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Demand for Milk Produced With and Without Recombinant Bovine Somatotropin

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This study focuses on the nature of Texas consumer perception and willingness to purchase milk produced using recombinant bovine somatotropin (rBST). Further, the possibility of market segmentation is analyzed by estimating the price sensitivity of consumer demand for conventionally produced milk versus rBST-produced milk. Results show that the price elasticities of demand for the two types of milk are different, indicating potential to develop niche markets for both rBST-produced and conventionally produced milk in Texas.

Key Words: bovine somatotropin, demand, milk

Livestock and their products usually account for more than half of the agricultural cash receipts in Texas. Texas ranked first nationally in the number of cattle, and sixth in the number of dairy cows raised in 1996 (U.S. Department of Agriculture). The dairy industry in Texas produced about 6.1 million pounds of milk in 1996, and had cash receipts of about $920.8 million, accounting for approximately 6.6% of the farm and ranch cash receipts for the state (U.S. Department of Agriculture). This represents about a 10% increase in milk production and about a 14% increase in cash receipts within a seven-year time period.

While it is believed that the dairy industry, in the future, will play an even more important role in the Texas economy, the introduction of recombinant bovine somatotropin (rBST) in dairy production has raised some new challenges for the industry. Scientists claim that by injecting rBST (a protein hormone) into dairy cows, the quantity of milk produced per cow can be increased by 10–25%, and feed efficiency can be increased by 5–15% (Preston, McGuirk, and Jones; Kronfeld; U.S. Congress/Office of Technology Assessment). Food processors and milk suppliers, however, have expressed concern that some consumers may be unwilling to purchase products produced with rBST. Preston, McGuirk, and Jones found that approximately 25% of households surveyed in Virginia did not approve of commercial use of rBST,

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and about 32% were uncertain. Kaiser, Scherer, and Barbano reported that approximately 18% of responding households in New York State would decrease their milk purchases if rBST was approved and there was no change in milk price. In reviewing results of various consumer surveys, Smith and Warland concluded that 11.3% of respondents would stop drinking milk produced with rBST.

Many earlier studies have addressed the issue of consumer attitude toward milk produced with rBST, with the objective of determining consumers' willingness to purchase rBST-produced milk. Tauer's investigation represents a departure from previous research in that it analyzes the value to milk producers of segmenting the market into rBST-produced and non-rBST-produced milk markets. In that study, the problem is approached from a conceptual perspective, where a hypothetical illustration is presented to show that if some consumers will not buy milk produced using rBST, then the opportunity to segment the market exists—and this market segmentation would benefit both types of producers in the form of higher milk prices.

Our analysis focuses on the nature of Texas consumer perception and willingness to purchase milk produced using rBST. Further, we analyze the possibility of market segmentation by estimating the price sensitivity of consumer demand for conventionally produced milk versus rBST-produced milk.

Methods and Procedures

A statewide consumer survey was conducted to collect data on consumers' attitudes, concerns, and willingness to purchase rBST-produced milk, as well as socioeconomic and demographic information. A mailing list of randomly selected Texas households was purchased from a private marketing company, and a mail survey was administered in the spring of 1995.

The survey questionnaire was developed in consultation with animal scientists, private biotechnology companies, and representatives of the Texas Department of Agriculture and the U.S. Department of Agriculture. The survey instrument included questions related to consumer perceptions and concerns about the use of rBST in milk production, consumers' willingness to purchase milk produced with rBST, consumers' current level of knowledge of rBST technology, and a number of socioeconomic and demographic characteristics.

The questionnaire was mailed to 2,000 randomly selected consumers along with a personalized letter via first-class mail. A self-addressed, postage-paid return envelope was enclosed to facilitate return of the completed questionnaire. The survey questionnaires were numbered for control purposes. A first reminder was sent to the nonrespondents approximately one week after the survey was mailed. A second personalized reminder, including a replacement copy of the survey and another self-addressed, postage-paid envelope, was sent approximately four weeks after the initial survey. A final reminder was sent approximately six weeks after the initial survey.

A second mail survey was administered to the confirmed survey participants in the summer of 1995, to collect price sensitivity information and to obtain data required

to determine the potential for market segmentation of rBST-produced and conventionally produced milk. The format of the second questionnaire was determined by the type of consumer response to the question on willingness to purchase milk produced with rBST in the first survey instrument. Three individual questionnaires were developed for the second survey. While the questions were similar for the three questionnaires, the format was altered according to whether the consumer responded "yes," "no," or "don't know" to the willingness-to-purchase question of the first survey. Consumers were provided with hypothetical variations in the prices (ranging from \$0.10 to \$1, in \$0.30 increments) of conventional and rBST-produced milk and were asked to estimate their relative monthly consumption response to these price changes.

Frequency analysis and descriptive statistics were used to develop a better understanding of consumer attitudes, concerns, and willingness to purchase milk produced with rBST. The ordinary least squares (OLS) procedure was used to estimate linear demand relationships for both rBST and conventional milk. Two independent linear models were formulated to express the demand relationships for both rBST and conventional milk. All of the independent variables in the model were nonstochastic, with the error term assumed to be normally distributed. The demand relationships included quantity demanded, price, and selected socioeconomic and demographic variables.

Quantity and price information for the demand equations was obtained from participants in the survey. Respondents in the consumer survey were asked to indicate the quantity of conventionally produced milk they would purchase per month at different price levels. Participants also were asked to indicate if they were willing to purchase milk produced using rBST. Respondents who reported they would purchase rBST milk were assumed to be indifferent to the technology, such that the indicated quantities of milk purchased could be assumed to represent the quantities of rBST milk they would be willing to purchase. The quantities and prices for conventionally produced milk were obtained from those respondents not willing to purchase rBST milk, even at lower prices. Price sensitivity was the only elasticity calculated from the demand relationships. The mean levels of those prices and quantities of milk purchased reported by respondents were used to calculate the elasticities.

The following socioeconomic and demographic characteristics are hypothesized to influence the quantity of milk purchased for each of the two types of milk: gender of the respondent (*SEX*), age of the respondent (*YEARS*), educational level of the respondent (*EDU*), household income (*INCOME*), household size (*HHSIZE*), and the number of household members less than 12 years of age (*CHILD*). This last characteristic assumes that there is a direct positive relationship between the quantity of milk purchased and the *CHILD* variable. Because of the perceived nutritional value associated with milk consumption, the consumption of milk is hypothesized to increase as the number of children in the household increases. Previous studies have found that the income elasticity of milk is negative (Heien and Wessells; Huang and Raunikar; Salathe; Boehm)—i.e., that milk is an inferior good. Age, education, and income levels of respondents all are deemed to have an effect on the quantity of milk purchased; however, the directions of the specific effects are uncertain.

The demand-relationship models are specified as follows:

$$(1) \quad QrBST = (PMILK, SEX, YEARS, EDU, HHSIZE, INCOME, CHILD) + \epsilon_1$$

and

$$(2) \quad QCONV = (PMILK, SEX, YEARS, EDU, HHSIZE, INCOME, CHILD) + \epsilon_2,$$

where *QrBST* is the monthly quantity demanded of milk produced with rBST, *QCONV* is the monthly quantity demanded of conventionally produced milk, *PMILK* is the price of milk, ϵ_1 and ϵ_2 are error terms, and the remaining variables are as previously defined.

Results

Survey Response Rate

The initial survey resulted in 393 returned questionnaires out of 1,850 actually delivered (from a total of 2,000 mailed), or a response rate of approximately 21%. The follow-up survey, delivered to each of the 393 respondents to the initial survey instrument, resulted in 255 returned questionnaires, representing a response rate of about 65%.

Respondent Characteristics

The socioeconomic and demographic characteristics of consumers in the sample are summarized in table 1. Approximately 68% of the respondents were male. About 86% of the respondents were Caucasian, while 14% were Afro-American, Hispanic, or of other races. This profile differs considerably from the population profile of the state of Texas, where Caucasians account for approximately 60% of the population, and 40% belong to other races (Kingston). The educational level of the sample was relatively high in that about 46% of the participants had earned a college degree, compared to Texas as a whole where the corresponding figure is about 20% (Kingston). The median household income level for respondents in the sample was also higher than the median household income for Texas residents. Well over half (63.3%) of the respondents reported incomes of $40,000 or more, whereas the median household income for the state of Texas is approximately $27,000 (Kingston). Thus the sample is biased toward Caucasian, higher educated, and higher income households.

Table 1. Summary of Socioeconomic and Demographic Characteristics of Survey Respondents (N = 255)

Characteristics	Total (%)	Characteristics	Total (%)
Gender:		Marital Status:	
Male	67.6	Married	70.3
Female	32.4	Other[a]	29.7
Race:		Household Size:	
Caucasian	85.8	1 person	17.1
Non-Caucasian	14.2	2–4 persons	72.5
		5 or more persons	10.4
Age:			
Under 29 years	7.8	Household Income:	
30–39 years	26.7	Under $20,000	10.1
40–49 years	30.3	$20,000–$39,999	26.6
50–59 years	17.3	$40,000–$74,999	42.6
Over 60 years	17.9	Over $75,000	20.7
Education:		Place of Residence:	
No college	20.9	Urban	69.0
Some college	33.3	Rural	31.0
College graduate	45.8		

[a] This group includes divorced/separated, widowed, and never married respondents.

Consumer Concern About rBST

A list of food production practices was included in the survey to identify respondents' concern about rBST in relation to other food safety concerns. The survey participants responded to this question on a five-point scale, where 1 = not concerned and 5 = extremely concerned. For the purpose of this analysis, however, the five-point scale was collapsed into three groups to include "no or little concern," "moderate concern," and "extreme concern." The results (table 2) suggest that pesticides and farm chemicals were perceived by survey respondents to reflect the greatest concern for food safety. This was followed by food additives, rBST, recombinant porcine somatotropin (rPST—a protein hormone developed to increase average daily weight gain and decrease the percentage of carcass fat in swine), irradiation, antibiotics, and genetic engineering of vegetables and fruits. These findings are consistent with those of earlier studies (Food Marketing Institute; Bruhn; Misra, Fletcher, and Huang) where pesticides/residues, antibiotics, and hormones were perceived as the most serious food safety threats.

Table 2. Consumer Perceptions About Selected Food Safety Concerns

	Degree of Concern (%)		
Food Safety Concerns	Little or None	Moderate	Extreme
Pesticides and farm chemicals	12.7	19.9	67.4
Food additives	18.1	21.2	60.7
rBST	19.4	21.1	59.5
rPST	20.7	21.7	57.6
Irradiation	25.6	23.3	51.1
Antibiotics	26.7	23.9	49.4
Genetic engineering of vegetables	43.8	18.3	37.9
Genetic engineering of fruits	44.1	18.5	37.4

About 60% of our respondents expressed extreme concern about the use of rBST in milk production, while another 21% were moderately concerned. A comparison of consumer concern between rBST and rPST revealed that the respondents were somewhat more concerned about rBST than rPST. The greater concern for rBST could possibly stem from adverse media publicity that has surrounded the discussion of rBST over the last several years.

In another question, respondents were asked to indicate their perceived effects of rBST on the nutritional value of milk, on the environment, on human health, and on the price of milk. Survey results (table 3) suggest that the majority of respondents did not know about the effect of rBST on the nutritional value of milk (52.6%), on the environment (60.6%), on human health problems (60.6%), or on the price of milk (48.4%). Approximately 14% of the responding consumers perceived that the use of rBST would increase the nutritional value of milk, whereas about 9% thought that it would have just the opposite effect. About 19% and 27% of the respondents perceived that the use of rBST would increase both environmental and human health problems, respectively, while, 24% of respondents thought that the use of rBST would decrease the market price of milk. Based on these results, the greatest concern of consumers is the potential negative effect of rBST on human health, with 27% of the respondents perceiving an increase in human health problems. It is clear, however, that most respondents are relatively uncertain about the effects of rBST. This uncertainty reveals that the information available to consumers is insufficient to enable them to form well-advised attitudes or perceptions regarding the use of rBST in milk production.

Consumer Awareness About rBST

Consumer awareness about rBST, rPST, and biotechnology in general was measured by two different methods. Participants were first asked to self-evaluate their

Table 3. Consumer Perceptions About rBST Effects

Description	Perceived Effects of rBST (%)			
	Increase	No Effect	Decrease	Uncertain
Nutritional value of milk	13.5	24.6	9.3	52.6
Environmental problems	18.5	18.8	2.1	60.6
Human health problems	26.9	10.6	1.9	60.6
Price of milk	16.1	11.2	24.3	48.4

knowledge of rBST, rPST, and the genetic engineering of fruits and vegetables. Respondents believed they were most informed about genetic engineering of fruits and vegetables, with approximately 67% indicating they had at least some knowledge of the process. About 64% of those surveyed stated that they were somewhat to very informed about rBST, and approximately 56% reported having at least some knowledge of rPST. One reason consumers ranked their perceived knowledge of rPST lower than their knowledge of rBST, and of genetic engineering of fruits and vegetables, possibly is explained by uneven media coverage of these technologies in the past.

A self-evaluation of awareness may not necessarily provide an adequate measure of consumers' knowledge. Thus, another measure of consumer awareness of biotechnology was developed for this analysis based on the responses to 12 factual statements regarding recombinant somatotropin. Responses to these statements were transferred to item scores and were coded so that a ranking of 1 indicated a correct answer, and a ranking of 0 indicated a wrong answer or a "don't know" response. The item scores for each respondent were first summed to obtain a total score. The total awareness scores then were expressed as an index ranging from 0 to 1, where an index value of 1 corresponded to the highest possible total score of 12 points.

The arithmetic mean of this constructed awareness index was found to be 0.198. This represents a very low level of consumer awareness of rBST, since 1 corresponds to perfect awareness. The constructed index had a maximum score of 0.917 and a minimum score of 0. A two-group classification scheme was further developed to make the index score more readily interpretable. Respondents with an index score of 0.5 or greater were classified as having a high knowledge level, and respondents with an index score of less than 0.5 were classified as having a low knowledge level. Using this classification technique, approximately 87% of the respondents were found to possess a low level of knowledge. A comparison of results from the consumers' self-evaluation of awareness and the constructed knowledge index clearly suggests that consumers perceive their awareness of somatotropin to be higher than their actual knowledge.

Consumer Willingness to Purchase

Survey participants were asked in another question to indicate if they would purchase milk produced using rBST. Approximately 23% of the respondents indicated that they were willing to purchase milk produced using rBST, about 33% expressed an unwillingness to purchase milk produced with rBST, and another 44% were uncertain about their purchasing decision. Respondents expressing an unwillingness or uncertainty about purchasing rBST-produced milk were further asked if they would consider buying milk produced with rBST if the price was lower than the current level. Approximately 28% of these individuals reported a willingness to purchase if the rBST milk was offered at a lower price. Those subjects expressing willingness to purchase milk produced with rBST at a lower price were included in the willingness-to-purchase group, such that the overall effective acceptance rate was approximately 48%. The inclusion of those respondents who were willing to purchase rBST-produced milk at a lower price in the willingness-to-purchase group is justified because it is expected that the introduction of rBST will lower the price of milk.

Respondents expressing an unwillingness or uncertainty about purchasing rBST-produced milk were asked to identify factors that they felt might have most influenced their behavioral intention. Approximately 97% of the consumers who were unwilling to purchase or were uncertain about purchasing milk produced using rBST indicated that they were somewhat to extremely concerned about the effects of rBST on their health. Of those who were not willing to purchase or were uncertain, about 94% indicated that a major factor in their purchase decision was a lack of information about rBST. Other factors contributing to respondents' purchase decisions were the effects of rBST on the health of the animals (86%), the effect of rBST on the environment (83%), and the effect of rBST on product prices (68%). The effects of rBST on human health and the lack of information on rBST were the two major reasons given by consumers who were unwilling to purchase rBST-treated milk.

Demand Relationships

The regression results of the estimated demand relationships for rBST-produced and conventionally produced milk are summarized in table 4. The *F*-statistics for the rBST and conventional milk demand equations were 59.291 and 21.673, respectively, and both were highly statistically significant. These results suggest that the overall fit of the models was reasonably good. The coefficients of determination for the estimated rBST (41.2%) and conventional milk (25.1%) demand equations indicate that the explanatory power of the models is reasonable for cross-sectional data.

The price variable (*PMILK*) was found to have a negative relationship and was statistically significant in both equations as expected (table 4). Our findings show that as the retail price of whole milk increases by $1, the monthly consumption of rBST-produced milk will decrease by 1.95 gallons, and the monthly consumption of

Table 4. Regression Summary of Demand Equation Estimation for rBST-Produced and Conventionally Produced Milk

	Demand Equation	
Variables	rBST	Conventional
PMILK	-1.951****	-0.741****
	(-6.951)	(-2.742)
EDU	0.817****	0.446****
	(5.167)	(3.260)
INCOME	-0.193**	-0.284****
	(-1.800)	(-2.691)
YEARS	-0.221*	1.461
	(-1.528)	(0.833)
CHILD	0.577****	1.461****
	(12.047)	(7.608)
HHSIZE	2.516****	0.771***
	(6.792)	(2.180)
SEX	0.772**	0.883****
	(1.934)	(2.710)
F-statistic	59.291	21.673
Probability level of *F*-statistic	0.0001	0.0001
R^2	0.4121	0.2513
Adjusted R^2	0.4052	0.2397

Notes: Numbers in parentheses are *t*-values. One, two, three, and four asterisks (*) denote significance at the .15, .10, .05, and .01 levels, respectively.

conventionally produced milk will decrease by 0.74 gallons. These results reveal that consumers purchasing rBST-produced milk are more price sensitive than those consumers purchasing conventionally produced milk. The income variable (*INCOME*) also was found to have a negative relationship and was significant at the 0.01 and 0.10 levels, respectively, for conventional and rBST-produced milk. The negative relationship between quantity and income suggests that milk is an inferior good—a finding consistent with previous empirical evidence.

The estimated demand relationships offer some interesting insights about the effects of socioeconomic and demographic variables on quantity demanded of each type of milk. The socioeconomic and demographic variables *EDU*, *CHILD*, and *HHSIZE* were found to have positive and highly significant effects on the quantity of rBST and conventional milk purchased (table 4). As the educational level (*EDU*), the household size of the respondent (*HHSIZE*), and the number of children under the age of 12 in the household (*CHILD*) increase, the quantity of milk consumption increases. The

variable *SEX* was found to have a positive effect on the quantity demanded of conventional and rBST milk, with a 0.01 and 0.10 level of significance, respectively. This suggests that male respondents consume greater quantities of milk than their female counterparts. The age variable (*YEARS*) was found to have a negative effect on the quantity demanded of rBST milk and was statistically significant at the 0.15 level; however, this variable was not statistically significant in the conventional milk demand equation.

Consumers' responsiveness to price changes was measured by estimating own-price elasticity of demand for both conventional and rBST-produced milk. The mean values for price and quantity of milk purchased were used in the calculation of the elasticity coefficients. The own-price elasticity of demand for rBST-produced milk was found to be −0.963 [calculated by multiplying the estimated price coefficient for rBST-produced milk (−1.951) by the ratio of mean price and mean quantity (2.544/5.154) from the data], implying that a 1% change in price would result in a −0.96% change in the quantity demanded of rBST-produced milk. The own-price elasticity of demand for conventionally produced milk was found to be −0.519 [calculated by multiplying the estimated price coefficient for conventionally produced milk (−0.741) by the ratio of mean price and mean quantity (2.646/3.779) from the data], revealing that the demand for conventionally produced milk is less price sensitive than the demand for rBST-produced milk. These estimated elasticities are consistent with the findings of earlier empirical studies that report a range from −0.48 to −1.45 for the price elasticities of demand for whole milk in the southern region of the United States (Boehm; Bullion).

Summary and Conclusion

A mail survey of 2,000 randomly selected Texas households, yielding 255 final survey respondents, was used to assess consumer concerns about the introduction of rBST in dairy production and the possibility of segmenting the market into rBST-produced and non-rBST-produced milk markets.

Survey results indicate that about 56% of the respondents were extremely concerned about the use of rBST in milk production, while another 23% were moderately concerned. The survey participants identified the potential negative effect of rBST on human health and a lack of information about rBST as the two most important reasons for their concerns. An assessment of consumers' awareness about somatotropins revealed that approximately 87% of the respondents possess a low level of knowledge about these technologies. The overall effective acceptance rate of milk produced with rBST was estimated at 48%.

Estimated demand equations for milk produced with and without rBST divulged that consumers perceive these to be differentiated products, and the price elasticities of demand for both types of milk are clearly different. In a recent study, Tauer suggests that a segmentation of the national milk market may be possible as rBST becomes a factor in milk production. Tauer argues that a market segmentation of

consumers between those who will buy milk produced using rBST and those who will consume only non-rBST-produced milk would be possible if producers are clearly differentiated. The findings of our analysis lend support to Tauer's argument and the hypothesis of market segmentation. These results imply that there is potential to develop niche markets for both rBST-produced and conventionally produced milk.

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