	-0.094	0.045	-0.053
	(0.097)	(0.240)	(0.136)
Race (white)	-0.107	-0.499**	-0.240*
	(0.091)	(0.241)	(0.133)
Education (>12 years)	-0.250	-0.501	-0.402*
	(0.157)	(0.389)	(0.220)
Income (>$40,000)	-0.360***	-0.668**	-0.462***
	(0.108)	(0.274)	(0.147)
Marital status (married)	0.499***	0.843**	0.688***
	(0.166)	(0.420)	(0.233)
Do not buy fresh produce	0.942***	2.989***	1.717***
	(0.136)	(0.583)	(0.355)
Consume dry fruits weekly	0.154	0.588**	0.314**
	(0.097)	(0.263)	(0.142)
Shape: Crossed Cut	-0.025	-0.053	-0.020
	(0.109)	(0.266)	(0.151)
Circular	0.185*	0.587**	0.340**
	(0.102)	(0.263)	(0.149)
μ_1		5.142***	2.605***
		(0.901)	(0.490)
μ_2		7.487***	3.899***
		(0.971)	(0.520)
μ_3		8.547***	4.491***
		(1.016)	(0.540)
μ_4		12.325***	6.632***
		(1.173)	(0.606)
Sample size (N)	363	363	363
Pseudo R^2	0.63	0.34	0.34

Note: Standard errors are in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

The coefficients of the household income and marital status variables are highly significant. Results indicate that participants with more than $40,000 annual income are less likely to purchase the dried jujube than the participants with lower income. On the other hand, study respondents who are married are more likely to buy the fruit.

Both of the fruit purchase behavior variables included in the model are significant and carry a positive sign. In particular, those who do not consume or purchase fresh fruits and vegetables are more likely to purchase dried jujube than those who consume fresh produce. Moreover, those who are currently consuming dried fruits at least once a week are more likely to buy dried jujube than those who do not.

The study participants evaluated three different shapes of dried jujube – diced, crosscut, and circular. The model includes two shape dummies for controlling the impact of circular and crosscut shapes on purchase intentions. Circular shape is significantly positive, implying that consumers prefer dried jujube that is circular than diced or crosscut.

Discussion and Conclusion

The results show flavor is the most crucial factor in determining the purchase decision followed by chewiness, after taste, and texture. Although most participants liked the sweetness of the fruit, it has no impact on their purchase decision. Only circular shape is significantly positive, implying higher demand for circular-shaped, dried jujube fruits as compared to those that are diced or crosscut. This study shows participants were, overall, willing to purchase oven-dried jujube fruit. Results indicate that jujube growers should produce jujube varieties that receive higher taste test scores on flavor, chewiness, after taste, and texture. This also shows that 'food shape does matter' and consumers consider the shape in making their purchase decisions.

Among the five socio-demographic variables evaluated in the study, race (white), education, and income are negatively associated with jujube purchase decisions. Since jujube is a relatively unknown commodity in New Mexico (and the U.S.), marketing campaigns mainly targeted to Caucasian, college graduates (> 2 years of college), and those with higher disposable income (>$40,000) are likely to boost demand. The results also show that participants who do not currently consume fresh fruits and vegetables and those who consume dried fruits at least once a week are more likely to buy jujube, indicating a significant opportunity for producers to expand their market reach.

This study expands on current research and discussions of consumer behavior and influence of shape on overall perceptions of food products. It also shows potential for increased marketing of an alternative New Mexico crop by beginning to examine expansion of the jujube supply chain through value-added processing. This will provide direction to the type of processing equipment for cutting and drying necessary to meet the demands of consumers. Overall, data from the sensory evaluation better prepares New Mexico producers who decide on this alternative crop by providing additional detail and direction as to how to effectively market dried jujube.

References

Agriculture, United States Department of. 2020. *Economic Research Service.* May 13. https://data.ers.usda.gov/reports.aspx?StateFIPS=35&StateName=New%20Mexico&ID=17854.

—. 2020. *Quick Stats.* April. https://quickstats.nass.usda.gov/results/DDCA8A4C-50A3-372D-8111-CADB83C8E984.

Creusen, Marielle E.H., and Jan P.L Schoormans. 2004. "The Different Roles of Product Appearance in Consumer Choice." *Journal of Product Innovation Management* 63-81.

Daykin, Anne R., and Peter G. Moffatt. 2002. "Analyzing Ordered Responses: A Review of the Ordered Probit Model." *Understanding Statistics* 157-166. doi:10.1207/S15328031US0103_02.

DeLong, Karen, and Carola Grebitus. 2016. "Why U.S. Consumers Support Country of Origin Labeling: Examining the Impact of Ethnocentrism and Food Safety." *International Food & Agribusiness Marketing* 1-17. doi:10.1080/08974438.2015.1110548.

Ehmke, Maria D., Jayson L. Lusk, and Tyner Wallace. 2008. "Measuring the relative importance of preferences for country of origin in China, France, Niger, and the United States." *Agricultural Economics, 38* 277-285. doi:10.1111/j.1574-0862.2008.00299.x.

Green, William H., and David A. Hensher. 2009. *Modeling Ordered Choices.* New York: Stern School of Business.

Jiang, Yuan, LIsa A. House, Hyeyoung Kim, and Susan S. Percival. 2017. "Zero-inflated ordered probit approach to modeling mushroom consumption in the United States." *International Food and Agribusiness Management Review, 20, 5.* doi:10.22004/ag.econ.266410.

Keogh, Cian, Chenguang Li, and Zhifeng Gao. 2019. "Evolving consumer trends for whey protein sports supplements: the Heckman ordered probit estimation." *Agriculture and Food Economics 7.* doi:10.1186/s40100-019-0125-9.

Kingdon, Geeta Gandhi, and John Knight. 2006. "Subjective well-being poverty vs. Income poverty and capabilities poverty?" *The Journal of Development Studies* 1199-1224. doi:10.1080/00220380600884167.

Maitra, Chandana, and D.S. Prasada Rao. 2015. "Poverty–Food Security Nexus: Evidence from a Survey of Urban Slum Dwellers in Kolkata." *World Development* 308-325. doi:10.1016/j.worlddev.2015.03.006.

Mishra, Saket, and Boris Krska. 2017. "Value Addition, Sensory, and Evaluation of Jujube Products." *International Journal of Pure & Applied Bioscience* 540-547. doi:10.18782/2320-7051.3093.

Nguyen, Thong Tien, and Hans Stubbe Solgaard. 2017. "Consumer's food motives and seafood consumption." *Food Quality and Preference 56* 181-188. doi:10.1016/foodqual.2016.10,008.

Nkegbe, Paul Kwame, Benjamin Musah Abu, and Haruna Issahaku. 2017. "Food security in the Savannah Accelerated Development Authority Zone of Ghana: an ordered probit with household hunger scale approach." *Agriculture & Food Security.* doi:10.1186/s40066-017-0111-y.

Sevilla, Julio, and Barbara E. Kahn. 2014. "The Completeness Heuristic: Product Shape Completeness Influences Size Perceptions, Preference, and Consumption." *Journal of Marketing Research.* doi:10.1509/jmr.12.0153.

Stone, Herbert. 2018. "Example food: What are its sensory properties and why is that important?" *Science of Food.* doi:10.1038/s41538-018-0019-3.

Velasco, Carlos, Andy T. Woods, Ophelia Deroy, and Charles Spence. 2015. "Hedonic mediation of the crossmodal correspondence between taste and shape." *Food Quality and Preference* 151 - 158. doi:10.1016.

Ward, Frank A., Ari Michelsen, and Leeann DeMouche. 2003. *Institutional Barriers to Water Conservation in the Rio Grande Basin.* Las Cruces: New Mexico State University College of Agricultural, Consumer, and Environmental Sciences.

Yang, Chin W., and Rod. D Raehsler. 2005. "An Economic Analysis on Intermediate Microeconomics: An Ordered Probit Model." *Journal for Economic Educators.*

Yao, Shengrui. 2012. *Jujube: Chinese Date in New Mexico.* Las Cruces: New Mexico State University College of Agriculture, Consumer, and Environmental Sciences.