# DESIGNING AN ADDED SUGAR TAX TO DISCOURAGE UNHEALTHY FOOD PURCHASES IN BRAZIL

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**Resumo**

O objetivo deste estudo é avaliar os efeitos de um imposto sobre o açúcar adicionado nas compras de alimentos em domicílios brasileiros. Utilizando dados da Pesquisa de Orçamento Familiar (POF) de 2017-2018, as elasticidades preço e despesa foram estimadas a partir de um Sistema Quadrático Quase-Ideal. Em seguida, foi possível simular o efeito de um imposto de 1% sobre cada grama de açúcar adicionado em 100 gramas de alimento. Os resultados mostram que o consumo de alimentos não saudáveis é elástico em relação ao preço. A tributação reduziria o consumo de açúcar e bebidas açucaradas e aumentaria a compra de frutas e verduras.

**Palavras-chave:** açúcar adicionado, tributação, elasticidade-preço, QUAIDS.

**Abstract**

The objective of this study is to evaluate the effects of a tax on added sugar in food purchases in Brazilian households. Using data from the 2017-2018 Family Budget Survey (POF), price and expenditure specifications were estimated using a Quasi-Ideal Quadratic System. Subsequently, it was possible to simulate the effect of a 1% tax on each gram of added sugar in 100 grams of food. The results show that food consumption is not price-elastic. Taxation would reduce the consumption of sugar and sugary drinks and increase the purchase of fruits and vegetables.

**Keywords:** added sugar, taxation, price elasticity, QUAIDS.

**JEL Classification:** I18, D12, H23

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## 1. INTRODUCTION

The growing phenomenon of obesity has intensified in the world, especially in middle- and low-income countries (GLOPAN, 2016). In Brazil, in particular, the proportion of obese people grew more than proportionally compared to the countries that make up the Organization for Economic Cooperation and Development (OECD). OECD (2019) report that the proportion of obese people in Brazil went from 12,7% in 1996 to 22,1% in 2016, while for the countries that make up OECD, the change was from 15,4% to 23,2% in the same period. Projections for the period between 2020 and 2050, a 5,5% reduction in the Gross Domestic Product (GDP) is also predicted due to the economic costs generated by obesity (OECD, 2019).

Obesity is a multifactorial disease caused by individual characteristics, environmental characteristics, and social hierarchy influences (LEE; CARDEL; DONAHOO, 2000; OKUNOGBE et al., 2022). Considering that, different strategies have been implemented to improve diet and reduce obesity in Brazil: control and regulation of food (front package labelling, marketing), food reformulation focused on salt, sugar, and fat content, promoting healthy environments, and food and nutritional education. However, changes in eating habits also involve economic aspects and financial constraints (FINKELSTEIN; ZUCKERMAN, 2008; HAN; SCHWARTZ; ELBEL, 2020).

With improvements in the production process, some foods have become relatively cheaper due to the addition of preservatives, acidulants, and flavourings. However, technological advances did not affect all foods equally (CUTLER; GLAESER; SHAPIRO, 2003). In general, foods that are consumed similarly to the way they leave the farm, such as fresh fruits and vegetables, were not as positively affected by advances in packaging and processing. On the other hand, foods with significant processing benefited more from new technologies (JUUL; BERE, 2024).

This situation created a change in relative prices, causing fresh foods, such as fruits and vegetables, to become relatively more expensive when compared to highly processed foods — rich in sugar, sodium, and fat (ABAY; IBRAHIM; BREISINGER, 2022; CUTLER; GLAESER; SHAPIRO, 2003; GIUNTELLA; RIEGER; ROTUNNO, 2020). For Brazil, Maia et al. (2020) estimate that highly processed foods (unhealthy) cost an average of R$ 7,31 in the period 2003–2010, and between 2011 and 2017 this cost decreased to R$ 6,67. Meanwhile, fresh or minimally processed foods cost about R$ 4,43 in the first period, and R$ 4,70 in the following period.

Taxation is a tool whereby the government can reverse the change in relative prices, influence individual consumption choices and potentially affect obesity rates. Mexico, France, Hungary, Denmark, South Africa and many of the Western Pacific Islands have passed health-related food taxes to induce a reduction in the consumption of sugar-sweetened beverages (SSB) and unhealthy food (BATIS et al., 2016; BÍRÓ, 2015; COLCHERO et al., 2016; SMED et al., 2016; SNOWDON; THOW, 2013). Evidence from implemented taxes and modelling studies has associated taxation with a reduction in purchasing of those foods, obesity prevalence and improvement in health (ALSUKAIT et al., 2020; ANDREYEVA et al., 2022; BLAKELY et al., 2020; EICHNER; RUNKEL, 2025).

To support the potential for taxes to improve health, different tax scenarios have been considered, including taxes on products with added sugar (CARO et al., 2017; EICHNER; RUNKEL, 2025). In Brazil, work by others has focused on the potential effect of SSB tax on consumption and health (BASTO-ABREU et al., 2023; CLARO et al., 2011; ENES et al., 2022; NUCCI et al., 2022; PEREDA et al., 2024). However, data from the Household Budget Survey 2008/09 and 2017/18 indicates other food categories that contribute to excessive sugar consumption in the Brazilian population (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2020, 2011).

Taxation based on sugar amount has advantages in reaching those products high in sugar content and presents greater effects on calories, sodium, carbohydrates, saturated fats, and total fats compared to SSB tax (CARO et al., 2017). Also, in the long term, it could incentivise manufacturers to reformulate to lower-sugar products and reduce the population's exposure to added sugar, similar to what happened to the SSB tax implemented in the UK and Seattle (POWELL; LEIDER; ODDO, 2021; SCARBOROUGH et al., 2020).

To simulate the potential impact of taxation of products with added sugar in Brazil, we estimated the own- and cross-price elasticities of foods for Brazilian households to assess the effect on food consumption. For this study, we followed the definition from Levy et al. (2012), which considers added sugar extracted from food and then used in culinary preparations or in the manufacture of processed foods.

## 2. DATA AND METHODS

### 2.1 DATA

For this study, we used cross-sectional data from the Household Budget Survey 2017-18 (POF, Portuguese acronym), collected by Instituto Brasileiro de Geografia e Estatística (2020). POF has national coverage and assesses the consumption pattern of the Brazilian population from information about the consumer profile, expenses and equity variation of households and socioeconomic characteristics of residents.

The research is based on a two-stage cluster sampling plan, which considers census areas as primary sampling units (PSU) and households as secondary units. In the first stage, a subsample of census areas was drawn considering the geographical and socioeconomic stratification of the PSU. In the second stage, households were drawn by simple random sampling, reaching a total of 57,920 households interviewed (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2020).

This work uses information from the sections about the characteristics of the household, the residents, and the collective purchasing book. From the first section, information regarding the residents was considered, such as the condition of the residents in the consumer unit (spouse, child, aggregate, among others), sex, education, and other household characteristics. From the collective purchasing book section, information regarding the amount purchased, type of product, total purchase value and place of purchase were considered.

For the proposed analysis, 15 food groups were considered: Grain Cereals, Vegetables, Fruits, Grains, Baked goods, Meats, Poultry, Dairy, Sugar, Salt, Cooking Oil, Sugary Drinks, Other Drinks, Processed Food, and Others. The detailed classification is listed in Appendix Table A1.

### 2.2 QUADRATIC ALMOST IDEAL SYSTEM (QAIDS)

To evaluate the impact of taxation, first, we estimate the elasticity price of demand and, based on this value, we simulate the effect of a tax based on the amount of added sugar on food consumption. In calculating elasticity, we use the Quadratic Almost Ideal Demand System (QUAIDS) considering that consumer data is censored at zero for many types of food.

To correct this problem, we use the two-stage approach proposed by Heien e Wessells (1990). In the first stage, we estimate a probit model to treat the possibility of a certain good being purchased or not, considering certain demographic characteristics. The probit can be defined as:

$$Y_{ik} = f(z_{ik}) \tag{1}$$

where $Y_{ik} = 1$ if the $k$-th household purchases the $i$-th food, and 0 otherwise; $z_{ik}$ represents a vector of demographic variables of the $k$-th household described in Table 1. The probability density functions $\phi(z_{ik})$ and the cumulative distribution function $\Phi(z_{ik})$ were derived for each food group and by household based on the estimated probit [7]. These functions were included in the estimated QUAIDS equations in the second stage (HEIEN; WESSELLS, 1990).

[7] The results of the estimated probit model are presented in Table A2 in the Appendix.

Tabela 1: Demographic variables of vectors $z_{ik}$, $A_{ik}$ and $D_k$.

| **Household Location** | |
|---|---|
| *situation** | Household located in the rural area = 1; otherwise = 0 |
| *Northeast** | Household located in the Northeast region = 1; otherwise = 0 |
| *Midwest** | Household located in the Midwest region = 1; otherwise = 0 |
| *Southeast** | Household located in the Southeast region = 1; otherwise = 0 |
| *South** | Household located in the South region = 1; otherwise = 0 |
| **Household Characteristics** ($A_{ik}$) | |
| *sex** | Head of the household is female = 1; otherwise = 0 |
| *education** | Years of study of the head of the household |
| *credit_card** | Head of the household has a credit card = 1; otherwise = 0 |
| *black** | Head of the household is black = 1; otherwise = 0 |
| *Asian** | Head of the household is Asian = 1; otherwise = 0 |
| *resident1* | Number of residents between 0 and 5 years |
| *resident2* | Number of residents between 6 and 12 years |
| *resident3* | Number of residents between 13 and 18 years |
| *resident4* | Number of residents between 19 and 59 years |
| *resident5* | Number of residents who are 60 or older |
| *lnincome** | Natural logarithm of monthly household income |
| *no_rooms** | Number of rooms in the house |
| *water** | Home has running water = 1; otherwise = 0 |
| *sewage** | Home has sewage system = 1; otherwise = 0 |
| *oven** | Home has an oven = 1; otherwise = 0 |
| *stove** | Home has a stove = 1; otherwise = 0 |
| *refrigerator** | Home has a refrigerator = 1; otherwise = 0 |
| *freezer** | Home has a freezer = 1; otherwise = 0 |

**Source:** Prepared by the authors.

**Note:** * variable that makes up only vectors $z_{ik}$ and $A_{ik}$.

The QUAIDS specification of the second stage with censoring correction can be derived as:

$$w_{ik} = \Phi(d_k)\left\{\alpha_i + \sum_{j=1}^{n}\gamma_{ij}\ln p_j + \beta_i\left[\ln\left(\frac{y}{f(p)}\right)\right] + \left(\frac{\lambda_i}{g(p)}\left[\ln\left(\frac{y}{f(p)}\right)\right]\right)^2\right\} + \delta_i\phi(d_k) + \xi_{ik} \tag{2}$$

where: $w_i = \frac{p_i q_i}{\sum_{i=1}^{n} p_i q_i}$ is the portion of home spending with the $i$-th good; $y$ is the total spending of the household with food; $p_j$ is the price of the food $j$; $\gamma_{ij}$, $\beta_i$ and $\varphi_i$ are parameters to be estimated.

The price aggregator $g(p)$ was calculated as:

$$\ln g(p) = \frac{1}{2}\sum_{i=1}^{n}\left(\bar{w}_i + \bar{w}_i^0\right)\ln\left(\frac{p_i}{p_i^0}\right) \tag{3}$$

where: $\bar{w}_i$ is the average portion of household spending with food $i$; $\bar{w}_i^0$ is the smallest portion of household spending different from zero with the $i$-th good; $p_i$ is the average price of the $i$-th good; $p_i^0$ is the lowest average household price different from zero with the $i$-th good. The price index $f(p)$, on the other hand — the Törnqvist price index used here (MATSUDA, 2006) — can be obtained by:

$$\ln f(p) = \sum_{i=1}^{n} \left(\bar{w}_i - \bar{w}_i^0\right) \ln\left(\frac{p_i}{p_i^0}\right) \tag{4}$$

Considering the weak separability of preferences, it is possible that the demanded quantity of the $i$-th good ($q_i$) and the total spending with food ($Y$) are simultaneously determined, which causes endogeneity in spending. To correct this problem, we modeled the spending as a function of a set of exogenous variables and calculated the residuals ($v_k$) of this regression:

$$\ln y = \alpha_0 + \sum_{k=1}^{n} \rho_k A_{ik} + \tau_j \ln f(p) + v_k \tag{5}$$

where: $\rho_k$ is the parameter vector associated with the characteristics' variables of the $k$-th household $A_{ik}$ described in Table 1; $\tau_j$ is the price index parameter $\ln f(p)$. Finally, we included the regression residuals ($v_k$) as an explanatory variable in the QUAIDS model demand equations, which, together with the spending, makes it possible to correct and test the endogeneity of total spending on food (BLUNDELL; ROBIN, 1999).

Once the corrections of the censoring and endogeneity of the spending are established, the QUAIDS model, defined in 2, was estimated as:

$$\begin{aligned} w_{ik} = \Phi(d_k) \Bigg\{ & \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \left[\ln\left(\frac{y}{f(p)}\right)\right] + \left(\frac{\lambda_i}{g(p)} \left[\ln\left(\frac{y}{f(p)}\right)\right]\right)^2 \\ & + \sum_{k=1}^{n} \varphi_{ik} D_{ik} + \theta_i \hat{v}_k \Bigg\} + \delta_i \phi(d_k) + \xi_{ik} \end{aligned} \tag{6}$$

where: $D_{ik}$ is a vector of demographic variables that characterize the $k$-th household (Table 1) and $astrictlypositiverelationshipbetweenpurchaseandhouseholdincome.hi_{ik}$ are the respective parameters to be estimated; $\theta_i$ is the parameter of the residuals of equation 5; $\xi_{ik}$ is an error term with average zero.

To ensure that results are consistent with the theoretical properties of demand, we consider the restrictions of:

**Additivity:** $\sum_{i=1}^{n} \alpha_i = 1$; $\sum_{i=1}^{n} \gamma_{ij} = 0,\ j = 1, \ldots, n$; $\sum_{i=1}^{n} \beta_i = 0$ and $\sum_{i=1}^{n} \lambda_i = 0$ (7)

**Homogeneity:** $\sum_{j=1}^{n} \gamma_{ij} = 0,\ i = 1, \ldots, n$ (8)

**Symmetry of the Slutsky matrix:** $\gamma_{ij} = \gamma_{ji}$ (9)

We estimated the demand system described in 6 with the seemingly unrelated regression (SUR) method for 14 food groups as proposed by Heien e Wessells (1990). The group Others was treated as the residual group.

The price of demand ($e_{ij}$) and spending ($e_i$) elasticities were calculated according to Matsuda (2006), as follows:

$$e_{ij} = \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i}\left(\frac{\bar{w}_j + \bar{w}_j^0}{2}\right) - \frac{\lambda_i}{w_i g(p)}\left[\bar{w}_j + \bar{w}_j^0 + (\bar{w}_j - \bar{w}_j^0)\ln\left(\frac{y}{f(p)}\right)\right]\ln\left(\frac{y}{f(p)}\right) - \delta_{ij}, \quad i,j = 1, \ldots, n \tag{7}$$

$$\varepsilon_i = 1 + \frac{\beta_i}{w_i} - \frac{2\lambda_i}{w_i g(p)} \ln\left(\frac{y}{f(p)}\right), \quad i = 1, \ldots, n \tag{8}$$

where: $\delta_{ij}$ represents the Kronecker delta, which is equal to 1 if $i = j$ and zero otherwise.

## 2.3 TAXATION SCENARIO

Based on the price of demand elasticities, the simulation considered the introduction of a 1% tax on each gram of sugar added to 100 grams of food, resulting in the rates for each group presented in Table 2. Arnoult, Tiffin e Traill (2008) find that a specific tax like this one is easy to implement and to be understood by consumers, avoiding problems such as information asymmetry. The choice for added sugar is justified by its positive relationship with the prevalence of diabetes, obesity, and cardiovascular disease (ALVARADO et al., 2021; LEVY et al., 2012; FERNANDEZ; RAINE, 2019; SROUR et al., 2020).

Tabela 2: Average composition regarding the added sugar and the tax rate of the proposed tax separated by food groups.

| **Food Groups** | **Added Sugar (g)*** | **Tax rate (%)** |
|---|---|---|
| Cereal Grains | 0.24 | 0.24 |
| Vegetables | 0.00 | 0.00 |
| Fruits | 0.00 | 0.00 |
| Grains | 0.80 | 0.80 |
| Baked Goods | 7.35 | 7.35 |
| Meats | 0.57 | 0.57 |
| Poultry | 0.00 | 0.00 |
| Dairy | 2.64 | 2.64 |
| Sugar | 84.08 | 84.08 |
| Salt | 1.39 | 1.39 |
| Cooking Oil | 0.00 | 0.00 |
| Sugary Drinks | 8.95 | 8.95 |
| Other Drinks | 0.01 | 0.01 |
| Processed Food | 4.11 | 4.11 |
| Others | 0.21 | 0.21 |

**Source:** Prepared by the authors based on data from the 2017-2018 POF and on the nutrient table provided by IBGE.

**Note:** * The values use 100g of food as reference, i.e., they represent the average amount of added sugar (g) in 100g of food in each of the food groups.

The impact of this taxation on consumer choices was calculated as the variation in the amount demanded after a price intervention, as proposed by Leifert (2013). Considering a full transfer of the taxation to the price, this variation was calculated as:

$$\Delta Q = (E) \cdot (\Delta P') \tag{9}$$

where $\Delta Q$ is a vector with $n$ percentage variations of the quantities purchased by individuals after tariff policy; $E$ is a $15 \times 15$ matrix of the own-price and cross-price elasticities of the $i$-th group; $\Delta P'$ is the transposed matrix of variation of the food group prices according to Table 2.

## 3. RESULTS

The average amount of added sugar purchased by Brazilian households was about 1.072 grams/week, equivalent to 298 grams/week per resident. It is important to highlight that such data does not directly represent home consumption, since the data refers only to purchasing and does not represent consumption outside the household.

Table 3 shows the results of the amount of added sugar purchased at the household according to the second food group and some selected variables. Sugar represents about 80% of the household's added sugar purchase and is followed by Sugary Drinks and Baked Goods. The total of added sugar purchased in the household has a relationship in the inverted-U format with the income. We observed a positive relationship between income and purchasing for households with monthly income below 10 minimum wages. For income ranges greater than 10 minimum wages, income contributes to reducing the purchase of foods rich in added sugar, such as those in the Sugar group. Groups like Grains, Baked Goods, Dairy, Salt, Other Drinks, and Processed Food show an increase in the purchase of added sugar along all income ranges, characterizing a strictly positive relationship between purchase and household income.

Tabela 3: Amount of added sugar purchased in the household (g), according to the food group and household characteristics.

| Variables | Frequency | Cereal Grains | Grains | Baked Goods | Meats | Poultry | Dairy | Sugar | Salt | Sugary drinks | Other drinks | Processed Food | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Income Range** | | | | | | | | | | | | | | |
| 1. Up to 2 MWs | 13.552 | 0,22 | 2,81 | 46,64 | 5,63 | 0,01 | 14,09 | 788,27 | 1,44 | 43,61 | 0,03 | 2,01 | 0,02 | 904,79 |
| 2. From 2 to 4 MWs | 17.007 | 0,43 | 3,49 | 64,74 | 6,78 | 0,01 | 25,30 | 902,03 | 3,29 | 68,12 | 0,05 | 3,62 | 0,04 | 1.077,80 |
| 3. From 4 to 10 MWs | 14.100 | 0,95 | 7,52 | 84,23 | 7,98 | 0,02 | 43,33 | 924,16 | 6,05 | 109,00 | 0,14 | 5,49 | 0,06 | 1.189,92 |
| 4. From 10 to 20 MWs | 3.552 | 2,18 | 16,55 | 103,86 | 8,15 | 0,04 | 59,86 | 833,12 | 8,26 | 128,32 | 0,21 | 6,63 | 0,04 | 1.166,51 |
| 5. Over 20 MWs | 1.372 | 1,54 | 26,29 | 128,92 | 7,69 | 0,03 | 69,52 | 753,36 | 9,77 | 117,26 | 0,28 | 9,42 | 0,03 | 1.124,12 |
| **Region** | | | | | | | | | | | | | | |
| North | 7.071 | 0,17 | 3,52 | 43,23 | 6,67 | 0,00 | 24,66 | 902,91 | 2,27 | 62,69 | 0,00 | 3,00 | 0,15 | 1.049,27 |
| Northeast | 17.379 | 0,44 | 4,80 | 70,88 | 5,50 | 0,01 | 21,71 | 815,07 | 2,51 | 52,21 | 0,04 | 2,94 | 0,02 | 976,12 |
| Midwest | 5.849 | 0,59 | 7,98 | 69,73 | 6,04 | 0,00 | 32,04 | 862,65 | 3,98 | 95,55 | 0,08 | 5,80 | 0,09 | 1.084,56 |
| Southeast | 12.140 | 0,85 | 7,66 | 78,37 | 8,23 | 0,02 | 38,36 | 899,68 | 5,15 | 88,20 | 0,11 | 4,83 | 0,01 | 1.131,49 |
| South | 7.144 | 1,54 | 7,04 | 79,40 | 9,20 | 0,02 | 46,71 | 933,74 | 8,12 | 129,17 | 0,27 | 5,28 | 0,01 | 1.220,49 |
| **Household situation** | | | | | | | | | | | | | | |
| Urban | 38.581 | 0,72 | 6,40 | 72,38 | 6,87 | 0,01 | 33,46 | 770,03 | 4,50 | 81,24 | 0,10 | 4,13 | 0,02 | 979,85 |
| Rural | 11.002 | 0,53 | 4,68 | 61,04 | 7,16 | 0,00 | 22,31 | 1.225,18 | 3,72 | 69,88 | 0,07 | 3,93 | 0,11 | 1.397,82 |
| p-value | | 0,1113 | 0,0458 | 0,0000 | 0,1789 | 0,0323 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0645 | 0,4764 | 0,0021 | 0,0000 |
| **Presence of children/teenagers** | | | | | | | | | | | | | | |
| No | 39.571 | 0,63 | 5,94 | 66,54 | 6,58 | 0,01 | 29,45 | 848,41 | 4,03 | 76,99 | 0,11 | 3,80 | 0,03 | 1.042,49 |
| Yes | 10.012 | 0,89 | 6,35 | 83,01 | 8,33 | 0,02 | 37,26 | 960,40 | 4,39 | 85,54 | 0,02 | 5,24 | 0,09 | 1.191,56 |
| p-value | | 0,0374 | 0,6428 | 0,0000 | 0,0000 | 0,0127 | 0,0000 | 0,0000 | 0,1520 | 0,0003 | 0,0983 | 0,0000 | 0,0395 | 0,0000 |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.

**Notes:** • MW: Minimum wage. Income Ranges are classified based on the minimum wage of R$ 954.00 (in force in 2018).

• The Vegetables, Fruits and Cooking Oil groups were omitted because they do not have added sugar.

Levy et al. (2012) show that food consumption and purchasing habits vary by region, either because of its size or due to socioeconomic and demographic factors. The results by region, in Table 3, show that households located in more economically developed regions are also those with the highest level of purchase of added sugar. The South region, for example, stands out for presenting the highest average purchase (1.220,49 g/household), followed by the Southeast (1.131,49 g/household) and the Midwest (1.084,56 g/household). This position, occupied by the South, predominates in most of the food groups analyzed. As for the Sugary Drinks group, the purchase of added sugar is greater in the South, and with a significant difference compared to other regions (more than twice as what is observed for the North and Northeast regions).

Considering the household situation, households located in rural areas present a higher total purchase of added sugar than those located in urban areas (1.397,82g and 979,85g, respectively), representing a significant difference of 417,97 grams/week between both situations (Table 3). This result is mainly because, when it comes to the Sugar group, rural households present a 59% higher total purchase of added sugar than urban households. Among urban households, the Sugary Drinks group stands out, being the second with the highest participation in the total added sugar and with a 16% higher purchase than those located in rural areas. These results are similar to those found by Levy et al. (2012), who observed a higher calorie consumption regarding added sugar in rural households, considering the 2002-2003 POF.

In households with children/teenagers, there is a 14% higher purchase of added sugar than in households with only adults. This difference is partially due to the purchase of food containing added sugar, especially in the groups Baked Goods, Meats, Dairy, Sugar, Sugary Drinks, and Processed Food.

## 3.1 SPENDING ELASTICITIES AND PRICE ELASTICITY

Elasticities can be understood as sensitivity measures of the amount demanded in relation to spending or in relation to price. Table 4 shows the spending elasticity for each of the food groups. The groups Vegetables (1,955), Grains (1,754), Meats (2,575), Dairy (2,956), Sugar (3,045), Salt (1,574), Cooking Oil (2,264), Other Drinks (2,771) and Processed Food (5,200) have a positive spending elasticity. Furthermore, they present elasticities greater than one, making these superior goods, that is, an increase in food spending generates an increase more than proportional to the amount purchased. Among these groups, Processed Foods stand out (5,200); an increase of 1% in total food spending generates an increase of about 5,2% in the amount purchased.

On the other hand, the spending elasticity calculated for the groups' Grain Cereals, Fruits, Baked Goods, and Poultry indicates that these are inferior goods since increases in food spending tend to cause decreases in purchasing. The most significant and surprising result regards the Fruits group since a 1% increase in spending tends to decrease purchases by 0,636%; a positive correlation between purchasing and spending was expected for this group.

As for some negative elasticities, a possible justification is the substitution effect between goods, more easily seen when analyzing spending instead of household income as a weight variable. For example, as food spending increases individuals tend to replace foods such as Fruits, Poultry, Grain Cereals and Baked Goods with foods such as Vegetables, Meats and Processed Foods. The latter, having spending elasticities higher than one, tend to gain greater participation in the total spending on food, partially replacing the groups with negative spending elasticity.

The results of own-price and cross elasticities, calculated based on the midpoint of the sample, are presented in Table 5. The results show negative and own-price elasticities higher than one for most food groups, except for Processed Foods. The results for Cereal Grains ($-3,223$), Vegetables ($-1,908$), Fruits ($-1,616$), Dairy ($-1,693$), Meats ($-1,429$), and Poultry ($-1,727$) suggest an elastic demand for these items. However, it contradicts the expected elasticity for items that constitute the foundation of the Brazilian diet, whose demand tends to be inelastic (Brasil, 2014). Inelastic behaviour for the group of Processed

Tabela 4: Estimated spending elasticities ($\eta$).

| **Food groups** | $\eta$ |
|---|---|
| Cereal Grains | $-0,419^{***}$ |
| Vegetables | $1,955^{***}$ |
| Fruits | $-0,636^{***}$ |
| Grains | $1,754^{***}$ |
| Baked Goods | $-0,884^{***}$ |
| Meats | $2,575^{***}$ |
| Poultry | $-0,631^{***}$ |
| Dairy | $2,956^{***}$ |
| Sugar | $3,045^{***}$ |
| Salt | $1,574^{***}$ |
| Cooking Oil | $2,264^{***}$ |
| Sugary Drinks | $0,078^{NS}$ |
| Other Drinks | $2,771^{***}$ |
| Processed Food | $5,200^{***}$ |
| Others | $-37,130^{***}$ |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.
**Notes:** $^{***}$ Statistically significant at 1%; $^{**}$ Statistically significant at 5%; $^{*}$ Statistically significant at 10%; NS Not significant.

Foods may be the result of the change in society's dietary pattern, which in recent years has increased the presence of processed and ultra-processed foods in the diet of the Brazilian population, making this type of food the foundation of this diet (Levy et al., 2012).

The results also show that the groups representing the main sources of added sugar (Sugary Drinks and Sugar) have a price-sensitive demand. In the specific case of sugary drinks, the price elasticity of $-4,05$ suggests that a low tax rate would tend to generate a large decrease in the purchase of added sugar.

Cross-price elasticities point to a substitution relationship between Sugar and Sugary Drinks, important sources of added sugar purchases, with Vegetables and Fruits. If an added sugar taxation policy is implemented, aimed especially at groups like Sugar and Sugary Drinks, the result would be twice as positive: the purchase of these foods, rich in added sugar, would decrease, and the purchase of products with zero added sugar and high nutritional value would increase. Based on this assumption, the next section deals with the effects, in terms of purchase, of the taxation of foods with added sugar.

Tabela 5: Own-price and cross elasticities ($e_{q_i p_j}$).

(continued)

| | **Cereal Grains** | **Vegetables** | **Fruits** | **Grains** | **Baked Goods** | **Meats** | **Poultry** |
|---|---|---|---|---|---|---|---|
| Cereal Grains | $-3,223^{***}$ | $0,223^{***}$ | $0,302^{***}$ | $-0,070^{**}$ | $0,631^{***}$ | $0,468^{***}$ | $0,834^{***}$ |
| Vegetables | $0,105^{***}$ | $-1,908^{***}$ | $-0,241^{***}$ | $-0,009^{NS}$ | $0,135^{***}$ | $0,111^{***}$ | $0,075^{**}$ |
| Fruits | $0,291^{***}$ | $-0,196^{***}$ | $-1,616^{***}$ | $0,139^{***}$ | $-0,218^{***}$ | $0,157^{***}$ | $0,131^{***}$ |
| Grains | $-0,162^{***}$ | $-0,005^{NS}$ | $0,142^{***}$ | $-1,358^{***}$ | $0,183^{***}$ | $-0,135^{**}$ | $0,236^{***}$ |
| Baked Goods | $0,210^{***}$ | $0,155^{***}$ | $-0,068^{***}$ | $0,089^{***}$ | $-1,071^{***}$ | $0,197^{***}$ | $-0,016^{NS}$ |
| Meats | $0,049^{***}$ | $0,025^{**}$ | $-0,043^{***}$ | $-0,041^{***}$ | $-0,109^{***}$ | $-1,429^{***}$ | $-0,061^{***}$ |
| Poultry | $0,470^{***}$ | $0,148^{***}$ | $0,078^{***}$ | $0,138^{***}$ | $-0,043^{*}$ | $0,183^{***}$ | $-1,727^{***}$ |
| Dairy | $-0,073^{***}$ | $-0,119^{***}$ | $0,095^{***}$ | $0,046^{***}$ | $0,047^{***}$ | $-0,167^{***}$ | $-0,074^{***}$ |
| Sugar | $-0,815^{***}$ | $0,065^{**}$ | $0,100^{***}$ | $-0,472^{***}$ | $0,493^{***}$ | $0,030^{NS}$ | $0,149^{***}$ |
| Salt | $-0,817^{***}$ | $0,185^{**}$ | $0,437^{***}$ | $-1,122^{***}$ | $0,772^{***}$ | $-0,002^{NS}$ | $0,613^{***}$ |
| Cooking Oil | $-1,417^{***}$ | $-0,094^{NS}$ | $0,450^{***}$ | $-0,439^{***}$ | $0,462^{***}$ | $0,341^{***}$ | $0,510^{***}$ |
| Sugary Drinks | $0,199^{***}$ | $0,206^{***}$ | $0,554^{***}$ | $0,058^{*}$ | $0,162^{***}$ | $0,038^{NS}$ | $0,362^{***}$ |
| Other Drinks | $0,121^{***}$ | $0,112^{***}$ | $0,143^{***}$ | $0,008^{NS}$ | $0,046^{**}$ | $-0,076^{***}$ | $0,107^{***}$ |
| Processed Food | $0,128^{NS}$ | $-0,131^{NS}$ | $0,568^{***}$ | $0,267^{***}$ | $-2,658^{***}$ | $0,531^{***}$ | $0,112^{NS}$ |
| Others | $11,782^{***}$ | $2,550^{***}$ | $-4,324^{***}$ | $2,730^{***}$ | $3,697^{***}$ | $-1,352^{***}$ | $-2,985^{***}$ |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.

**Notes:** • Interpreting the elasticities should be done as follows: an increase in the price of the column group generates variation in the demand of the row group.

• The own-price elasticities are highlighted.

• $^{***}$ Statistically significant at 1%; $^{**}$ Statistically significant at 5%; $^{*}$ Statistically significant at 10%; NS Not significant.

Tabela 5: Own-price and cross elasticities ($e_{q_i p_j}$).

(conclusion)

| | **Dairy** | **Sugar** | **Salt** | **Cooking Oil** | **Sugary Drinks** | **Other Drinks** | **Processed Food** | **Others** |
|---|---|---|---|---|---|---|---|---|
| Cereal Grains | $0,040^{NS}$ | $-0,499^{***}$ | $-0,182^{***}$ | $-0,491^{***}$ | $0,126^{***}$ | $0,219^{***}$ | $0,144^{***}$ | $1,219^{***}$ |
| Vegetables | $-0,122^{***}$ | $0,055^{***}$ | $0,033^{**}$ | $-0,025^{NS}$ | $0,063^{***}$ | $0,113^{***}$ | $-0,009^{NS}$ | $0,107^{***}$ |
| Fruits | $0,337^{***}$ | $0,137^{***}$ | $0,116^{***}$ | $0,185^{***}$ | $0,322^{***}$ | $0,239^{***}$ | $0,355^{***}$ | $-0,577^{***}$ |
| Grains | $0,180^{***}$ | $-0,447^{***}$ | $-0,390^{***}$ | $-0,226^{***}$ | $0,022^{NS}$ | $0,043^{**}$ | $0,244^{***}$ | $0,325^{***}$ |
| Baked Goods | $0,211^{***}$ | $0,184^{***}$ | $0,077^{***}$ | $0,085^{***}$ | $0,045^{***}$ | $0,118^{***}$ | $-0,347^{***}$ | $0,023^{**}$ |
| Meats | $-0,059^{***}$ | $0,017^{*}$ | $-0,005^{NS}$ | $0,032^{***}$ | $-0,032^{***}$ | $-0,013^{*}$ | $0,113^{***}$ | $-0,164^{***}$ |
| Poultry | $0,104^{***}$ | $0,130^{***}$ | $0,100^{***}$ | $0,134^{***}$ | $0,132^{***}$ | $0,161^{***}$ | $0,114^{***}$ | $-0,297^{***}$ |
| Dairy | $-1,693^{***}$ | $-0,047^{***}$ | $0,014^{*}$ | $-0,046^{***}$ | $0,083^{***}$ | $-0,053^{***}$ | $0,009^{NS}$ | $0,010^{NS}$ |
| Sugar | $-0,124^{***}$ | $-1,403^{***}$ | $-0,094^{***}$ | $-0,580^{***}$ | $-0,022^{NS}$ | $-0,113^{***}$ | $-0,156^{***}$ | $0,936^{***}$ |
| Salt | $0,168^{***}$ | $-0,276^{***}$ | $-2,408^{***}$ | $-1,089^{***}$ | $0,261^{***}$ | $0,166^{***}$ | $-0,298^{**}$ | $2,033^{***}$ |
| Cooking Oil | $-0,185^{***}$ | $-1,086^{***}$ | $-0,721^{***}$ | $-1,311^{***}$ | $0,280^{***}$ | $0,073^{*}$ | $0,193^{*}$ | $1,354^{***}$ |
| Sugary Drinks | $0,394^{***}$ | $0,031^{NS}$ | $0,118^{***}$ | $0,196^{***}$ | $-4,055^{***}$ | $0,025^{NS}$ | $0,608^{***}$ | $0,559^{***}$ |
| Other Drinks | $-0,083^{***}$ | $-0,072^{***}$ | $0,031^{***}$ | $0,019^{NS}$ | $-0,030^{*}$ | $-2,561^{***}$ | $-0,061^{**}$ | $0,406^{***}$ |
| Processed Food | $-0,073^{NS}$ | $-0,255^{***}$ | $-0,165^{***}$ | $0,108^{NS}$ | $0,622^{***}$ | $-0,190^{***}$ | $-0,119^{NS}$ | $-1,785^{***}$ |
| Others | $2,092^{***}$ | $6,526^{***}$ | $4,603^{***}$ | $4,781^{***}$ | $3,508^{***}$ | $4,840^{***}$ | $-7,430^{***}$ | $-13,601^{***}$ |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.

**Notes:**
- Interpreting the elasticities should be done as follows: an increase in the price of the column group generates variation in the demand of the row group.
- The own-price elasticities are highlighted.
- $^{***}$ Statistically significant at 1%; $^{**}$ Statistically significant at 5%; $^{*}$ Statistically significant at 10%; NS Not significant.

## 3.2 EFFECTS OF TAXATION ON ADDED SUGAR PURCHASES

Based on the own-price and cross elasticities, calculated in the previous section, it is possible to observe the effects that the taxation would have on the purchase of products with added sugar for each group analyzed. In this section, we present the effects on purchasing with the introduction of a 1% tax for each gram of added sugar in 100 grams of food, as proposed in Appendix Table A1.

Table 6 shows that tax introduction generates significant reductions for some food groups that are rich in added sugar, such as Sugar and Sugary Drinks. For the specific case of Sugar, the decrease in purchase is total, i.e., an 84,08% increase in prices would lead to zero purchase of all foods in that group. For Sugary Drinks, the result is also significant: an increase of 8,95% in prices would represent a more than proportional decrease in the amount demanded (−31,19%). This is exclusively the result of the own-price elasticity of Sugary Drinks (−4,055), and partially counterbalanced by the complementarity relationships with 11 out of the 15 groups analyzed, making the final effect less significant than it would be if it evaluated only the impact of own-price elasticity.

The Cooking Oil group is indirectly the most affected by taxation, data that does not concern this increase in prices. The 86,31% decrease in purchasing is due to the strong replacement relationships that this group has with 5 out of the other 14 groups. In particular, Cooking Oil and Sugar present a cross-price elasticity of −1,086, causing the 84,08% increase in the price of Sugar to result, by itself, in a decrease in the purchase of Cooking Oil by about 91,31%, which is partially counterbalanced by complementary relationships with other groups. Conversely, the Poultry group presents a distinct behaviour. Due to the replacement relationship with the Sugar group, its purchase is positively affected by the price increase, which translates into an increase in the purchase of Poultry by about 12,96%.

Tabela 6: Effects of added sugar taxation on consumption by food groups

| **Food groups** | $\nabla P$ (%) | $\nabla Q$ (%) |
|---|---|---|
| Cereal Grains | 0,24 | −36,14 |
| Vegetables | 0,00 | 6,02 |
| Fruits | 0,00 | 15,48 |
| Grains | 0,80 | −36,46 |
| Baked Goods | 7,35 | 7,46 |
| Meats | 0,57 | −0,24 |
| Poultry | 0,00 | 12,96 |
| Dairy | 2,64 | −7,40 |
| Sugar | 84,08 | −115,86 |
| Salt | 1,39 | −17,47 |
| Cooking Oil | 0,00 | −86,31 |
| Sugary Drinks | 8,95 | −31,19 |
| Other Drinks | 0,01 | −6,36 |
| Processed Food | 4,11 | −35,47 |
| Others | 0,21 | 590,06 |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.

**Notes:** $\nabla P$ represents the price variation and $\nabla Q$ represents the variation of the amount purchased.

Grains ($-36,46\%$), Cereal Grains ($-36,14\%$) and Salt ($-17,47\%$) are indirectly and significantly affected by the added sugar taxation. Despite having little added sugar in its composition, these groups are greatly affected by the relationships resulting from cross-price elasticities, especially with the Sugar group. Due to this complementary relationship, the price negatively affects the purchase of Grains, Cereal Grains, and Salt.

As for Baked Goods (7,46%), which are one of the main sources of added sugar, a 7,35% tax is not enough to decrease the purchase of foods that make up this group. What happens, in fact, is an increase in purchase by about 7,46%, the result of the 11 complementarity relationships existing with other groups, especially with Sugar.

As a positive result of taxation, the Vegetables and Fruits groups, which are not in fact taxed, show significant increases in purchases, 6,02% and 15,48%, respectively. These foods are rich in vitamins and minerals and poor in added sugar, thus improving the food quality in the household (Brasil, 2014). Another positive outcome can be seen in the replacement of Meat ($-0,24$) with Poultry (12,96): the latter is, on average, higher in protein and has a smaller percentage of fat when compared to red meats, therefore improving diet quality (Pereira and Vicente, 2013).

## 3.3 DISCUSSION

The findings of this study demonstrate that taxation is effective in reducing the consumption of unhealthy products and might contribute to improving nutrient intake in households. This implies that fiscal policy should be considered in conjunction with health and nutritional policies to improve eating habits in Brazil. Recently, this country has approved a tax reform that includes the possibility of differentiated taxation for products that cause harm to health. The results of this study consider a taxation scheme based on the quantity of added sugar, with a fixed tax rate for each considered group. The proposed tax rate can serve as the basis for future discussions about the implementation of this new tax scheme.

The elasticities point to substitution relationships among groups with a high amount of added sugar, implying that taxation policies aimed at reducing sugar consumption should not focus on a single product. The results show the food groups with higher added sugar content (sugar, sugary drinks, and baked goods) which may be the focus of this new tax rate and other policies to discourage sugar consumption. The policies can include restrictions on the marketing of these foods, industry regulation with reinforcement and adjustments in the agreement for sugar reduction, and incentives for product reformulation.

It is important to point out that one of the main arguments against the imposition of such a specific tax is the existence of regressivity, that is, households with lower income would proportionally pay a higher tax than those with a higher income. Using data from the 2008–2009 POF, Julião (2019) finds that a tax like this generates regressivity, as lower-class households have a larger portion of compromised home income (3,75%) than upper-class households (0,75%).

Conversely, it can be argued that there is a progression in terms of health, that is, even if lower-income individuals are more harshly affected by the tax, they would have, proportionally, greater health gains, reducing the weight of negative aspects of taxation, as pointed out by Lal et al. (2017). In this sense, sugar tax also might contribute to reduce health costs related to non-communicable chronic disease such as diabetes and obesity. The costs related to obesity account US$ 654 million to Brazilian Unified Health System in 2019 (Ferrari et al., 2022). And the direct cost related to diabetes was estimated in US$633 million (Pereda, 2022). The illustration of these points aims only to present counterpoints to public policy in this proposed work, and its investigation should be an incentive for future work.

### 4. CONCLUSION

This paper sought to investigate how the taxation of added sugar tends to impact the amount demanded, using data from the 2017–2018 Consumer Expenditure Survey (POF). More specifically, we investigated how sociodemographic variables impact the likelihood of purchasing foods that make up the Brazilian diet.

The results found that households located in rural areas purchase on average more products with added sugar than urban households. A similar relationship exists in households with children and teenagers, who on average purchase more products with added sugar. There is also a positive relationship between income and purchasing of products with added sugar for households with up to 10 minimum wages (R$ 954,00). From this salary range onwards, the relationship is reversed. As for the location, households from the southern region are on average the ones that purchase the highest number of products with added sugar, purchasing around 1.220 grams per week.

The analysis of the spending elasticities shows that increases in spending tend to change the food purchasing pattern within the household. In general, households tend to replace Cereal Grains, Fruits, Baked Goods and Poultry with Vegetables, Grains, Meats, Sugar, Salt, Cooking Oil, Other Beverages, and Processed Foods. This pattern shows that when the household income increases, the purchasing of products with added sugar and spending on food also tends to increase.

The results of own-price elasticities show great sensitivity to the demand for foods such as Cereal Grains, Salt, and Sugary Drinks in relation to the price itself. Another outcome was the inelasticity of the demand for Processed Foods in relation to the price, showing that an increase in the price of these foods would have little effect on the amount purchased (disregarding cross-relationships). Regarding cross-price elasticities, most relationships are substitution relationships, representing about 58%. In particular, there are some strong complementarity relationships, such as the one found between Processed Foods and Baked Goods, as well as between Cooking Oil and Grain Cereals, results that were expected given the Brazilian food consumption pattern.

As for the actual effects of the taxation of 1% per gram of added sugar for every 100 grams of food, the results are generally positive, as was expected. There would be a total decrease in the purchase of Sugar, as well as a 31% decrease in the purchase of Sugary Drinks and 35% in the purchase of Processed Foods, as these groups are important sources of added sugar. There was an unexpected effect regarding Baked Goods, whose demand was not negatively affected despite being the third largest source of added sugar purchasing. Even with a 7,35% tax on its price, the demanded amount increased by 7,46%, a result of the cross relationship between this group and the others.

Finally, there is a positive effect that is marked by the increase in the purchasing of Fruits and Vegetables, which after the taxation would have increased of 15,48% and 6,02%, respectively. As a post-taxation result, households would tend to purchase fewer foods rich in sugars, such as Sugar and Sugary Drinks, and increase the consumption of foods with zero sugar and highly nutritional foods such as Fruits and Vegetables.

Thus, the present work aims to support the proposition of public policies that aim to improve the quality of the food for Brazilian citizens, and the tariff policy is an important tool for the government. It is important to point out that such consideration does not exclude the importance of proposing other policies, such as promoting physical activity, food education in schools and encouraging the adoption of healthy habits, that do not involve relative prices. A detailed investigation into the regressivity of taxation escapes the scope of this work, being a suggestion for future research.

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## APPENDIX

Table A1 - Food Classification by Groups.

| **Food Groups** | **Food** | | | **Added Sugar (g)*** |
|---|---|---|---|---|
| **Cereal Grains** | Rice | Beans | Others | 0,24 |
| **Vegetables** | Pumpkin<br>Chinese cabbage<br>Garlic<br>Potato<br>Beet<br>Onion | Carrot<br>Parsley and green onion<br>Chicoria<br>Cabbage<br>Cauliflower<br>Jiló | Manioc<br>Maxixe<br>Cucumber<br>Bell pepper<br>Tomato<br>Others | 0,00 |
| **Fruits** | Avocado<br>Pineapple<br>Banana<br>Guava | Orange<br>Lemon<br>Apple<br>Watermelon | Melon<br>Strawberry<br>Grape<br>Others | 0,00 |
| **Grains** | Cornstarch<br>Flour | Pasta<br>Lasagna pasta | Pizza dough<br>Others | 0,80 |
| **Baked Goods** | Cake<br>Cookie | Bread<br>Bagel | Toast<br>Others | 7.35 |
| **Meats** | Beef<br>Meat from other animals<br>Pork | Processed meat<br>Fish<br>Bovine viscera | Swine viscera<br>Other viscera | 0,57 |
| **Poultry** | Poultry | Eggs | | 0,00 |
| **Dairy** | Cream<br>Yogurt<br>Milk | Condensed milk<br>Fermented milk<br>Butter | Cheese<br>Others | 2,64 |
| **Salt** | Salt | Spices | | 1,39 |
| **Cooking Oil** | Olive Oil and Cooking Oil | Margarine | Others | 0,00 |
| **Sugary drinks** | Soft Drinks and Juice | Dairy beverages | Others | 8,95 |
| **Other drinks** | Alcoholic beverages<br>Coffee<br>Tea | Diet soft drinks<br>Light soft drinks<br>Diet juice | Light juice<br>Others | 0,01 |
| **Processed Food** | Frozen food<br>French fries<br>Roasted meat<br>Roasted chicken | Uncooked pasta<br>Meal<br>Salty snacks<br>Sandwich | Food mixtures<br>Others | 4,11 |
| **Others** | Açaí<br>Coconut | Chestnuts<br>Nuts | Other products | 0,21 |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.

Table A2 - Results of the estimated probit model

(continued)

| Variables | Food Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Cereal** | **Vegetables** | **Fruits** | **Grains** | **Baked Goods** | **Meats** | **Poultry** | **Dairy** |
| situation | 0,050*** | 0,050*** | -0,072*** | -0,030* | -0,423*** | -0,148*** | 0,076*** | -0,070*** |
| Northeast | -0,111*** | 0,125*** | 0,230*** | -0,149*** | 0,273*** | -0,307*** | 0,012NS | 0,051*** |
| Midwest | -0,346*** | 0,118*** | 0,069*** | -0,559*** | -0,306*** | -0,395*** | -0,262*** | 0,010NS |
| Southeast | -0,295*** | 0,155*** | 0,113*** | -0,451*** | 0,090*** | -0,413*** | -0,282*** | 0,087*** |
| South | -0,235*** | 0,299*** | 0,239*** | -0,263*** | -0,042NS | -0,250*** | -0,159*** | 0,166*** |
| sex | -0,049*** | 0,020* | 0,049*** | 0,026** | 0,027** | -0,030** | 0,016NS | 0,038*** |
| education | 0,000NS | 0,004*** | 0,014*** | 0,006*** | 0,014*** | 0,005*** | 0,003*** | 0,018*** |
| credit_card | -0,006NS | 0,011NS | 0,041*** | 0,003NS | 0,037*** | 0,008NS | 0,005NS | 0,021** |
| Black | -0,022* | -0,025* | -0,060*** | -0,049*** | -0,071*** | -0,019NS | -0,010NS | -0,117*** |
| Asian | 0,147*** | 0,023NS | 0,065NS | 0,090NS | 0,018NS | -0,022NS | 0,023NS | 0,088NS |
| resident1 | -0,016NS | -0,101*** | -0,095*** | 0,049*** | 0,022* | -0,034*** | -0,022* | 0,109*** |
| resident2 | 0,057*** | -0,049*** | -0,097*** | 0,045*** | 0,107*** | 0,026** | 0,051*** | 0,001NS |
| resident3 | 0,071*** | -0,052*** | -0,128*** | 0,051*** | 0,067*** | 0,038*** | 0,055*** | -0,041*** |
| resident4 | 0,076*** | -0,015* | -0,110*** | 0,049*** | 0,048*** | 0,041*** | 0,065*** | -0,062*** |
| resident5 | 0,082*** | 0,019NS | -0,010NS | 0,067*** | 0,066*** | 0,045*** | 0,060*** | -0,057*** |
| Lnincome | 0,003NS | 0,150*** | 0,207*** | 0,045*** | 0,094*** | 0,119*** | 0,068*** | 0,174*** |
| no._rooms | 0,006* | 0,026*** | 0,029*** | 0,005* | -0,013*** | 0,006* | -0,002NS | 0,016*** |
| water | 0,078** | -0,116*** | 0,007NS | 0,059* | -0,048NS | 0,147*** | -0,031NS | -0,080** |
| sewage | 0,089*** | 0,064*** | -0,014NS | 0,070*** | -0,121*** | 0,055*** | 0,042*** | -0,036** |
| oven | -0,011NS | 0,074*** | 0,065*** | 0,042** | -0,040** | -0,035** | 0,064*** | 0,068*** |
| stove | 0,004NS | 0,143** | 0,084NS | 0,127** | 0,251*** | 0,104* | 0,125** | 0,224*** |
| refrigerator | 0,009NS | 0,100*** | 0,041NS | -0,070* | 0,120*** | -0,120*** | -0,061* | 0,077** |
| freezer | 0,009NS | 0,097*** | 0,031* | 0,013NS | -0,131*** | -0,070*** | 0,043** | 0,027NS |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.
**Notes:** *** Statistically significant at 1%; ** Statistically significant at 5%; * Statistically significant at 10%; NS Not significant.

Table A2 - Results of the estimated probit model

(conclusion)

| **Variables** | **Food Groups** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Sugar** | **Salt** | **Cooking Oil** | **Sugary Drinks** | **Other Drinks** | **Processed Food** | **Others** |
| situation | 0,013NS | -0,033* | 0,000NS | -0,137*** | -0,037** | -0,263*** | 0,060** |
| Northeast | -0,068*** | -0,060*** | -0,115*** | -0,057*** | -0,059*** | -0,150*** | -0,818*** |
| Midwest | -0,272*** | -0,023NS | -0,196*** | 0,132*** | -0,208*** | -0,145*** | -0,890*** |
| Southeast | -0,201*** | 0,051** | -0,110*** | 0,125*** | -0,210*** | -0,035NS | -0,835*** |
| South | 0,039NS | 0,249*** | -0,031NS | 0,403*** | 0,003NS | 0,110*** | -0,811*** |
| sex | 0,008NS | 0,007NS | -0,012NS | -0,033*** | -0,048*** | -0,044*** | -0,024NS |
| education | 0,007*** | 0,007*** | -0,001NS | 0,013*** | 0,007*** | 0,020*** | 0,010*** |
| credit_card | 0,024*** | 0,027*** | -0,002NS | 0,030*** | 0,038*** | 0,048*** | 0,048*** |
| Black | -0,055*** | -0,041*** | -0,028** | -0,060*** | -0,045*** | -0,062*** | 0,008NS |
| Asian | 0,153*** | 0,161*** | 0,168*** | 0,079NS | 0,072NS | -0,067NS | 0,112NS |
| resident1 | 0,016NS | -0,038*** | -0,006NS | 0,029** | -0,077*** | 0,000NS | -0,063*** |
| resident2 | 0,038*** | 0,013NS | 0,074*** | 0,038*** | -0,028*** | -0,017NS | -0,011NS |
| resident3 | 0,014NS | 0,028*** | 0,078*** | 0,052*** | -0,005NS | -0,017NS | -0,041** |
| resident4 | -0,001NS | 0,028*** | 0,087*** | 0,006NS | 0,011NS | -0,071*** | -0,039*** |
| resident5 | 0,008NS | 0,019NS | 0,083*** | -0,077*** | 0,014NS | -0,123*** | -0,035* |
| Lnincome | 0,099*** | 0,104*** | 0,020** | 0,139*** | 0,097*** | 0,201*** | 0,172*** |
| no._rooms | 0,004NS | 0,006* | -0,001NS | -0,015*** | 0,004NS | -0,003NS | 0,015*** |
| water | 0,125*** | 0,031NS | 0,089** | -0,145*** | 0,126*** | -0,055NS | 0,111** |
| sewage | 0,030** | 0,038** | 0,045*** | -0,020NS | 0,007NS | -0,051*** | 0,106*** |
| oven | 0,070*** | 0,051*** | 0,020NS | 0,007NS | 0,004NS | 0,054*** | 0,052* |
| stove | -0,077NS | 0,188*** | 0,041NS | -0,045NS | -0,033NS | -0,056NS | 0,298*** |
| refrigerator | -0,090** | 0,039NS | 0,021NS | 0,136*** | -0,103*** | -0,032NS | -0,257*** |
| freezer | -0,007NS | 0,015NS | 0,017NS | 0,001NS | 0,016NS | -0,029NS | 0,090*** |

**Source:** Prepared by the authors based on data from the 2017-2018 POF.
**Notes:** *** Statistically significant at 1%; ** Statistically significant at 5%; * Statistically significant at 10%; NS Not significant.