# Consumer Values of Health-Related Food Symbols and Chemical Food Additives*

## *The Case of Breakfast Cereals*

Linda Thunström

The Swedish Retail Institute (HUI), SE-11858 Stockholm, Sweden

**Abstract**

In this paper we analyze consumers' revealed values of food symbols indicating nutritious and organic food, as well as consumers' revealed values for chemical food additives. We do so by estimating a hedonic price function based on a rich data set on breakfast cereal purchases. Our findings suggest that consumers positively value chemical food additives in breakfast cereals, suggesting that the positive taste effect from e.g. chemical taste enhancers, emulsifiers, colourings and preservatives outweighs consumers' health concerns regarding such additives. We find no evidence that consumers positively value the symbol indicating nutritious food. In addition, surprisingly enough, our results imply that consumers have a negative willingness-to-pay for the symbol indicating organic food.

**Keywords**: consumer economics; hedonic pricing; food labelling; food additives.

**JEL classification**: D12; I10

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## 1. Introduction

The modern diet, often rich in calories, sweeteners and fat, while low in nutritional values, constitutes a threat to public health. Poor nutrition has been linked to several types of cancer, cardiovascular disease, diabetes, osteoporosis, and dental caries as well as overweight and obesity, themselves major risk factors of many of these diseases. In the U.S., about one third of the adult population is overweight, one third is obese, and one third is normal or underweight.[1] The corresponding figures for Sweden are more modest: around 10 percent of the adult population is obese, but the trend is worrying. Since the 1980s, there has been a steady increase in many illnesses related to poor diet, such as cardiovascular diseases, respiratory illnesses, and diabetes (Statistics Sweden).

Due to the awareness of the mounting health problems related to poor dieting, both private and public agents in the food market provide consumers with information aimed at helping consumers make healthier food choices. Even if nutritional information is readily available on the food package, consumers may however lack the time and knowledge to evaluate such information. Evaluating food information is costly to the consumer. Therefore, consumers often act on incomplete information when making food choices, and when consumers lack the adequate knowledge of the food consumed, consumption of unhealthy food increases (Kin et al. 2000). Easily accessible nutrition symbols, however, can help reduce search costs for healthy food and thereby guide consumers to healthier food consumption (Neuhouser et al. 1999).

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[1] BMI is equal to an individual's body weight divided by the square of his/her height (i.e. BMI=kg/$m^2$). People with a Body Mass Index (BMI) of 25-30 are generally considered overweight and people with a BMI over 30 are considered obese.

The aim of this paper is to analyze consumer revealed values of health-related food symbols and consumer revealed values of chemical food additives. Regarding the food symbols, we focus on the most widely used symbols in Sweden indicating nutritious food and organic food, respectively.

Health-related food symbols could be both private symbols and symbols certified by public authorities based on certain characteristics of the food (i.e. high fibre content, low fat or salt content). In this study, we will focus on the nutrition symbol (the “Keyhole”) certified by the Swedish Food Administration (SLV) to products defined as particularly healthy by the SLV. Organic food has also increasingly been linked to health. Consumer survey studies conclude that one of the most important motivations for consumers to buy organic is the belief that organic is healthy (Wier and Calverley, 2002). We therefore include consumer revealed values of the most commonly used organic symbol in Sweden (the “KRAV-symbol”) in the analysis. Noteworthy is that sales of organic food has increased rapidly over the last few years in many Western countries. In Sweden, the share of food purchases that are organic increased from 2.2 percent in 2006 to 3.4 percent in 2008 (Statistics Sweden), and sales of organic food continue to grow in 2009 (the Nielsen Company).

Another type of health-related food characteristic that has attracted attention from consumers are chemical food additives (labelled with “E-numbers” in the European Union as well as a few Western countries outside the European Union). In Sweden, there has been a vivid debate over the last couple of years on the use of chemical food additives, as well as their health effects, to a large extent initiated by two best-selling books by the journalist Mats-Eric Nilsson. Food additives have different purposes, such as enhancing the taste of the food (taste enhancers), preserve the freshness (preservatives), colour the food (colourings), providing the food with a certain texture (emulsifiers). As such, they should be positively valued by consumers. However, they do not rhyme well with the recent increase in consumer interests of natural food and it is debated whether or not chemical food additives are hazardous to consumer health. For instance, MacInnis and Rausser (2005) show that food additives contribute to obesity in children. A survey shows that Swedish consumers express concerns about the health effects of food additives, to the extent that food additives now is the number one worry regarding food contents, followed by sugar and sweeteners (YouGov, 2009).

To analyze consumer revealed values of the nutrition symbol, the organic symbol and chemical food additives we apply a hedonic price function to highly disaggregate retail sales data on breakfast cereals, provided by the Nielsen Company Sweden. Previous studies have used hedonic price methods to estimate consumer values of food characteristics in breakfast cereals (Stanley and Tschirhart, 1991; Shi and Price, 1998; and Thunström and Rausser, 2009), where Thunström and Rausser also analyze consumer values of the nutrition symbol.[2] To the best of our knowledge, this is, however, the first study analyzing consumer revealed values of chemical food additives.

The paper proceeds as follows. Section 2 outlines the theory behind hedonic models. Sections 3 and 4 describe the data and the empirical method. Section 5 reports the results and Section 6 presents our conclusions.

[2] In this study we use a richer and newer data set over breakfast cereals than do Thunström and Rausser (2009), though.

## 2. Theoretical model

Lancaster (1966) and Rosen (1974) formalize a theoretical framework where products are treated as bundles of characteristics. Stanley and Tschirhart (1991) build upon their work and adjust the theory to non-durable goods, applying the model to breakfast cereals. We follow Stanley and Tschirhart (1991) and specify a theoretical model where utility from consuming breakfast cereals depends on the services breakfast cereals provide. The services consist of taste, nutrition and convenience such that the utility of the representative consumer from breakfast cereal consumption is

$$U = \tilde{U}(s_1, s_2, s_3, X) \tag{1}$$

where $s_1, s_2$ and $s_3$ are the taste, nutrition and convenience services of the breakfast cereal, and $X$ is the composite good. Utility is assumed to increase in each argument and to be strictly concave. The services are in turn determined by the $n$ characteristics of the breakfast cereal: package size, food labels (including information symbols), brand name, grams of carbohydrates, fat, saturated fat, fiber, salt and sugar, added vitamins or minerals as well as the content of chemical food additives. Let $\mathbf{z} = z_1, ..., z_n$ denote these characteristics. We can then define $s_h = s_h(\mathbf{z})$, for $h$ = 1,2,3. Each characteristic can affect several services simultaneously and oppositely; e.g., sugar might affect taste positively, but the nutritional value negatively. The utility function can then be rewritten

$$\tilde{U}(s_1(\mathbf{z}), s_2(\mathbf{z}), s_3(\mathbf{z}), X) = U(\mathbf{z}, X) \tag{2}$$

where utility can increase or decrease in particular characteristics. If, for instance, the negative effect of sugar on the nutritional value outweighs its positive effect on taste, utility will decrease in sugar.

The market price of breakfast cereals equals $P(\mathbf{z})$, i.e. the price of a product is assumed to be a function of its specified characteristics. The price function, $P(\mathbf{z})$, is continuously differentiable in the elements of **z**. It can then be shown (see Stanley and Tschirhart, 1991, and Thunström and Rausser, 2009) that the utility maximizing consumer chooses the level of characteristic *i* such that

$$p_i = U_{z_i} / U_X \qquad i = 1,...,n \qquad (3)$$

where $p_i = \partial P(\mathbf{z}) / \partial z_i$, $U_{z_i} = \partial U / \partial z_i$, and $U_X = \partial U / \partial X$.

I.e., the increase in the price of the staple good from adding another unit of characteristic *i* is equal to the marginal rate of substitution between characteristic *i* and the composite good. The consumer therefore chooses a combination of characteristics so the change in the product price, from a marginal increase in a particular characteristic, equals the marginal willingness-to-pay (the marginal implicit price) for that characteristic. The marginal implicit price of characteristic *i* can be either positive or negative, due to the fact that each characteristic can affect utility either negatively or positively, or in opposing ways. Signing the marginal implicit price of a characteristic is therefore an empirical question.

## 3. Data and expected effects of food characteristics

To perform the analysis, we use a rich data set from the Nielsen Company Sweden on nation wide breakfast cereal purchases (scanner data) during the 12-month-period from April 2007 to March 2008. The data contains the average price per kilo gram for each breakfast cereal sold in Sweden during the study period, package size, brand name, the presence of the nutrition symbol ("Keyhole"), an organic symbol ("KRAV-symbol") and if the product is a private label. Via producer websites and manual collection of data in stores, we also gathered information on the nutritional content: fiber, fat, saturated fat, carbohydrates, added sugar and sodium per 100 gram breakfast cereal, as well as vitamins and minerals added and the content of chemical food additives. Chemical food additives are defined as food additives labelled with E-numbers by the European Union.

The data also contains information on products sold in each of the four food store types: the largest store type (hyper market) with more than 2500 square meters of sales area, the second largest store type (large supermarkets) with 1001-2500 square meters of sales area, the third largest store type (small supermarkets) with 401-1000 square meters of sales area, and the smallest stores with 100-400 square meters of sales area. We are therefore able to calculate the average price per kilogram for each breakfast cereal in each store type, i.e. to control for price variations over store types in the analysis. The total number of breakfast cereal products in the sample used here amounts to 160. Most of these products, but not all, have been sold in all four store types during the study period. All the products have been sold in the largest store type (hyper market), whereas the smallest number of products (amounting to 130) have been sold in the smallest store type. The total number of observations amounts to 602.

Breakfast cereals for which contents of nutrients and additives was not found via websites or in supermarkets were excluded from the data set. In a few cases, the same product appears twice in the data set in the same store type, i.e. sales of the same type of product is registered in two different places. In these cases, the observations have been merged by calculating a weighted average of the product price, where the weights are based on the volume sold of the duplicates in each store type.

The symbols used in the analysis are all well-known to Swedish consumers. The nutrition symbol; the "Keyhole", is certified by the Swedish Food Administration (SLV) based on certain criteria (see SLVFS 1989:2 and LIVSFS 2005:9). The certification criteria of the Keyhole for breakfast cereals cover the fat, fiber, salt and sugar content.[3] The organic symbol ("KRAV-symbol") is a registered trademark certified by the private organisation "KRAV" and its certification criteria cover mainly environmental aspects of production, but also animal welfare, health and social responsibility (see KRAV, 2008).

The private labels are often named with the retailer's own name, such that the consumer easily can identify the private label. However, in some cases (especially low-end private labels), the private label holds a name different to the retailer's, meaning that uninformed consumers may not know that it is a private label.

Brand dummies were created for each brand name that sold minimum 5 products during the study period. Brands that sold less than five different products during the study period have

[3] Breakfast cereals that meet the following criteria are allowed to carry the Keyhole symbol: fat: max. 7g/100g, sugar: max. 13g/100g, sodium: max. 500mg/100g, and fiber: min 1.9g/100 kcal.

been gathered in the dummy “Others”. The largest amount of products sold under the same brand name in the sample is 31.

Table 1 presents summary statistics on the characteristics of the products in the sample. for the continuous variables, mean and standard deviations are presented. For the dummy variables, the number of observations for which the dummy variable takes the value 1 is presented.

Insert Table 1 here.

For most of the characteristics, it is difficult to form prior expectations of the effects on the price, i.e. the sign of the marginal willingness-to-pay for the characteristic. Sugar, salt, fat and saturated fat are all assumed to positively affect taste, but at the same time, they are assumed to negatively affect health. Fiber is assumed to affect health positively, but it’s effect on taste is ambiguous. Chemical food additives are assumed to affect taste positively, and either have a neutral or a negative impact on health. Following Stanley and Tschirhart (1991), the enhancement of vitamins and minerals is assumed to have no effect on taste but positively affect health and convenience, where the latter is based on the argument that consumers otherwise would need to access these vitamins and minerals elsewhere, for instance from vitamin supplements. All food labels (including the symbols indicating nutritious and organic food) are assumed to have no effect on taste or health but positively affect convenience, since they provide easily accessible product information to consumers. A priori, vitamin and mineral enhancements as well as food labels are therefore expected to be positively valued by consumers. Finally, the brand labels may also be regarded as signals of the quality of the product, negative or positive.

## 4. Method

Marginal implicit prices of the characteristics in breakfast cereals are estimated from a hedonic price function, based on the theoretical model presented above. Theory provides no guidance on the functional form of the hedonic price function, though. Researchers have therefore used various types of functional forms. For instance, Box-Cox transformations of the variables in the regression have often been used, in order to find the functional form that best fits the data. However, the use of Box-Cox transformations have been questioned. Cropper et al. (1988) find that a linear function of Box-Cox transformed variables offers the preferred functional form under perfect information about relevant characteristics. However, in the more realistic case, with omitted variables or proxies, the preferred functional form is the standard linear model, with untransformed variables. Also, Cassel and Mendelsohn (1985) argue that the results from the Box-Cox transformation are unstable and hard to interpret.[4]

We start off by estimating a linear model with untransformed variables. We thereafter use a Box-Cox transformation to find the functional form best suited for the data. The Box-Cox

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[4] Hedonic regressions based on breakfast cereal data have been estimated by Stanley and Tschirhart (1991), Shi and Price (1998) and Thunström and Rausser (2009). All of these studies use different functional forms for the hedonic price function. Stanley and Tschirhart estimate a hedonic regression specified as a linear Box-Cox function. Shi and Price estimate a linear regression on more aggregated food product data, and also include interaction terms with household characteristics. Thunström and Rausser estimate a quadratic model. Neither Stanley and Tschirhart nor Shi and Price control for brand or store effects and Thunström and Rausser do not control for store effects.

results imply that the a log-log model performs best with the data available: the hypothesis that the power parameter, lambda, is equal to zero cannot be rejected (Prob > $\chi^2$ is equal to 0.731). The log-log model also has the advantage of providing results that are easy to interpret (see the critique above from Cassel and Mendelsohn, 1985). The hedonic price function estimated and reported here is therefore represented by the following log-log model[5]:

$$\ln P = a + \boldsymbol{\beta} \ln \mathbf{z} + \boldsymbol{\varphi} \mathbf{D} + e \qquad (4)$$

$P_j^k$ is the price per kilo gram of product $j$ (where $j = 1,\ldots,J$ ), $\mathbf{z}$ is a vector of the continuous characteristics in the product (grams of fibre, carbohydrates, sugar, fat, saturated fat and sodium per 100 gram product) and the vector $\mathbf{D}$ contains dummy variables for discrete characteristics (indicators of the nutrition and organic symbols, private label, minerals, vitamins, chemical food additives and store type of the purchase) as well as indicators of the brands in the data. The reference store type is store type 1 (i.e. the largest store type) and the reference brand is the market leader.

The same breakfast cereal (e.g. cornflakes of label A) is sold both in boxes of different sizes and in different store types. The characteristics of some observations are therefore similar, or identical, apart from the store type and the package size (e.g. cornflakes of label A sold in store type 1, size 500 grams, and cornflakes of label A sold in store type 3, size 750 grams). To obtain robust estimates, we cluster such observations in the empirical analysis. The number of clusters in the data amounts to 131.

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[5] It should be noted that the estimated coefficients from the Box-Cox and the log-linear model are very similar and that the signs of the parameter estimates are the same as those resulting from the linear model.

Finally, we extend the analysis by investigating if the values consumers attach to the food characteristics of interest (the nutrition symbol, organic symbol, private label, and the presence of chemical food additives in the product) vary over store types. For instance, it might be that consumers who generally make their purchases in the largest store type (hyper markets) are more prone to planning ahead, whereas consumers who generally make their purchases in the smallest store type are more impulsive. Impulsive consumers may attach a lower value to health related characteristics (see the literature on self-control problems, e.g. O'Donoghue and Rabin, 2003, and Aronsson and Thunström, 2008). We test this empirically by interacting the dummy variables indicating food labels and additives with the dummy variables indicating store type.

## 5. Results

In this section, we first present the results from the estimated hedonic price function, as given by equation (4), and thereafter comment on the results from the extended regression that includes the interaction terms between store type and the food characteristics of prime interest. Although not reported here, both regressions contain a set of dummy variables indicating the brand of the breakfast cereal. ***F***-tests reveal that in both regressions, the product brands jointly contribute to the explanatory power of the model.[6]

Multicollinearity seems to be a minor problem in the models estimated. Bilateral correlation coefficients are generally small and the variance inflation factor (VIF), measuring multilateral

[6] The ***F***-test results in F(17,130)=10.33, Prob>F=0.00 for the less extensive model and F(17,130)=9.71, Prob>F=0.00 for the more extensive model.

collinearity, implies that the variance of the coefficients in the model are little enhanced by collinearity (e.g. in the less extensive model, the mean VIF-value is 4.52).

Results from the estimated hedonic price model as given by equation (4) are presented in Table 2.

Insert Table 2 here.

As shown by Table 2, the elasticity of the nutrients with respect to the price of breakfast cereals is generally small and statistically insignificant. Sugar is the exception here. If the content of sugar increases by 1 percent, the price per kilo gram of breakfast cereals increases by around 0.1 percent. Our results also imply that the average consumer positively value chemical food additives in breakfast cereals, but seem to be less concerned with vitamin of mineral enhancements of the product. As expected, the price of breakfast cereals is significantly higher in store type 2,3 and 4, relative to store type 1 (the largest store type). Also, as the package size for breakfast cereals increases by 1 percent, the price of the product decreases by around 0.5 percent. Finally, private label products are significantly cheaper than brand label products and, interestingly enough, the price of a product seems to be negatively affected by the organic label, implying that consumers negatively value the information provided by the organic label.

To further explore the positive marginal willingness-to-pay for chemical food additives, we estimated a model with dummy variables for each type of additives included in the data (colourings, preservatives, antioxidants, emulsifiers, chemical sweeteners and acids). Our results suggest that consumers positively value colourings, preservatives, emulsifiers and acids in breakfast cereals, whereas no statistically significant effects were obtained for antioxidants and chemical sweeteners.[7] The results for the other variables remained the same as reported in Table 2.

As mentioned in the previous section, we also estimate a more extensive model that includes interaction terms between store type and food symbols as well as store type and chemical food additives. However, none of the interaction terms turns out to be statistically significant. In addition, ***F***-tests reveal that the interaction terms as groups do not significantly improve the explanatory power of the model.[8] We therefore conclude that consumers value food symbols and additives the same, regardless of the store type in which they make their purchase, and choose not to report the results from the more extensive regression. Except for the dummy for store type 3 (which is no longer statistically significant in the extensive regression), all variables that are statistically significant in the less extensive regression remain the same both in value and in statistical significance as reported in table 3.

## 6. Conclusions

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[7] *Colorings*: coefficient: 0.10, t-value: 2.39 (P-value 0.018), *preservatives*: coefficient: 0.09, t-value: 3.31 (P-value 0.001), *emulsifiers*: coefficient: 0.05, t-value: 2.10 (P-value 0.037), *acids*: coefficient: 0.06, t-value: 1.88 (P-value 0.063).

[8] The result of the ***F***-test for the interaction terms between different store types and the nutrition label is F(3,130)=0.82, Prob>F=0.49, the F-test for the interaction terms between different store types and the environment label results in F(3,130)=1.13, Prob>F=0.34, the ***F***-test for the interaction terms between different store types and private label results in F(3,130)=1.82, Prob>F=0.15, and, finally, the ***F***-test for the interaction terms between store types and additives results in F(3,130)=0.66, Prob>F=0.58

In this paper we analyze the average consumer's revealed values of health-related food symbols and chemical food additives. We focus on two widely used symbols indicating nutritious food (the "Keyhole") and organic food (the "KRAV-symbol") and define chemical food additives as additives labelled with an E-number by the European Union. To perform the analysis, we estimate a hedonic price function based on a rich data set from the Nielsen Company Sweden on breakfast cereal purchases.

Our findings imply that consumers positively value chemical food additives in breakfast cereals. This implies that the taste enhancing effects from chemical food additives (by providing e.g. longer sustainability, improved texture, colouring or taste enhancers) outweighs consumers' health concerns regarding chemical food additives.

Food symbols help consumers by providing easily accessible information on the content of a food product. A priori, such symbols are therefore expected to be positively valued by consumers. However, the symbol indicating organic food surprisingly has a negative effect on the price of breakfast cereals, though, implying that consumers negatively value the information provided by the symbol. Also, our results indicate that the nutrition symbol (the "Keyhole") certified by the Swedish National Food Administration has no statistically significant effect on the price of breakfast cereals, implying that consumers are unwilling to pay for the easily accessible nutrition information provided by the symbol. Thunström and Rausser (2009) find that consumers have a negative willingness-to-pay for the nutrition symbol. However, our results do not support that finding. Consumers simply appear to be indifferent to the nutrition symbol.

In addition, our results imply that consumers are unwilling to pay more for additional grams of fiber, carbohydrates, fat, saturated fat or sodium in breakfast cereals, as well as for vitamin and mineral enhancements. However, consumers positively value added sugar in breakfast cereals. Our results imply that if the content of sugar increases by 1 percent, the price of breakfast cereals increases by 0.1 percent. The finding of a positive effect of sugar on breakfast cereal price is consistent with the results in previous studies (Stanley and Tschirhart, 1991; Shi and Price, 1998; Thunström and Rausser, 2009). Stanley and Tschirhart also find that fibre in breakfast cereals is negatively valued by consumers. Our estimates result in a negative elasticity for fibre but the parameter is not statistically significant. Further, Thunström and Rausser (2009) find that consumers negatively value salt in breakfast cereals. Again, we estimate a negative elasticity of salt on the product price but the parameter is not statistically significant.

More research is needed to understand why consumers either negatively value food symbols or appear indifferent. Do these symbols signal something else to consumers, besides the information they are intended to provide, such as a high price or poor taste? Also, information on the nutritional value and ingredients, especially chemical food additives (E-numbers), generally appears on the back of the product package, in small text. With purchase decisions in food stores mostly being made in split seconds (Nordfält, 2007), consumers may therefore make purchases while not being fully informed. This may very well affect our results, for instance the positive values consumers attach to chemical food additives. Experimental studies would be helpful in providing knowledge on consumer responses to (full) information on both the product characteristics and their respective health effects.

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YouGov**,** Livsmedelsinnehåll i Sverige 2009.

Table 1. Summary statistics for breakfast cereal characteristics

| Variable | Mean | Std. deviation |
|---|---|---|
| Price per kilo gram (in SEK)* | 48.894 | 21.861 |
| Package size in grams | 612.865 | 332.837 |
| Grams of fibre per 100 gram | 8.749 | 4.458 |
| Grams of carbohydrates per 100 gram | 68.321 | 9.474 |
| Grams of sugar per 100 gram | 15.452 | 11.538 |
| Grams of fat per 100 gram | 5.723 | 5.041 |
| Grams of saturated fat per 100 gram | 1.802 | 2.179 |
| Grams of sodium per 100 gram | 0.453 | 0.457 |
| | | |
| Number of obs with nutrition symbol | 177 | - |
| Number of obs with environment symbol | 22 | - |
| Number of obs with private label | 199 | - |
| Number of obs showing vitamin info | 163 | - |
| Number of obs showing mineral info | 200 | - |
| Number of obs containing additives | 170 | - |
| | | |
| Number of obs in smallest store type | 130 | - |
| Number of obs in second smallest store type | 153 | - |
| Number of obs in second largest store type | 160 | - |
| Number of obs in largest store type | 159 | - |
| Number of brands | 18 | - |

* On July 23 2009, USD/SEK = 7.54.

Table 2. Results from the hedonic regression on breakfast cereals

| Variable | Coefficient | Variable | Coefficient |
|---|---|---|---|
| Nutrition label | 0.01 (0.53) | Second largest store type | 0.02** (5.03) |
| Environment label | -0.06** (-2.23) | Second smallest store type | 0.03** (4.20) |
| Private label | -0.53** (-8.95) | Smallest store type | 0.06** (8.56) |
| Log_gram | -0.53** (-4.93) | Vitamins | -0.02 (-0.48) |
| Log_fiber | -0.01 (-0.31) | Minerals | -0.00 (-0.09) |
| Log_carbohydrates | -0.12 (-0.68) | Additives | 0.05** (2.34) |
| Log_sugar | 0.09** | *Constant* | -3.237** |

| | | | |
|---|---|---|---|
| | (3.41) | | (6.50) |
| Log_fat | 0.04 | $R^2$ : 0.81 | |
| | (0.70) | | |
| Log_saturated fat | -0.05 | | |
| | (-1.39) | | |
| Log_sodium | 0.02 | | |
| | (0.88) | | |

The dependent variable is the logarithm of the average price per kilo gram product during the study period. Superscript * indicates the variable has a statistically significant effect at the 10 percent level and superscript ** indicates the effect is significant at the 5 percent level; *t*-values are in parentheses.