EVALUATION OF QUALITY ATTRIBUTES IN PEACHES PRODUCED IN THE STATE OF SÃO PAULO THROUGH A HEDONIC PRICE MODEL

Lilian Maluf de Lima
Lilian Amorim
José Vicente Caixeta Filho
Marise Cagnin Martins

Abstract
An econometric model was developed to estimate the implicit prices for selected quality attributes of fresh peaches commercialized in the state of Sao Paulo at the producer stage. The estimation is conducted for this stage of the distribution chain, namely, producer sales. Data on price and quality attributes (such as size, varieties, and categories) of fresh peaches were obtained from *cross-sectional* data. The estimation of hedonic prices is proposed as a method to evaluate post-harvest price variations from producer sales. The results obtained allowed us to identify the gains accrued in this stage, which are derived from improvements in product quality attributes.

KEYWORDS: **peach, hedonic price, evaluation, quality, losses.**

INTRODUCTION

The occurrence of physical losses along the production chain, particularly in the horticultural sector, is usually demonstrated in sectoral analysis related to the production of food in Brazil. Characterized by climacteric behavior, many fruits require careful handling, even after harvest, because of the ripening process. Fruit ripening can be accelerated by temperature variations, transport impacts, handling, and other factors. As the fruits ripen, the pulp softens, making them more sensitive to many types of damage that may occur during the commercialization process. In Brazil, postharvest fruit damage estimates vary between 10% and 50% from production to final consumption (GUTIERREZ, 2005; BENATO, 1999; DURIGAN, 1999), with the greatest impact on climacteric fruits.

Among climacteric fruits, peaches stand out as having high rates of injuries, up to 87%, resulting from handling, packaging, and transportation to market (MARTINS et al., 2006). The occurrence of injuries is largely associated with activities that occur during fruit handling. These injuries are particularly relevant in the State of São Paulo, which is responsible for a significant portion of the peach market in Brazil. Mechanical damage is caused by improper handling in the field (during harvest), in the packing-house, and when loading trucks that transport the fruit to other links in the chain. Transportation is, for the most part, not refrigerated, which contributes to lower fruit quality and shorter shelf life. Moreover, trucks used to transport peaches in the State of São Paulo have open structures and are rarely covered with canvas, which does not protect the load from rain.

Thus, the high perishability and the climacteric behavior of peaches, combined with the lack of appropriate care during harvest, transport, storage, and handling, cause a series of damage to the fruits. These injuries compromise their appearance, make them susceptible to attack by pathogens, and threaten quality. Postharvest losses results in consequent changes in sale prices, which are noticeable at several levels of the market, including the producer, wholesale, and retail levels (Amorim et al, 2007).

The literature on the valuation of quality attributes of the price of peaches and of fruits in general is very scarce. Thus, it becomes relevant to analyze and identify a set of appropriate procedures to evaluate quality attributes and their consequences on the sale price of peaches in the State of São Paulo.

Among several references found concerning valuation, the theory of hedonic prices has been the most widely used and documented theoretical model to measure the influence of a perceptible feature in the price of goods (Waugh, 1928; Lancaster, 1966; Rosen, 1974). The idea of a price index based on econometric models referring to the theory of hedonic prices is proposed by Griliches (1971). Thus, the purpose of this study is to develop a model from hedonic price methodology that can determine the implicit marginal price of each quality attribute in peach sale prices in the State of São Paulo for the producer.

Materials and Methods

Estimations of the economic value of the quality attributes of peaches were obtained by multiple hedonic regression estimation, from the ordinary least squares (OLS) method. Because the theory establishes values of characteristics for buyers of peaches directly from the producer, it is not necessary to formally model the supply side of this market. However, it is necessary to assume that the market is at equilibrium (Aguirre & Faria, 1996).

In the empirical model used in this study, the price of the *i*-th good – in this case, the peach – is considered to be a function of characteristics such as damage, size, and color, for example. Therefore, the function of hedonic price can generally be expressed by (Jordan et al., 1987):

$$P(X_i) = P(X_{11},...,X_{ij};u_i) \qquad (1)$$

in which:

$P(X_i)$ are the observed prices of the *i*-th peach;
X_{ij} corresponds to the amount of the *j*-th feature of the *i*-th peach; and
u_i is the random error term.

The hedonic approach gives the implicit marginal price of each attribute via the regression of the product's observed price, $P(X_i)$, against all its features, using the best functional form (as the transformation of Box & Cox, 1964). From the variation of $P(X_i)$ with its respective attributes, we have the implicit marginal price of each feature. This allows for a monetary representation of each feature in the final price for the sale of peach in the commercialization stage.

The sample, which refers to producers, is composed of 2,769 observations concerning the details of fruit sales (from crop 2003 to crop 2006). The data were supplied by producers of Cooperativa Agroindustrial Holambra II – SP and correspond to the sale prices of peaches in that city and the characteristics of the peaches. Peach sale data in Holambra II were faxed weekly to the University de São Paulo and later compiled into a spreadsheet. The price data were deflated from the IGP-DI (GETÚLIO VARGAS FOUNDATION - FGV, 2006) based on December 2006.

The hedonic model referring to the producer is represented by the following equation[1]:

$$\ln Y = \alpha + \sum_{i=1}^{26} \beta_i X_i + \sum_{w=1}^{15} \gamma_w X_w + \sum_{j=1}^{3} \theta_j X_j + \sum_{k=1}^{4} \psi_k X_k + \varepsilon \qquad (2)$$

where:

$\ln Y$ corresponds to the natural logarithm of the fruit sold in Holambra (SP), in the Brazilian currency (Reais) per kilo;

α, β_i, γ_w, θ_j, and ψ_k are the parameters of the model to be estimated;

i refers to the harvest period (week/month), where i = 1, 2, 3 ..., 26, for every week from the second week of August 2003 to the second week of January 2006, respectively;

w refers to peach varieties, with w = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15 for the varieties *Aurora, Biuti, Diamante, Douradão, Dourado, Flor da Prince, IAC, Jóia, Marli, Ouro Mel, Primavera, Regis, São Pedro, Tropical* and *Tropic Beauty*, respectively;

j corresponds to peach size, with j = 1, 2, 3 for small sizes (up to 4.5 cm in diameter), medium sizes (diameters greater than 4.5 up to 5.6 cm), and large sizes (over 5.6 cm in diameter), respectively;

k refers to the categories, with k = 1,..., 4 for the categories 'extra' (up to 5% of light and total damage), category 1 (between 5% and 12% of light and total damage), category 2 (between 12% and 20% of light and total damage), and "no category" (light and total damage over 20%), respectively;

X_i refers to the binary variable corresponding to the peach season (week/month) i;

X_w refers to the binary variable for the w-th variety of fruit, with the variable names corresponding to the variety names in parentheses: AURORA (*Aurora*), BIUTI (*Biuti*), DIAMANTE (*Diamante*), DOURADAO (*Douradão*), AMARELO (*Dourado*), FPRINCE (*Flor da Prince*), IAC (*IAC*), JOIA (*Jóia*), MARLI (*Marli*), OUROMEL (*Ouro Mel*), PRIMAVERA (*Primavera*), REGIS (*Regis*), SPEDRO (*São Pedro*), TROPICAL (*Tropical*) and TBEAUTY (*Tropic Beauty*);

X_j refers to the binary variable for the *j*-th diameter. For j = 1, 2 and 3, the variables are CALI1, CALI2, and CALI3, respectively;

X_k refers to the binary variable for the k- th category of fruit. For k = 1, 2, 3, 4, the variables are EXTRA, CATI1, CATI2, and CATI3 respectively; and

ε is the random error term (normal distribution N (0,1) is assumed).

The most influential and representative characteristics in peach sale prices will not be directly given by the coefficients of the log-lin model (equation 2), making it necessary to calculate the implicit price of each peach quality attribute. The implicit price for each characteristic, because all variables are binary, is the difference in sale prices "with" and "without" the *i*-th feature from the equation, based on Rudstrom (2004):

[1] Box Cox transformation on the price variable to choose the semi-log functional form. More details about this method are available in Box & Cox (1964).

$$\Delta P_d = \left[\exp^{(\alpha + \sum_{i=1}^{n} \hat{\beta}_i x_i)} \Big|_{x_d = 1} \right] - \left[\exp^{(\alpha + \sum_{i=1}^{n} \hat{\beta}_i x_i)} \Big|_{x_d = 0} \right] \qquad (3)$$

where ΔP_d is the estimated variation in peach sale price, in R$/kg, from the occurrence of the binary variable from which the implicit price will be obtained. The parameter α is a constant, and β_i is the parameter of each exogenous variable x_i from the equation (2) and X_d is a dummy variable analised.

Before using the model, the data were compiled, and the mean and standard deviation were calculated (Table 1). This procedure identified the occurrence of fruit sales according to each feature in the harvest years 2003/04, 2004/05, 2005/06, and 2006/07.

Table 1. Occurrence of producer fruit sales according to the feature "quality", calculated from the mean and standard deviation, of harvests 2003/04 to 2006/07.

Variables	Description	Mean of the four year-harvests	Standard Deviation
Harvest Period			
AUG_2	1 if 2nd week of August, 0 otherwise	0.003	0.050
AUG _3	1 if 3rd week of August, 0 otherwise	0.006	0.076
AUG _4	1 if 4th week of August, 0 otherwise	0.004	0.060
AUG _5	1 if 5th week of August, 0 otherwise	0.013	0.113
SEP_1	1 if 1st week of September, 0 otherwise	0.033	0.179
SEP_2	1 if 2nd week of September, 0 otherwise	0.023	0.149
SEP_3	1 se 3rd week of September, 0 otherwise	0.057	0.232
SEP_4	1 if 4th week of September, 0 otherwise	0.065	0.247
SEP_5	1 if 5th week of September, 0 otherwise	0.014	0.116
OCT_1	1 if 1st week of October, 0 otherwise	0.088	0.284
OCT _2	1 if 2nd week of October, 0 otherwise	0.095	0.293
OCT _3	1 if 3rd week of October, 0 otherwise	0.093	0.290
OCT _4	1 if 4th week of October, 0 otherwise	0.090	0.286
OCT _5	1 if 5th week of October, 0 otherwise	0.024	0.153
NOV_1	1 if 1st week of November, 0 otherwise	0.085	0.278
NOV_2	1 if 2nd week of November, 0 otherwise	0.073	0.260
NOV_3	1 if 3rd week of November, 0 otherwise	0.062	0.241
NOV_4	1 if 4th week of November, 0 otherwise	0.056	0.229
NOV_5	1 if 5th week of November, 0 otherwise	0.021	0.143
DEC_1	1 if 1st week of December, 0 otherwise	0.038	0.190
DEC _2	1 if 2nd week of December, 0 otherwise	0.027	0.162
DEC _3	1 if 3rd week of December, 0 otherwise	0.016	0.126
DEC _4	1 if 4th week of December, 0 otherwise	0.005	0.071
DEC _5	1 if 5th week of December, 0 otherwise	0.005	0.071

JAN_1	1 if 1st week of January, 0 otherwise	0.005	0.068
JAN_2	1 if 1st week of January, 0 otherwise	0.002	0.047
Cultivar			
AURORA	1 if the variety is Aurora, 0 otherwise	0.150	0.357
BIUTI	1 if the variety is Biuti, 0 otherwise	0.070	0.255
DIAMANTE	1 if the variety is Diamante, 0 otherwise	0.016	0.124
DOURADAO	1 if the variety is Douradão, 0 otherwise	0.189	0.391
AMARELO	1 if the variety is Dourado, 0 otherwise	0.137	0.344
FPRINCE	1 if the variety is Flor da Prince, 0 otherwise	0.033	0.177
IAC	1 if the variety is IAC, 0 otherwise	0.023	0.150
JOIA	1 if the variety is Jóia, 0 otherwise	0.005	0.073
MARLI	1 if the variety is Marli, 0 otherwise	0.040	0.196
OUROMEL	1 if the variety is Ouro of Mel, 0 otherwise	0.053	0.224
PRIMAVERA	1 if the variety is Primavera, 0 otherwise	0.034	0.180
REGIS	1 if the variety is Regis, 0 otherwise	0.062	0.242
SPEDRO	1 if the variety is São Pedro, 0 otherwise	0.075	0.264
TBEAUTY	1 if the variety is Tropic Beauty, 0 otherwise	0.101	0.302
TROPICAL	1 if the variety is Tropical, 0 otherwise	0.012	0.110
Classes			
CALI1	1 if the diameter is small, 0 otherwise	0.373	0.484
CALI2	1 if the diameter is medium, 0 otherwise	0.409	0.492
CALI3	1 if the diameter is large, 0 otherwise	0.218	0.413
Category			
EXTRA	1 if the category is 'extra', 0 otherwise	0.033	0.177
CAT1	1 if the category is 1, 0 otherwise	0.733	0.442
CAT2	1 if the category is 2, 0 otherwise	0.219	0.414
CAT3	1 if there is no category, 0 otherwise	0.015	0.122

Source: research data.

According to the averages in Table 1, the highest sales from 2003 to 2006 took place in the second and third weeks of October, representing 9.5% and 9.3% of total sales respectively. The beginnings of August and January showed sales close to zero, due to the beginning and the end of the peach season in São Paulo, respectively (low amount offered).

The varieties that were sold the most were *Douradão, Aurora*, and *Dourado* (AMARELO), representing 19%, 15%, and 14% of total commercialization from 2003 to 2006, respectively. It was observed that 41% of sales corresponded to medium-sized fruits, and 73% of the commerce of that period was associated with fruits of category 1 (Table 1).

Results and Discussion

The coefficients of each exogenous variable, their *t* statistics, and implicit prices can be seen in Table 2.

Table 2. Components of the valuation analysis of peach quality attributes for producers compared with a standard peach with the following variable-control: Period of season: 2nd week of August (AGO_2); Variety: Douradão (DOURADAO); Size: Large (CALI3); Category: Extra (CAT3); Expected peach price#: R$ 5.62/kg

Exogenous Variables	Coefficients	*t* Statistics	Implicit Price (R$/kg)
Constant	1.72722*	14.68	-
Period-season			
AGO_3	-.03219***	-0.24	-0.1782
AGO_4	-0.05163***	-0.35	-0.2830
AGO_5	0.02711***	0.22	0.1546
SET_1	0.01525***	0.13	0.0864
SET_2	-0.00617***	-0.05	-0.0346
SET_3	-0.10391***	-0.91	-0.5551
SET_4	-0.22261**	-1.96	-1.1226
SET_5	-0.44254*	-3.59	-2.0115
OUT_1	-0.39677*	-3.49	-1.8422
OUT_2	-0.52362*	-4.61	-2.2929
OUT_3	-0.70013*	-6.19	-2.8321
OUT_4	-0.81474*	-7.17	-3.1345
OUT_5	-0.88394*	-7.59	-3.3010

NOV_1	-0.84975*	-7.42	-3.2202
NOV_2	-0.73985*	-6.44	-2.9408
NOV_3	-0.66357*	-5.71	-2.7281
NOV_4	-0.68722*	-5.89	-2.7958
NOV_5	-0.63313*	-5.32	-2.6385
DEZ_1	-0.90466*	-7.73	-3.3487
DEZ_2	-0.83549*	-6.87	-3.1856
DEZ_3	-0.85261*	-7.00	-3.2270
DEZ_4	-0.96869*	-7.69	-3.4899
DEZ_5	-1.14630*	-8.88	-3.8373
JAN_1	-1.09167*	-7.87	-3.7369
JAN_2	-1.24082*	-9.46	-3.9985
Variety			
AURORA	-0.16274*	-6.66	-0.8448
BIUTI	-0.10013**	-2.47	-0.5360
DIAMANTE	-0.22432*	-4.59	-1.1303
AMARELO	-0.13049*	-5.34	-0.6881
FPRINCE	-0.48648*	-11.96	-2.1668
IAC	-0.07588***	-1.51	-0.4111
JOIA	-0.42058*	-7.12	-1.9312
MARLI	0.10848*	3.07	0.6445
OUROMEL	-0.12735*	-4.06	-0.6726
PRIMAVERA	-0.17044*	-3.97	-0.8815
REGIS	-0.39913*	-11.41	-1.8512
SPEDRO	-0.20637*	-7.29	-1.0489
TBEAUTY	-0.13330*	-5.08	-0.7020
TROPICAL	-0.20289*	-3.45	-1.0329
Size			
CALI1	-0.98501*	-52.51	-3.5244
CALI2	-0.30374*	-18.67	-1.4734
Category			
CAT1	-0.12793*	-3.89	-0.6755
CAT2	-0.70574*	-19.55	-2.8477
CAT3	-0.96110*	-13.19	-3.4736
R-Squared			0.7157
Remarks			2.769
F Statistics			179.59*

expected price from the model specified to the producer.
* Denotes significance at 1%; ** Denotes significance at 5%; *** Denotes significance above 10%.

Source: research data.

Harvest Time

Fruits sold in the fifth week of October (OUT_5) had one of the largest reductions in value, equivalent to R$ 3.30/kg from the sale price of fruit with the basic characteristics (R$ 5.62/kg) sold in the second week of August (AGO_2), with all other characteristics held constant. In percentage terms, we can say that a peach being sold in the fifth week of October (rather than the second week of August) implies a reduction of approximately 58.70% in peach price in Holambra II - SP, holding other characteristics constant.

According to agents in the sector, the price reduction during this time of the year is due to the peak of peach season. Thus, excessive volumes of peaches from Sao Paulo can be observed in that period; consequently, a significant reduction in the sale price ensues.

Fruits sold in the second week of January (JAN_2), which corresponds to the end of the harvest in Sao Paulo, had the largest decrease in sale value (approximately R$ 4.00/kg), when compared to fruits with basic characteristics (beginning of harvest). This may be associated with the end of the harvest in São Paulo and the low quality of fruits when compared to peaches from other regions. In relative terms, the price of fruits sold in the second week of January (JAN_2), holding all other characteristics constant, would result in a reduction of 71.10% against the basic peach price (sold in the second week of August, Table 2).

Varieties

Analyzing the signs of most coefficients of quality features related to varieties, it was observed that there is a reduction in the sale price of the basic peach when the variety is not *Douradão*, holding all other characteristics constant. Thus, for the fruits of varieties that present a price reduction compared to the basic peach (variety *Douradão*), the producer would not earn (or would be losing) R$ 0.85/kg, R$ 0.54/kg, R$ 1.13/kg, R$ 0.69/kg, R$ 2.17/kg, R$ 1.93/kg, R$ 0.67/kg, R$ 0.88/kg, R$ 1.85/kg, R$1.049/kg, R$0.70/kg, R$1.03/kg in the sale price for the varieties *Aurora, Biuti, Diamante, Dourado (AMARELO), Flor da Prince (FPRINCE), Jóia, Ouro Mel, Primavera, Regis, São Pedro (SPEDRO), Tropic Beauty (TBEAUTY),* and *Tropical*, respectively (see Table 2). In the case of the *Marli* variety, holding other characteristics of the basic peach constant, the implicit price indicated by the model was an increase of R$ 0.64/kg in the sale price of the basic peach, equivalent to a 1.5% increase.

Size

If the fruits had small or average sizes, holding other characteristics constant, losses of R$ 3.52/kg and R$ 1.47/kg would be observed, respectively, in their sale prices in Holambra - SP. In percentage terms, these fluctuations in basic peach prices would correspond to reductions of 62.65% and 26.20%, respectively, compared to the price of the basic large peach (Table 2).

Category

The fact that the fruits are classified by categories "1", "2", and " 3 (no category)" show that the producer will lose R$ 0.67/kg, R$ 2.85/kg, and R$ 3.47/kg, respectively, in the price of peaches with basic characteristics (category “extra”). Peaches classified as "no category" or CAT3 (due to damage) are the peaches that show a greater decline in sale values in relation to the basic peach, a reduction of 62%.

Conclusion

A significant sample of primary data of four years’ worth of harvests (2003/04, 2004/05, 2005/06, and 2006/07) allowed for consistent empirical results and the perception that fruit quality attributes of “category” and “size” were the greatest contributors to the valuation of peach sale prices. Cost-benefit analysis is a valuable tool to determine whether investments in techniques to obtain the most valued characteristics are economically viable for agents responsible for each commercialization stage. Thus, the valuation of characteristics of peaches performed in this study using the methodology of hedonic prices can help quantify the benefits of farming practices, including thinning, that aim to obtain larger fruit at pre-harvest. From there, agents in the value chain will be able to observe the valuation of their products in the market and increase their earnings.

Acknowledgements
The authors wish to acknowledge CAPES and FAPESP for financial support and the producers of Holambra II - SP for providing the data.

REFERENCES

AGUIRRE, A., FARIA, D.M.C.P. **A utilização dos preços hedônicos na avaliação social de projeto**. Belo Horizonte: CEDEPLAR/UFMG, 1996. 35 p. (Texto para discussão, 103).

AMORIM, L.; MARTINS, C.M.; LOURENÇO, S.A.; GUTIERREZ, A.S.D.; ABREU, F.M.; GONÇALVES, F.P. Stone fruit injuries and damage at the wholesale market of São Paulo, Brazil. **Postharvest Biology and Technology**, Sep. 2007. Disponível em: <http://www.sciencedirect.com/science/journal/09255214>. Acesso em: 12 dez. 2007.

BENATO, E.A. Controle de doenças pós-colheita em frutas tropicais. **Summa Phytopathologica**, Jaboticabal, v. 25, n. 1, p. 90-93, 1999.

BOX, G.E.P.; COX, D.R. An analysis of transformations**. Journal of the Royal Statistical Society (B)**. v. 26, n. 2, p. 211-252, 1964. Disponível em:

<http://www.jstor.org/view/00359246/di993152/99p02493/0>. Acesso em: 15 Nov. 2006.

DURIGAN, J.F. Uso da modificação da atmosfera no controle de doenças. **Summa Phytopathologica**, Jaboticabal, v. 25, n. 1, p. 83-88, 1999.

FUNDAÇÃO GETÚLIO VARGAS – FGV. **Índices Gerais de Preços** . Disponível em:<http://www.fgv.br/dgd/asp/index.asp>. Acesso em: 2 mar. 2006.

GRILICHES, Z.; Hedonic Price Indexes Revisited**.** In: GRILICHES, Z.; (Ed.). **Price indexes and quality change**: studies in new methods of measurement. Cambridge: Harvard University Press, 1971. Disponível em: <http://www.jstor.org/view/01621459>. Acesso em: 15 nov. 2006.

GUTIERREZ, A.S.D. **Danos mecânicos pós-colheita em pêssego fresco.** 2005, 124 p. Tese (Doutorado em Fitotecnia) – Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, 2005.

JORDAN, J.L.; SHEWFELT, R.L.; PRUSSIA, S.E. The value of peach quality characteristics in the postharvest system. **Acta Horticulturae**, Georgia, v. 203, n. 203, , p.175-182, June 1987.

LANCASTER, K.J. A new approach to consumer theory. **The Journal of Political Economy**, Chicago, v. 74, n. 2, p. 132-157, April 1966.

MARTINS, M.C.; LOURENÇO, S.A.; GUTIERREZ, A.S.D.; JACOMINO, A.P.; AMORIM, L. Quantificação de danos pós-colheita em pêssegos no mercado atacadista de São Paulo. **Fitopatologia Brasileira**, v. 31, n. 1, 10 p. jan./fev. 2006. Disponível em: <http://www.scielo.br/scielo.php?pid=S0100-41582006000100001&script=sci_arttext>. Acesso em: 4 Nov. 2006.

ROSEN, S. Hedonic prices and implicit markets: product differentiation in pure competition. **The Journal of Political Economy**. Local, v. 82, n. 1, p. 34-55, Jan./Feb. 1974.

RUDSTROM, M. Determining implicit prices for hay quality and bale characteristics. Review of Agricultural Economics, v. 26, n. 4, pages 552-562, December, 2004.

WAUGH, F.V. Quality Factors influencing vegetables prices**. Journal of Farm Economics**. v. 10, p. 185-196, 1928. Disponível em: <http://chla.library.cornell.edu/cgi/t/text/text-idx?page=simple&c=chla>. Acesso em: 15 Out. 2006.