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Commentary

Will COVID-19 affect food supply in distribution centers of Brazilian regions affected by the pandemic?

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ABSTRACT

Background: Currently, there is great concern about the consequences of COVID-19 on health and also on food supply globally. Ceasas are important food distribution centers in Brazil that have great economic importance in Brazilian agribusiness.
Scope and approach: In this work, the price of fruits and vegetables sold in four Ceasas in different regions affected by COVID-19 in the first quarter of 2020 were evaluated, with the aim of verifying the possible effects of the pandemic on food supply chains. Data were collected from the institutions' websites and subjected to analysis of variance and Tukey's test ($p \leq 0.05$), principal component analysis and Cluster analysis (Euclidean distance).
Key findings and conclusions: The regions affected by COVID-19 showed great variations in the prices of products sold in the studied Ceasas. Statistical analysis showed that food prices were dependent on the regions and the period in which they were traded. In general, the month of March proved to have the greatest impact on the consumer's pocket. The strengthening of Ceasas as platforms for supplying food from short supply chains is essential to guarantee internal food security during crises such as that caused by the new coronavirus.

1. Introduction

Worldwide, food production and consumption are gaining more and more attention. Thus, there is an increasing concern with production capacity in order to meet the global demand of food (de Lima, Fioriolli, Padula, & Pumi, 2018). In this sense, Brazil is considered one of the largest producers and exporters of vegetable foods in the world. In 2017, Brazilian agriculture was responsible for a 13% growth in Gross Domestic Product (GDP). In this scenario, fruits and vegetables have shown increasing importance, both in the internal and international markets. In the same year, fruit exports amounted to 878 thousand tons, resulting in US$ 946.79 million (MAPA, 2018).

In Brazil, a large part of the internal supply of food of vegetable origin is carried out by the State Supply Centers (Ceasas), characterized as wholesale and retail establishments that serve a very diverse group of customers (Santos et al., 2020). The main objective of Ceasas is to supply the fruit and vegetable market, and its secondary activity also covers the sale of various other products such as packaging, electronics, clothing, among others, in addition to activities of complementary goods and services such as restaurants and snack bars (Lima, Pasqualetto, Calil, & De Castro, 2017; Mendes, 2019). However, the pandemic caused by COVID-19 has threatened production chains and

has put countries on alert for a possible food supply crisis in the world.

The number of confirmed cases and deaths by COVID-19 in the world has increased substantially in recent months, mainly in the European and American continents (WHO, 2020). According to data from the Ministry of Health, Brazil is one of the countries most affected by the new coronavirus in the American continent, with the Southeast region of the country being the most affected, followed by the Northeast, North, South and Midwest regions (Brasil, 2020).

With the arrival of the coronavirus in Brazil, the industrial, agribusiness and services sectors have already suffered major impacts in the first quarter of the year. In the first two months of the year, the effects of the pandemic on the Brazilian economy were diluted, as they were limited to a possible reduction in international demand and concerns related to the supply of necessary inputs in some industrial sectors. In March, with the restriction measures adopted to contain the disease, the projection is that GDP growth will be affected (Borges et al., 2020).

Thus, taking into account the importance of Ceasas as essential platforms for food supply and the current scenario of the Brazilian economy, this study aimed to assess the impacts of COVID-19 in Ceasas located in regions affected by the pandemic. To this end, we conducted a survey of the prices of some fruits and vegetables sold in the first quarter of the year in these establishments, in order to verify the

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possible effects caused by the coronavirus on the internal supply of food.

2. Food distribution centers (Ceasas)

In view of the great demand for fresh food and the need to establish support units for the production and distribution of fruits and vegetables, the Brazilian government created in 1969 the "Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP)", marking the beginning of the opening of logistics marketing platforms, namely, the Ceasas. Today, Ceasas are considered fundamental parts of the food distribution policy across the country (CONAB, 2020; Taha, 2012).

According to the National Supply Company (CONAB), the Ceasas "*are diversified economic and social spaces that bring together sellers and buyers, producers and traders, consumers and service providers, public and informal agents in an intense commercial and social relationship carried out in a short period of time*" (CONAB, 2010). In this sense, Ceasas are considered an excellent food supply and distribution channel that allows the flow of agricultural production (generating employment, income and boosting the different sectors of the production chain), the food and nutritional security of the Brazilian population. In addition, Ceasas are important places that allow the connection of different regions of the country, which allows, for example, the supply of vegetable products in non-producing regions.

In 2018, Ceasas traded about 16.828.901 tons of fruits and vegetables in 62 units spread across 18 Brazilian states (including the Brasília unit, in the Federal District), which represented approximately US$ 6.75 billion traded (more than R$ 36.1 billion). The Southeast region of Brazil was responsible for about 54% of the commercialization (9.149.548 tons, 56% of the amount traded), followed by the Northeast region with 22% (3.633.532 tons, 19%), South 13% (2.247.281 tons, 13%), Midwest 9% (1.514.784 tons, 10%) and North 2% (283.756 tons, 2%) (CONAB, 2019).

According to Barreto Junior (2004), Ceasas provided several beneficial changes that are difficult to measure, some of which are subjective, as they refer to social, cultural and economic effects, which involve the entire food production chain, with emphasis on producers, traders, agents and companies in the agricultural and consumer sectors.

Given the above, the socioeconomic importance and representativeness of these supply units in Brazilian agribusiness is evident. However, what will be the impact of COVID-19 on the distribution, supply and commercialization/sale of goods in Brazilian Ceasas? Is it possible to ensure the activities of the production chain even in the midst of a pandemic with real threats to the health and food security of the world population?

3. Survey design and approach

In order to assess the potential impact of COVID-19 on the internal distribution of food, we evaluated the price variation of some of the main vegetables (Potato, watermelon, banana, orange, tomato, papaya, onion, melon, avocado, pineapple and guava) marketed in Ceasas from different Brazilian regions affected by the pandemic in the first quarter of the year. For this purpose, the prices of these vegetables were evaluated from January 2nd to March 31st with an interval of 3–4 days, due to the difficulty of obtaining daily information about the prices of the products. The Ceasas evaluated were: Ceasa Rio de Janeiro (Ceasa-RJ, located in the Southeast region); Ceasa Rio Grande do Sul (Ceasa-RS, South region); Ceasa Goiás (Ceasa-GO, Midwest region) and Ceasa Pernambuco (Ceasa-PE, Northeast region). Product prices were collected from the following websites: Ceasa-RJ (http://www.ceasa.rj.gov. br/ceasa_portal/view/portal.asp); Ceasa-RS (http://ceasa.rs.gov.br); Ceasa-GO (https://www.ceasa.go.gov.br), and Ceasa-PE (http://www. ceasape.org.br). The variation in fruit and vegetable prices was calculated based on the values of January 2, 2020 and the values were converted using the dollar price on the same day (US$ 1 = R$ 4.02). The graphs representing the price variation were generated using the Microsoft® Office Excel package.

3.1. Statistical analysis

Principal Component Analysis (PCA) Biplot and cluster analysis were performed using Past version 4.01 software (Past, 2020). The PCA model was developed using the prices of food sold in the four Ceasas in the three months evaluated. Pre-processing of the data was necessary to assign equivalent weights to each variable. Thus, the data were standardized so that the mean value of the variables was equal to 0 and the variance value was equal to 1. The number of factors that best represents the data was chosen based on the loadings (which indicates the correlation between the variables and each factor) and eigenvalues (which represents the relative contribution of each component in explaining the total variation of the data) (Table 1). To evaluate the generalizability of this model, a resampling was carried out, randomly selecting eight of the eleven variables studied (fruits and vegetables). The number of principal components for this new model was determined by V-fold cross-validation, with V value = 7. For the cluster analysis by hierarchical method, the data were standardized and the Euclidean distance was used as a similarity coefficient. The clustering strategy used was the paired group method. In addition, the collected data also were evaluated by analysis of variance (ANOVA) and the results were compared by Tukey's test at 5% probability level using the Statistica software version 7.0 (Statsoft, 2004).

Table 1
Values of loading, eigenvector, and variable contributions from PCA Biplot.

Variables	Loading			Eigenvector			Variable contributions		
	Fator 1	Fator 2	Fator 3	Fator 1	Fator 2	Fator 3	Fator 1	Fator 2	Fator 3
Potato	0,846	0382	−0,184	0427	0,219	−0,110	0182	0,050	0010
Watermelon	0,838	0067	0,358	0423	0,038	0215	0,175	0001	0,050
Orange	0,964	−0,219	0032	0,486	−0,126	0019	0,237	0015	0,001
Banana	0,124	0931	0,009	0062	0,533	0006	0,003	0284	0,000
Onion	0,247	0192	0,878	0125	0,110	0527	0,013	0011	0,281
Papaya	0,560	−0,584	−0,566	0283	−0,335	−0,339	0084	0,108	0115
Tomato	0,540	−0,429	0564	0,273	−0,246	0339	0,072	0062	0,114
Avocado	0,506	0518	−0,558	0255	0,297	−0,335	0067	0,092	0106
Pineapple	0,599	−0,268	−0,694	0302	−0,154	−0,417	0096	0,021	0172
Melon	0,280	−0,737	0521	0,141	−0,422	0312	0,019	0181	0,096
Guava	−0,457	−0,731	−0,375	−0,230	−0,419	−0,225	0050	0,174	0055
Eigenvalue	3931	3045	2777						
Cumulative variance (%)	35,741	63,419	88,661						

4. Findings and implications

4.1. Impact of COVID-19 on the price of fruits and vegetables sold in Brazilian Ceasas

Faced with a scenario of uncertainties and in the midst of a pandemic that threatens not only the economy, but above all the health and life of millions of people around the world, it is difficult to gauge, at least so far, the real impacts of COVID -19 in Brazilian agribusiness, especially in supply centers, due to the lack of information released by official agencies. However, it is possible to make a preliminary analysis of the data made available by the supply centers. Fig. 1 shows the daily variation in fruits and vegetable prices marketed in the first quarter of the year in the different Ceasas of the Brazilian regions affected by the COVID-19 pandemic. As can be seen, the price of some vegetables varied widely from January to March. At Ceasa-RJ (Fig. 1A), the price of tomatoes increased significantly during the month of January, presenting an increase of 183.82% in relation to 01/02/2020, and decreased in the first days of February (−72.80% in relation to the price of 01/30/2020). Bananas reduced 57.2% of the price on 01/06/2020 and closed the quarter with a 40% reduction in relation to the price charged at the beginning of the quarter. In March, tomato was the product that suffered the greatest price variation, with the biggest variation on 03/16/2020 (216.91% increase compared to 02/01/2020) and closed the quarter with 66.91%. Onion significantly increased the price in March, closing the quarter with an increase of 101.53%. Fruits such as oranges, guava, pineapples, papayas and watermelons showed low prices in most of the quarter.

At Ceasa-RS, avocado showed a price reduction throughout the first quarter of 2020 (around −50%). On the other hand, the month of March was responsible for the biggest variation in the price of other products, mainly for onion (+127.27%) and guava (−50%) (Fig. 1B). This behavior was similar in Ceasa-PE (Fig. 1D), where tomato and onion obtained the highest prices in March (+164.7 and + 153.91% respectively) and guava fell by −33.33% in price. Interestingly, the price of tomato at Ceasa-PE was up in the second week of March, and suffered a significant reduction at the end of the quarter (−85.71% in relation to the price of 03/12/2020). In turn, Ceasa-GO (Fig. 1C) showed a large variation in the price of tomatoes over the first quarter, with a significant increase on 03/05/2020 (+214.46%) and closed the quarter with a 66.6% reduction in relation to the same day. Onion had an increase of 75% and avocado reduced by 50% in relation to the price of 01/02/2020.

Principal Component analysis (PCA) Biplot was carried out to verify in which Ceasa/month there was greater similarity/dissimilarity based on the variation in food prices, and if this variation is related to evolution of the pandemic in Brazil (Fig. 2A and B). In this analysis, components 1, 2 and 3 were used because they explained 88.66% of the behavior of the data variation (Table 1). Thus, it was observed that there was variation between the prices of vegetables sold in the different months and studied Ceasas. In Ceasa-PE and Ceasa-RJ, there was similarity in the variation in prices between the months of January and February (Fig. 2A). On the other hand, the prices of commercialized foods showed dissimilarity in the month of March for all evaluated Ceasas, suggesting that there was a greater variation in the prices of products in that period (Fig. 2B).

The cluster analysis can be considered as a complement to the PCA and, therefore, it was used to classify the Ceasas in groups according to
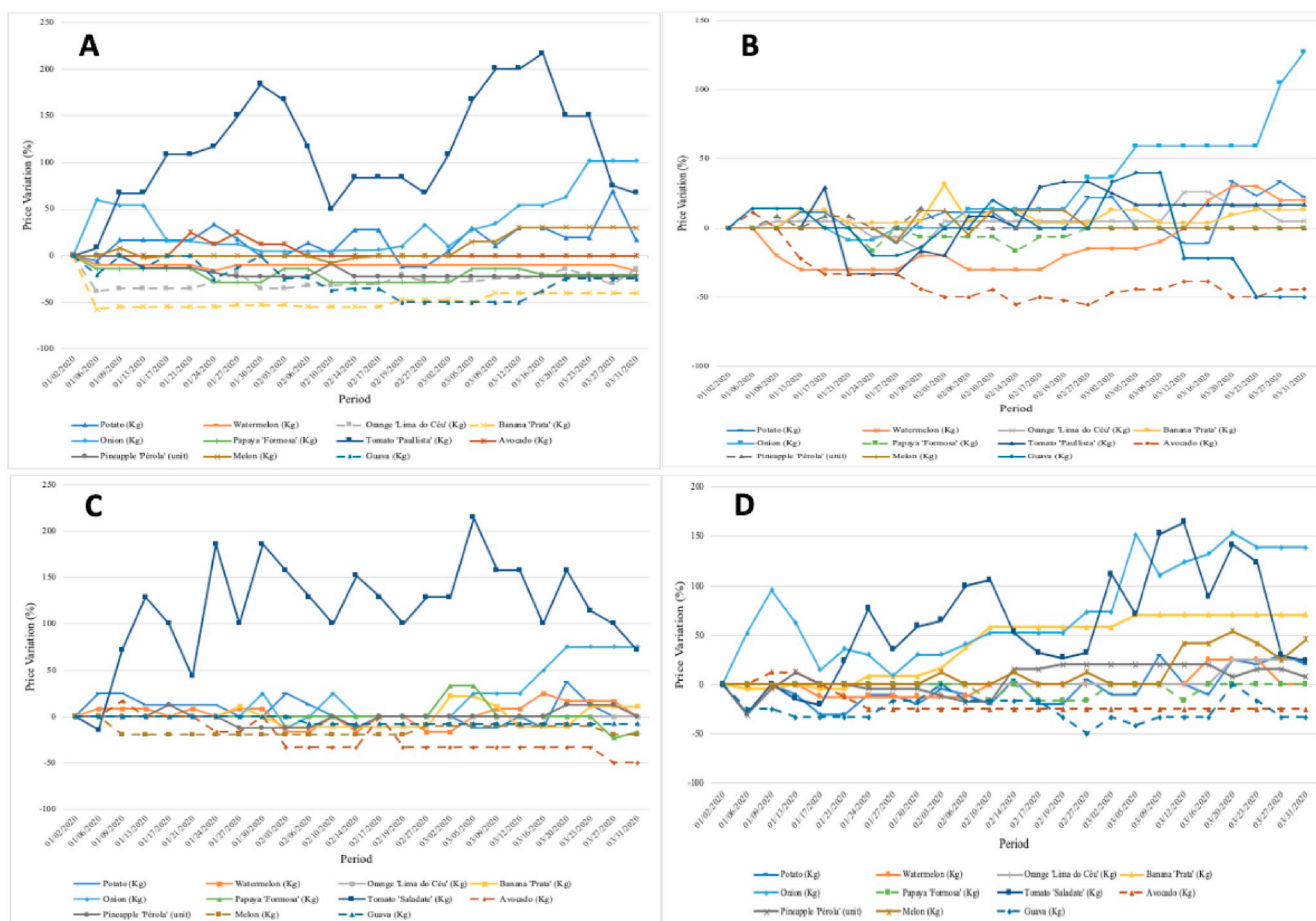

Fig. 1. Variation in fruits and vegetable prices marketed in the first quarter of 2020 in the different Ceasas studied.
A: Ceasa Rio de Janeiro; **B:** Ceasa Rio Grande do Sul; **C:** Ceasa Goiás; **D:** Ceasa Pernambuco.
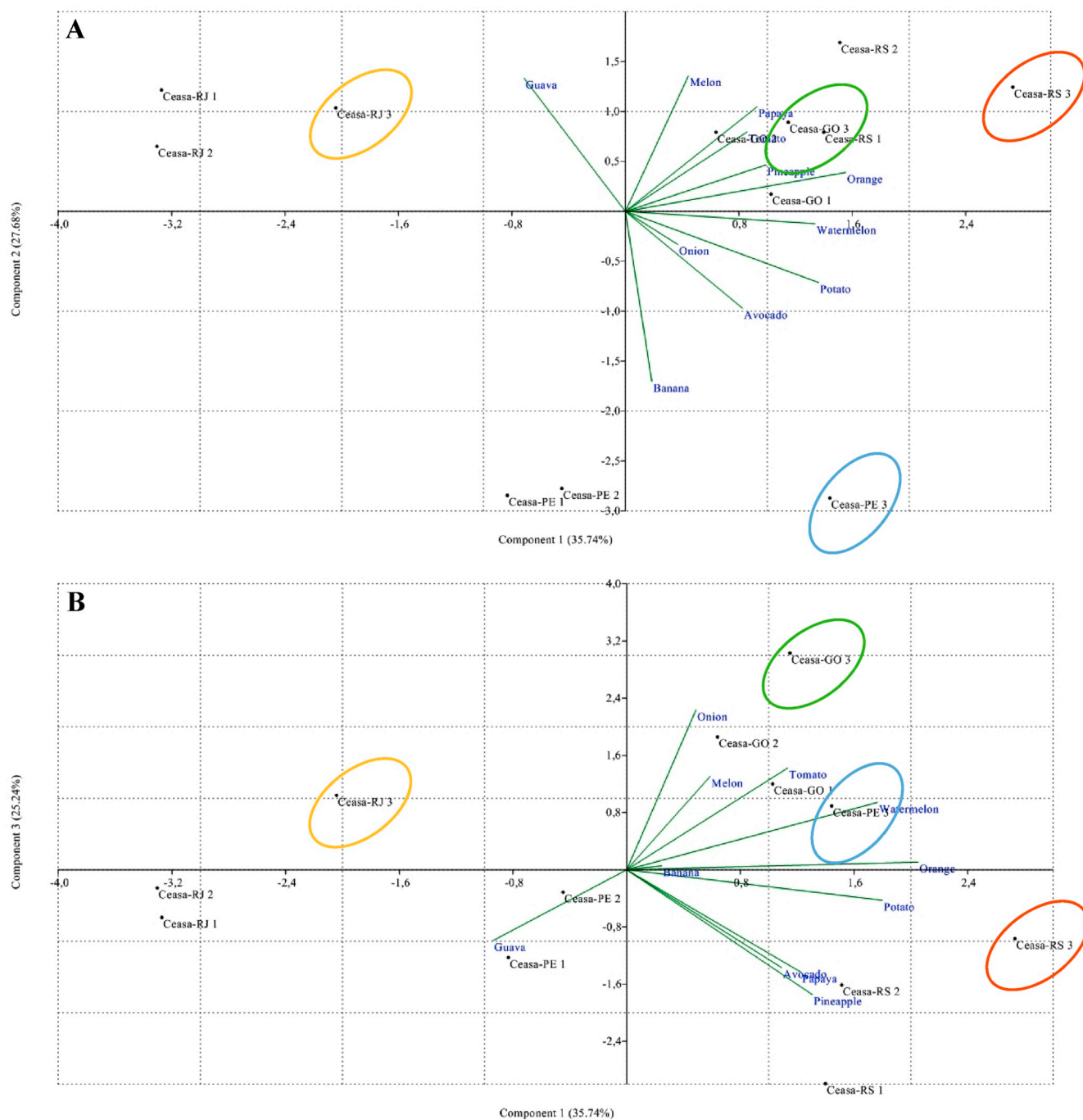
Fig. 2. Principal Component Analysis (PCA) of fruits and vegetables marketed in the first quarter of 2020 in the different Ceasas studied.
A: Principal Component Analysis of factor 1 *vs* factor 2. **B**: Principal Component Analysis of factor 1 *vs* factor 3. **Ceasa-RJ**: Ceasa Rio de Janeiro; **Ceasa-RS**: Ceasa Rio Grande do Sul; **Ceasa-GO**: Ceasa Goiás; **Ceasa-PE**: Ceasa Pernam-buco. The numbers "**1**", "**2**" and "**3**" represent the months of January, February and March, respectively.

the price of the products, and thus to verify the relationship between the distribution centers and the food marketing period. Thus, it was observed that the similarity between the Ceasas is low, that is, the price of the products depends on the region where it is sold (Fig. 3). In addition, it was demonstrated that in March there was the greatest variation in the prices of products in Ceasa-PE, Ceasa-RJ and Ceasa-GO, reinforcing the results shown previously in Fig. 2.

Table 2 shows the total costs necessary to purchase fruits and vegetables in the different Ceasas in the first quarter of 2020. As can be seen, although there is variation in the price of fruits and vegetables between months and Ceasas (See Fig. 1), this did not impact the total

price for purchasing the same quantity of these foods at Ceasa-RS. At Ceasa-RJ and Ceasa-GO, there was a reduction in the total cost of these products in February (−12.96 and −4.75%, respectively), demonstrating that the consumer spent less to purchase these foods. However, there is a trend towards an increase in the total cost of products in March, mainly in Ceasa-RJ and Ceasa-GO, While Ceasa-PE showing a significant increase of 14.04% in relation to February (Table 2).

In view of this, the following question arises: Would this price variation in fruits and vegetables in March be a first impact caused by the pandemic on the distribution of food in Ceasas? Unfortunately, some information necessary to "quantify" the real impacts of the
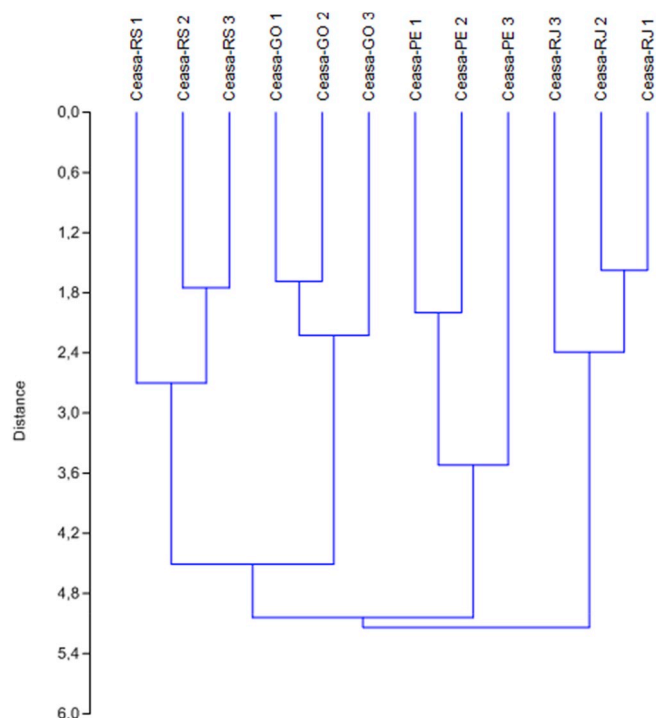
Fig. 3. Cluster analysis of the different Ceasas studied based on the commercialization of fruits and vegetables in the first quarter of 2020.
Ceasa-RJ: Ceasa Rio de Janeiro; **Ceasa-RS**: Ceasa Rio Grande do Sul; **Ceasa-GO**: Ceasa Goiás; **Ceasa-PE**: Ceasa Pernambuco. The numbers "**1**", "**2**" and "**3**" represent the months of January, February and March, respectively.

Table 2
Monitoring of the amounts (US$) required to purchase fruits and vegetable at different destruction centers in Brazil in the first quarter of 2020.

Ceasa	January	February	March
Rio de Janeiro	6.17 ± 0.36^{Ab}	5.37 ± 0.31^{Bd}	6.06 ± 0.43^{Ad}
Rio Grande do Sul	7.27 ± 0.57^{Aa}	7.25 ± 0.17^{Ab}	7.46 ± 0.36^{Ab}
Goiás	6.52 ± 0.22^{Ab}	6.21 ± 0.12^{Bc}	6.67 ± 0.27^{Ac}
Pernambuco	6.61 ± 0.24^{Cb}	7.69 ± 0.30^{Ba}	8.77 ± 0.40^{Aa}

Capital letters in the lines compare the total amount needed to purchase fruits and vegetables over the months for each Ceasa. Lowercase letters in the column compare the total amount needed to buy fruits and vegetables in different Ceasas for each month. Equal letters in the rows or columns do not differ statistically from each other by the Tukey test (p ≤ 0.05).

pandemic on the food supply chain in Brazil is not yet available in the literature (for example, pandemic impacts on food production, supply, sales and waste, among others). However, when we observe the current scenario and economic projections for the country, we can hypothesize, in principle, that the price fluctuation of the food products studied here may be related to supply/demand variation for these products, reflecting the impact of the pandemic on other sectors of the economy.

Product prices are influenced by several factors, such as seasonality, product quality, environmental variables, risk of losses, government measures, financial resources, productive capacity, among others (Souza, Aguilar, & Nogueira, 2009). However, it can also be a good indicator of changing consumer behavior. As noted, tomato suffered greater variation in price. The increase in the price of this food in February in Ceasa-GO and Ceasa-PE (Fig. 1C–D), may be related to a lower supply of this product. According to CONAB, the supply of tomatoes decreased by 7% in relation to January in some Ceasas in Brazil, as a consequence of the reduction in the summer harvest, currently responsible for supplying internal markets. On the other hand, the reduction in the price of bananas in Ceasa-RJ and avocado in other Ceasas

in February, can be explained by the reduction in supply associated with difficulties in marketing due to holidays and rains (CONAB, 2020a).

Interestingly, the increase in the price of tomatoes in the first weeks of March coincided with the beginning of the quarantine period in Brazil. In this period, with government measures, consumers began to prepare their meals at home more frequently and thus accumulate more food in the refrigerator, which may have caused a greater demand for this product (considering that this food is widely used in Brazilian cuisine). Thus, a higher demand and a lower supply, reflecting the lower supply in February, certainly contributed to the increase in the price of tomatoes in the first weeks of March. As of the second half of this month, this behavior reversed. With the normalization of the availability of this product, the supply increased and its demand decreased, possibly due to the greater accumulated volume of this food by consumers in the previous weeks. Like tomatoes, onions are an essential food in Brazilian cuisine. The rise in the price of this product can be explained by its lower offer. According to data from CONAB, onion production in the Northeast region (a large onion producer) was very low in this period and this increased the volume of purchase of this food in other producing regions, mainly the South region, which resulted in an increase in the price of this product in the studied Ceasas. In addition, with restrictions on international trade, onion imports were reduced, and domestic production did not meet all demand (CONAB, 2020b).

The increase in the price of some products such as tomatoes and onions in March, may make it difficult for consumers to access these foods. In addition, restricting farmers' access to markets, purchasing inputs and selling products, can reduce the supply of fresh food, increase losses or waste on farms (Galanakis, 2020). On the other hand, the reduction in the price of some very perishable fruits such as guava and avocado in the same month, may indicate that these products are being less sought after, which leads to waste and generates losses for producers.

According to Hobbs (2020), with the intensification of social distancing measures, a good part of consumers showed a behavior of accumulation of food caused by fear, which led to a sudden increase in demand in the main categories of food distribution, resulting in short-term interruptions. Although, at first, Ceasas do not appear to have major impacts on food availability, this does not guarantee that they can be "immune" to the consequences caused by COVID-19 in the country. We must not forget that the supplementation of food in the distribution centers depends on the good functioning of the entire production chain. Thus, it is necessary to ensure that the food is produced and reaches the final consumer with adequate quality and prices.

According to the Food and Agriculture Organization of the United Nations (FAO), until March, the global distribution of food has taken place properly and the markets were functioning within normality. However, problems expected in the coming months, such as restrictions on the circulation of goods, shortages of fertilizers, veterinary medicines and other inputs, could affect agricultural production and lead to disruptions in food supply chains (FAO, 2020a). In this sense, guaranteeing the supplementation of food in distribution centers is essential to avoid the increase in basic food prices, which would threaten food security and would bring even greater damage to the population, especially for the most vulnerable.

Borges et al. (2020) state that COVID-19 reduced growth in various sectors of the Brazilian economy in the first quarter of the year. In trade for example, according to the authors, the projection is that the food, beverage and tobacco sector will be affected by 33%, while supermarkets and hypermarkets will be affected by 46%. The instability in these and other sectors of the Brazilian economy, brings a series of negative consequences, such as the reduction of family income and the increase in the unemployment rate, which reduces the purchasing power of consumers, generates uncertainties and can impact in the demand for foods. In addition, restrictions on the movement of people

and measures to prevent crowding, recommended by government officials and health authorities to try to reduce the transmission of the virus, can also reduce the demand for these products. The closing of school and restaurant is also a factor that will certainly have an impact on the commercialization of products by Ceasas.

Food Price Index of FAO (FFPI) that monthly monitors the price of products sold worldwide registered a significant drop in March (-4.3% in relation to the previous month). Among foods, sugar had the biggest drop in FFPI compared to February (19.1% reduction in the value of the product), followed by vegetable oil (-12%), dairy (-3%), cereals (-1.9%) and meat (-0.6%). According to FAO, the reduction in the prices of these foods was caused mainly by factors related to demand, which in turn are influenced by the retraction in the world economy (FAO, 2020b).

Even suffering constant threats of economic crisis, it is worth mentioning that Ceasas can be an excellent tool to guarantee the availability and commercialization of food in the internal market, and thus avoid a second problem related to food scarcity and environmental sustainability (Recchia, Cappelli, Cini, Garbati Pegna, & Boncinelli, 2019). Thus, investing in the strengthening of Ceasas as centers for the distribution of food from short supply chains, can be an alternative to guarantee access to food during crises such as the COVID-19 pandemic (Cappelli & Cini, 2020).

5. Conclusions and remarks

- The variation in product prices depended on the region and the marketing period.
- The results showed that there seems to be a correlation between the variation in vegetable prices with the Brazilian regions mostly affected by COVID-19 in March.
- At first, Ceasas seem to keep their food supply activities within normal limits. However, the reduction in the price of some vegetables suggests that they are being less sought after by consumers, probably due to the consequences caused by the pandemic in other sectors of the economy.
- Rising prices for some fruits and vegetables may limit consumers' access to and consumption of these foods. On the other hand, the cheapness of some products, especially the most perishable, increases waste and brings losses to producers.
- At a time when global health is threatened, it is essential that Brazilian government agencies create measures that ensure the proper functioning of food production chains, in order to guarantee the country's food security during the current crisis.
- Thus, the importance of Ceasas as tools to guarantee the internal supply of essential foods in the diet is evident.
- In conclusion, this study may encourage future approaches that aim to confirm the real impacts of COVID-19 on the food production chain and its effects on the economy of the corresponding sector, not only in Brazil, but also in other regions of the world.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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