Demand for Enhanced Foods and the Value of Nutritional Enhancements of Food: The Case of Margarines

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Abstract

This paper evaluates consumer preferences and choice of nutritionally enhanced food products based on economic, geographic, ethnic and other socioeconomic characteristics. Household scanner data allow estimation of hedonic price functions and a probit model on the choice of margarine that promotes good health. The empirical estimation established a positive value for nutritional enhancement.

Key words: scanner data, hedonic approach, demand for healthy food

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Introduction

New production and processing methods have led to significant changes in foods in response to consumer preferences for health-promoting attributes in foods. Changes in observed food prices reflect changes in the market for existing foods as well as the added value from new foods (foods with new product attributes). As with other new or changed product introduction, the different values in the market pose a problem for understanding what the observed product price means and whether consumer welfare has improved with the introduction of the new product.

The introduction of new margarine products provides an example of a nutritionally-enhanced food. In May 1999, the Food and Drug Administration approved the sale of Take Control and Benecol margarines. The products include components that block the absorption or re-absorption of cholesterol. Product sales reached a level of $27 million in 2000. To improve understanding of recent developments in the food marketing system and consumer valuation of new food products and product attributes today, we evaluate consumer preferences and food choices based on economic, geographic, ethnic and other socioeconomic characteristics with specific attention to food groups that entail value added processes to enhance the nutritional attributes of products, in particular the Benecol and Take Control margarines that contain plant sterol or plant stanol esters to reduce the risk of coronary heart disease (CHD).

Coronary heart disease, one of the most common and serious forms of cardiovascular disease, causes more deaths in the U.S. than any other disease. Risk factors for CHD include high total cholesterol levels and high levels of low-density lipoprotein (LDL) cholesterol. Until very recently, nutritional concerns have focused on excessive consumption of fats, saturated fats, and sodium. Many consumers have become aware of the link between dietary fat intake and the increased risk of chronic diseases, such as coronary heart disease, cancer, and stroke. Chern et al. (1995) model the impact of health information (the knowledge of the link of fat intake and coronary heart disease) on demand for fats and oils and find that the health information increases the consumption of margarines and decreases the consumption of butter and lard. Gould (1997, 1998) models consumer demand for butter, margarine and blends and the factors affecting the purchases and the timing of the purchases. Kim and Chern (1995) use a characteristics demand model to estimate the consumer's values of various fatty acids and to examine the impact of health information on demand for fats and oils.

Recently, new scientific evidence has focused on specific attributes of the food-borne fats. For example, evidence that trans fatty acids affect CHD risk and can adverse effects on blood cholesterol levels has spurred new labeling requirements on type of fat content in foods (FDA Rule July 11, 2003). In addition, a number of functional foods have been promoted or introduced in markets or are under development (e.g., lycopene content of tomato products, low cholesterol eggs). Therefore, it is important to understand the consumer's interest in consuming nutritionally enhanced food products.

In this paper we model the consumer food choices based on economic, ethnic and other socioeconomic characteristics with respect to Benecol and Take Control margarines. We use the hedonic method to estimate consumer values of various attributes of the products applied to data from the A.C. Nielsen 1999 HomeScan retail scanner data panel. Consumer implicit values (i.e. hedonic prices) of attributes are estimated by a regression, which expresses the price of a product as a function of the coefficients associated with each characteristic. Next a probit model on the choice of margarine that promotes good health is estimated.

The paper is organized in the following manner. First, we provide a theoretical model of household's consumption decisions. Second, we provide the empirical specification and estimation methods. And, following a section that describes data and variables, we present results and conclusions.

Theoretical Model

Following the household consumption models by Becker (1965) and Grossman (1972), the household attempts to maximize its satisfaction subject to prices, wages, household income, as well as socio-demographic characteristics, to derive its demand for market goods and commodities such as nutrition and health. To model the household consumption and production decisions consider the following model:

$$U=U\ (H, N, L; Z_1), \tag{1}$$

where U is the household utility function, H is a commodity of health and nutrition and N is all other consumption goods. H is produced by the household by combining purchased food attributes and time according to the health production function: $H=f\ (A, L; Z_2)$ where A is a vector of products' characteristics (k=1,…, K) and L is leisure. Z_1 and Z_2 are vectors of household characteristics.

The cash income I budget constraint is

$I = wT_m + V = h_kA + p_NN,$

where $T_m = (T\text{-}L)$ is the time spent in the market, T is time endowment, w is the wage rate, V is a non-labor income, h_k is the price of attribute A_k, and p_N is the price of N. The full income is:

$$F = wT + V = h_kA + p_NN + wL. \qquad (2)$$

The household chooses A, N and L to maximize utility in (1) subject to the budget constraint in (2).

The first order conditions yield derived demand equations:

$$A = f_A\,(w, p_N, h_k, V; Z_1, Z_2)$$

$$L = f_L\,(w, p_N, h_k, V; Z_1, Z_2)$$

$$N = f_N\,(w, p_N, h_k, V; Z_1, Z_2)$$

We focus on the reduced form demand equation for the health promoting attributes, A.

Empirical Specification and Estimation

Let the household random indirect utility function be:

$$V_{ki}=\alpha_{ki}X+\varepsilon_{ki} \qquad (3)$$

where **X** is a vector of individual(household) characteristics and prices, $\boldsymbol{\alpha_{ki}}$ is the choice-specific parameter vector and ε_{ki} is unobserved random component. The household *i* chooses attribute *k* such that $V_{ki}>V_{ji}$. The probability C_{ki} of the household's choice of characteristic *k* is:

$$\begin{aligned}\text{Prob}(C_{ki}=1)&=\text{Prob}(V_{ji}<V_{ki})\\ &=\text{Prob}(\alpha_{ji}X+\varepsilon_{ji}<\alpha_{ki}X+\varepsilon_{ki}) \qquad (4)\end{aligned}$$

$=\text{Prob}(\varepsilon_{ji}-\varepsilon_{ki}<\alpha_{ki}X-\alpha_{ji}X)$

$= \text{Prob}(\varepsilon_i<\alpha_i X)=\Phi(\alpha_i X)$,

where $\Phi(\alpha_i X)$ is the standard normal distribution (Green 2000).

We estimate the household consumption using the single standard probit model. The consumption variable is a limited dependent variable equal to 1 if the household purchased the dairy product characteristic and 0 otherwise.

The empirical specification of the price function is:

$$\ln p_s = \sum_{k=1}^{K} h_{sk} A_{sk} + e_s, \qquad (5)$$

where h_{sk} is the price of k attribute in product s and e_s is the regression residual. This function can be fitted to data on market price and observed characteristics. When the market for attributes is in equilibrium the hedonic method provides an objective valuation of attributes. The National Research Council (2002) highlights the hedonic models to value new products. We use the semilog functional form for the hedonic equation to allow for one or more characteristics being equal to zero, which is important if new characteristics come to the market (Diewert 2003). The new products that came to the market May 1999 are Benecol and Take Control. The characteristics (A_{sk}) consist of indicators (0, 1) if the product is: diet; butter (including blend); Benecol or Take Control brands; and for regions (reference western region), and a dummy variable for urban (=1 if the household lives in an urban area, and 0 otherwise).

Data and Variables

Scanner data provide opportunities for improving economic measurement. Scanner data also provide information on quantity and prices, and allows examining the demand for more disaggregated commodities/brands. It also contains detailed information on products' attributes. The advantages of the scanner data are the large datasets, more frequent observations and many attributes of the products (existing and new goods), all valuable to hedonic analysis of product characteristics.

To estimate our model we use the 1999 AC Nielsen household scanner panel, which links data on product purchases and household demographics. This data set consists of dairy department purchase data, dry grocery department purchase data, UPC produce meat frozen department, and USDA random weight purchase data for 1999. The data contains information on purchase date, brand, quantity (packages); price paid deal; price paid non-deal, coupon value, and product attributes. We match the households with the household purchases. The household characteristics include household size, income, age, education, and employment of female and male head, marital status, race, region of residence.

The households in our sample have an income higher then the average for the country (for US is $41,994); the household size is very similar to the national (2.59); 65.9% of our sample are married couples compared to 51.7% of the national; 84.7%, 9.3% and 6.4% in our sample are white, black and Hispanic respectively compared to 75.1%, 12.3%, and 12.5 in the national sample (Census 2000). The price variables were calculated to estimate the model in (5) for the commodity (dairy product) groups of interest. Price was calculated as follows: expenditure per month on dairy product was divided by quantity purchased per month. The individual expenditure for each purchased occasion was calculated net of any promotion or coupon. We exclude from our sample households who did not have any dairy purchases for two consecutive months. The total number of households in our sample is 6,607.

We include in our analysis the following commodities:

- butter: contains not less than 80% by weight of butterfat (The Institute of Shortening and Edible Oils, 1999)
- regular blends: butter-margarine blends usually proportioned 40 to 60 percent respectively
- diet blends: blends including butter and diet margarine
- regular margarine: prepared by blending fats and/or oils with other ingredients such as water and/or milk products, suitable edible proteins, salt, flavoring and coloring materials and Vitamins A and D; must contain at least 80% fat by federal regulation (The Institute of Shortening and Edible Oils, 1999)
- diet margarine: may contain 0-80% fat. The fats or oils are normally refined and can be hydrogenated to give the desired "hard" or "soft" texture (The Institute of Shortening and Edible Oils, 1999; Invensys APV)
- regular Benecol and diet Benecol products: Benecol products include plant stanol esters, an ingredient derived from pine trees, which has been shown to lower blood cholesterol levels. It is made with canola oil and soybean oil (Lipid Disorders Clinic)
- regular Take Control: contains naturally occurring unsaturated sterols, primarily sitosterol from soybean oil. It is made with canola oil, sunflower oil and soybean oil (Lipid Disorders Clinic).

For the purposes of our analysis, the products are classified as “regular” (which includes lactose free) and “diet” (which includes diet, light, low-fat, reduced fat, fat free and non fat). Reduced-fat or reduced-calorie/diet margarine—contains no more than 60 percent oil (25% reduction in fat and calories). Light/lower fat margarine—contains no more than 40 percent oil (50% or more reduction in fat). Fat-free margarine, the ingredients of which include gelatin, rice starch and lactose, are virtually fat-free. Diet or reduced calorie margarines contain a large amount of water (55-60 percent). The lower calorie level is due to lower fat content and higher water content (Zavadil J., 1989.) All these products are grouped as diet.

Table 1 presents the number of households who purchase the different dairy groups, the average monthly quantity purchased, the average monthly expenditure (of those purchasing the product) and the average unit value paid for the product. There are 6,607 households (or sample) that purchased dairy products during the 1999. Most (98 percent) households consumed one of the dairy spread products. Sixty one percent of the sample purchased butter and 34 percent of the households purchased some diet margarine or spread.

The products of particular interest in this study are Benecol and Take Control; 7.2 percent of the households purchased these products during 1999. They were introduced during the month of May. The unit value is computed as the ratio of the household monthly expenditure on butter, margarine and spreads (in dollars) and the household monthly quantity purchased (in pounds). For all dairy products, the average expenditure per month was \$3.03 with an average unit value of \$1.23 per pound. For Benecol and Take Control, the average monthly expenditure by consuming households was \$4.52, with an average unit value of $7.55 per pound. Figure 1 presents the purchases of Benecol and Take Control by month in 1999. The largest number of purchases of Benecol was in June and July of 1999 just after the product was introduced in the market and promoted by coupons. The purchases of Take Control increased gradually after the product was introduced 1999, and reached its pick in December 1999.

As shown in Table 2, over 70 percent of butter consumers purchasers also purchased special, light or diet spreads. And 58 percent of the margarine purchasers consume butter.

Table 3 presents the definitions of the variables in the model and Table 4 present the means of the variables for the whole sample, for the households that purchased only butter; only margarine and spreads; and only diet products. In the full sample, the average household income is $52,423. The highest average income is for the households who purchased only diet products $59,188. The average household size for the sample is 2.6 and 31 percent of the sampled household include children.

Results

First, we estimated the hedonic equation in (5). The dependent variable is the unit value of butter, margarine and spreads. Since Benecol and Take Control were introduced in the market during the month of May, we use data from June through December 1999. The results for the pooled sample are presented in Table 5. The empirical results show that the attribute Benecol and Take Control is supplied at 134.9% higher value that the regular margarine; the value of the diet attribute is 7% higher, and 77% higher for butter (including regular blend) compared to the regular margarine. In addition to attribute variables we have included in the hedonic equation dummy variables for the four regions, and for urban residence. Relative to the west region, the east region has higher unit values, and the central and south have lower unit values. Urban areas have higher unit values.

The estimates from the hedonic equation were used to create regional hedonic prices for the attributes for butter taste, diet and "Benecol/Take Control". We use these hedonic values in the estimation of the probability of consuming Benecol and Take Control as a function of demographic variables, income and prices.

Table 6 presents the estimates of the probit model for consumption of the health-enhanced product attribute (Benecol/Take Control) in (4). We estimated the probability of the household consuming Benecol or Take Control, as a function of the demographic characteristics of the households, income and the hedonic prices for the attributes. We also included monthly dummy variables. Most of the demographic household characteristics are statistically significant. Higher income and having college and post college degree increase the probability of consuming Benecol/Take Control. Being a married couple household and age over 50 has a positive effect on Benecol/Take Control consumption.

The own-price effect is negative and statistically significant. The cross-price effects with the butter taste and diet are positive and statistically significant also, and suggest that the diet and butter taste are substitute attributes.

In sum, the estimation established a positive value for nutritional enhancement and substitution in consumer choice with other product attributes.

Conclusions

The consumer choice of quantity and quality of many products, including improvements in existing goods and the production of new goods, increase every year. There are significant changes in markets as commodity agriculture shifts to add value to products in response to consumer preferences, to meet regulations for food safety, and to develop new technologies for producing and manufacturing of foods that meet changes in consumer demand for improved food attributes. Changes in observed food prices reflect changes in the market for existing foods as well as the added value from new foods (foods with new product attributes). As with other new or changed product introduction, the different values in the market pose a problem for understanding what observed price changes mean and whether consumer welfare has improved.

The goal of this study was to evaluate consumer preferences and food choices based on economic, geographic, ethnic and other socioeconomic characteristics with specific attention to food groups that entail value added processes to enhance the nutritional attributes of products, in particular the Benecol and Take Control margarines. The results showed that the value of the attribute diet is 7% higher than the regular margarine and the butter (including regular blend) value is 77% higher. The value of Benecol/Take Control is 134.9% higher compared to the margarine. The empirical estimation established a positive value for nutritional enhancement. The distribution of the composition of household purchases (Table 2) shows that a majority of households consume a mix of products including purchases of both butter and diet spreads. This finding suggests that the consumer choice on nutritional attributes is relatively complex, and that consumers chose a mix of products to meet their preferences for table spreads.

The paper explores the ways to use scanner panel data to address important market and policy problem.

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Table 1. Number of Households that Purchased a Particular Dairy Product

Product Category	Number of Households	Percent of Households	Average Monthly Quantity (pounds)	Average Monthly Expenditure ($)	Average Unit Value ($/lb)
Total Dairy	6607	100.0%	2.32	3.03	1.23
Butter, Margarine & Spread	6486	98.2%	2.74	3.57	1.51
Butter	4056	61.4%	1.89	4.70	2.65
Margarine & Spread	5820	88.1%	2.63	2.38	1.05
Margarine	2486	37.6%	1.94	1.79	0.96
Spread	5533	83.7%	2.55	2.29	1.07
Blends	65	1.0%	1.23	1.92	1.59
Regular Margarine & Spread	5626	85.2%	2.57	2.27	1.02
Diet Margarine & Spread	2274	34.4%	1.89	1.93	1.28
Benecol & Take Control	477	7.2%	0.65	4.52	7.55

Table 2. Distributions of the Butter, Margarine and Diet Purchasers

	Total		**Butter**		**Margarine**		**Special,Lite,Diet**	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Butter Purchasers	4056	61%	4056	100.0%	3366	83.0%	2858	70.5%
Margarine Purchasers	5794	88%	3366	58.1%	5794	100%	3897	67.3%
Diet Purchasers	4231	64%	2858	67.5%	3897	92.1%	4231	100%
All	6607	100%						

Table 3. Definitions of the Variables in the Model

Variable	Definition
No hhlds	Number of households
Hhinc	Household income
Hhsize	Household size
Binary Variables	
Agef30	equal to 1 if female head's age is under 30, and 0 otherwise
Agef50	equal to 1 if female head's age is between 30&49 and 0 otherwise
Agef64	equal to 1 if female head's age is between 50&64 and 0 otherwise
Agef65	equal to 1 if female head's age is 65 and older, and 0 otherwise
Nofemage	equal to 1 if no female head is present, and 0 otherwise
Agem30	equal to 1 if male head's age is under 30, and 0 otherwise
Agem50	equal to 1 if male head's age is between 30&49 and 0 otherwise
Agem64	equal to 1 if male head's age is between 50&64 and 0 otherwise
Agem65	equal to 1 if male head's age is 65 and older, and 0 otherwise
Nomalage	equal to 1 if no male head is present, and 0 otherwise
Kids	equal to 1 if the family has children, and 0 otherwise
Emplm	equal to 1 if the male head is employed, and 0 otherwise
Emplf	equal to 1 if the female head is employed, and 0 otherwise
Edmhs	equal to 1 if the male head's education is high school or less, and 0 otherwise
Edmscol	equal to 1 if the male head's education is some college, and 0 otherwise
Edmcolpc	equal to 1 if the male head's education is college &post college, and 0 otherwise
Edfhs	equal to 1 if female head's education is high school or less, and 0 otherwise
Edfscol	equal to 1 if the female head's education is some college, and 0 otherwise
Edfcolpc	equal to 1 if female head's education is college &post college, and 0 otherwise
Married	equal to 1 if the family is married, and 0 otherwise
Retiredm	equal to 1 if the male head is retired, and 0 otherwise
Retiredf	equal to 1 if the female head is retired, and 0 otherwise
White	equal to 1 if the race is white, and 0 otherwise
Black	equal to 1 if the race is black, and 0 otherwise
Other	equal to 1 if the race is other, and 0 otherwise
Hispanic	equal to 1 if the family is Hispanic, and 0 otherwise
t6	equal to1 if the month is June and 0 otherwise
t7	equal to1 if the month is July and 0 otherwise
t8	equal to1 if the month is August and 0 otherwise
t9	equal to1 if the month is September and 0 otherwise
t10	equal to1 if the month is October and 0 otherwise
t11	equal to1 if the month is November and 0 otherwise
t12	equal to1 if the month is December and 0 otherwise
East	equal to 1 if the family lives in the East region, and 0 otherwise
Central	equal to 1 if the family lives in the Central region, and 0 otherwise
South	equal to 1 if the family lives in the South region, and 0 otherwise
West	equal to 1 if the family lives in the West region, and 0 otherwise
Urban	equal to 1 if the family lives in urban area, and 0 otherwise

Table 4. Variables and Means of the Sample (all households), the households that purchased only Butter; only Margarine & Spreads; and only Diet Products

Variable	Sample	Only Butter	Only Margarine& Spreads	Only diet
No hhlds	6607	690	2428	540
Hhinc	52423	58650	47866	59188
Hhsize	2.60	2.33	2.58	2.30
Agef30	4.0%	3.2%	6.2%	5.0%
Agef50	43.2%	43.6%	42.8%	41.7%
Agef64	30.8%	29.9%	28.3%	33.3%
Agef65	13.9%	9.3%	12.8%	8.7%
Nofemage	8.1%	14.1%	10.0%	11.3%
Agem30	2.5%	2.0%	3.8%	3.3%
Agem50	34.3%	35.8%	34.5%	32.4%
Agem64	27.3%	28.4%	25.7%	25.9%
Agem65	13.3%	10.1%	12.2%	10.9%
Nomalage	22.6%	23.6%	23.8%	27.4%
Kids	30.8%	25.4%	31.9%	24.3%
Emplm	59.4%	61.6%	58.7%	57.6%
Emplf	60.8%	59.4%	60.3%	62.6%
Edmhs	21.3%	14.5%	23.7%	12.8%
Edmscol	23.7%	20.4%	24.6%	19.3%
Edmcolpc	32.5%	41.4%	27.9%	40.6%
Edfhs	24.5%	16.1%	27.8%	14.8%
Edfscol	31.2%	26.5%	29.1%	26.1%
Edfcolpc	36.2%	43.3%	33.1%	47.8%
Married	65.9%	58.6%	62.4%	58.9%
Retiredm	24.2%	19.6%	24.1%	20.0%
Retiredf	30.8%	26.4%	29.7%	26.3%
White	84.7%	85.2%	82.0%	87.6%
Black	9.3%	6.2%	11.5%	4.8%
Other	6.0%	8.6%	6.5%	7.6%
Hispanic	6.4%	5.5%	7.4%	7.8%
East	20.7%	33.0%	14.7%	23.7%
Central	25.3%	19.1%	25.4%	21.9%
South	34.0%	28.0%	40.1%	34.3%
West	20.0%	19.9%	19.8%	20.2%
Urban	84.3%	89.1%	82.6%	88.7%

Table 5. Estimates of the Hedonic Equation

Variable	Estimate
Intercept	-0.082(0.008)***
Diet	0.071(0.008)***
Butter (incl. reg. blend)	0.772(0.006)***
Benecol or Take Control	1.349(0.017)***
East	0.017(0.008)**
Central	-0.075(0.007)***
South	-0.063(0.007)***
Urban	0.062(0.007)***
R-square	0.39
Number of Observations	40675

Note: * Statistically significant at the 10 % level;
** Statistically significant at the 5 % level;
*** Statistically significant at the 1 % level.
Standard errors are in parentheses.

Table 6. Estimates from the probit model of consumption of Benecol/Take Control spreads

Parameter	Coefficient (Std. error)
Intercept	-13.666 (3.887)***
Hhincs	0.003 (0.000)***
Hhsize	-0.035 (0.013)**
Kids	-0.069(0.035)*
Married	0.192(0.055)***
White	0.132 (0.051)**
Black	-0.061 (0.062)
Hispanic	0.116 (0.046)**
agef50	0.560 (0.108)***
agef64	0.870 (0.110)***
agef65	0.922 (0.112)***
nofemage	0.496 (0.126)***
agem50	0.095 (0.118)
agem64	0.359 (0.119)***
agem65	0.460 (0.122)***
nomalage	0.291 (0.131)**
Emplm	-0.059 (0.030)*
Emplf	-0.084 (0.023)***
Edmhs	-0.117 (0.029)***
Edmscol	-0.128 (0.026)***
Edfhs	-0.031 (0.027)
Edfscol	-0.056 (0.023)**
t7	0.006 (0.035)
t8	-0.007 (0.035)
t9	-0.002 (0.035)
t10	-0.001 (0.035)
t11	-0.004 (0.035)
t12	-0.003 (0.035)
Price of Benecol/TK	-9.181 (2.980)***
Price of Butter	13.727 (4.821)***
Price of Diet	5.390 (1.226)***

Note: * Statistically significant at the 10 % level;
** Statistically significant at the 5 % level;
*** Statistically significant at the 1 % level.
Standard errors are in parentheses

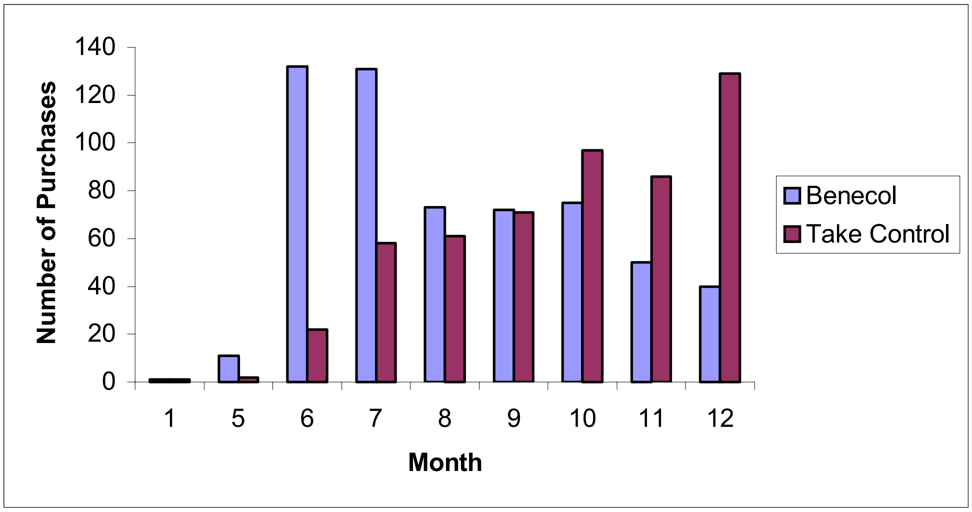

Figure 1. Number of Benecol and Take Control Purchases per Month, 1999.