Pricing Quality Attributes at the Wholesale Level*

by

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Statement of Problem

As fresh fruits and vegetables move through the food distribution system, changes occur in the quality of the produce. A recent report on produce losses (Pierson, et al.) estimated that between 9.04 percent and 16.61 percent of the dollar value of U.S. produce was lost in 1977 in the transportation, wholesaling, and related stages of the food distribution process. This loss, including the decline in the quality of the produce, accounted for a lost value of between $.64 to $1.26 billion.

Efforts to improve handling methods during the postharvest stage have produced large investments in packaging and equipment by participants in the food distribution chain. While the costs of new handling methods or techniques can generally be determined prior to investment, the benefits to industry participants are less readily apparent. A method is required to aid the produce industry in determining the value of changes in the food distribution process.

Objectives

This paper reports on the initial findings of an interdisciplinary project aimed at providing a method of evaluating the price benefits to shippers and wholesale-distributors of changes in the handling of fresh produce. To accomplish this objective, this study estimated the value of selected quality characteristics of fresh snap beans at the wholesaler-distributor level represented by the Atlanta Terminal Market. Knowing the value of quality attributes of snap beans will enable the wholesaler to better evaluate whether a new handling method or technology will produce benefits above costs.

Snap beans were selected for study based on economic importance, perishability, handling difficulty, and regional production. Principles developed studying snap beans will have general applicability to other fruits and vegetables.[1] Since snap beans are highly perishable, handling at the wholesale level can affect quality. Snap beans are susceptible to injury due to warm temperatures as well as chilling injury (russeting). Snap beans should be stored in a narrow range of temperature from 3^{0} to 6^{0}C (38^{0} to 42^{0}F) and should be kept at about 90 percent relative humidity. Physical injury during handling can occur by pods rubbing against each other, by machine harvesting and during rough transport, and by the rubbing of pods against rough containers (Ryall and Lipton; Salunkhe and Desai). Further, the perceived quality of snap beans is affected by color, where a yellowish color is the sign of senescence. Consequently, bean quality plays an important role in the price received at the wholesale level.

Methodology

In order to estimate the price of quality characteristics of snap beans, 1) quality measurements of snap beans were collected at the Atlanta Terminal Market, and; 2) those measurements were used in a hedonic price function to estimate prices for selected characteristics.

Seven lots of snap beans were sampled at five wholesale locations (produce dealers or food chain warehouses) in Atlanta area over a two-day period in May, 1984. A sample consisting of 1.5 to 2 pounds was collected from eight randomly selected boxes from each lot (one to two pallets packed and shipped from the same locations) and placed in a plain brown paper sandwich bag. Wholesale prices (prices paid to the wholesaler by the retail outlet were recorded for each lot. The observed prices were those market clearing prices on the day of sampling. Each of the seven lots represented a different price level, ranging from $10.35 to $16.10. This reflects the operation of many of the fresh markets where there is variation in the independent variables and less variation in the dependent variable.[2] Quality measure-

ments included damage, color, firmness, maturity and storability. Since the hedonic price function attempts to isolate the effect of quality on price, the samples were taken in a two-day period so that market changes over time would not affect the observed prices.

Damage was measured for each box as the percent of snap beans with evident defects as described in USDA grade standards. Color measurements were obtained using an 8-point circumferential measurement with a Gardner colorimeter. Maturity was measured using a shear press and storability was measured by the change in bean color when stored for six days at 70^{0}F.

At the time of price determination, the wholesaler does not know the exact rate of deterioration, six days hence. However, through industry surveys, it is known that expected shelf life is an important factor in price determination at the wholesale level. There exists no accurate prediction for shelf life however, based on physical or chemical measures at one point in time. The only way to include shelf life in the study is to measure the deterioration over a storage period and include that measurement in an equation. A Pearson product-moment correlation was carried out to determine the correlation between price and all quality variables. Those strongly related to price were then included in the statistical analysis based on biological knowledge and statistical inference. There was a stronger correlation between price and the color difference measure than between price and any single color measurement. It appears that an information mechanism, based on the past performances of suppliers, growers, and location of production, exist so that retailers can predict shelf life when determining prices. This information-feedback mechanism, while evident, is not quantifiable. Consequently, the color different measure was used as the best method to include shelf life in the equation.

The hedonic price function used to estimate the price of quality characteristics is a regression technique that assumed the price of a commodity is affected by the level of

some bundle of attributes. The simple hedonic model can be stated:[3]

$$P_i = P(X_{ij}; \varepsilon_i)$$

where:

P_i = the observed price of commodity i

X_{ij} = the amount of some quality characteristic j per unit of i.

ε_i = error term.

The coefficients that result from the regression equation are the marginal implicit prices of the quality characteristics. In essence, what is estimated is the effect of a one-unit change in a quality attribute on the wholesale price of snap beans.

Results and Conclusion

At the wholesale level, as well as for packers and repackers, the quality characteristics that most affect the prices received included the level of damage, maturity, and expected shelf-life or storability. Consequently, the model specified for this study can be expressed:

$$(1) \quad P_i = \beta_0 - \beta_1 DEF_i - \beta_2 MATURE_i - \beta_3 SHELF_i + \varepsilon_i$$

where:
P_i = the price of the ith sample on a per box basis.
DEF_i = percent of scorable defects on a per box basis.
$MATURE_i$ = Maturity index based on shear press level of texture (toughness) of a sample of beans from each box.[4]
$SHELF_i$ = Storability of snap beans measured by the average daily change in the hue angle value (color measurement)[5] from day 1 to day 6, stored at $70^{\circ}F$.

The expected signs for all the variables are negative. The intercept term (β_0) should therefore approximate the expected price of a "perfect" box of snap beans; where no defects exist and maturity and storability are optimum. The sign for DEF should be negative since an increase in damage should lower price and a decrease in damage would increase price. The sign for MATURE should also be negative. A high shear level indicates a tough bean that is more mature and has lower quality. As the shear level increases, quality decreases and price should also decrease. Finally, the sign for SHELF should also be negative. Shelf-life was measured by the average daily change in a color measure; the hue angle value. A high hue angle value indicates a short shelf-life due to rapid change towards a yellow color. As hue angle increases, price should decrease.

Table 1 shows the results of using ordinary least squares regression to estimate equation (1). The results indicate that a one percent reduction in damage would increase the price of a box of snap beans by about 16 cents; a one unit decrease in toughness (less mature), will increase the price of a box over 74 cents; and by increasing the shelf life (decreasing hue angle), a box of snap beans will increase $2.14 for a one unit change in deterioration. This study was conducted at one point in the bean season. It is possible that the magnitude of the coefficients could change depending on the absolute price level observed in the marketplace. However, similar research on tomatoes (Jordan, et al., 1985b) throughout the season found that the magnitudes of the coefficients remained stable regardless of the absolute price level.

In terms of statistical properties, the R^2 is high for this type of cross-section data and all coefficients are significantly different than zero at the 5 percent level. The F-value suggests that the regression is significant.

Implications

From the perspective of the wholesaler, and the food industry generally, this research indicates that it is possible to estimate the price of quality characteristics and thus the potential benefits of changes in the food distribution process. The marginal implicit prices that were estimated for snap beans gives the wholesaler an indication of the benefit of, for example, decreasing the damage in a box.

In the samples of snap beans used in this study, the mean values of the independent variables were: DEF = 4.36; MATURE = 7.83; and SHELF = 0.415. At these mean values, the price of a box of snap beans would be $14.41. If a wholesaler could reduce the mean percent damage in a load of beans to 4 percent (from the mean of near 4.5 percent), the price of a box of beans would go to $14.47. Thus, a one-half percentage point reduction in mean damage could increase the price the wholesaler could expect by 6 cents. This 6 cents then, represents the benefit to the wholesaler of a 0.5 percent reduction in mean damage.

Table 1.

Results of Hedonic Estimation for Snap Beans

Variable	Coefficient/Marginal Implicit Price	Standard Error
DEF	-.1640 (-3.00)	.0550
MATURE	-.7429 (-2.82)	.2639
SHELF	-2.1432 (-5.21)	.4110

Value in parenthesis is the calculated t-statistic.

Intercept = 21.84

R^2 = .49   F value = 16.639

Standard Error of Estimate = 1.026

The cost of any change in handling procedures or in packaging that reduces the mean damage by 0.5 percentage points could then be evaluated against the estimated benefit. Physical damage to snap beans can be caused by the rubbing of pods against rough containers. A new container that was smoother, and reduced damage by 0.5 percentage points, would have to cost less than the 6 cent increase in price estimated in this study. Also early cooling (less than two hours after harvest), may decrease hue angle by one or more units. Therefore, pressure cooling would be feasible if it could be done for less than $2.14 per box. Further research is necessary to find the relationship between the length of delay in cooling and changes in the hue angle.

In this way, a type of cost-benefit analysis is suggested so that participants in the food industry can evaluate the use of new handling techniques or technologies. The results given by the hedonic price method outlined in this study can be used to determine the economic feasibility of improvements in the quality of fresh produce.

Endnotes

[1] Similar work has been carried out on fresh tomatoes and is reported in Jordan, et al. (1985a) and was abstracted in the Journal of Food Distribution Research, Vol. 16, No. 1, Feb. 1985.

[2] The lack of variability in the dependent variable could bias the standard errors reported. What this implies is a lack of precision in the estimated coefficient. However, if the estimates are biased as a result of the dependent variable, those coefficients that are significant remain so, with increased variability. The bias does not affect the significance of parameter estimates. The confidence interval is widened. If the coefficients are strongly significant, the bias problem is less important.

[3] For an introduction to hedonic price functions, see: Brown and Rosen; Ethridge and Davis; Griliches; Ladd and Martin; Lucas; Rosen; Wilson.

[4] The shear press is used to determine the toughness or fibrousness of snap beans. The shear press measures the force required in kg to shear a 50g sample of beans in a standard cell, producing a figure on texture (Ryall and Lipton).

[5] Hue angle $= (\tan^{-1} b/a)$: an angle whose tangent is b/a where (b) is a measure of yellow character and (a) is a measure of green character. As hue angle increases, the bean is becoming more yellow indicating senescence, reducing shelf-life (Little).

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