

The COVID-19 pandemic in a Brazilian metropolis: repercussion on food prices

A pandemia de COVID-19 em uma metrópole brasileira: repercussão sobre o preço dos alimentos

La pandemia de COVID-19 en una metrópolis brasileña: repercusión en los precios de las comidas

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doi: 10.1590/0102-311XEN166721

Abstract

We analyzed the impact of the efforts to combat the COVID-19 pandemic on the prices of food sold by a food supply center located in the sixth largest city in Brazil. We examined the percentage change in the prices of 20 types of foods, adjusted by market conditions, using municipal contingency plan stages to compare opening and closing of non-essential services, including bars and restaurants (stage 1: first phase of essential services-only; stage 2: flexibilization; and stage 3: second phase of essential services-only with a “pre-pandemic” period [stage 0]). Log-prices were lower in all contingency stages for leafy greens (variation: 42% to 56%) and vegetables (variation: 28% to 40%). Log-prices of eggs and fruit were 20% and 16% lower during stages 1 and 3, respectively. Strategies to combat the COVID-19 pandemic lowered the prices of eggs, fruit, leafy greens, and vegetables regardless of the market conditions. Accordingly, the supply and demand for fresh and minimally processed foods were affected by the economic crisis and difficulties to access and/or buy perishable foods more often. The impacts of efforts to defeat the pandemic must ensure the human right to adequate food, considering that low prices do not necessarily indicate food security.

COVID-19; Pandemics; Food Supply; Vegetables; Fruits

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Introduction

By February 2021, COVID-19 had infected over 170 million people and caused 3.7 million deaths worldwide ¹. The first COVID-19 case in Brazil was confirmed on February 26th, 2020, warranting a declaration of a public health emergency four days later and the creation of a committee for prevention and contingency. On March 18th, schools and workplaces were closed, all commercial activity defined as non-essential was suspended (i.e., bars and restaurants), and only essential services were allowed to remain open (i.e., drugstores, bakeries, grocery stores, dairy stores, butcher shops, produce shops, supermarkets, and restaurants with delivery, drive-through, and/or curbside pickup services). Belo Horizonte, capital of the Minas Gerais State and the sixth largest city in Brazil, adopted its own contingency plan with criteria and phases for gradually reopening services and commercial activities ².

Besides increasing morbidity and mortality, the pandemic has caused the local and global economy to slow down or even go into recession ³. As the economy declines, food access is likely to suffer adverse effects from a combination of income reduction, unemployment, contingency measures to reduce viral spread, and negative changes in food availability, quality, and prices in local markets ^{3,4,5}.

This economic scenario associated with changes in the food environment and food insecurity is aggravated in Brazil, a country with fragile social safety networks and political challenges that hinder combat against COVID-19 ^{5,6,7,8}. Brazil has recently returned to the Hunger Map, with 13.8 million people (6.7% of the population) classified as extremely poor in 2019 ^{9,10}. The *2020 Global Report on Food Crises*, written before the pandemic, estimated that 113 million people in 53 countries faced acute hunger in 2018 ¹¹. The pandemic will likely increase these numbers ³.

Belo Horizonte is internationally recognized as a successful example of public policies for food security and nationally praised for its implementation of the Brazilian Unified National Health System (SUS) ¹². The city, which has the third largest economy in Brazil, has been controlling the pandemic well despite the challenges ¹³. The wholesale food supply center CeasaMinas (Centrais de Abastecimento de Minas Gerais S.A./Minas Gerais State Supply Centers) is essential to ensure food security in the city and its metropolitan area ^{6,14}. Belo Horizonte also has one of the largest number of bars and restaurants in the country (over 90,000) ¹⁵, out of which most likely purchase their food items at CeasaMinas.

To understand the initial effects of the pandemic on a large Brazilian metropolis food system, especially regarding the prices of fresh and minimally processed foods, this article aimed to analyze the impact of contingency measures to combat the COVID-19 pandemic on the prices of fresh and minimally processed foods sold by CeasaMinas in Belo Horizonte.

Methods

Database

Data on food prices and market conditions were obtained from the CeasaMinas institutional website (<http://www.ceasaminas.com.br/>). The center's headquarters are located in the municipality of Contagem (Belo Horizonte metropolitan area, also known as "Great BH").

Market information from the daily price bulletin was filtered by food group (eggs, fruits, vegetables, and roots and tubers). The research team analyzed data from the CeasaMinas-Great BH unit only.

Data on market conditions were obtained from the seasonal calendar of warehouse prices ¹⁶. This calendar shows price trends based on average sales in CeasaMinas-Great BH over the past five years, classifying the monthly situation of each food into higher prices (more favorable for the supplier), balanced prices, or lower prices (more favorable for the customer). The calendar is available in PDF format and data was entered by trained researchers.

Data on contingency measures to combat the COVID-19 pandemic and reopening measures in Belo Horizonte were obtained from the institutional website of the Belo Horizonte City Hall (<https://prefeitura.pbh.gov.br/saude/coronavirus>).

Collected data and variables

Data was collected from January 6th to June 26th, 2020. According to the city's Master Plan, the city underwent four contingency stages in this period: stage 0 (pre-pandemic, from January 6th to March 17th); stage 1 (first phase of essential services-only, from March 18th to May 24th); stage 2 (flexibilization, from May 25th to June 8th); and stage 3 (second phase of essential services-only, from June 9th to June 26th). Box 1 shows the list of essential services and their respective opening hours in Belo Horizonte.

For analyses, contingency stages were divided into three binary variables representing each period (with "pre-pandemic" being the reference category in each variable). The pre-pandemic period was defined as from January 6th to March 17th, corresponding to the period of two months before contingency measures were implemented in the city. This reflects our aim of understanding the effects of the first contingency measures in the city while avoiding other factors, including the usual changes in food prices in December, new variants of the virus affecting the epidemic curve, the onset of the immunization program, and the reopening of schools.

To compare prices of fresh and minimally processed foods between the three pandemic phases and the pre-pandemic period, data was collected and analyzed on 20 items: fruit (banana, orange, apple, papaya, watermelon, tangerine, grape, mango), leafy greens (lettuce, kale, cabbage), vegetables

Box 1

List of essential services and their respective opening hours in Belo Horizonte, Minas Gerais State, Brazil, 2020. First and second phase of essential services-only.

DESCRIPTION	OPENING HOURS
Bakery	From 5 a.m. to 9 p.m.
Retail trade of dairy and cold products	From 7 a.m. to 9 p.m.
Butcheries and fishmongers	From 7 a.m. to 9 p.m.
Fruits and vegetables	From 7 a.m. to 9 p.m.
Mini-markets, grocery stores and warehouses	From 7 a.m. to 9 p.m.
Supermarkets and hypermarkets	From 7 a.m. to 9 p.m.
Pharmaceutical articles	No time restrictions
Pharmaceutical articles, with formula handling	No time restrictions
Retail trade of optical articles	No time restrictions
Medical and orthopedic articles	No time restrictions
Paints, solvents and painting material	From 7 a.m. to 9 p.m.
Electric and hydraulic equipment, glass and hardware	From 7 a.m. to 9 p.m.
Wood	From 7 a.m. to 9 p.m.
General building material	From 7 a.m. to 9 p.m.
Motor vehicle fuels	No time restrictions
Retail trade of liquefied petroleum gas (LPG)	No time restrictions
Wholesale trade in the retail chain of activities listed in this list	From 5 a.m. to 5 p.m.
Bank branches: credit institutions, insurance, capitalization, commerce and administration of real estate values	No time restrictions
Lottery houses	No time restrictions
Post office and telegraph	No time restrictions
Trade in medicines for animals	No time restrictions
Service activities and collective use services, except those specified in art. 2 of Decree n. 17,328, of April 8, 2020	No time restrictions
Industrial activities	No time restrictions
Restaurants, as long as they are delivered or picked up at the door	No time restrictions
Newspaper and magazine stand	No time restrictions

(pumpkin, chayote, cucumber, tomato), roots and tubers (carrot, sweet potato, potato, cassava), and eggs. These data of daily prices in Brazilian Reais (BRL) are freely available from the CeasaMinas headquarters website. Except for eggs, items were selected based on the most frequently consumed fruit and vegetables in Brazil⁶. When any of the items included more than one variety, the most commonly available variety was selected based on information obtained from the CeasaMinas website in 2019, similarly to a previous study⁶. If two or more varieties were equally available, the one with the lowest price was chosen. For foods with varied sizes, the price of an average-sized item was considered for analysis⁶.

Data on market conditions are available from the CeasaMinas's seasonal calendar. The calendar is not simply a proxy for the time of year, but a measurement of market conditions for each product, referring to the monthly variation in trading prices from 2015 to 2019¹⁶. Food were defined as "low prices, favoring the customer" (when in season), "neutral prices", or "high prices, favoring the supplier" (when off-season). For analyses, market conditions were divided into two binary variables: one indicating whether prices are "favorable to the supplier" and the other indicating if they are "favorable to the customer", with "neutral prices" being the reference category in both variables. This variable is understood as the seasonality of each food item throughout the year.

Analysis

Prices of the selected foods were converted from BRL to American Dollars (USD) according to the daily exchange rates available at Yahoo Finance¹⁷. Converted prices were then transformed into average weekly prices (the price of a dozen eggs was estimated from the price of 30 dozen by dividing it by 30).

Firstly, the behavior of average weekly prices for each item was described across contingency stages. Afterwards, a sequence of Gaussian linear mixed models¹⁸ were estimated to the logarithm of mean weekly prices of each food category (eggs, fruit, leafy greens, roots and tubers, and vegetables) to compare average changes in log-prices during the three contingency stages and the pre-pandemic period. Average weekly prices were computed by taking the simple average of all days of the week for which price data was available for a given food.

Model 1 included only a random intercept for each food type to show how market conditions affect average weekly prices. Model 2 included only contingency stages to show how prices vary between the various contingency stages and the pre-pandemic period. Model 3 included the binary variables representing each contingency stage, combining Models 1 and 2 to show how prices vary according to contingency stages after controlling for market conditions. Models were fitted for each food category (fruit, leafy greens, vegetables, roots and tubers, and eggs). Incidence rate ratios (IRR) and 95% confidence intervals (95%CI) were estimated for each association and an intraclass correlation coefficient (ICC) was estimated for each model.

All analyses were performed using the R statistical software (<http://www.r-project.org>) and statistical significance was set at 5%. Linear mixed models were fitted using the *glmmTMB* package.

Results

Figure 1 shows the mean weekly prices for each food type and category from January 6th to June 26th. During the first phase of essential services-only, eggs, potato, pumpkin, and chayote had the largest price variations, lettuce and collard greens had the highest prices, and cabbage and cassava had the lowest prices.

Table 1 shows the mean weekly prices and standard deviations for each food across categories of market conditions, including p-values for the Kruskal-Wallis test when prices were available for more than one category of market conditions. All foods had statistically significant differences in prices according to the market conditions except eggs, grape, mango, papaya, cabbage, collard greens, lettuce, cassava, sweet potato, chayote, and tomato (differences could not be evaluated for cucumber since its market conditions remained stable for the entire period).

Figure 1

Mean weekly prices in American Dollars (USD) for each food type and category, from January to July. Minas Gerais State Supply Centers (CeasaMinas), Belo Horizonte, Minas Gerais State, Brazil, 2020.

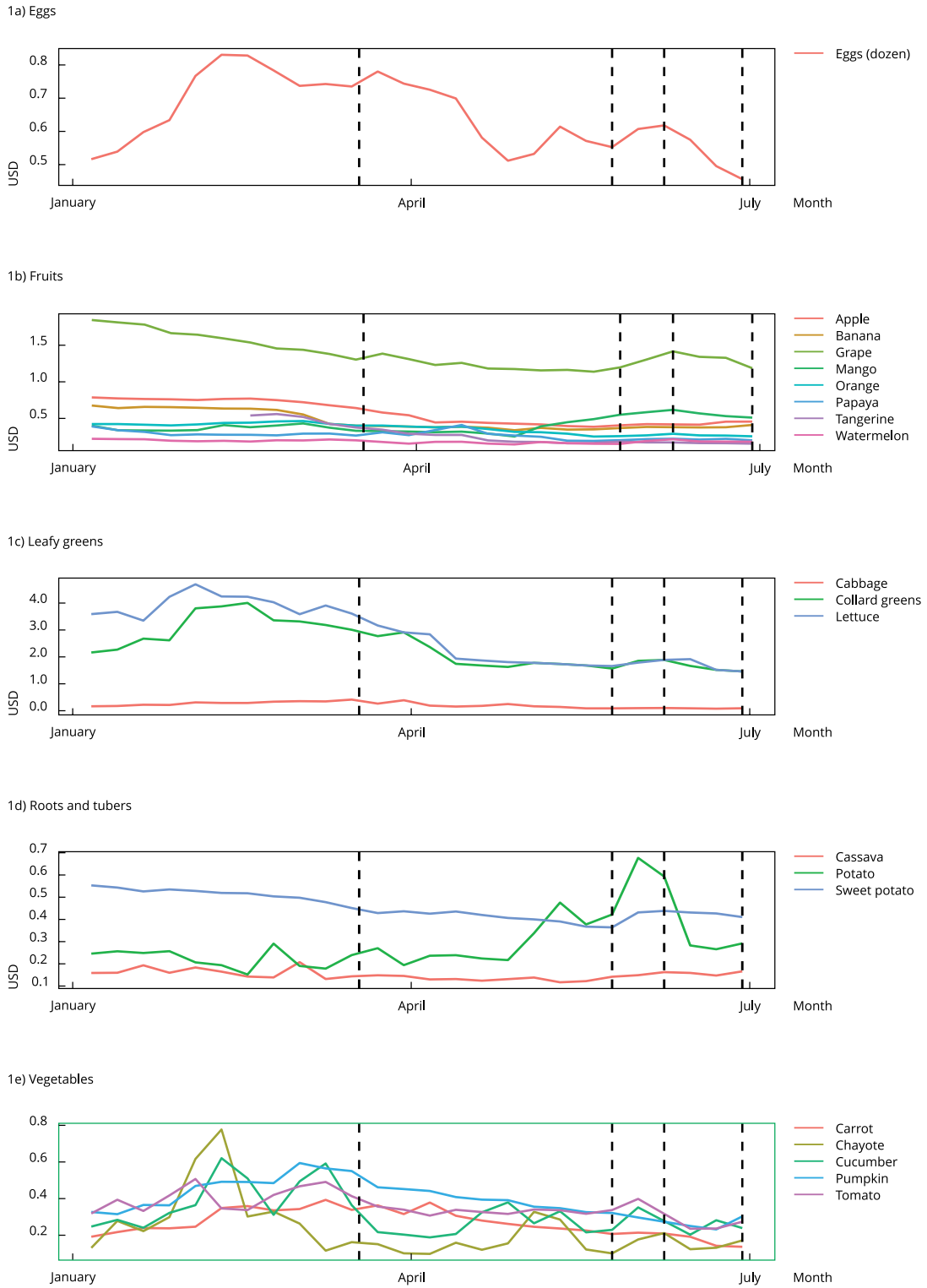


Table 1

Mean weekly prices in American Dollars (USD) for each food type across categories of market conditions. Belo Horizonte, Minas Gerais State, Brazil, 2020.

Food type	Prices favored the customer	Neutral prices	Favored the supplier	p-value *
	Mean (SD)	Mean (SD)	Mean (SD)	
Eggs				
Eggs (dozen)	0.57 (0.05)	0.67 (0.12)	0.65 (0.12)	0.429
Fruits				
Apple	0.43 (0.03)	0.69 (0.09)	0.76 (0.01)	< 0.001
Banana	0.39 (0.02)	0.39 (0.05)	0.64 (0.02)	< 0.001
Grape	**	1.40 (0.12)	1.38 (0.29)	0.198
Mango	0.35 (0.03)	0.38 (0.03)	0.43 (0.12)	0.694
Orange	0.27 (0.01)	0.35 (0.08)	0.41 (0.04)	0.005
Papaya	0.25 (0.06)	**	0.30 (0.05)	0.025
Tangerine	0.17 (0.01)	0.23 (0.05)	0.44 (0.10)	< 0.001
Watermelon	0.19 (0.01)	0.16 (0.01)	0.20 (0.02)	0.001
Leafy greens				
Cabbage	**	0.19 (0.09)	0.23 (0.11)	0.397
Collard greens	**	2.01 (0.45)	2.61 (0.89)	0.100
Lettuce	**	2.79 (1.22)	2.85 (0.81)	0.726
Roots and tubers				
Cassava	0.16 (0.03)	0.15 (0.02)	**	0.720
Potato	**	0.23 (0.04)	0.41 (0.14)	< 0.001
Sweet potato	**	0.46 (0.07)	0.45 (0.05)	0.739
Vegetables				
Carrot	**	0.20 (0.04)	0.30 (0.06)	< 0.001
Chayote	0.13 (0.03)	0.19 (0.07)	0.51 (0.23)	0.004
Cucumber	**	0.32 (0.12)	**	***
Pumpkin	**	0.36 (0.08)	0.47 (0.08)	0.007
Tomato	**	0.37 (0.08)	0.33 (0.01)	0.071

SD: standard deviation.

Source: Minas Gerais State Supply Centers (CeasaMinas).

* Kruskal-Wallis test's p-value;

** No observations were found between the food type and the corresponding market conditions in the sample;

*** The test could not be performed since only one group of market conditions was available for that food type in the sample.

Table 2 shows the mean weekly prices and standard deviations for each food across the four periods (pre-pandemic, first phase of essential services-only, flexibilization, and second phase of essential services-only), including Kruskal-Wallis test p-values. Statistically significant differences were observed for all foods except apple, banana, grape, papaya, watermelon, chayote, and cucumber.

Table 3 and Figure 2 show the estimated associations of mean weekly prices with market conditions (Model 1), contingency stages (Model 2), and both (Model 3). After adjusting for market conditions (Model 3) considering "pre-pandemic" as the reference category, log-prices of eggs were 24% lower when prices "favored the supplier" and 34% lower during the "second phase of essential services-only". Log-prices of fruit were 20% lower when prices "favored the customer", 16% higher when prices "favored the supplier", and 24% lower during the "first phase of essential services-only". Log-prices of leafy greens and vegetables in all three pandemic periods were lower than in the "pre-pandemic" period (leafy greens = 44%, 56%, and 54% lower, respectively; vegetables = 27%, 28%, and 35% lower, respectively). However, log-prices were higher for roots and tubers (IRR = 1.33; 95%CI: 1.17-1.51) and vegetables (IRR = 1.41; 95%CI: 1.25-1.59) when prices "favored the supplier".

Table 2

Mean weekly prices in American Dollars (USD) for each food type across contingency stages. Belo Horizonte, Minas Gerais State, Brazil, 2020.

Food type	Stage 0 (pre-pandemic)	Stage 1 (first phase of essential services-only)	Stage 2 (flexibilization)	Stage 3 (second phase of essential services-only)	p-value *
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Eggs					
Eggs (dozen)	0.70 (0.11)	0.64 (0.10)	0.58 (0.04)	0.54 (0.07)	0.085
Fruits					
Apple	0.74 (0.04)	0.46 (0.07)	0.41 (0.01)	0.44 (0.02)	0.001
Banana	0.59 (0.10)	0.37 (0.02)	0.38 (0.01)	0.39 (0.02)	< 0.001
Grape	1.59 (0.18)	1.22 (0.08)	1.25 (0.08)	1.32 (0.10)	0.001
Mango	0.37 (0.04)	0.35 (0.08)	0.57 (0.02)	0.56 (0.05)	0.002
Orange	0.43 (0.02)	0.34 (0.05)	0.26 (0.01)	0.27 (0.01)	< 0.001
Papaya	0.30 (0.04)	0.28 (0.07)	0.21 (0.01)	0.21 (0.01)	0.023
Tangerine	0.48 (0.08)	0.23 (0.07)	0.18 (0.01)	0.16 (0.01)	0.003
Watermelon	0.20 (0.01)	0.17 (0.01)	0.17 (0.03)	0.19 (0.02)	0.001
Leafy greens					
Cabbage	0.28 (0.08)	0.20 (0.09)	0.09 (0.01)	0.09 (0.01)	0.002
Collard greens	3.12 (0.63)	2.03 (0.51)	1.71 (0.20)	1.63 (0.19)	0.001
Lettuce	3.92 (0.40)	2.19 (0.60)	1.72 (0.09)	1.70 (0.24)	< 0.001
Roots and tubers					
Cassava	0.16 (0.02)	0.13 (0.01)	0.15 (0.00)	0.16 (0.01)	0.005
Potato	0.22 (0.04)	0.29 (0.09)	0.55 (0.18)	0.36 (0.16)	0.015
Sweet potato	0.51 (0.03)	0.41 (0.02)	0.40 (0.05)	0.43 (0.01)	< 0.001
Vegetables					
Carrot	0.30 (0.07)	0.29 (0.05)	0.21 (0.00)	0.17 (0.04)	0.007
Chayote	0.32 (0.20)	0.17 (0.08)	0.14 (0.05)	0.16 (0.04)	0.088
Cucumber	0.40 (0.14)	0.26 (0.07)	0.29 (0.09)	0.24 (0.04)	0.039
Pumpkin	0.46 (0.10)	0.40 (0.05)	0.31 (0.02)	0.26 (0.04)	0.005
Tomato	0.40 (0.07)	0.33 (0.02)	0.37 (0.04)	0.25 (0.02)	0.005

SD: standard deviation.

Source: Minas Gerais State Supply Centers (CeasaMinas).

* Kruskal-Wallis test's p-value.

Table 4 shows the ICC for each category for Models 1 to 3. The ICC for fruit, leafy greens, and roots and tubers ranged from 0.80 to 0.96, indicating statistically significant differences between average log-prices for foods in these categories. Although vegetables had smaller ICC (ranging from 0.34 to 0.99), their between-group variations still seem significant. Figure 3 includes the adequacy and residuals of the final models.

Discussion

Strategies to combat the COVID-19 pandemic lowered the prices of eggs, fruit, leafy greens, vegetables, roots and tubers in a wholesale food supply center during contingency stages in a Brazilian metropolis. The prices of fruit and eggs significantly decreased during the first and second phases of essential services-only and during the flexibilization period. These results show the effects of measures to combat COVID-19 on the supply and demand for fresh and minimally processed foods, mainly vegetables and leafy greens.

Table 3

Estimated incidence rate ratios (IRR) and 95% confidence intervals (95%CI) for Models 1 to 3. Belo Horizonte, Minas Gerais State, Brazil, 2020.

Exposure	Model 1		Model 2		Model 3	
	IRR	95%CI	IRR	95%CI	IRR	95%CI
Eggs *						
Prices favored the customer	0.87	0.72-1.04	-	-	0.76	0.66-0.87
Favored the supplier	0.97	0.85-1.12	-	-	1.08	0.97-1.19
First phase of essential services-only	-	-	0.91	0.81-1.04	0.83	0.75-0.92
Flexibilization	-	-	0.84	0.67-1.04	0.74	0.63-0.88
Second phase of essential services-only	-	-	0.77	0.65-0.91	0.66	0.57-0.76
Fruits						
Prices favored the customer	0.81	0.75-0.88	-	-	0.80	0.74-0.86
Favored the supplier	1.19	1.11-1.28	-	-	1.16	1.09-1.22
First phase of essential services-only	-	-	0.75	0.70-0.80	0.76	0.72-0.80
Flexibilization	-	-	0.72	0.65-0.81	0.84	0.76-0.92
Second phase of essential services-only	-	-	0.75	0.69-0.81	0.90	0.84-0.98
Leafy greens						
Prices favored the customer	**	**	-	-	**	**
Favored the supplier	1.19	0.98-1.44	-	-	1.22	1.06-1.41
First phase of essential services-only	-	-	0.62	0.55-0.71	0.56	0.49-0.65
Flexibilization	-	-	0.44	0.35-0.54	0.44	0.36-0.54
Second phase of essential services-only	-	-	0.42	0.36-0.50	0.46	0.38-0.54
Roots and tubers						
Prices favored the customer	1.03	0.85-1.27	-	-	1.03	0.85-1.26
Favored the supplier	1.31	1.17-1.47	-	-	1.33	1.17-1.51
First phase of essential services-only	-	-	0.94	0.84-1.05	0.90	0.81-0.99
Flexibilization	-	-	1.19	0.98-1.45	1.07	0.90-1.29
Second phase of essential services-only	-	-	1.08	0.93-1.25	0.93	0.80-1.08
Vegetables						
Prices favored the customer	0.65	0.47-0.90	-	-	0.75	0.56-0.99
Favored the supplier	1.40	1.22-1.59	-	-	1.41	1.25-1.59
First phase of essential services-only	-	-	0.77	0.69-0.87	0.73	0.66-0.82
Flexibilization	-	-	0.70	0.58-0.86	0.72	0.61-0.85
Second phase of essential services-only	-	-	0.60	0.51-0.70	0.65	0.57-0.75

Source: Minas Gerais State Supply Centers (CeasaMinas).

Note: Model 1 (only market conditions; reference category = neutral prices); Model 2 (only contingency stages; reference category = stage 0 or "pre-pandemic"); Model 3 (both market conditions and contingency stages). The outcome for all models is the logarithm of weekly mean prices in USD, from January 6th to June 29th.

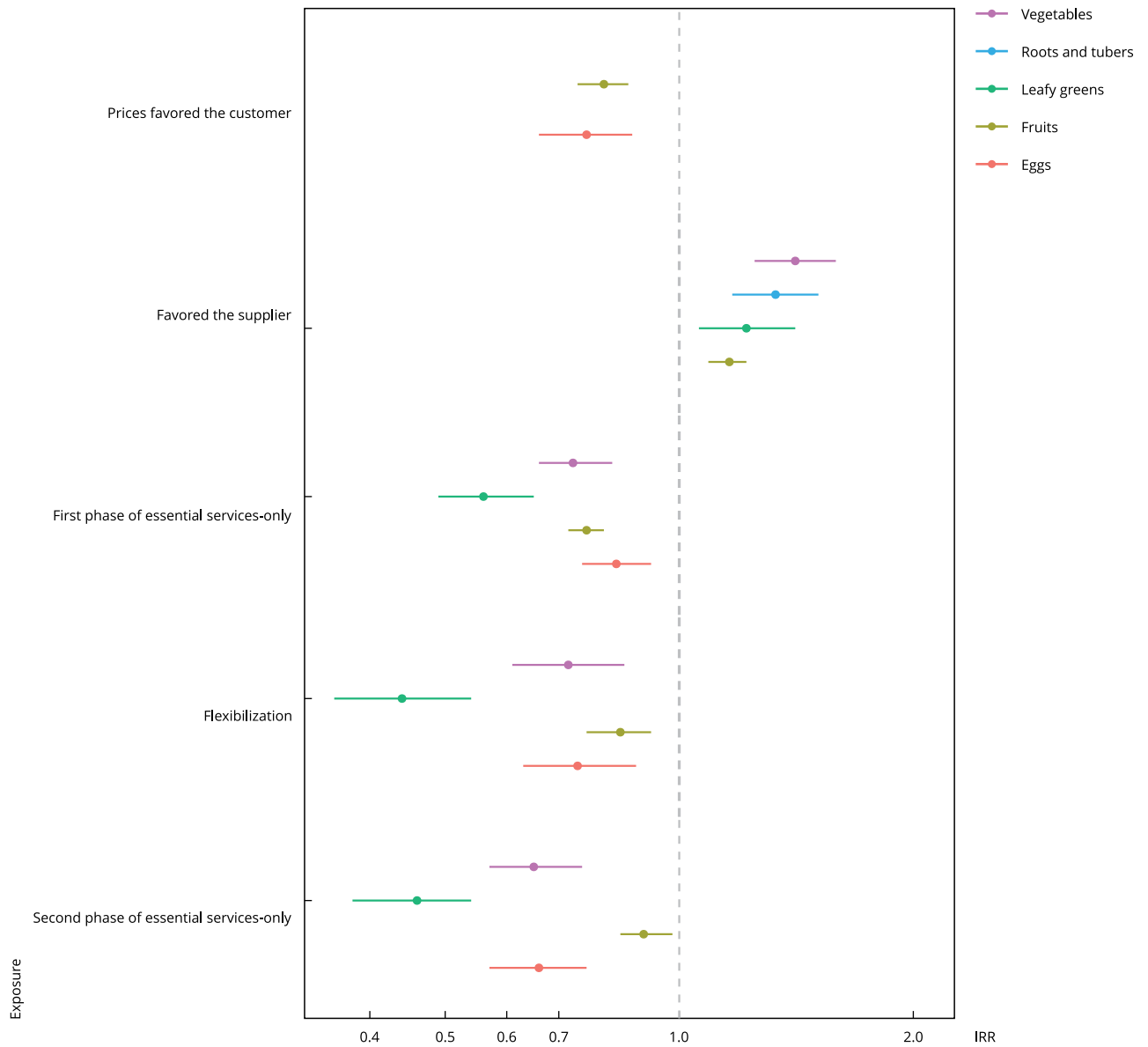
* Models for eggs do not include a random intercept since this category only contains one food type;

** Food type had no observations in the corresponding market conditions.

The prices of fruit, vegetables, and leafy greens could have decreased in all contingency stages regardless of market conditions because of a reduced demand for these foods, possibly caused by the reduced purchasing power of individuals and families, the delays on Emergency Aid payments, the rising prices of staple foods such as rice, beans, and vegetable oil, the increasing levels of food insecurity, and the tendency of food-insecure families of abdicating these foods ^{19,20,21,22,23}. Fruit, vegetables, and leafy greens are also highly perishable and require thorough washing and drying before being prepared or stored, which might have led people to choose more convenient foods while avoiding frequent grocery store trips ²⁴.

Figure 2

Forest plot of the estimated incidence rate ratios. Minas Gerais State Supply Centers (CeasaMinas), Belo Horizonte, Minas Gerais State, Brazil, 2020.



IRR: incidence rate ratios.

School closures may also have lowered the demand for these foods ¹⁹. Before the pandemic, large amounts of vegetables and leafy greens were constantly purchased for preparing school meals ^{24,25,26}. However, on March 18th (when all school activities were suspended), school meals were replaced by non-perishable foods and cooking ingredients (rice, beans, cornmeal, cassava flour, pasta, canned sardines, tomato paste, vegetable oil, powdered milk, sugar, and salt), distributed to students and families ²⁷.

Table 4

Intraclass correlation coefficients (ICC) for each category for Models 1 to 3. Belo Horizonte, Minas Gerais State, Brazil, 2020.

Food type	ICC		
	Model 1	Model 2	Model 3
Eggs *	**	**	**
Fruits	0.89	0.89	0.92
Leafy greens	0.89	0.96	0.96
Roots and tubers	0.79	0.81	0.80
Vegetables	0.34	0.39	0.44

Source: Minas Gerais State Supply Centers (CeasaMinas).

Note: Model 1 (only seasonal availability); Model 2 (only contingency stages) and Model 3 (both seasonal availability and contingency stages).

* Models for the eggs do not include a random intercept and therefore do not have a corresponding ICC value.

Similarly, the closing of bars, restaurants, and other non-essential food outlets could have further reduced the demand for fresh and minimally processed foods at CeasaMinas-Great BH, lowering the prices. The closing of these establishments is associated with both COVID-19 control measures and the bankruptcy of many small and medium businesses, which will not return to CeasaMinas-Great BH even with flexibilization rules. This intense economic crisis irreversibly damaged the food sector. As an example, the metropolitan area of Belo Horizonte had 22,000 bars and restaurants in operation. During the pandemic, 7,000 of them ended their activities ²⁸.

The 2020 management report of CeasaMinas shows that the center did not adjust its tariffs in 2020, seeking to lessen the economic challenges faced by farmers and greengrocers and to help warehouses maintain their activities ²⁹. Although this could have partially reduced the prices observed in this study, we were unable to measure this variable and estimate its impact on food prices.

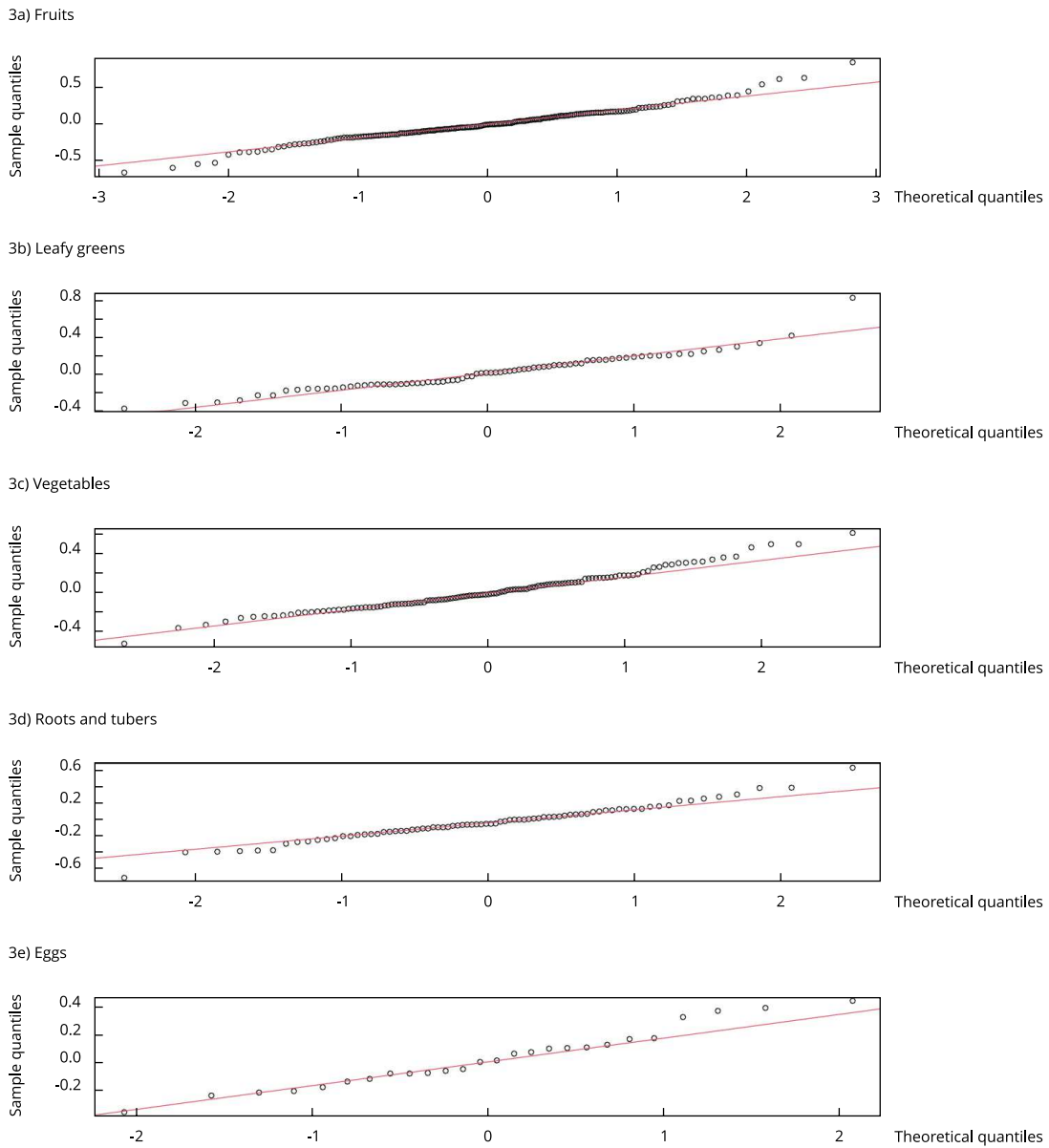
The price elasticity concept could also explain our results regarding the prices of fruit, eggs, and roots and tubers. Notably, consumption is a function of income, that is, the greater the income, the greater the consumption. However, in a microeconomic aspect, price elasticity must be considered. Food price elasticity is a measure of consumption sensitivity, representing how the demand for a specific item responds to a change in its price. Food items thus have highly sensitive (elastic) prices, if increased prices reduce demand, or inelastic prices, if increased prices do not affect the demand ³⁰.

Factors that can affect price elasticity and explain the differences in price changes across food categories are: (1) substitute foods: a food item that has substitute foods will have a greater price elasticity than others that do not have substitute foods since if the price of an item increases while prices of substitutes remain constant, consumers will naturally look for substitutes; (2) degree of essentiality: the more essential or necessary a food is to consumers, the less sensitive it is to price changes; and (3) period: demand tends to be more elastic in long-term than short-term because consumers can find alternatives and adjust their purchases according to price changes ³¹.

We hypothesize that food categories in this study could have different price elasticities. Since roots and tubers are important food staples in the Brazilian dietary pattern, the population has stable demand for them even with a reduced purchasing power ³¹. Although fruits are also essential for an adequate and healthy diet, a qualitative study carried out with health promotion program users in Belo Horizonte found that fruits are usually seen only as dessert, medicine, or meal replacement, affecting their purchase and intake ³². On the other hand, eggs are generally seen as a substitute for meat, a food group which was not analyzed in this study but whose prices significantly increased in the period ³³.

Figure 3

Quantile-quantile plots of the final models.



Note: "sample quantiles" are the residual quantiles, and theoretical quantiles are the corresponding Gaussian-distributed quantiles.

Although the population did not undergo food shortages ²⁰, the first months of the pandemic likely altered food-purchasing patterns, in which ultra-processed foods replaced fresh and minimally processed foods because of their convenience and durability ²⁴. The economic crisis associated with the COVID-19 pandemic increases levels of food insecurity and malnutrition, which, together with reduced physical activity levels, contribute to overweight, obesity, and other non-communicable diseases ⁵. With food insecurity, obesity and malnutrition form a double burden of disease and are part of a global syndemic as risk factors for death from COVID-19 ^{26,34,35}. We therefore emphasize the

importance of including access to adequate and healthy food as a prevention measure for COVID-19 and its complications, along with vaccines, hygiene, and social distancing ²³.

The economic crisis associated with the pandemic is also an aggravating factor with potential negative effects on the human right to adequate and healthy food. At the time of this article's review, retail food prices have significantly increased, whereas the population's purchasing power worsened with the end of Emergency Aid payments. The rising inflation increased food prices, exposing some Brazilians to extreme situations, with likely repercussions on other human rights ^{21,22}.

The situation is aggravated by the persistence of food inflation, caused by the devaluation of the Brazilian currency and the absence of public exchange control or export taxation policies to protect domestic consumers from the interests of exporters ²³. A study compared Brazil's food inflation in the first half of 2020 with its inflation of 2007 and 2019, finding that, during these years, foreign trade conditions, international prices, and exchange rates greatly influenced food inflation. However, in the first half of 2020, one of the causes for inflation was the increased demand for food in supermarkets, not accompanied by an expansion of food supplies ²³.

Our study has some limitations. Firstly, we only analyzed data from a wholesale food supply center, not investigating the consumers' food environment nor the retail network. However, price changes at CeasaMinas could have reflected on the rest of the food supply chain since the center's main customers are grocery stores, supermarkets, and fruit and vegetable stores ⁶. CeasaMinas is one of largest food supply centers in Brazil, with databases on food prices and market data that are updated almost daily.

Another limitation of this study is the timeframe of the analyzed data. We chose to analyze the effects of the city's first contingency measures on food prices. Price bulletins are updated many times a week, requiring several months to complete data collection; however, we believe that publishing these first results is critical. This urgency increases with the delays and reductions on the Emergency Aid payments, the increase in obesity prevalence (according to the most recent *Brazilian National Health Survey*), and Brazil's return to the United Nations' Hunger Map ^{10,36}.

More recent data are being collected to identify the effects of the developing contingency measures on food prices. We chose to analyze immunization program and the reopening of schools in another paper, considering the effects of new measures on the prolonged evolution of the pandemic. The strengths of this study include adjustments for seasonality and for unobserved variability by random effects, making our data robust and our results more credible.

Furthermore, we could not analyze other variables that could affect food prices, including climate variations, food routes, marketing channels, or the purchasing power of individuals before and during the pandemic. Since the COVID-19 pandemic is not an isolated event, price changes are multicausal and may be associated with political choices that favor the hegemonic food system and ultra-processed foods. The interpretation of these results thus require caution.

Climate change, obesity, and malnutrition pandemics have created a global syndemic. Its common causes include commercial interests related to the hegemonic food system, policy inertia, and fragile and insufficient social participation. Effects of climate change on food prices and malnutrition are thus undeniable ^{21,35}.

Our study has important strengths. To our knowledge, this is the first study to assess the effects of COVID-19 prevention measures on the price of fresh and minimally processed foods. Although these data are not regularly explored in the literature, they are freely available for scientific use as long as the data source is properly cited. Moreover, controlling the price analysis for market conditions removed the direct effect of seasonality, one of the main variables that affect availability and price of the included foods. This approach allowed creating better results, contributing to the literature on the interplay between strategies to combat the COVID-19 pandemic and food supply in Brazil.

We concluded that combat measures for COVID-19, including flexibility in opening and closing non-essential services in Belo Horizonte, greatly affect the price of fresh and minimally processed foods regardless of market conditions. This result seems good to consumers, but the lower price could be caused by a lower demand with the population's reduced purchasing power and/or preference for foods of longer duration. Results must therefore be completed beyond the low processes observed, rethinking the urban food system and working on immediate and concrete actions to create a more just, nutritious, sustainable, and resilient food and land use system. Lower prices do not immediately

result in better access to food or healthier eating habits, requiring efforts to combat the pandemic's effects on individuals and communities in the short, medium, and long term and to guarantee their right to adequate food.

We therefore emphasize the valuable contribution of food banks in Belo Horizonte for food and nutrition security in the city and its metropolitan region. Food banks seek to reduce food insecurity among vulnerable population groups by food donations, waste reduction, and food and nutrition education ³⁷. During the pandemic, food banks in Belo Horizonte and CeasaMinas-Great BH continued to function as an emergency service while new institutions were registered and the volume of food collections increased ^{37,38}.

The consumption of fresh and minimally processed foods must be stimulated, whereas unhealthy habits, including ultra-processed food consumption, should be discouraged. Individuals and families tend to purchase, store, and eat more of ultra-processed foods during crises such as the COVID-19 pandemic because of their convenience and long shelf life. Individuals must learn how to prepare their own meals and to observe hygiene and safety measures when purchasing food. Food waste at CeasaMinas may have increased because of the low demand for fresh and minimally processed foods, a contradiction when Brazil has returned to the Hunger Map.

The political efforts to ensure the human right to adequate food during this pandemic are critical in an unequal country such as Brazil, where viral spread is facilitated and consequences of COVID-19 are even more devastating due to social inequality, precarious housing and sanitation, and a high prevalence of noncommunicable diseases ³⁹. The country also has to face the denial of science, the disarticulation of important instances for the debate on food and nutrition security – such as the Brazilian National Food Security Council and the Brazilian Ministry of Social Development and Fight Against Hunger –, persistent austerity in health financing, the double burden of obesity and malnutrition, conflicts of interest, and a lack of transparency of the Brazilian Ministry of Health ^{19,21,39,40,41,42}.

Contributors

M. S. Lopes and A. C. S. Lopes contributed to the study conception and planning, data interpretation, writing, and review. P. P. Freitas contributed to the study planning, data interpretation, and review. M. C. R. Carvalho contributed to the writing and review. U. M. Silva contributed to the study planning, data analysis and interpretation, and review. All the authors approved the final version of the manuscript.

Acknowledgments

The authors would like to thank all the healthcare professionals who have been combating the virus during the COVID-19 pandemic. We thank the Minas Gerais State Supply Centers (CeasaMinas) and the Research Group on Nutrition Interventions for their cooperation on data collection.

Additional informations

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References

- World Health Organization. WHO Director-General's statement on IHR Emergency Committee on Novel Coronavirus (2019-nCoV). [https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-\(2019-ncov\)](https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-(2019-ncov)) (accessed on 04/May/2020).
- Prefeitura de Belo Horizonte. Coronavírus. <http://prefeitura.pbh.gov.br/saude/coronavirus> (accessed on 04/May/2020).
- Food and Agriculture Organization of the United Nations. Joint statement on COVID-19 impacts on food security and nutrition. <http://www.fao.org/news/story/en/item/1272058/icode/> (accessed on 04/May/2020).
- The Lancet Global Health. Food insecurity will be the sting in the tail of COVID-19. *Lancet Glob Health* 2020; 8:E737.
- Coordenação Geral de Alimentação e Nutrição, Departamento de Promoção da Saúde, Secretaria de Atenção Primária à Saúde, Ministério da Saúde. Ofício Circular nº 3/2020/CGAN/DEPROS/SAPS/MS. Recomendações da Coordenação Geral de Alimentação e Nutrição, do Departamento de Promoção da Saúde, do Ministério da Saúde às Secretarias Estaduais de Saúde e do Distrito Federal visando contribuir para a saúde e a segurança alimentar e nutricional no contexto epidemiológico do novo coronavírus (COVID-19). http://189.28.128.100/dab/docs/portaldab/documentos/relatorio_gestao_2020_rag_2020cgan.pdf (accessed on 04/May/2020).
- Lopes MS, Araujo ML, Lopes ACS. National general truck drivers' strike and food security in a Brazilian metropolis. *Public Health Nutr* 2019; 22:3220-8.
- Costa NS, Santos MO, Carvalho CPO, Assunção ML, Ferreira HS. Prevalence and factors associated with food insecurity in the context of the economic crisis in Brazil. *Curr Dev Nutr* 2017; 1:e000869.
- The Lancet. COVID-19 in Brazil: "So what?". *Lancet* 2020; 395:P1461.
- Instituto Brasileiro de Geografia e Estatística. PNAD Contínua – Pesquisa Nacional por Amostra de Domicílios Contínua. <https://www.ibge.gov.br/estatisticas/sociais/trabalho/17270-pnad-continua.html?=&t=o-que-e> (accessed on Apr/2021).
- Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares 2017-2018: análise da segurança alimentar no Brasil. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2020.
- Global Network Against Food Crises; Food Security Information Network. 2020 Global Report on Food Crises: joint analysis for better decisions. https://www.fsinplatform.org/sites/default/files/resources/files/GRFC_2020_ONLINE_200420.pdf (accessed on 04/May/2020).
- Prefeitura de Belo Horizonte. Qualidade da política de segurança alimentar de BH é referência internacional. <https://prefeitura.pbh.gov.br/noticias/qualidade-da-politica-de-seguranca-alimentar-de-bh-e-referencia-internacional> (accessed on 15/Feb/2021).
- Prefeitura de Belo Horizonte. Reabertura de atividades. https://prefeitura.pbh.gov.br/sites/default/files/estrutura-de-governo/planejamento/2020/pbh_reaberturadeatividades_210920-1.pdf (accessed on 15/Feb/2021).
- Centrais de Abastecimento de Minas Gerais S.A. Histórico. <http://www.ceasaminas.com.br/historicogeral.asp> (accessed on May/2020).
- Associação Brasileira de Bares e Restaurantes. Associados. <https://mg.abrasel.com.br/> (accessed on Nov/2020).
- Centrais de Abastecimento de Minas Gerais S.A. Sazonalidade do preço de hortigranjeiros. <http://www.ceasaminas.com.br/informacoesmercado/CelendarioComercializacaoSAZONALIDADEPRECOS2019NOVO1.pdf> (accessed on 30/Mar/2020).
- Yahoo! Finance. USD/BRL (USDBRL=X). <https://finance.yahoo.com/quote/USDBRL%3DX/history?p=USDBRL%3DX> (accessed on 30/Mar/2020).
- Jiang J. Linear and generalized linear mixed models and their applications. New York: Springer Science & Business Media; 2007.
- Ribeiro-Silva RC, Pereira M, Campello T, Aragão E, Guimarães JMM, Ferreira AJF, et al. Implicações da pandemia COVID-19 para a segurança alimentar e nutricional no Brasil. *Ciênc Saúde Colet* 2020; 25:3421-30.
- Silva Filho OJ, Gomes Júnior NN. The future at the kitchen table: COVID-19 and the food supply. *Cad Saúde Pública* 2020; 36:e00095220.
- Recine E, Fagundes A, Silva BL, Garcia GS, Ribeiro RCL, Gabriel CG. Reflections on the extinction of the National Council for Food and Nutrition Security and the confrontation of COVID-19 in Brazil. *Rev Nutr* 2020; 33:e200176.
- Rede Brasileira de Pesquisa em Soberania e Segurança Alimentar e Nutricional. Inquérito Nacional sobre Insegurança Alimentar no Contexto da Pandemia da COVID-19 no Brasil. <http://olheparaafome.com.br/> (accessed on 05/Apr/2021).
- Baccarin JG, Oliveira JA. Inflação de alimentos no Brasil em período da pandemia da COVID-19, continuidade e mudanças. *Segur Aliment Nutr* 2021; 28:e021002.
- Mendes LL, Canella DS, Araújo ML, Jardim MZ, Cardoso LO, Pessoa MC. Food environments and the COVID-19 pandemic in Brazil: analysis of changes observed in 2020. *Public Health Nutr* 2021; 25:32-5.

25. Pedroso MTM, Corcioli G, Foguesatto C. A crise do coronavírus e o agricultor familiar produtor de hortaliças. *Gestão & Sociedade* 2020; 14:3740-9.
26. Huang I, Lim MA, Pranata R. Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia: a systematic review, meta-analysis, and meta-regression. *Diabetes Metab Syndr* 2020; 14:395-403.
27. Prefeitura de Belo Horizonte. Cesta básica para públicos vulneráveis. <https://prefeitura.pbh.gov.br/smasac/cestas-basicas-para-publicos-vulneraveis> (accessed on 15/Feb/2021).
28. Assé R. Um ano de pandemia: setor de bares e restaurantes pede socorro. *Estado de Minas* 2021; 9 apr. https://www.em.com.br/app/noticia/economia/2021/04/09/internas_economia,1255547/um-ano-de-pandemia-setor-de-bares-e-restaurantes-pede-socorro.shtml.
29. Centrais de Abastecimento de Minas Gerais S.A. Relatório de gestão – 2020. http://www.transparencia.ceasaminas.com.br/upload/rfm/transparencia-prestacao-contas/relatorio-gestao/Relat%C3%B3rio_CeasaMinas_2020_site.pdf (accessed on 11/Nov/2021).
30. Sarti FM, Claro RM, Bandoni DH. Contribuições de estudos sobre demanda de alimentos à formulação de políticas públicas de nutrição. *Cad Saúde Pública* 2011; 27:639-47.
31. Mendes JTG, Padilha Junior JB. *Agronegócio, uma abordagem econômica*. São Paulo: Prentice Hall Brasil; 2007.
32. Figueira T, Lopes A, Modena C. Barreiras e fatores promotores do consumo de frutas e hortaliças entre usuários do Programa Academia da Saúde. *Rev Nutr* 2016; 29:85-95.
33. Precota Agro Brasil. Carnes preço kg Ceasa Belo Horizonte. <https://precota.com.br/agro/grafico-preco-tabela-carnes-ceasa-belo-horizonte-kg/> (accessed on 11/Nov/2021).
34. Pranata R, Huang I, Lim MA, Wahjoepramono EJ, July J. Impact of cerebrovascular and cardiovascular diseases on mortality and severity of COVID-19: systematic review, meta-analysis, and meta-regression. *J Stroke Cerebrovasc Dis* 2020; 29:104949.
35. Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, et al. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *Lancet* 2019; 393:791-846.
36. Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional de Saúde: 2019. Informações sobre domicílios, acesso e utilização dos serviços de saúde: Brasil, grandes regiões e unidades da federação. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2020.
37. Prefeitura de Contagem. Ações do Banco de Alimentos de Contagem em tempos de pandemia. <http://www.contagem.mg.gov.br/voportal/acoes-do-banco-de-alimentos-de-contagem-em-tempos-de-pandemia/> (accessed on 11/Nov/2021).
38. Prefeitura de Belo Horizonte. Banco de alimentos. <https://prefeitura.pbh.gov.br/smasac/susan/equipamentos/banco-de-alimentos> (accessed on 11/Nov/2021).
39. Shadmi E, Chen Y, Dourado I, Farah-Perach I, Furler J, Hangoma P, et al. Health equity and COVID-19: global perspectives. *Int J Equity Health* 2020; 19:104.
40. Idrovo AJ, Manrique-Hernández EF, Fernández Niño JA. Report from Bolsonaro's Brazil: the consequences of ignoring science. *Int J Health Serv* 2020; 51:31-6.
41. Cuevas A, Barquera S. COVID-19, obesity and undernutrition: a major challenge for Latin American countries. *Obesity (Silver Spring)* 2020; 28:1791-2.
42. Silva AG, Teixeira RA, Prates EJS, Malta DC. Monitoramento e projeções das metas de fatores de risco e proteção para o enfrentamento das doenças crônicas não transmissíveis nas capitais brasileiras. *Ciênc Saúde Colet* 2021; 26:1193-206.

Resumo

Foi analisado o impacto dos esforços para combater a pandemia da COVID-19 sobre o preço dos alimentos comercializados por uma central de abastecimento na sexta maior cidade brasileira. Examinou-se as variações percentuais dos preços de vinte tipos de alimentos, ajustados pelas condições de mercado e pelas fases dos planos de contingência municipais com a abertura e fechamento de serviços não essenciais como bares e restaurantes (fase 1: primeira fase, apenas de serviços essenciais; fase 2: flexibilização; e fase 3: segunda fase apenas de serviços essenciais em comparação com o período “pré-pandêmico” [fase 0]). Os preços logarítmicos eram mais baixos em todas as fases de contingência para vegetais folhosos (variação: 42% e 56%) e hortaliças (variação: 28% a 40%). Os preços logarítmicos de ovos e frutas eram 20% e 16% mais baixos durante as fases 1 e 3, respectivamente. As estratégias para mitigar a pandemia da COVID-19 resultaram em preços mais baixos para ovos, frutas, vegetais folhosos e hortaliças, independentemente das condições de mercado. Isso revela a repercussão das estratégias de combate sobre a procura e oferta de alimentos in natura e minimamente processados, o que pode ser modulado pela crise econômica e pelas dificuldades em acessar e/ou comprar alimentos perecíveis regularmente. Os esforços para eliminar os impactos da pandemia devem assegurar o direito humano à alimentação adequada, uma vez que os preços baixos podem não ser sinônimos de segurança alimentar.

COVID-19; Pandemias; Abastecimento de Alimentos; Verduras; Frutas

Resumen

Analizamos el impacto de los esfuerzos para luchar contra la pandemia de COVID-19 en los precios de las comidas vendidas por un centro de suministro alimentario, localizado en la sexta ciudad más grande de Brasil. Examinamos el porcentaje de cambios en los precios de veinte tipos de comidas, ajustados por las condiciones de mercado, por las etapas del plan de contingencia municipal, con la apertura y cierre de los servicios no esenciales como bares y restaurantes (etapa 1: 1ª fase de solo servicios esenciales; etapa 2: flexibilización; y etapa 3: 2ª fase de solo servicios esenciales, en comparación con un periodo “pre-pandemia” [etapa 0]). El registro de precios era más bajo en todas las etapas de contingencia para todas las verduras de hoja verde (variación: 42% a 56%) y hortalizas (variación: 28% a 40%). El registro de precios de huevos y frutas fueron un 20% y un 16% más bajo durante las etapas 1 y 3, respectivamente. Las estrategias para mitigar la pandemia de COVID-19 resultaron en precios más bajos para los huevos, frutas, verduras de hojas verdes y hortalizas, independientemente de sus condiciones de mercado. Además, revela su repercusión en el suministro y demanda de comidas naturales y mínimamente procesadas, lo que quizás se vio modulado por la crisis económica y las dificultades para acceder y/o comprar alimentos perecederos más frecuentemente. Los esfuerzos para eliminar los impactos de la pandemia deben garantizar el derecho humano a alimentos adecuados, puesto que un bajo precio no es indicativo de seguridad alimentaria.

COVID-19; Pandemias; Abastecimiento de Alimentos; Verduras; Frutas

Submitted on 06/Jul/2021

Final version resubmitted on 13/Dec/2021

Approved on 27/Dec/2021